Appendix B Errata

B.1.16 Colusa Basin Drain, Diazinon

Evidence of Impairment

Between 1994 and 2000~~1998~~, multiple studies analyzed a total of 56 ambient water samples collected from the CBD at Road 99E, near Knights Landing, for diazinon (Table B-2). Most samples were collected during the orchard dormant spray season. Overall, 14~~18~~ of 56 samples (about 25~~32~~%) contained diazinon concentrations at or above CDFG chronic water quality criterion of 0.05 µg/L and 10~~11~~ of 56 (about 18~~20~~%) samples exceeded CDFG acute water quality criterion of 0.08 µg/L.

Table B-2. Summary of Diazinon Concentrations in the Colusa Basin Drain

Data Source	Sample Years	Number of Sample Dates	Range of Diazinon Concentrations	Criteria[a]		Number of Sample Dates Equal to or Above Criteria	Percent of Sample Dates Equal to or Above Criteria
Holmes *et al*, 2000	1994	29	nd - 0.42 µg/L	Chronic	0.05 µg/L	11~~8~~	38~~28~~%
				Acute	0.08 µg/L	9	31%
Domagalski, 2000	1996	2	nd	Chronic	0.05 µg/L	0	0%
				Acute	0.08 µg/L	0	0%
Domagalski, 2000	1997	15	nd - 0.073 µg/L	Chronic	0.05 µg/L	2~~0~~	130%
				Acute	0.08 µg/L	0~~2~~	0~~13~~%
Domagalski, 2000	1998	4	0.007 - 0.098 µg/L	Chronic	0.05 µg/L	1~~0~~	25~~0~~%
				Acute	0.08 µg/L	1	25%
Dileanis, *et al*, 2001	2000	6	nd - 0.038 µg/L	Chronic	0.05 µg/L	0	0%
				Acute	0.08 µg/L	0	0%
Summary	1994 - 2000	56	nd - 0.42 µg/L	Chronic	0.05 µg/L	14~~8~~	25~~14~~%
				Acute	0.08 µg/L	10~~12~~	18~~21~~%

[a] CDFG water quality criteria for the protection of aquatic life (Siepmann and Finlayson, 2000)
nd = not detected

B.1.18 Del Puerto Creek, Chlorpyrifos

Evidence of Impairment

Several studies have measured chlorpyrifos levels in Del Puerto Creek (Table B-2). The samples analyzed for these studies were collected between January and June, 1991 to 1993. Ten~~Five~~ of the 30 samples (33~~17~~%) analyzed for chlorpyrifos exceeded the CDFG chronic water quality criterion for chlorpyrifos, and ten~~three~~ of the samples (33~~10~~%) exceeded the CDFG acute criterion.

Table B-2. Summary of Chlorpyrifos Concentrations in Del Puerto Creek

Data Source	Sample Years	Number of Sample Dates	Range of Chlorpyrifos Concentrations	Criteria[a]		Number of Sample Dates Equal to or Above Criteria	Percent of Sample Dates Equal to or Above Criteria
Ross 1992 and 1993; Ross *et al*, 1996 and 1999; Fujimura, 1991a,b and 1993a,b,c,d	1991-1993	8	nd	Chronic	0.014 µg/L	0	0%
				Acute	0.02 µg/L	0	0%
Foe, 1995	1991	8	nd – 0.12 µg/L	Chronic	0.014 µg/L	3	38%
				Acute	0.02 µg/L	3	38%
Foe, 1995	1992	14	nd – 0.04 µg/L	Chronic	0.014 µg/L	7	50%
				Acute	0.02 µg/L	7	50%
Summary	1991-1993	30	nd – 0.12 µg/L	Chronic	0.014 µg/L	10	33~~30~~%
				Acute	0.02 µg/L	10	33~~30~~%

[a] CDFG water quality criteria for the protection of aquatic life (Siepmann and Finlayson, 2000)
nd = not detected

B.1.19 Del Puerto Creek, Diazinon

Evidence of Impairment

Several studies have measured diazinon concentrations in Del Puerto Creek (Table B-2). The samples analyzed for these studies were collected between January and June 1991 to 1993. Ten of the 30 samples (33%) analyzed for diazinon exceeded the CDFG chronic water quality criterion for diazinon, and nine~~six~~ of the 30 samples (30~~20~~%) exceeded the CDFG acute criterion.

B.1.24 Ingram/Hospital Creek, Diazinon

Evidence of Impairment

Between 1991 and 1993, multiple studies analyzed a total of 32~~28~~ water samples collected from Ingram/Hospital Creek for diazinon. Sixteen of the 32 samples (50%) analyzed for diazinon exceeded the CDFG chronic water quality criterion for diazinon, and eleven of the 32 samples (34%) exceeded the CDFG acute criterion. The data are summarized in Table B-2.

B.1.25 Jack Slough, Diazinon

Evidence of Impairment

Between 1994 and 2000, the Regional Board and the USGS monitoring studies analyzed a total of 19~~26~~ ambient water samples collected in Jack Slough, during rain events, for diazinon. Overall, 19~~26~~ out of 19~~26~~ samples (100%) exceeded the CDFG chronic water quality criteria of 0.05 parts per billion (ppb) and the acute water quality criteria of 0.08 ppb in January and February, coinciding with the orchard dormant spray season. Pollutant concentrations in ambient water samples collected from Jack Slough ranged up to more than 16~~22~~ times the CDFG chronic water quality criteria. Table B-2 summarizes the available data.

B.1.34 Newman Wasteway, Chlorpyrifos

Evidence of Impairment

Between 1991 and 1993, a total of ten ambient water samples collected from the Newman Wasteway were analyzed for chlorpyrifos (Table B-2). Most samples were collected between January and April. Two of the ten (20%) samples contained chlorpyrifos concentrations at or above the CDFG chronic water quality criterion of .014 ug/l, and two~~one~~ of the ten (20~~10~~%) were~~was~~ above the CDFG acute water quality criterion of 0.020 ug/l. Overall, chlorpyrifos concentrations in samples collected from Newman Wasteway ranged from less than 1 to 15 times the CDFG chronic water quality criteria (Foe, 1995; Ross, 1992, 1993; Ross *et al*~~.~~, 1996, 1999; Fujimura, 1991a,b, 1993a,b,c,d).

B.1.51 Sutter Bypass, Diazinon

Evidence of Impairment

Several studies have measured diazinon concentrations in water samples collected from the Sutter Bypass (Table B-2). These studies were conducted between December and March, the winter orchard dormant season. A total of 78 samples were analyzed for diazinon; of these 78 samples 1827 (2335%) exceeded the CDFG chronic water quality criterion for diazinon, and sixten (813%) exceeded the acute criterion (Nordmark, 1998, 1999, and 2000).

Table B-2. Summary of Diazinon Concentrations in the Sutter Bypass

Data Source	Sample Years	Number of Samples	Range of Diazinon Concentration	Criteria[a]		Number of Samples Equal to or Above Criteria	Percent Samples Equal to or Above Criteria
Nordmark *et al*, 1998	Dec. 1996 – Mar. 1997	16	nd - 0.086 µg/L	Chronic	0.05 µg/L	40	250%
				Acute	0.08 µg/L	1	6%
Nordmark, 1998	Dec. 1997 – Mar. 1998	20	nd - 0.104 µg/L	Chronic	0.05 µg/L	50	250%
				Acute	0.08 µg/L	3	15%
Nordmark, 1999	Dec. 1998 – Mar. 1999	20	nd - 0.11 µg/L	Chronic	0.05 µg/L	72	3510%
				Acute	0.08 µg/L	13	515%
Nordmark, 2000	Dec. 1999 – Mar. 2000	22	nd - 0.093 µg/L	Chronic	0.05 µg/L	20	90%
				Acute	0.08 µg/L	1	4%
Summary	1996 - 2000	78	nd - 0.11 µg/L	Chronic	0.05 µg/L	182	232%
				Acute	0.08 µg/L	68	810%

[a] CDFG water quality criteria for the protection of aquatic life (Siepmann and Finlayson, 2000)
nd = not detected

B.1.1 Avena Drain, Ammonia

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region, (Regional Board) recommends the addition of the Avena Drain to California's Clean Water Act Section 303(d) list due to impairment by ammonia. Information available to the Regional Board on ammonia levels indicates that water quality objectives are not being attained. The basis for this recommendation is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Avena Drain	**Pollutants/Stressors**	Ammonia
Hydrologic Unit		**Sources**	Agriculture/Dairies
Total Length	8.5 Miles	**TMDL Priority**	
Size Affected	6.5 Miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	The upper 6.5 miles of Avena Drain	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	37° 50' 05"	**Upstream Extent Longitude**	121° 00' 27"
Downstream Extent Latitude	37° 50' 44"	**Downstream Extent Longitude**	121° 07' 37"

Watershed Characteristics

Avena Drain is a modified natural channel approximately 8.5 miles in length. The Avena Drain is tributary to Lone Tree Creek, which is tributary to the Delta. Storm water runoff (mainly from cropland) and irrigation tail water are the main sources of water. Due to the flow of tail water, the drain is no longer ephemeral during the dry season. Although there are few trees growing along the drain, there is some riparian vegetation.

Water Quality Objectives Not Attained

The narrative objective for toxicity is not being attained in the Avena Drain. The narrative toxicity objective in the Basin Plan states, in part, "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life." The narrative toxicity objective further states that "The Regional Water Board will also consider ... numerical criteria and guidelines for toxic substances developed by the State Water Board, the California Office of Environmental Health Hazard Assessment, the California Department of Health Services, the U.S. Food and Drug Administration, the National Academy of Sciences, the U.S. Environmental Protection Agency, and other appropriate organizations to evaluate compliance with this objective (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/~rwqcb5/bsnplnab.pdf)."

Ammonia levels in Avena Drain frequently exceed the Basin Plan objective for toxicity. To maintain healthy aquatic life in fresh water, the California Department of Fish and Game (CDFG) has determined that ammonia levels (measured as NH_3) should not exceed 0.02 mg/L undissociated ammonia (CRWQCB-CVR, 2001a).

Evidence of Impairment

There are 12 dairies that have the potential and propensity to discharge wastewater containing manure, which can cause high ammonia levels, into Avena Drain. These discharges arise from the inability of the dairies to retain wastewater during the winter months, and from irrigation with wastewater during the spring, summer and fall. Between 1978 and 2000, multiple dairies have been cited for discharging wastewater to the Avena Drain. In March 1978, a "deposit in Avena Drain (of) dairy manure and wastes," caused "a severe fish kill," of more than 1,000 carp. Over a period of ten years, samples collected from water entering the drain and from the drain have shown undissociated ammonia levels ranging from 0.66 to 3.03 mg/L, with an average undissociated ammonia level of 1.93 mg/L (CRWQCB-CVR, 2001a). Analytical results from discharges to the drain were used when no other flow, besides the discharge, was in the drain at the time of the inspection and sample collection. All of the samples contained undissociated ammonia levels above the CDFG criterion of 0.02 mg/L.

Extent of Impairment
Avena Drain begins on a dairy farm east of Brennan Avenue in San Joaquin County. Ten of the 12 dairies along the drain are located on the upper 6 ½ miles.

Potential Sources
The source of the ammonia in Avena Drain is from manure carried in dairy wastewater. The samples were taken during known discharges of wastewater.

Documents Supporting Listing a Waterbody-Pollutant on the 2002 303(d) List

Waterbody	**Pollutant**	**Sources**	**Location: Folder #; Tab Title**
Arcade Creek	Cu	Fact Sheet	1; Arcade Creek
Arcade Creek	Cu	Larry Walker Associates. 2001a. SRWP 99-00 Database. Unpublished Data.	1; Disk 1
Arcade Creek	Cu	Larry Walker Associates. 2001b. *Sacramento River Watershed Program Annual Monitoring Report: 1999-2000.* Prepared for the Sacramento River Watershed Program by Larry Walker Associates, Davis, California.	1; Arcade Creek
Arcade Creek	Cu	Russick, K. 2001. *Characterization of OP 2; Pesticides in Sacramento Urban Runoff and Receiving Waters.* Unpublished Draft CALFED Repot. Russik Environmental Consultant, Elk Grove, California.	1; Arcade Creek
Arcade Creek	Cu	USGS (U.S. Geological Survey). 2001. *National Water Information System.* http://water.usgs.gov/nwis/ (August 28, 2001). Query: 1; Arcade Creek.	1; Disk 2
Arcade Creek	Cu	Woodward-Clyde. 1992. *Source Identification and Control Report, December 1, 1992.* Report prepared for the Santa Clara Valley Nonpoint Source Pollution Control Program by Woodward-Clyde Consultants, Oakland, California.	NA
Arcade Creek	Ammonia	Fact Sheet	1; Avena Drain
Avena Drain	Ammonia	CRWQCB-CVR. 2001a. *1; Avena Drain File.* File Containing Regional Board Staff Field notes and lab results from 1; Avena Drain and surrounding dairies.	1; Avena Drain
Avena Drain	Pathogens	Fact Sheet	1; Bacteria
Avena Drain	Pathogens	Jennings, B. 2001. Letter from Bill Jennings (DeltaKeeper A Project of San Francisco BayKeeper) to Mr. Jerry Bruns and Mr. Joe Karkoski (California Regional Water Quality Control Board, Central Valley Region) dated May 14, 2001, regarding DeltaKeeper com	1; Bacteria
Bear Creek	Mercury	Fact Sheet	1; Bear Crk
Bear Creek	Mercury	Foe, C. and W. Croyle. 1998. *Mercury Concentrations and Loads from the Sacramento River and from Cache Creek to the Sacramento-San Joaquin Delta Estuary.* California Regional Water Quality Control Board, Central Valley Region Report. June 1998.	1; Bear Crk
Bear River, Lower	Diazinon	Fact Sheet	1; Bear and Butte Crks
Bear River, Lower	Diazinon	CDPR. 2001. Surface Water Database. Access formatted database, using the parameters of Bear River and diazinon	1; Disk 1
Bear River, Lower	Diazinon	Dileanis, P.D., J.L. Domagalski, and K.P. Bennett. 2000. Occurrence and Transport of Diazinon in the Sacramento River and its Tributaries During Three Winter Storms, January-February 2000. Water-Resources Investigations Draft Report. U.S. Geological Survey. Sacramento, CA.	1; Bear and Butte Crks
Bear River, Lower	Diazinon	Holmes, R., C. Foe, and V. de Vlaming. 2000. *Sources and Concentrations of Diazinon in the Sacramento Watershed During the 1994 Orchard Dormant Spray Season.* California Regional Water Quality Control Board – Central Valley Region. Sacramento, CA. (CDPR and hard copy)	1; Bear and Butte Crks
Bear River, Upper	Mercury	Fact Sheet	2; HU:516 & 517
Bear River, Upper	Mercury	Alpers and Hunerlach. 2000. *Mercury Contamination from Historic Gold Mining in California.* USGS Report FS-061-00. Ca.water.usgs.gov/mercury/fs06100.html	2; HU:516 & 517

Waterbody	Pollutant	Sources	Location: Folder #; Tab Title
Bear River, Upper	Mercury	May, J.T., R.L. Hothem, C.N. Alpers, M.A. Law. 2000. *Mercury Bioaccumulation in Fish in a Region Affected by Historic Gold Mining: The South Yuba River, Deer Creek, and Bear River Watersheds, California, 1999.* U.S. Geological Survey. Sacramento, CA. 2000.	2; HU:516 & 517
Bear River, Upper	Mercury	Montoya, B. and X. Pan. 1992. *Inactive Mine Drainage in the Sacramento Valley, California.* California Regional Water Quality Control Board, Central Valley Region Report. July 1992.	2; HU:516 & 517
Bear River, Upper	Mercury	Nevada County, Department of Environmental Health. 2000. *Press Release, Three County Environmental Health Agencies Issue Interim Public Health Notification on Mercury in Fish.* (http://www.co.nevada.ca.us/ehealth/hg/press_release_10-03-00.htm)	2; HU:516 & 517
Black Butte Res	Mercury	Fact Sheet	1; Black Butte
Black Butte Reservoir	Mercury	Brodberg, R. K. and G. A. Pollock. 1999. *Prevalence of Selected Target Chemical Contaminants in Sport Fish from Two California Lakes: Public Health Designed Screening Study.* California Environmental Protection Agency, Office of Environmental Health Hazard Assessment Final Report. June 1999. Sacramento, California.	1; Black Butte
Black Butte Reservoir	Mercury	OEHHA (Office of Environmental Health Hazard Assessment). 2000. Draft Evaluation of Potential Health Effects of Eating Fish From 1; Black Butte Reservoir (Glenn and Tehama Counties): Guidelines for Sport Fish Consumption, Pesticide and Environmental Toxicology Section, California Environmental Protection Agency, Office of Environmental Health Hazard Assessment.	1; Black Butte
Butte Slough	Diazinon	Fact Sheet	1; Bear and Butte Crks
Butte Slough	Diazinon	Chilcott, J. 1992. *Agenda Item #11 for Meeting of California Regional Water Quality Control Board, Central Valley Region. September 25, 1992. Fresno, CA.* Staff Report on Consideration of Water Body Designations to Comply with Provisions of the Water Quality Control Plan for Inland Surface Waters of California. Including Appendix B.	1; Bear and Butte Crks
Butte Slough	Diazinon	Dileanis, P.D., J.L. Domagalski, and K.P. Bennett. 2000. *Occurrence and Transport of Diazinon in the Sacramento River and its Tributaries During Three Winter Storms, January-February 2000.* U.S. Geological Survey Water Resources Investigations Report, Draft. Sacramento, CA.	1; Bear and Butte Crks
Butte Slough	Diazinon	Holmes, R., C. Foe, and V. de Vlaming. 2000. *Sources and Concentrations of Diazinon in the Sacramento Watershed During the 1994 Orchard Dormant Spray Season.* California Regional Water Quality Control Board – Central Valley Region. Sacramento, CA. (CDPR and hard copy)	1; Bear and Butte Crks
Butte Slough	Diazinon	NCWA (Northern California Water Association). *The Lower Butte Creek Project.* (http://norcalwater.org/lower_butte_creek_project.htm). Last updated Sept 4, 2001.	1; Bear and Butte Crks
Butte Slough	Molinate	Fact Sheet	1; Bear and Butte Crks
Butte Slough	Molinate	California Rice Commission. 2001. *CA Rice.* Chapter 3: Water Quality in Relation to Rice Farming http://www.calrice.org/frame.tpl?_page=environment/balance-sheet/	1; Bear and Butte Crks
Butte Slough	Molinate	CDPR. 2001. Surface Water Database. Access formatted database, using the parameters of Butte Slough and molinate	1; Disk 1
Butte Slough	Molinate	Gorder, N.K.N., J.M. Lee, and K. Newhart. 1995. *Information on Rice 2; Pesticides Submitted to the California Regional Water Quality Control Board Central Valley Region.* Environmental Monitoring and Pest Management Branch, Department of Pesticide Regulation, Sacramento, CA. December 28, 1995.	1; Bear and Butte Crks

Waterbody	Pollutant	Sources	Location: Folder #; Tab Title
Butte Slough	Molinate	Gorder, N.K.N., J.M. Lee, and K. Newhart. 1996. *Information on Rice 2; Pesticides Submitted to the California Regional Water Quality Control Board Central Valley Region*. Environmental Monitoring and Pest Management Branch, Department of Pesticide Regulation, Sacramento, CA. December 31, 1996.	1; Bear and Butte Crks
Butte Slough	Molinate	NCWA (Northern California Water Association). *The Lower Butte Creek Project*. (http://norcalwater.org/lower_butte_creek_project.htm). Last updated Sept 4, 2001.	1; Bear and Butte Crks
Butte Slough	Molinate	Newhart, K., D. Jones, and S. Ceesay. 2000. *Information on Rice 2; Pesticides-Submitted to the California Regional Water Quality Control Board*. California Environmental Protection Agency, Department of Pesticide Regulation. Environmental Monitoring and Pest Management Branch. Environmental Hazards Assessment Program. December 31, 2000.	1; Bear and Butte Crks
Butte Slough	Molinate	Newhart, K. and K. Bennett. 1999. *Information on Rice 2; Pesticides-Submitted to the California Regional Water Quality Control Board.* California Environmental Protection Agency, Department of Pesticide Regulation. Environmental Monitoring and Pest Management Branch. Environmental Hazards Assessment Program. December 31, 1999.	1; Bear and Butte Crks
Calaveras River, Lower	Dissolved Oxygen	Fact Sheet	2; Low DO
Calaveras River, Lower	Dissolved Oxygen	*CALFED Bay-Delta Program. 2000. Water Quality Program Plan, Final Programmatic EIS/EIR Technical Appendix. July 2000.	2; Low DO
Calaveras River, Lower	Dissolved Oxygen	Lee G.F. Dissolved Oxygen Depletion in the Stockton Sloughs. August 2000. (Prepared for DeltaKeeper)	2; Low DO
Calaveras River, Lower	Dissolved Oxygen	Lee, G.F. and A. Jones-Lee. 2001b. *Review of the City of Stockton Urban Stormwater Runoff Aquatic Life Toxicity Studies Conducted by the Central Valley Regional Water Quality Control Board, DeltaKeeper, and the University of California, Davis, Aquatic Toxicology Laboratory between 1994 and 1999.* Final Report. November 2001. G. Fred Lee & Associates. El Macero, CA. (Prepared for DeltaKeeper).	2; Putah Creek
Calaveras River, Lower	Pathogens	Fact Sheet	1; Bacteria
Calaveras River, Lower	Pathogens	Jennings, B. 2001. Letter from Bill Jennings (DeltaKeeper A Project of San Francisco BayKeeper) to Mr. Jerry Bruns and Mr. Joe Karkoski (California Regional Water Quality Control Board, Central Valley Region) dated May 14, 2001, regarding DeltaKeeper comments on section 303(d) list update.	1; Bacteria
Camanche Reservoir	Aluminum	Fact Sheet	1; Camanche Res
Camanche Reservoir	Aluminum	Buer, S.M., S.R. Phillippe, and T.R. Pinkos. 1979. *Inventory and Assessment of Water Quality Problems related to Abandoned and Inactive Mines in the Central Valley Region of California.* CRWQCB-CVR (California Regional Water Quality Control Board, Central Valley Region), Report.	1; Camanche Res
Camanche Reservoir	Aluminum	CDFG (California Department of Fish and Game). 1991. *Lower Mokelumne River Fisheries Plan.* The Resources Agency, Department of Fish and Game, Stream flow Requirements Program. November 1991.	1; Camanche Res
Camanche Reservoir	Aluminum	CH2MHILL. 2000a. *Closure Report: Penn Mine Environmental Restoration Project.* Prepared for: East Bay Municipal Utility District and Regional Water Quality Control Board-Central Valley Region. Oakland, California. December 2000.	1; Camanche Res
Camanche Reservoir	Aluminum	CH2MHILL. 2000b. *(Draft) Post-Restoration Final Effectiveness Report: Penn Mine Environmental Restoration Project.* Prepared for: East Bay Municipal Utility District and Regional Water Quality Control Board-Central Valley Region. Oakland, California. September 2000.	1; Camanche Res

Waterbody	Pollutant	Sources	Location: Folder #; Tab Title
Camanche Reservoir	Aluminum	EBMUD (East Bay Municipal Utility District). 2000. All About EBMUD. EBMUD Public Affairs Office publication. Available: http://www.ebmud.com/pubs/annual/allaboutebmud_2000.pdf. Accessed: August 2, 2001.	1; Camanche Res
Camanche Reservoir	Aluminum	EDAW, Inc. 1992. *Draft EIS/EIR for the Updated Water Supply Management Program, Volume III, Technical Appendices B1 and B2.* Prepared for: East Bay Municipal Utility District. Oakland, California. December 1992.	1; Camanche Res
Camanche Reservoir	Aluminum	SCH EIR. 1996. *Draft EIR for The Penn Mine Site, Long-Term Solution Project.* Prepared for: East Bay Municipal Utility District and Regional Water Quality Control Board-Central Valley Region. SCH EIR No. 95103036. May 1996.	1; Camanche Res
Camanche Reservoir	Aluminum	SWRCB (State Water Resources Control Board). 1990. *Water Quality Problems Associated with Operation of Pardee and Camanche Reservoir.* State Water Resources Control Board, Division of Water Quality staff report.	1; Camanche Res
Camp Far West Reservoir	Mercury	Fact Sheet	2; 516 & 517-Mercury
Camp Far West Reservoir	Mercury	Alpers, C.N., M.P. Hunerlach. 2000. *Mercury Contamination from Historic Gold Mining in California.* U.S. Geological Survey. Fact Sheet FS-061-00. May 2000.	2; 516 & 517-Mercury
Camp Far West Reservoir	Mercury	May, J.T., R.L. Hothem, C.N. Alpers, M.A. Law. 2000. *Mercury Bioaccumulation in Fish in a Region Affected by Historic Gold Mining: The South Yuba River, Deer Creek, and Bear River Watersheds, California, 1999.* U.S. Geological Survey. Sacramento, CA. 2000.	2; 516 & 517-Mercury
Camp Far West Reservoir	Mercury	Montoya, B. and X. Pan. 1992. *Inactive Mine Drainage in the Sacramento Valley, California.* California Regional Water Quality Control Board, Central Valley Region Report. July 1992.	2; 516 & 517
Camp Far West Reservoir	Mercury	Nevada County, Department of Environmental Health. 2000. Press Release, Three County Environmental Health Agencies Issue Interim Public Health Notification on Mercury in Fish. (http://www.co.nevada.ca.us/ehealth/hg/press_release_10-03-00.htm)	2; 516 & 517-Mercury
Camp Far West Reservoir	Mercury	Slotton, D.G., S.M. Ayers, J.E. Reuter, C.R. Goldman. 1996. Gold Mining Impacts on Food Chain Mercury in Northwestern Sierra Nevada Streams (1996 Revision). Division of Environmental Studies, University of California, Davis. December 1996.	2; 516 & 517-Mercury
Clover Creek	Fecal Coliform	Fact Sheet	1; cow creek
Clover Creek	Fecal Coliform	Hannaford MJ and North State Institute for Sustainable Communities. 2000. Preliminary Water Quality Assessment of 1; cow creek Tributaries. Department of Fish and Game. May 15, 2000. (http://www.delta.dfg.ca.gov/afrp/documents/cowcrk.rpt.pdf).	1; cow creek
Colusa Drain	Azinphos Methyl	Fact Sheet	1; CBD
Colusa Drain	Azinphos Methyl	CDPR. 2001. Surface Water Database. Access formatted database, using the parameters of Colusa Drain and Azinphos Methyl.	1; Disk 1
Colusa Drain	Azinphos Methyl	Domagalski, J.L. 2000. *Pesticide Monitoring in the Sacramento River Basin for the USGS National Water Quality Assessment Program.* Report in prep. USGS. As presented in CDPR, 2000a.	1; Disk 1
Colusa Drain	Diazinon	Fact Sheet	1; CBD

Waterbody	Pollutant	Sources	Location: Folder #; Tab Title
Colusa Drain	Diazinon	Holmes, R., C. Foe, and V. de Vlaming. 2000. *Sources and Concentrations of Diazinon in the Sacramento Watershed During the 1994 Orchard Dormant Spray Season*. California Regional Water Quality Control Board – Central Valley Region. Sacramento, CA. (CDPR and hard copy)	1; Bear and Butte Crks
Colusa Drain	Molinate	Fact Sheet	1; CBD
Colusa Drain	Molinate	CDPR. 2001. Surface Water Database. Access formatted database, using the parameters of Colusa Drain and molinate.	1; CBD
Colusa Drain	Molinate	Domagalski, J.L. 2000. *Pesticide Monitoring in the Sacramento River Basin for the USGS National Water Quality Assessment Program.* Report in prep. USGS. As presented in CDPR, 2000a.	1; Disk 1
Colusa Drain	Molinate	Gorder, N.K.N., J.M. Lee, and K. Newhart. 1995. Information on Rice 2; Pesticides Submitted to the California Regional Water Quality Control Board Central Valley Region. Environmental Monitoring and Pest Management Branch, Department of Pesticide Regulation, Sacramento, CA. December 28, 1995.	1; CBD
Colusa Drain	Molinate	Gorder, N.K.N., J.M. Lee, and K. Newhart. 1996. *Information on Rice 2; Pesticides Submitted to the California Regional Water Quality Control Board Central Valley Region*. Environmental Monitoring and Pest Management Branch, Department of Pesticide Regulation, Sacramento, CA. December 31, 1996.	1; CBD
Colusa Drain	Molinate	Gorder, N.K.N., J.M. Lee, and K. Newhart. 1997. *Information on Rice 2; Pesticides Submitted to the California Regional Water Quality Control Board Central Valley Region.* Environmental Monitoring and Pest Management Branch, Department of Pesticide Regulation, Sacramento, CA. December 31, 1997.	1; CBD
Colusa Drain	Molinate	Gorder, N.K.N., J.M. Lee, and K. Newhart. 1998. *Information on Rice 2; Pesticides Submitted to the California Regional Water Quality Control Board Central Valley Region*. Environmental Monitoring and Pest Management Branch, Department of Pesticide Regulation, Sacramento, CA. December 31, 1998.	1; CBD
Colusa Drain	Molinate	Holmes, R., C. Foe and V. de Vlaming. 1998. *Sources and Concentrations of Diazinon in the Sacramento Watershed During the 1994 Orchard Dormant Spray Season.* Central Valley Regional Water Quality Control Board. Draft, June 1998.	1; Bear and Butte Crks
Colusa Drain	Molinate	Newhart, K. and K. Bennett. 1999. *Information on Rice 2; Pesticides-Submitted to the California Regional Water Quality Control Board.* California Environmental Protection Agency, Department of Pesticide Regulation. Environmental Monitoring and Pest Management Branch. Environmental Hazards Assessment Program. December 31, 1999.	1; Bear and Butte Crks
Colusa Drain	Molinate	Newhart, K., D. Jones, and S. Ceesay. 2000. *Information on Rice 2; Pesticides-Submitted to the California Regional Water Quality Control Board.* California Environmental Protection Agency, Department of Pesticide Regulation. Environmental Monitoring and Pest Management Branch. Environmental Hazards Assessment Program. December 31, 2000.	1; Bear and Butte Crks
Del Puerto Crk	Chlorpyrifos	Fact Sheet	2; Pesticides
Del Puerto Crk	Chlorpyrifos	CDPR. 2001. Surface Water Database. Access formatted database, using the parameters of Del Puerto Crk and chlorpyrifos	1; Disk 1

Waterbody	Pollutant	Sources	Location: Folder #; Tab Title
Colusa Drain	Diazinon	CDPR. 2001. Surface Water Database. Access formatted database, using the parameters of Colusa Drain and diazinon.	1; Disk 1
Colusa Drain	Diazinon	Dileanis, P., J. Domagalski, and K.P. Bennett. 2001. *Occurrence and Transport of Diazinon in the Sacramento River and its Tributaries During Three Winter Storms, January-February 2000.* U.S. Geological Survey Water Resources Investigations Report, Draft. Sacramento, CA	1; Bear and Butte Crks
Colusa Drain	Diazinon	Domagalski, J.L. 2000. *Pesticide Monitoring in the Sacramento River Basin for the USGS National Water Quality Assessment Program.* Report in prep. USGS. As presented in CDPR, 2000a.	1; Disk 1
Del Puerto Crk	Chlorpyrifos	Foe, C. 1995. *Insecticide Concentrations and Invertebrate Bioassay Mortality in Agricultural Return Water from the San Joaquin Basin.* Central Valley Regional Water Quality Control Board. Sacramento, CA December 1995.	2; Pesticides
Del Puerto Crk	Chlorpyrifos	Fujimura, R. 1991a. *Chemical and Toxicity Test Results from the San Joaquin River at Three Sites from July 2 to September 13, 1991.* Memorandum to Lisa Ross, Department of Pesticide Regulation. Sacramento, CA. November 6, 1991. As presented in CDPR, 2000a.	1; Disk 1
Del Puerto Crk	Chlorpyrifos	Fujimura, R. 1991b. *Chemical and Toxicity Test Results from the San Joaquin River and Tributaries During March 4 to April 26, 1991.* Memorandum to Lisa Ross, Department of Pesticide Regulation. Sacramento, CA. November 6, 1991. As presented in CDPR, 2000a.	1; Disk 1
Del Puerto Crk	Chlorpyrifos	Fujimura, R. 1993a. *Chemical Analyses and Bioassay Test Results for Samples Collected from December 29 to February 25,, 1993.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. March 26, 1993. As presented in CDPR, 2000a.	1; Disk 1
Del Puerto Crk	Chlorpyrifos	Fujimura, R. 1993b. *Chemical Analyses and Bioassay Test Results for Samples Collected from July 9 to September 9, 1992.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. March 23, 1993. As presented in CDPR, 2000a.	1; Disk 1
Del Puerto Crk	Chlorpyrifos	Fujimura, R. 1993c. *Chemical Analyses and Bioassay Test Results for Samples Collected from March 16 to April 30, 1992.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. March 22, 1993. As presented in CDPR, 2000a.	1; Disk 1
Del Puerto Crk	Chlorpyrifos	Fujimura, R. 1993d. *Chemical Analyses and Bioassay Test Results for Samples Collected from December 23, 1991 to February 27, 1992.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. February 23, 1993. As presented in CDPR, 2000a.	1; Disk 1
Del Puerto Crk	Chlorpyrifos	Ross, L. 1992. Preliminary Results of the San Joaquin River Study; Summer, 1991. Memorandum to Kean Goh. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. May 21, 1992. As presented in CDPR, 2000a.	1; Disk 1
Del Puerto Crk	Chlorpyrifos	Ross, L. 1993. Preliminary Results of the San Joaquin River Study; Summer, 1992. Memorandum to Kean Goh. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. September 22, 1993. As presented in CDPR, 2000a.	1; Disk 1

Waterbody	Pollutant	Sources	Location: Folder #; Tab Title
Del Puerto Crk	Chlorpyrifos	Ross, L., J. Stein, J. Hsu, J. White, and K. Hefner. 1996. Distribution and Mass Loading of Insecticides in the San Joaquin River, California: Winter 1991-92 and 1992-93. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. Report EH 96-02. November, 1996. As presented in CDPR, 2000a.	1; Disk 1
Del Puerto Crk	Chlorpyrifos	Ross, L., J. Stein, J. Hsu, J. White, and K. Hefner. 1999. Distribution and Mass Loading of Insecticides in the San Joaquin River, California: Spring 1991 and 1992. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. Report EH 99-01. April, 1999. As presented in CDPR, 2000a.	1; Disk 1
Del Puerto Crk	Diazinon	Fact Sheet	2; Pesticides
Del Puerto Crk	Diazinon	CDPR. 2001. Surface Water Database. Access formatted database, using the parameters of Del Puertro Creek and diazinon.	1; Disk 1
Del Puerto Crk	Diazinon	Foe, C. 1995. *Insecticide Concentrations and Invertebrate Bioassay Mortality in Agricultural Return Water from the San Joaquin Basin.* Central Valley Regional Water Quality Control Board. Sacramento, CA December 1995.	2; Pesticides
Del Puerto Crk	Diazinon	Fujimura, R. 1991a. *Chemical and Toxicity Test Results from the San Joaquin River at Three Sites from July 2 to September 13, 1991.* Memorandum to Lisa Ross, Department of Pesticide Regulation. Sacramento, CA. November 6, 1991. As presented in CDPR, 2000a.	1; Disk 1
Del Puerto Crk	Diazinon	Fujimura, R. 1991b. *Chemical and Toxicity Test Results from the San Joaquin River and Tributaries During March 4 to April 26, 1991.* Memorandum to Lisa Ross, Department of Pesticide Regulation. Sacramento, CA. November 6, 1991. As presented in CDPR, 2000a.	1; Disk 1
Del Puerto Crk	Diazinon	Fujimura, R. 1993a. *Chemical Analyses and Bioassay Test Results for Samples Collected from December 29 to February 25,, 1993.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. March 26, 1993. As presented in CDPR, 2000a.	1; Disk 1
Del Puerto Crk	Diazinon	Fujimura, R. 1993b. *Chemical Analyses and Bioassay Test Results for Samples Collected from July 9 to September 9, 1992.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. March 23, 1993. As presented in CDPR, 2000a.	1; Disk 1
Del Puerto Crk	Diazinon	Fujimura, R. 1993c. *Chemical Analyses and Bioassay Test Results for Samples Collected from March 16 to April 30, 1992.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. March 22, 1993. As presented in CDPR, 2000a.	1; Disk 1
Del Puerto Crk	Diazinon	Fujimura, R. 1993d. *Chemical Analyses and Bioassay Test Results for Samples Collected from December 23, 1991 to February 27, 1992.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. February 23, 1993. As presented in CDPR, 2000a.	1; Disk 1
Del Puerto Crk	Diazinon	Ross, L. 1992. Preliminary Results of the San Joaquin River Study; Summer, 1991. Memorandum to Kean Goh. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. May 21, 1992.	1; Disk 1

Waterbody	Pollutant	Sources	Location: Folder #; Tab Title
Del Puerto Crk	Diazinon	Ross, L. 1993. Preliminary Results of the San Joaquin River Study; Summer, 1992. Memorandum to Kean Goh. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. September 22, 1993.	1; Disk 1
Del Puerto Crk	Diazinon	Ross, L., J. Stein, J. Hsu, J. White, and K. Hefner. 1996. Distribution and Mass Loading of Insecticides in the San Joaquin River, California: Winter 1991-92 and 1992-93. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. Report EH 96-02. November, 1996.	1; Disk 1
Del Puerto Crk	Diazinon	Ross, L., J. Stein, J. Hsu, J. White, and K. Hefner. 1999. Distribution and Mass Loading of Insecticides in the San Joaquin River, California: Spring 1991 and 1992. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. Report EH 99-01. April, 1999.	1; Disk 1
Don Pedro Lake	Mercury	Fact Sheet	1; Don Pedro Lake
Don Pedro Lake	Mercury	DWR (California Department of Water Resources). 1993. Dams within Jurisdiction of the State of California. DWR Bulletin 17, as presented by the Berkeley Digital Library Project. Accessed on August 23, 2001 (http://elib.cs.berkeley.edu/dams/about.html).	1; Don Pedro Lake
Don Pedro Lake	Mercury	OMR. 2000. California's Abandoned Mines – A Report on the Magnitude and Scope of the Issue in the State. California Department of Conservation, Office of Mine Reclamation, Abandoned Mine Lands Unit (OMR). http://www.consrv.ca.gov/omr/AMLU/amlurpt/Sacramento, CA. June 2000.	1; Don Pedro Lake
Don Pedro Lake	Mercury	SWRCB (State Water Resources Control Board, Division of Water Quality). 1995. Toxic Substances Monitoring Program: Freshwater Bioaccumulation Monitoring Program: Data Base (Metals_Wet).	1; Disk 1
Five Mile Slough	Dissolved Oxygen	Fact Sheet	2; Low DO
Five Mile Slough	Dissolved Oxygen	Lee G.F. *Dissolved Oxygen Depletion in the Stockton Sloughs*. August 2000. (Prepared for DeltaKeeper)	2; Low DO
Five Mile Slough	Dissolved Oxygen	Lee, G.F. and A. Jones-Lee. 2001b. *Review of the City of Stockton Urban Stormwater Runoff Aquatic Life Toxicity Studies Conducted by the Central Valley Regional Water Quality Control Board, DeltaKeeper, and the University of California, Davis, Aquatic Toxicology Laboratory between 1994 and 1999*. Final Report. November 2001. G. Fred Lee & Associates. El Macero, CA. (Prepared for DeltaKeeper).	2; Smith Canal
Five Mile Slough	Pathogens	Fact Sheet	1; Bacteria
Five Mile Slough	Pathogens	Jennings, B. 2001. Letter from Bill Jennings (DeltaKeeper A Project of San Francisco BayKeeper) to Mr. Jerry Bruns and Mr. Joe Karkoski (California Regional Water Quality Control Board, Central Valley Region) dated May 14, 2001, regarding DeltaKeeper comments on section 303(d) list update.	1; Bacteria
Ingram/ Hospital Crk	Chlorpyrifos	Fact Sheet	2; Pesticides
Ingram/ Hospital Crk	Chlorpyrifos	CDPR. 2001. Surface Water Database. Access formatted database, using the parameters of Ingram/Hospital Creek and chlorpyrifos.	1; Disk 1

Waterbody	Pollutant	Sources	Location: Folder #; Tab Title
Ingram/ Hospital Crk	Chlorpyrifos	Foe, C. 1995. *Insecticide Concentrations and Invertebrate Bioassay Mortality in Agricultural Return Water from the San Joaquin Basin.* Central Valley Regional Water Quality Control Board. Sacramento, CA December 1995.	2; Pesticides
Ingram/ Hospital Crk	Chlorpyrifos	Fujimura, R. 1991a. *Chemical and Toxicity Test Results from the San Joaquin River at Three Sites from July 2 to September 13, 1991.* Memorandum to Lisa Ross, Department of Pesticide Regulation. Sacramento, CA. November 6, 1991. As presented in CDPR, 2000a.	1; Disk 1
Ingram/ Hospital Crk	Chlorpyrifos	Fujimura, R. 1991b. *Chemical and Toxicity Test Results from the San Joaquin River and Tributaries During March 4 to April 26, 1991.* Memorandum to Lisa Ross, Department of Pesticide Regulation. Sacramento, CA. November 6, 1991. As presented in CDPR, 2000a.	1; Disk 1
Ingram/ Hospital Crk	Chlorpyrifos	Fujimura, R. 1993a. *Chemical Analyses and Bioassay Test Results for Samples Collected from December 29 to February 25,, 1993.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. March 26, 1993. As presented in CDPR, 2000a.	1; Disk 1
Ingram/ Hospital Crk	Chlorpyrifos	Fujimura, R. 1993b. *Chemical Analyses and Bioassay Test Results for Samples Collected from July 9 to September 9, 1992.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. March 23, 1993. As presented in CDPR, 2000a.	1; Disk 1
Ingram/ Hospital Crk	Chlorpyrifos	Fujimura, R. 1993c. *Chemical Analyses and Bioassay Test Results for Samples Collected from March 16 to April 30, 1992.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. March 22, 1993. As presented in CDPR, 2000a.	1; Disk 1
Ingram/ Hospital Crk	Chlorpyrifos	Fujimura, R. 1993d. *Chemical Analyses and Bioassay Test Results for Samples Collected from December 23, 1991 to February 27, 1992.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. February 23, 1993. As presented in CDPR, 2000a.	1; Disk 1
Ingram/ Hospital Crk	Chlorpyrifos	Ross, L. 1992. Preliminary Results of the San Joaquin River Study; Summer, 1991. Memorandum to Kean Goh. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. May 21, 1992.	1; Disk 1
Ingram/ Hospital Crk	Chlorpyrifos	Ross, L. 1993. Preliminary Results of the San Joaquin River Study; Summer, 1992. Memorandum to Kean Goh. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. September 22, 1993.	1; Disk 1
Ingram/ Hospital Crk	Chlorpyrifos	Ross, L., J. Stein, J. Hsu, J. White, and K. Hefner. 1996. Distribution and Mass Loading of Insecticides in the San Joaquin River, California: Winter 1991-92 and 1992-93. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. Report EH 96-02. November, 1996.	1; Disk 1
Ingram/ Hospital Crk	Chlorpyrifos	Ross, L., J. Stein, J. Hsu, J. White, and K. Hefner. 1999. Distribution and Mass Loading of Insecticides in the San Joaquin River, California: Spring 1991 and 1992. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. Report EH 99-01. April, 1999. As presented in CDPR, 2000a.	1; Disk 1

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Ingram/ Hospital Crk	Diazinon	Fact Sheet	2; Pesticides
Ingram/ Hospital Crk	Diazinon	CDPR. 2001. Surface Water Database. Access formatted database, using the parameters of Ingram/Hospital Creek and diazinon	1; Disk 1
Ingram/ Hospital Crk	Diazinon	Foe, C. 1995. *Insecticide Concentrations and Invertebrate Bioassay Mortality in Agricultural Return Water from the San Joaquin Basin.* Central Valley Regional Water Quality Control Board. Sacramento, CA December 1995.	2; Pesticides
Ingram/ Hospital Crk	Diazinon	Fujimura, R. 1991a. *Chemical and Toxicity Test Results from the San Joaquin River at Three Sites from July 2 to September 13, 1991.* Memorandum to Lisa Ross, Department of Pesticide Regulation. Sacramento, CA. November 6, 1991. As presented in CDPR, 2000a.	1; Disk 1
Ingram/ Hospital Crk	Diazinon	Fujimura, R. 1991b. *Chemical and Toxicity Test Results from the San Joaquin River and Tributaries During March 4 to April 26, 1991.* Memorandum to Lisa Ross, Department of Pesticide Regulation. Sacramento, CA. November 6, 1991. As presented in CDPR, 2000a.	1; Disk 1
Ingram/ Hospital Crk	Diazinon	Fujimura, R. 1993a. *Chemical Analyses and Bioassay Test Results for Samples Collected from December 29 to February 25,, 1993.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. March 26, 1993. As presented in CDPR, 2000a.	1; Disk 1
Ingram/ Hospital Crk	Diazinon	Fujimura, R. 1993b. *Chemical Analyses and Bioassay Test Results for Samples Collected from July 9 to September 9, 1992.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. March 23, 1993. As presented in CDPR, 2000a.	1; Disk 1
Ingram/ Hospital Crk	Diazinon	Fujimura, R. 1993c. *Chemical Analyses and Bioassay Test Results for Samples Collected from March 16 to April 30, 1992.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. March 22, 1993. As presented in CDPR, 2000a.	1; Disk 1
Ingram/ Hospital Crk	Diazinon	Fujimura, R. 1993d. *Chemical Analyses and Bioassay Test Results for Samples Collected from December 23, 1991 to February 27, 1992.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. February 23, 1993. As presented in CDPR, 2000a.	1; Disk 1
Ingram/ Hospital Crk	Diazinon	Ross, L. 1992. Preliminary Results of the San Joaquin River Study; Summer, 1991. Memorandum to Kean Goh. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. May 21, 1992. As presented in CDPR, 2000a.	1; Disk 1
Ingram/ Hospital Crk	Diazinon	Ross, L. 1993. Preliminary Results of the San Joaquin River Study; Summer, 1992. Memorandum to Kean Goh. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. September 22, 1993. As presented in CDPR, 2000a.	1; Disk 1
Ingram/ Hospital Crk	Diazinon	Ross, L., J. Stein, J. Hsu, J. White, and K. Hefner. 1996. Distribution and Mass Loading of Insecticides in the San Joaquin River, California: Winter 1991-92 and 1992-93. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. Report EH 96-02. November, 1996. As presented in CDPR, 2000a.	1; Disk 1

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Ingram/ Hospital Crk	Diazinon	Ross, L., J. Stein, J. Hsu, J. White, and K. Hefner. 1999. Distribution and Mass Loading of Insecticides in the San Joaquin River, California: Spring 1991 and 1992. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. Report EH 99-01. April, 1999. As presented in CDPR, 2000a.	1; Disk 1
Jack Slough	Diazinon	Fact Sheet	1; Bear and Butte Crks
Jack Slough	Diazinon	CDPR. 2001. Surface Water Database. Access formatted database, using the parameters of Jack Slough and diazinon	1; Disk 1
Jack Slough	Diazinon	Dileanis, P.D., J.L. Domagalski, and K.P. Bennett. 2000. Occurrence and Transport of Diazinon in the Sacramento River and its Tributaries During Three Winter Storms, January-February 2000. Water-Resources Investigations Draft Report. U.S. Geological Survey. Sacramento, CA.	1; Bear and Butte Crks
Jack Slough	Diazinon	Holmes, R. 2001. Personal Communication with C. Spector. CVRWQCB. August 28, 2001.	1; Bear and Butte Crks
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Lake Combie	Mercury	Fact Sheet	2; HU:516 & 517
Lake Combie	Mercury	Alpers, C.N., M.P. Hunerlach. 2000. *Mercury Contamination from Historic Gold Mining in California*. U.S. Geological Survey. Fact Sheet FS-061-00. May 2000.	2; HU:516 & 517
Lake Combie	Mercury	May, J.T., R.L. Hothem, C.N. Alpers, M.A. Law. 2000. *Mercury Bioaccumulation in Fish in a Region Affected by Historic Gold Mining: The South Yuba River, Deer Creek, and Bear River Watersheds, California, 1999.* U.S. Geological Survey. Sacramento, CA. 2000.	2; HU:516 & 517
Lake Combie	Mercury	Montoya, B. and X. Pan. 1992. *Inactive Mine Drainage in the Sacramento Valley, California.* California Regional Water Quality Control Board, Central Valley Region Report. July 1992.	2; HU:516 & 517
Lake Combie	Mercury	Nevada County, Department of Environmental Health. 2000. *Press Release, Three County Environmental Health Agencies Issue Interim Public Health Notification on Mercury in Fish.* (http://www.co.nevada.ca.us/ehealth/hg/press_release_10-03-00.htm)	2; HU:516 & 517
Lake Englebright	Mercury	Fact Sheet	2; HU:516 & 517
Lake Englebright	Mercury	Alpers, C.N., M.P. Hunerlach. 2000. *Mercury Contamination from Historic Gold Mining in California*. U.S. Geological Survey. Fact Sheet FS-061-00. May 2000.	2; HU:516 & 517
Lake Englebright	Mercury	May, J.T., R.L. Hothem, C.N. Alpers, M.A. Law. 2000. *Mercury Bioaccumulation in Fish in a Region Affected by Historic Gold Mining: The South Yuba River, Deer Creek, and Bear River Watersheds, California, 1999.* U.S. Geological Survey. Sacramento, CA. 2000.	2; HU:516 & 517
Lake Englebright	Mercury	Montoya, B. and X. Pan. 1992. *Inactive Mine Drainage in the Sacramento Valley, California.* California Regional Water Quality Control Board, Central Valley Region Report. July 1992.	2; HU:516 & 517
Lake Englebright	Mercury	Nevada County, Department of Environmental Health. 2000. *Press Release, Three County Environmental Health Agencies Issue Interim Public Health Notification on Mercury in Fish.* (http://www.co.nevada.ca.us/ehealth/hg/press_release_10-03-00.htm)	2; HU:516 & 517

Waterbody	Pollutant	Sources	Location: Folder #; Tab Title
Lake Englebright	Mercury	Slotton, D.G., S.M. Ayers, J.E. Reuter, C.R. Goldman. 1996. *Gold Mining Impacts on Food Chain Mercury in Northwestern Sierra Nevada Streams (1996 Revision).* Division of Environmental Studies, University of California, Davis. December 1996.	2; HU:516 & 517
Little Deer Creek	Mercury	Fact Sheet	2; HU:516 & 517
Little Deer Creek	Mercury	Alpers, C.N., M.P. Hunerlach. 2000. *Mercury Contamination from Historic Gold Mining in California.* U.S. Geological Survey. Fact Sheet FS-061-00. May 2000.	2; HU:516 & 517
Little Deer Creek	Mercury	May, J.T., R.L. Hothem, C.N. Alpers, M.A. Law. 2000. *Mercury Bioaccumulation in Fish in a Region Affected by Historic Gold Mining: The South Yuba River, Deer Creek, and Bear River Watersheds, California, 1999.* U.S. Geological Survey. Sacramento, CA. 2000.	2; HU:516 & 517
Little Deer Creek	Mercury	Montoya, B. and X. Pan. 1992. *Inactive Mine Drainage in the Sacramento Valley, California.* California Regional Water Quality Control Board, Central Valley Region Report. July 1992.	2; HU:516 & 517
Little Deer Creek	Mercury	Nevada County, Department of Environmental Health. 2000. *Press Release, Three County Environmental Health Agencies Issue Interim Public Health Notification on Mercury in Fish.* (http://www.co.nevada.ca.us/ehealth/hg/press_release_10-03-00.htm)	2; HU:516 & 517
Little Deer Creek	Mercury	Slotton, D.G., S.M. Ayers, J.E. Reuter, C.R. Goldman. 1996. *Gold Mining Impacts on Food Chain Mercury in Northwestern Sierra Nevada Streams (1996 Revision).* Division of Environmental Studies, University of California, Davis. December 1996.	2; HU:516 & 517
Mokelumne River, Lower	Aluminum	Fact Sheet	1; Camanche Res
Mokelumne River, Lower	Aluminum	Buer, S.M., S.R. Phillippe, and T.R. Pinkos. 1979. *Inventory and Assessment of Water Quality Problems related to Abandoned and Inactive Mines in the Central Valley Region of California.* CRWQCB-CVR (California Regional Water Quality Control Board, Central Valley Region), Report.	1; Camanche Res
Mokelumne River, Lower	Aluminum	CDFG (California Department of Fish and Game). 1991. *Lower Mokelumne River Fisheries Plan.* The Resources Agency, Department of Fish and Game, Stream flow Requirements Program. November 1991.	1; Camanche Res
Mokelumne River, Lower	Aluminum	CH2MHILL. 2000a. *Closure Report: Penn Mine Environmental Restoration Project.* Prepared for: East Bay Municipal Utility District and Regional Water Quality Control Board-Central Valley Region. Oakland, California. December 2000.	1; Camanche Res
Mokelumne River, Lower	Aluminum	CH2MHILL. 2000b. *(Draft) Post-Restoration Final Effectiveness Report: Penn Mine Environmental Restoration Project.* Prepared for: East Bay Municipal Utility District and Regional Water Quality Control Board-Central Valley Region. Oakland, California. September 2000.	1; Camanche Res
Mokelumne River, Lower	Aluminum	EBMUD (East Bay Municipal Utility District). 2000. All About EBMUD. EBMUD Public Affairs Office publication. Available: http://www.ebmud.com/pubs/annual/allaboutebmud_2000.pdf. Accessed: August 2, 2001.	1; Camanche Res
Mokelumne River, Lower	Aluminum	EDAW, Inc. 1992. *Draft EIS/EIR for the Updated Water Supply Management Program, Volume III, Technical Appendices B1 and B2.* Prepared for: East Bay Municipal Utility District. Oakland, California. December 1992.	1; Camanche Res
Mokelumne River, Lower	Aluminum	SCH EIR. 1996. *Draft EIR for The Penn Mine Site, Long-Term Solution Project.* Prepared for: East Bay Municipal Utility District and Regional Water Quality Control Board-Central Valley Region. SCH EIR No. 95103036. May 1996.	1; Camanche Res

Waterbody	Pollutant	Sources	Location: Folder #; Tab Title
Mokelumne River, Lower	Aluminum	SWRCB (State Water Resources Control Board). 1990. *Water Quality Problems Associated with Operation of Pardee and Camanche Reservoir.* State Water Resources Control Board, Division of Water Quality staff report.	1; Camanche Res
Mokelumne River, Lower	Aluminum	USFWS (U.S. Fish & Wildlife Service). 1992. *Before the State Water Resources Control: In the Matter of the Water Rights Hearing for the Lower Mokelumne River – Closing Statement, Enclosure 2 (EBMUD Data – Aluminum, Cadmium, Zinc, Iron and Zinc).* Prepared by J.W. Burke, III (Regional Solicitor, USFWS Pacific Southwest Region) and Lynn Cox (Assistant Regional Solicitor, USFWS Pacific Southwest Region).	1; Camanche Res
Mokelumne River, Lower	Aluminum	USGS (U.S. Geological Survey). 1976. Lodi North, California. 7.5' Topographic Quadrangles, as presented by TopoZone.com (© 2000 Maps a la carte, Inc.). Accessed on August 6, 2001 (http://www.topozone.com/default.asp).	1; Camanche Res
Mormon Slough	Dissolved Oxygen	Fact Sheet	2; Low DO
Mormon Slough	Dissolved Oxygen	Lee G.F. Dissolved Oxygen Depletion in the Stockton Sloughs. August 2000. (Prepared for DeltaKeeper)	2; Low DO
Mormon Slough	Dissolved Oxygen	Lee, G.F. and A. Jones-Lee. 2001b. *Review of the City of Stockton Urban Stormwater Runoff Aquatic Life Toxicity Studies Conducted by the Central Valley Regional Water Quality Control Board, DeltaKeeper, and the University of California, Davis, Aquatic Toxicology Laboratory between 1994 and 1999.* Final Report. November 2001. G. Fred Lee & Associates. El Macero, CA. (Prepared for DeltaKeeper).	2; Smith Canal
Mormon Slough	Pathogens	Fact Sheet	1; Bacteria
Mormon Slough	Pathogens	Jennings, B. 2001. Letter from Bill Jennings (DeltaKeeper A Project of San Francisco BayKeeper) to Mr. Jerry Bruns and Mr. Joe Karkoski (California Regional Water Quality Control Board, Central Valley Region) dated May 14, 2001, regarding DeltaKeeper comments on section 303(d) list update.	1; Bacteria
Mosher Slough	Dissolved Oxygen	Fact Sheet	2; Low DO
Mosher Slough	Dissolved Oxygen	Lee G.F. Dissolved Oxygen Depletion in the Stockton Sloughs. August 2000. (Prepared for DeltaKeeper)	2; Low DO
Mosher Slough	Dissolved Oxygen	Lee, G.F. and A. Jones-Lee. 2001b. *Review of the City of Stockton Urban Stormwater Runoff Aquatic Life Toxicity Studies Conducted by the Central Valley Regional Water Quality Control Board, DeltaKeeper, and the University of California, Davis, Aquatic Toxicology Laboratory between 1994 and 1999.* Final Report. November 2001. G. Fred Lee & Associates. El Macero, CA. (Prepared for DeltaKeeper).	2; Smith Canal
Mosher Slough	Pathogens	Fact Sheet	1; Bacteria
Mosher Slough	Pathogens	Jennings, B. 2001. Letter from Bill Jennings (DeltaKeeper A Project of San Francisco BayKeeper) to Mr. Jerry Bruns and Mr. Joe Karkoski (California Regional Water Quality Control Board, Central Valley Region) dated May 14, 2001, regarding DeltaKeeper comments on section 303(d) list update.	1; Bacteria
Newman Wasteway	Chlorpyrifos	Fact Sheet	2; Pesticides
Newman Wasteway	Chlorpyrifos	CDPR. 2001. Surface Water Database. Access formatted database, using the parameters of Newman Wasteway and chlorpyrifos	1; Disk 1

Waterbody	Pollutant	Sources	Location: Folder #; Tab Title
Newman Wasteway	Chlorpyrifos	Foe, C. 1995. *Insecticide Concentrations and Invertebrate Bioassay Mortality in Agricultural Return Water from the San Joaquin Basin.* Central Valley Regional Water Quality Control Board. Sacramento, CA December 1995.	2; Pesticides
Newman Wasteway	Chlorpyrifos	Fujimura, R. 1991a. *Chemical and Toxicity Test Results from the San Joaquin River at Three Sites from July 2 to September 13, 1991.* Memorandum to Lisa Ross, Department of Pesticide Regulation. Sacramento, CA. November 6, 1991. As presented in CDPR, 2000a.	1; Disk 1
Newman Wasteway	Chlorpyrifos	Fujimura, R. 1991b. *Chemical and Toxicity Test Results from the San Joaquin River and Tributaries During March 4 to April 26, 1991.* Memorandum to Lisa Ross, Department of Pesticide Regulation. Sacramento, CA. November 6, 1991. As presented in CDPR, 2000a.	1; Disk 1
Newman Wasteway	Chlorpyrifos	Fujimura, R. 1993a. *Chemical Analyses and Bioassay Test Results for Samples Collected from December 29 to February 25,, 1993.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. March 26, 1993. As presented in CDPR, 2000a.	1; Disk 1
Newman Wasteway	Chlorpyrifos	Fujimura, R. 1993b. *Chemical Analyses and Bioassay Test Results for Samples Collected from July 9 to September 9, 1992.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. March 23, 1993. As presented in CDPR, 2000a.	1; Disk 1
Newman Wasteway	Chlorpyrifos	Fujimura, R. 1993c. *Chemical Analyses and Bioassay Test Results for Samples Collected from March 16 to April 30, 1992.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. March 22, 1993. As presented in CDPR, 2000a.	1; Disk 1
Newman Wasteway	Chlorpyrifos	Fujimura, R. 1993d. *Chemical Analyses and Bioassay Test Results for Samples Collected from December 23, 1991 to February 27, 1992.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. February 23, 1993. As presented in CDPR, 2000a.	1; Disk 1
Newman Wasteway	Chlorpyrifos	Ross, L. 1992. Preliminary Results of the San Joaquin River Study; Summer, 1991. Memorandum to Kean Goh. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. May 21, 1992. As presented in CDPR, 2000a.	1; Disk 1

Waterbody	Pollutant	Sources	Location: Folder #; Tab Title
Newman Wasteway	Chlorpyrifos	Ross, L. 1993. Preliminary Results of the San Joaquin River Study; Summer, 1992. Memorandum to Kean Goh. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. September 22, 1993. As presented in CDPR, 2000a.	1; Disk 1
Newman Wasteway	Chlorpyrifos	Ross, L., J. Stein, J. Hsu, J. White, and K. Hefner. 1996. Distribution and Mass Loading of Insecticides in the San Joaquin River, California: Winter 1991-92 and 1992-93. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. Report EH 96-02. November, 1996. As presented in CDPR, 2000a.	1; Disk 1
Newman Wasteway	Chlorpyrifos	Ross, L., J. Stein, J. Hsu, J. White, and K. Hefner. 1999. Distribution and Mass Loading of Insecticides in the San Joaquin River, California: Spring 1991 and 1992. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. Report EH 99-01. April, 1999. As presented in CDPR, 2000a.	1; Disk 1
Newman Wasteway	Diazinon	Fact Sheet	2; Pesticides
Newman Wasteway	Diazinon	CDPR. 2001. Surface Water Database. Access formatted database, using the parameters of Newman Wasteway and diazinon.	1; Disk 1
Newman Wasteway	Diazinon	Foe, C. 1995. *Insecticide Concentrations and Invertebrate Bioassay Mortality in Agricultural Return Water from the San Joaquin Basin.* Central Valley Regional Water Quality Control Board. Sacramento, CA December 1995.	2; Pesticides
Newman Wasteway	Diazinon	Fujimura, R. 1991a. *Chemical and Toxicity Test Results from the San Joaquin River at Three Sites from July 2 to September 13, 1991.* Memorandum to Lisa Ross, Department of Pesticide Regulation. Sacramento, CA. November 6, 1991. As presented in CDPR, 2000a.	1; Disk 1
Newman Wasteway	Diazinon	Fujimura, R. 1991b. *Chemical and Toxicity Test Results from the San Joaquin River and Tributaries During March 4 to April 26, 1991.* Memorandum to Lisa Ross, Department of Pesticide Regulation. Sacramento, CA. November 6, 1991. As presented in CDPR, 2000a.	1; Disk 1
Newman Wasteway	Diazinon	Fujimura, R. 1993a. *Chemical Analyses and Bioassay Test Results for Samples Collected from December 29 to February 25,, 1993.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. March 26, 1993. As presented in CDPR, 2000a.	1; Disk 1
Newman Wasteway	Diazinon	Fujimura, R. 1993b. *Chemical Analyses and Bioassay Test Results for Samples Collected from July 9 to September 9, 1992.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. March 23, 1993. As presented in CDPR, 2000a.	1; Disk 1
Newman Wasteway	Diazinon	Fujimura, R. 1993c. *Chemical Analyses and Bioassay Test Results for Samples Collected from March 16 to April 30, 1992.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. March 22, 1993. As presented in CDPR, 2000a.	1; Disk 1
Newman Wasteway	Diazinon	Fujimura, R. 1993d. *Chemical Analyses and Bioassay Test Results for Samples Collected from December 23, 1991 to February 27, 1992.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. February 23, 1993. As presented in CDPR, 2000a.	1; Disk 1

Waterbody	Pollutant	Sources	Location: Folder #; Tab Title
Newman Wasteway	Diazinon	Ross, L. 1992. Preliminary Results of the San Joaquin River Study; Summer, 1991. Memorandum to Kean Goh. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. May 21, 1992. As presented in CDPR, 2000a.	1; Disk 1
Newman Wasteway	Diazinon	Ross, L. 1993. Preliminary Results of the San Joaquin River Study; Summer, 1992. Memorandum to Kean Goh. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. September 22, 1993. As presented in CDPR, 2000a.	1; Disk 1
Newman Wasteway	Diazinon	Ross, L., J. Stein, J. Hsu, J. White, and K. Hefner. 1996. Distribution and Mass Loading of Insecticides in the San Joaquin River, California: Winter 1991-92 and 1992-93. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. Report EH 96-02. November, 1996. As presented in CDPR, 2000a.	1; Disk 1
Newman Wasteway	Diazinon	Ross, L., J. Stein, J. Hsu, J. White, and K. Hefner. 1999. Distribution and Mass Loading of Insecticides in the San Joaquin River, California: Spring 1991 and 1992. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. Report EH 99-01. April, 1999. As presented in CDPR, 2000a.	1; Disk 1
Oak Run Creek	Fecal Coliform	Fact Sheet	1; cow creek
Oak Run Creek	Fecal Coliform	Hannaford MJ and North State Institute for Sustainable Communities. 2000. Preliminary Water Quality Assessment of 1; cow creek Tributaries. Department of Fish and Game. May 15, 2000. (http://www.delta.dfg.ca.gov/afrp/documents/cowcrk.rpt.pdf).	1; cow creek
Orestimba Creek	Azinphos Methyl	Fact Sheet	2; Pesticides
Orestimba Creek	Azinphos Methyl	CDPR. 2001. Surface Water Database. Access formatted database, using the parameters of Orestimba and azinphos methyl	1; Disk 1
Orestimba Creek	Azinphos Methyl	Fujimura, R. 1991a. *Chemical and Toxicity Test Results from the San Joaquin River at Three Sites from July 2 to September 13, 1991.* Memorandum to Lisa Ross, Department of Pesticide Regulation. Sacramento, CA. November 6, 1991. As presented in CDPR, 2000a.	1; Disk 1
Orestimba Creek	Azinphos Methyl	Fujimura, R. 1991b. *Chemical and Toxicity Test Results from the San Joaquin River and Tributaries During March 4 to April 26, 1991.* Memorandum to Lisa Ross, Department of Pesticide Regulation. Sacramento, CA. November 6, 1991. As presented in CDPR, 2000a.	1; Disk 1
Orestimba Creek	Azinphos Methyl	Fujimura, R. 1993a. *Chemical Analyses and Bioassay Test Results for Samples Collected from December 29 to February 25,, 1993.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. March 26, 1993. As presented in CDPR, 2000a.	1; Disk 1
Orestimba Creek	Azinphos Methyl	Fujimura, R. 1993b. *Chemical Analyses and Bioassay Test Results for Samples Collected from July 9 to September 9, 1992.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. March 23, 1993. As presented in CDPR, 2000a.	1; Disk 1

Waterbody	Pollutant	Sources	Location: Folder #; Tab Title
Orestimba Creek	Azinphos Methyl	Fujimura, R. 1993c. *Chemical Analyses and Bioassay Test Results for Samples Collected from March 16 to April 30, 1992.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. March 22, 1993. As presented in CDPR, 2000a.	1; Disk 1
Orestimba Creek	Azinphos Methyl	Fujimura, R. 1993d. *Chemical Analyses and Bioassay Test Results for Samples Collected from December 23, 1991 to February 27, 1992.* Memorandum to Brian Finlayson, Pesticide Investigations Unit, California Department of Fish and Game. Rancho Cordova, CA. February 23, 1993. As presented in CDPR, 2000a.	1; Disk 1
Orestimba Creek	Azinphos Methyl	Panshin, S.Y., N.M. Dubrovsky, J.M. Gronberg, and J.L. Domagalski. 1998. Occurrence and Distribution of Dissolved 2; Pesticides in the San Joaquin River Basin, California. USGS National Water Quality Assessment Program, Water Resources Investigations report No. 98-4032.	1; Disk 1
Orestimba Creek	Azinphos Methyl	Ross, L. 1992. Preliminary Results of the San Joaquin River Study; Summer, 1991. Memorandum to Kean Goh. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. May 21, 1992. As presented in CDPR, 2000a.	1; Disk 1
Orestimba Creek	Azinphos Methyl	Ross, L. 1993. Preliminary Results of the San Joaquin River Study; Summer, 1992. Memorandum to Kean Goh. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. September 22, 1993. As presented in CDPR, 2000a.	1; Disk 1
Orestimba Creek	Azinphos Methyl	Ross, L., J. Stein, J. Hsu, J. White, and K. Hefner. 1996. Distribution and Mass Loading of Insecticides in the San Joaquin River, California: Winter 1991-92 and 1992-93. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. Report EH 96-02. November, 1996. As presented in CDPR, 2000a.	1; Disk 1
Orestimba Creek	Azinphos Methyl	Ross, L., J. Stein, J. Hsu, J. White, and K. Hefner. 1999. Distribution and Mass Loading of Insecticides in the San Joaquin River, California: Spring 1991 and 1992. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. California Department of Pesticide Regulation. Sacramento, CA. Report EH 99-01. April, 1999. As presented in CDPR, 2000a.	1; Disk 1
Orestimba Creek	DDE	Fact Sheet	2; Pesticides
Orestimba Creek	DDE	CDPR. 2001. Surface Water Database. Access formatted database, using the parameters of Orestimba and DDE	1; Disk 1
Orestimba Creek	DDE	Panshin, S.Y., N.M. Dubrovsky, J.M. Gronberg, and J.L. Domagalski. 1998. Occurrence and Distribution of Dissolved 2; Pesticides in the San Joaquin River Basin, California. USGS National Water Quality Assessment Program, Water Resources Investigations report No. 98-4032.	1; Disk 1
Putah Creek, Lower	Mercury	Fact Sheet	2; Putah Creek
Putah Creek, Lower	Mercury	Slotton, D.G., S.M. Ayers, J.E. Reuter, C.R. Goldman. 1999. *Lower 2; Putah Creek 1997-1998 Mercury Biological Distribution Study. February 1999.* Dept. of Environmental Science and Policy, University of California, Davis. February 1999.	2; Putah Creek
Putah Creek, Lower	Mercury	USDHHS- ATSDR, 1998. *Fish Sampling in 2; Putah Creek (Phase II), Laboratory for Energy Related Health Research, Davis, Yolo County California, Cerclis No. CA2890190000.* Agency for Toxic Substance and Disease Registry. September 1998.	2; Putah Creek

Waterbody	Pollutant	Sources	Location: Folder #; Tab Title
Putah Creek, Lower	Mercury	USDHHS-ATSDR, 1997. *Fish Sampling in 2; Putah Creek, 1996, Laboratory for Energy Related Health Research, Davis, Yolo County California, Cerclis No. CA2890190000.* Agency for Toxic Substance and Disease Registry (ATSDR). April 1997.	2; Putah Creek
Putah Creek, Lower	Unknown Toxicity	Fact Sheet	2; Putah Creek
Putah Creek, Lower	Unknown Toxicity	Larsen K, M McGraw, V Connor, L Deanovic, T Kimball, and D Hinton. 2000. *Cache Creek and 2; Putah Creek Watersheds Toxicity Monitoring Results: 1998-1999* Final Report. November 2000.	2; Putah Creek
Putah Creek, Upper	Unknown Toxicity	Fact Sheet	2; Putah Creek
Putah Creek, Upper	Unknown Toxicity	Larsen K, M McGraw, V Connor, L Deanovic, T Kimball, and D Hinton. 2000. *Cache Creek and 2; Putah Creek Watersheds Toxicity Monitoring Results: 1998-1999* Final Report. November 2000.	2; Putah Creek
Rollins Reservoir	Mercury	Fact Sheet	2; HU:516 & 517
Rollins Reservoir	Mercury	Alpers, C.N., M.P. Hunerlach. 2000. *Mercury Contamination from Historic Gold Mining in California.* U.S. Geological Survey. Fact Sheet FS-061-00. May 2000.	2; HU:516 & 517
Rollins Reservoir	Mercury	May, J.T., R.L. Hothem, C.N. Alpers, M.A. Law. 2000. *Mercury Bioaccumulation in Fish in a Region Affected by Historic Gold Mining: The South Yuba River, Deer Creek, and Bear River Watersheds, California, 1999.* U.S. Geological Survey. Sacramento, CA. 2000.	2; HU:516 & 517
Rollins Reservoir	Mercury	Montoya, B. and X. Pan. 1992. *Inactive Mine Drainage in the Sacramento Valley, California.* California Regional Water Quality Control Board, Central Valley Region Report. July 1992.	2; HU:516 & 517
Rollins Reservoir	Mercury	Nevada County, Department of Environmental Health. 2000. *Press Release, Three County Environmental Health Agencies Issue Interim Public Health Notification on Mercury in Fish.* (http://www.co.nevada.ca.us/ehealth/hg/press_release_10-03-00.htm)	2; HU:516 & 517
Rollins Reservoir	Mercury	SWRCB-DWQ (State Water Resources Control Board, Division of Water Quality). 1995. *Toxic Substances Monitoring Program: Freshwater Bioaccumulation Monitoring Program: Data Base (Met_Wet).*	1; Disk 1
San Joaquin River	Mercury	Fact Sheet	2; SJR
San Joaquin River	Mercury	Davis, J. A. and M. D. May. 2000. *Contaminant Concentrations in Fish from the Sacramento-San Joaquin Delta and Lower San Joaquin River – 1998.* San Francisco Estuary Institute report. Richmond, California. September 2000.	2; Pesticides
San Joaquin River	Mercury	Slotton, D. G., T.H. Suchanek, and S.M. Ayers. 2000. Delta Wetlands Restoration and the Mercury Question: Year 2 Findings of the CALFED UC Davis Mercury Study. IEP Newsletter. 13(4): 34-44.	2; SJR
San Joaquin River	Mercury	SWRCB (State Water Resources Control Board, Division of Water Quality). 1995. Toxic Substances Monitoring Program: Freshwater Bioaccumulation Monitoring Program: Data Base (Metals_Wet).	1; Disk 1
Scott's Flat Reservoir	Mercury	Fact Sheet	2; HU:516 & 517
Scott's Flat Reservoir	Mercury	Alpers, C.N., M.P. Hunerlach. 2000. *Mercury Contamination from Historic Gold Mining in California.* U.S. Geological Survey. Fact Sheet FS-061-00. May 2000.	2; HU:516 & 517

Scott's Flat Reservoir	Mercury	May, J.T., R.L. Hothem, C.N. Alpers, M.A. Law. 2000. *Mercury Bioaccumulation in Fish in a Region Affected by Historic Gold Mining: The South Yuba River, Deer Creek, and Bear River Watersheds, California, 1999.* U.S. Geological Survey. Sacramento, CA. 2000.	2; HU:516 & 517
Scott's Flat Reservoir	Mercury	Nevada County, Department of Environmental Health. 2000. *Press Release, Three County Environmental Health Agencies Issue Interim Public Health Notification on Mercury in Fish.* (http://www.co.nevada.ca.us/ehealth/hg/press_release_10-03-00.htm)	2; HU:516 & 517
Scott's Flat Reservoir	Mercury	Slotton, D.G., S.M. Ayers, J.E. Reuter, C.R. Goldman. 1996. *Gold Mining Impacts on Food Chain Mercury in Northwestern Sierra Nevada Streams (1996 Revision).* Division of Environmental Studies, University of California, Davis. December 1996.	2; HU:516 & 517
Smith Canal	Dissolved Oxygen	Fact Sheet	2; Low DO
Smith Canal	Dissolved Oxygen	CDM (Camp Dresser & McKee Inc). 1999. Assessment of Water Quality Data from 2; Smith Canal Canal. July 27, 1999. (Appendix B-2 to City of Stockton & San Joaquin County Storm Water Management Program).	2; Low DO
Smith Canal	Dissolved Oxygen	Chen C., and Tsai W. *Application of Stockton's Water Quality Model to Evaluate Stormwater Impact on 2; Smith Canal Cana*l. February 23, 1999. (Attachment to March 17, 1999 letter from City of Stockton, G. Birdzell)	2; Low DO
Smith Canal	Dissolved Oxygen	Lee, G.F. and A. Jones-Lee. 2001b. *Review of the City of Stockton Urban Stormwater Runoff Aquatic Life Toxicity Studies Conducted by the Central Valley Regional Water Quality Control Board, DeltaKeeper, and the University of California, Davis, Aquatic Toxicology Laboratory between 1994 and 1999.* Final Report. November 2001. G. Fred Lee & Associates. El Macero, CA. (Prepared for DeltaKeeper).	2; Smith Canal

Waterbody	**Pollutant**	**Sources**	**Location: Folder #; Tab Title**
Smith Canal	Dissolved Oxygen	Larsen, K., K.A. Cortright., P.Young, V. Connor, L.A.Deanovic, D.E. Hinton. 1998. *Stockton Fish Kills Associated With Urban Storm Runoff: The Role of Low Dissolved Oxygen.* CRWQCB-CVR. June 1998.	2; Low DO
Smith Canal	Dissolved Oxygen	Lee G.F. *2000. Dissolved Oxygen Depletion in the Stockton Sloughs.* August 2000. (Prepared for DeltaKeeper)	2; Low DO
Smith Canal	Organo-phosphorus Pesticides	Fact Sheet	2; Smith Canal
Smith Canal	Organo-phosphorus Pesticides	Larsen K, M McGraw, V Connor, L Deanovic, T Kimball, and D Hinton. 2000. *Cache Creek and 2; Putah Creek Watersheds Toxicity Monitoring Results: 1998-1999* Final Report. November 2000.	2; Putah Creek
Smith Canal	Organo-phosphorus Pesticides	Lee G.F., and A. Jones – Lee. 2001. Review of the City of Stockton Urban Stormwater Runoff Aquatic Life Toxicity Studies Conducted by the CVRWQCB, DeltaKeeper and the University of California, Davis, Aquatic Toxicology Laboratory between 1994 and 1999. April 1, 2001.	2; Smith Canal
Smith Canal	Pathogens	Fact Sheet	1; Bacteria
Smith Canal	Pathogens	Jennings, B. 2001. Letter from Bill Jennings (DeltaKeeper A Project of San Francisco BayKeeper) to Mr. Jerry Bruns and Mr. Joe Karkoski (California Regional Water Quality Control Board, Central Valley Region) dated May 14, 2001, regarding DeltaKeeper comments on section 303(d) list update.	1; Bacteria
South cow creek	Fecal Coliform	Fact Sheet	1; cow creek
South cow creek	Fecal Coliform	Hannaford MJ and North State Institute for Sustainable Communities. 2000. Preliminary Water Quality Assessment of 1; cow creek Tributaries. Department of Fish and Game. May 15, 2000. (http://www.delta.dfg.ca.gov/afrp/documents/cowcrk.rpt.pdf).	1; cow creek
Stanislaus River, Lower	Mercury	Fact Sheet	2; SJR
Stanislaus River, Lower	Mercury	USBR (U.S. Bureau of Reclamation). 2001. *U.S. Bureau of Reclamation DataWeb: Power Plants, Dams & Reservoirs.* Accessed on August 22, 2001 (http://dataweb.usbr.gov/).	NA
Stanislaus River, Lower	Mercury	SWRCB (State Water Resources Control Board). 1995. *Toxic Substances Monitoring Program: Freshwater Bioaccumulation Monitoring Program: Data Base.* As presented in TSMP database (Metals_Wet).	1; Disk 1
Stanislaus River, Lower	Mercury	Davis, J.A., M.D. May, G. Ichikawa, and D. Crane. 2000. *Contaminant Concentrations in Fish from the Sacramento-San Joaquin Delta and Lower San Joaquin River – 1998.* San Francisco Estuary Institute report. Richmond, California. September 2000.	2; Pesticides
Stanislaus River, Lower	Mercury	OMR (Office of Mine Reclamation). 2000. *California's Abandoned Mines – A Report on the Magnitude and Scope of the Issue in the State.* California Department of Conservation, Office of Mine Reclamation, Abandoned Mine Lands Unit (OMR). Sacramento, CA. June 2000.	1; Don Pedro Lake
Stockton Deep Water Channel	Pathogens	Fact Sheet	1; Bacteria
Stockton Deep Water Channel	Pathogens	Jennings, B. 2001. Letter from Bill Jennings (DeltaKeeper A Project of San Francisco BayKeeper) to Mr. Jerry Bruns and Mr. Joe Karkoski (California Regional Water Quality Control Board, Central Valley Region) dated May 14, 2001, regarding DeltaKeeper comments on section 303(d) list update.	1; Bacteria

Waterbody	**Pollutant**	**Sources**	**Location: Folder #; Tab Title**
Sutter Bypass	Diazinon	Fact Sheet	2; Pesticides
Sutter Bypass	Diazinon	CDPR. 2001. Surface Water Database. Access formatted database, using the parameters of Sutter Bypass and Diazinon	1; Disk 1
Sutter Bypass	Diazinon	Nordmark, C. In prep. *Preliminary Results of Acute and Chronic Toxicity Testing of Surface Water Monitored in the Sacramento River Watershed, Winter 1999-00.* Memorandum to Don Weaver, Environmental Monitoring and Pest Management, Department of Pesticide Regulation. Sacramento, CA. As presented in CDPR, 2000a.	1; Disk 1
Sutter Bypass	Diazinon	Nordmark, C. 1998. *Preliminary Results of Acute and Chronic Toxicity Testing of Surface Water Monitored in the Sacramento River Watershed, Winter 1998-99.* Memorandum to Don Weaver, Environmental Monitoring and Pest Management, Department of Pesticide Regulation. Sacramento, CA. July 31, 1998 As presented in CDPR, 2000a.	1; Disk 1
Sutter Bypass	Diazinon	Nordmark, C. 1999. *Preliminary Results of Acute and Chronic Toxicity Testing of Surface Water Monitored in the Sacramento River Watershed, Winter 1998-99.* Memorandum to Don Weaver, Environmental Monitoring and Pest Management, Department of Pesticide Regulation, Sacramento, CA. May 26, 1999. As presented in CDPR, 2000a.	1; Disk 1
Sutter Bypass	Diazinon	Nordmark, C.E., K.P. Bennett, H. Feng, J. Hernandez, and P. Lee. 1998. Occurrence of aquatic toxicity and dormant spray pesticide detections in the Sacramento River watershed. Winter 1996-97. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch. Department of Pesticide Regulation. Sacramento, CA. Report EH98-01. February, 1998. As presented in CDPR, 2000a.	1; Disk 1
Walker Slough	Pathogens	Fact Sheet	1; Bacteria
Walker Slough	Pathogens	Jennings, B. 2001. Letter from Bill Jennings (DeltaKeeper A Project of San Francisco BayKeeper) to Mr. Jerry Bruns and Mr. Joe Karkoski (California Regional Water Quality Control Board, Central Valley Region) dated May 14, 2001, regarding DeltaKeeper comments on section 303(d) list update.	1; Bacteria
Wolf Creek	Fecal Coliform	Fact Sheet	1; Bacteria
Wolf Creek	Fecal Coliform	City of Grass Valley. 2000. *Discharger self-monitoring reports (DSMRs) for Grass Valley Waste Water Treatment Plant.*	1; Bacteria
Wolf Creek	Fecal Coliform	City of Grass Valley. 2001. *Discharger self-monitoring reports (DSMRs) for Grass Valley Waste Water Treatment Plant.*	1; Bacteria
Wolf Creek	Fecal Coliform	Jennings, B. 2001. Letter from Bill Jennings (DeltaKeeper A Project of San Francisco BayKeeper) to Mr. Jerry Bruns and Mr. Joe Karkoski (California Regional Water Quality Control Board, Central Valley Region) dated May 14, 2001, regarding DeltaKeeper comments on section 303(d) list update.	1; Bacteria

Documents Supporting Changing to Information Presented on the 1998 303(d) List

Waterbody	Pollutant	Sources	Location: Folder #; Tab Title
Cache Creek	UTX, Hg	Fact Sheet	3 ; Change: Mines
Cache Creek	UTX, Hg	Buer, S.M., S.R. Phillippe, and T.R. Pinkos. 1979. Inventory and Assessment of Water Quality Problems Related to Abandoned and Inactive Mines in the Central Valley Region of California. California Regional Water Quality Control Board, Central Valley Region Draft Report, 1979.	3; Change: Mines
Cache Creek	UTX, Hg	Foe, C. and W. Croyle. 1998. Mercury Concentrations and Loads from the Sacramento River and from Cache Creek to the Sacramento-San Joaquin Delta Estuary. California Regional Water Quality Control Board, Central Valley Region. June 1998.	1; Bear Crk
Cache Creek	UTX, Hg	Montoya, B. and X. Pan. 1992. Inactive Mine Drainage in the Sacramento Valley, California. California Regional Water Quality Control Board, Central Valley Region Report. July 1992.	2; HU: 516 & 517- Hg
Camanche Reservoir	Copper	Fact Sheet	1 ; Camanche Res
Camanche Reservoir	Copper	Buer, S.M., S.R. Phillippe, and T.R. Pinkos. 1979. *Inventory and Assessment of Water Quality Problems related to Abandoned and Inactive Mines in the Central Valley Region of California*. CRWQCB-CVR (California Regional Water Quality Control Board, Central Valley Region), Report.	1; Camanche Res
Camanche Reservoir	Copper	CDFG (California Department of Fish and Game). 1991. *Lower Mokelumne River Fisheries Plan.* The Resources Agency, Department of Fish and Game, Stream flow Requirements Program. November 1991.	1; Camanche Res
Camanche Reservoir	Copper	CH2MHILL. 2000a. *Closure Report: Penn Mine Environmental Restoration Project.* Prepared for: East Bay Municipal Utility District and Regional Water Quality Control Board-Central Valley Region. Oakland, California. December 2000.	1; Camanche Res
Camanche Reservoir	Copper	CH2MHILL. 2000b. *(Draft) Post-Restoration Final Effectiveness Report: Penn Mine Environmental Restoration Project.* Prepared for: East Bay Municipal Utility District and Regional Water Quality Control Board-Central Valley Region. Oakland, California. September 2000.	1; Camanche Res
Camanche Reservoir	Copper	EBMUD (East Bay Municipal Utility District). 2001. Unpublished dissolved copper concentration data for the lower Mokelumne River downstream of Camanche Dam, generated as part of EBMUD's NPDES requirements. Provided electronically by Alexander R. Coate (Manger of Regulatory Compliance, EBMUD) to Michelle L. Wood (Environmental Specialist, Central Valley Regional Water Quality Control Board) on August 2, 2001.	1; Camanche Res
Camanche Reservoir	Copper	EDAW, Inc. 1992. *Draft EIS/EIR for the Updated Water Supply Management Program, Volume III, Technical Appendices B1 and B2.* Prepared for: East Bay Municipal Utility District. Oakland, California. December 1992.	1; Camanche Res
Camanche Reservoir	Copper	Montoya, B., and X. Pan. 1992. *Inactive Mine Drainage in the Sacramento Valley, California.* California Regional Water Quality Control Board, Central Valley Region Report. July 1992.	2; HU: 516 & 517- Hg
Camanche Reservoir	Copper	SCH EIR. 1996. *Draft EIR for The Penn Mine Site, Long-Term Solution Project.* Prepared for: East Bay Municipal Utility District and Regional Water Quality Control Board-Central Valley Region. SCH EIR No. 95103036.	1; Camanche Res

Waterbody	Pollutant	Sources	Location: Folder #; Tab Title
Camanche Reservoir	Zinc	Fact Sheet	1; Camanche Res
Camanche Reservoir	Zinc	Buer, S.M., S.R. Phillippe, and T.R. Pinkos. 1979. *Inventory and Assessment of Water Quality Problems related to Abandoned and Inactive Mines in the Central Valley Region of California*. CRWQCB-CVR (California Regional Water Quality Control Board, Central Valley Region), Report.	1; Camanche Res
Camanche Reservoir	Zinc	CDFG (California Department of Fish and Game). 1991. *Lower Mokelumne River Fisheries Plan.* The Resources Agency, Department of Fish and Game, Stream flow Requirements Program. November 1991.	1; Camanche Res
Camanche Reservoir	Zinc	CH2MHILL. 2000a. *Closure Report: Penn Mine Environmental Restoration Project.* Prepared for: East Bay Municipal Utility District and Regional Water Quality Control Board-Central Valley Region. Oakland, California. December 2000.	1; Camanche Res
Camanche Reservoir	Zinc	CH2MHILL. 2000b. *(Draft) Post-Restoration Final Effectiveness Report: Penn Mine Environmental Restoration Project.* Prepared for: East Bay Municipal Utility District and Regional Water Quality Control Board-Central Valley Region. Oakland, California. September 2000.	1; Camanche Res
Camanche Reservoir	Zinc	EBMUD (East Bay Municipal Utility District). 2001. Unpublished dissolved copper concentration data for the lower Mokelumne River downstream of Camanche Dam, generated as part of EBMUD's NPDES requirements. Provided electronically by Alexander R. Coate (Manger of Regulatory Compliance, EBMUD) to Michelle L. Wood (Environmental Specialist, Central Valley Regional Water Quality Control Board) on August 2, 2001.	1; Camanche Res
Camanche Reservoir	Zinc	EDAW, Inc. 1992. *Draft EIS/EIR for the Updated Water Supply Management Program, Volume III, Technical Appendices B1 and B2.* Prepared for: East Bay Municipal Utility District. Oakland, California. December 1992.	1; Camanche Res
Camanche Reservoir	Zinc	Montoya, B., and X. Pan. 1992. *Inactive Mine Drainage in the Sacramento Valley, California.* California Regional Water Quality Control Board, Central Valley Region Report. July 1992.	1; Camanche Res
Camanche Reservoir	Zinc	SCH EIR. 1996. *Draft EIR for The Penn Mine Site, Long-Term Solution Project.* Prepared for: East Bay Municipal Utility District and Regional Water Quality Control Board-Central Valley Region. SCH EIR No. 95103036.	1; Camanche Res
Delta	2; Low DO	Fact Sheet	3; Change: General
Delta	All (except 2; Low DO)	Fact Sheet	3; Change: General
Delta	All	NA (extent of impairment corrected)	NA
Dunn Creek	Hg, Metals	Fact Sheet	3; Change: Mt Diablo
Dunn Creek	Hg, Metals	Buer, S.M., S.R. Phillippe, and T.R. Pinkos. 1979. Inventory and Assessment of Water Quality Problems Related to Abandoned and Inactive Mines in the Central Valley Region of California. CRWQCB-CVR.	3; Change: Mines
Dunn Creek	Hg, Metals	Iovenitti, J.L., Weiss Associates, and J. Wessman. 1989. Mount Diablo Mine: Surface Impoundment Technical Report. Pleasant Hill, Ca.	3; Change:Mt Diablo
Dunn Creek	Hg, Metals	Slotton DG, SM Ayers, and JE Reuter. 1996. Marsh Creek Watershed: 1995 Mercury Assessment Project. March 1996.	3; Change:Mt Diablo
Fall Creek	Sedimentation/Siltation	Fact Sheet	3; Change: Fall Crk

Waterbody	Pollutant	Sources	Location: Folder #; Tab Title
Fall Creek	Sedimentation/Siltation	CRWQCB-CVR (California Regional Water Quality Control Board, Central Valley Region). 1982. Fall River Water Quality Monitoring Survey. July 1982.	3; Change: Fall Crk
Fall Creek	Sedimentation/Siltation	CDWR (Department of Water Resources). 1998. Aquatic Monitoring and Assessment for the Upper Fall River, Memorandum Report. May 1998.	3; Change: Fall Crk
Fall Creek	Sedimentation/Siltation	North State Resources and T Holmes (prepared for the Fall River Resource Conservation District). A study of the Habitat Characteristics of the Aquatic Vegetation of the Upper Fall River: Final Report. Redding, Ca. December 8, 1997.	3; Change: Fall Crk
Fall Creek	Sedimentation/Siltation	Tetra Tech, Inc (for the Fall River Resource Conservation District). 1998. Analysis of Sedimentation and Action Plan Development for the Upper Fall River, Shasta County, California. San Francisco, Ca. May 20, 1998.	3; Change: Fall Crk
Fall Creek	Sedimentation/Siltation	USDA (United States Department of Agriculture), River Basin Planning Staff, in cooperation with Fall River Resource Conservation District. 1983. Fall River Watershed Area Study, Summary Report. Davis, Ca. June 1983.	3; Change: Fall Crk
French Ravine	Bacteria	Fact Sheet	3; 3; Change: General
French Ravine	Bacteria	Horizons Technology, Inc., 1997. Sure! MAPS® RASTER Map Sets (U.S. Geological Survey 7.5' Topographic Quadrangles), Version 2.1.2.	NA
Horse Creek	Metals	Fact Sheet	3; Change: Mines
Horse Creek	Metals	Montoya, B., and X. Pan. 1992. *Inactive Mine Drainage in the Sacramento Valley, California.* California Regional Water Quality Control Board, Central Valley Region Report. July 1992.	2; HU: 516 & 517- Hg
Humbug Creek	Sedimentation/Siltation, Metals, Hg	Fact Sheet	3; Change: Mines
Humbug Creek	Sedimentation/Siltation, Metals, Hg	Montoya, B., and X. Pan. 1992. *Inactive Mine Drainage in the Sacramento Valley, California.* California Regional Water Quality Control Board, Central Valley Region Report. July 1992.	2; HU: 516 & 517- Hg
James Creek	Hg, Ni	Fact Sheet	3; Change: Mines
James Creek	Hg, Ni	Buer, S.M., S.R. Phillippe, and T.R. Pinkos. 1979. *Inventory and Assessment of Water Quality Problems Related to Abandoned and Inactive Mines in the Central Valley Region of California.* California Regional Water Quality Control Board, Central Valley Region Draft Report. 1979.	3; Change: Mines
James Creek	Hg, Ni	Montoya, B. and Pan, X., 1992. *Inactive Mine Drainage in the Sacramento Valley, California.* California Regional Water Quality Control Board, Central Valley Region Report. July 1992.	2; HU: 516 & 517- Hg
Marsh Creek	Metals	Fact Sheet	3; Change: Mt Diablo
Marsh Creek	Hg	Fact Sheet	3; Change: Mt Diablo

Waterbody	Pollutant	Sources	Location: Folder #; Tab Title
Marsh Creek	Metals, Hg	Buer, S.M., S.R. Phillippe, and T.R. Pinkos. 1979. Inventory and Assessment of Water Quality Problems Related to Abandoned and Inactive Mines in the Central Valley Region of California. CRWQCB-CVR.	3; Change : Mines
Marsh Creek	Metals, Hg	CRWQCB-CVR. 1978. *Waste Discharge Requirements for Mount Diablo Quicksilver Mine, Contra Costa County.* Sacramento, Ca: CRWQCB.	3; Change: Mt Diablo
Marsh Creek	Metals, Hg	Iovenitti, J.L., Weiss Associates, and J. Wessman. 1989. Mount Diablo Mine: Surface Impoundment Technical Report. Pleasant Hill, Ca.	3; Change: Mt Diablo
Marsh Creek	Metals, Hg	Slotton DG, SM Ayers, and JE Reuter. 1996. Marsh Creek Watershed: 1995 Mercury Assessment Project. March 1996.	3; Change: Mt Diablo
Mokulmne River, Lower	Copper	Fact Sheet	1 ; Camanche Res
Mokulmne River, Lower	Copper	Buer, S.M., S.R. Phillippe, and T.R. Pinkos. 1979. *Inventory and Assessment of Water Quality Problems related to Abandoned and Inactive Mines in the Central Valley Region of California.* CRWQCB-CVR (California Regional Water Quality Control Board, Central Valley Region), Report.	1; Camanche Res
Mokulmne River	Copper	CDFG (California Department of Fish and Game). 1991. *Lower Mokelumne River Fisheries Plan.* The Resources Agency, Department of Fish and Game, Stream flow Requirements Program. November 1991.	1; Camanche Res
Mokulmne River	Copper	CH2MHILL. 2000a. *Closure Report: Penn Mine Environmental Restoration Project.* Prepared for: East Bay Municipal Utility District and Regional Water Quality Control Board-Central Valley Region. Oakland, California. December 2000.	1; Camanche Res
Mokulmne River	Copper	CH2MHILL. 2000b. *(Draft) Post-Restoration Final Effectiveness Report: Penn Mine Environmental Restoration Project.* Prepared for: East Bay Municipal Utility District and Regional Water Quality Control Board-Central Valley Region. Oakland, California. September 2000.	1; Camanche Res
Mokulmne River	Copper	EBMUD (East Bay Municipal Utility District). 2001. Unpublished dissolved copper concentration data for the lower Mokelumne River downstream of Camanche Dam, generated as part of EBMUD's NPDES requirements. Provided electronically by Alexander R. Coate (Manger of Regulatory Compliance, EBMUD) to Michelle L. Wood (Environmental Specialist, Central Valley Regional Water Quality Control Board) on August 2, 2001.	1; Camanche Res
Mokulmne River	Copper	EDAW, Inc. 1992. *Draft EIS/EIR for the Updated Water Supply Management Program, Volume III, Technical Appendices B1 and B2.* Prepared for: East Bay Municipal Utility District. Oakland, California. December 1992.	1; Camanche Res
Mokulmne River	Copper	Montoya, B., and X. Pan. 1992. *Inactive Mine Drainage in the Sacramento Valley, California.* California Regional Water Quality Control Board, Central Valley Region Report. July 1992.	2; HU: 516 & 517- Hg
Mokulmne River	Copper	SCH EIR. 1996. *Draft EIR for The Penn Mine Site, Long-Term Solution Project.* Prepared for: East Bay Municipal Utility District and Regional Water Quality Control Board-Central Valley Region. SCH EIR No. 95103036.	1; Camanche Res
Mokulmne River	Zinc	Fact Sheet	1; Camanche Res
Mokulmne River	Zinc	Buer, S.M., S.R. Phillippe, and T.R. Pinkos. 1979. *Inventory and Assessment of Water Quality Problems related to Abandoned and Inactive Mines in the Central Valley Region of California.* CRWQCB-CVR (California Regional Water Quality Control Board, Central Valley Region), Report.	1; Camanche Res

Waterbody	Pollutant	Sources	Location: Folder #; Tab Title
Mokulmne River	Zinc	CDFG (California Department of Fish and Game). 1991. *Lower Mokelumne River Fisheries Plan.* The Resources Agency, Department of Fish and Game, Stream flow Requirements Program. November 1991.	1; Camanche Res
Mokulmne River	Zinc	CH2MHILL. 2000a. *Closure Report: Penn Mine Environmental Restoration Project.* Prepared for: East Bay Municipal Utility District and Regional Water Quality Control Board-Central Valley Region. Oakland, California. December 2000.	1; Camanche Res
Mokulmne River	Zinc	CH2MHILL. 2000b. *(Draft) Post-Restoration Final Effectiveness Report: Penn Mine Environmental Restoration Project.* Prepared for: East Bay Municipal Utility District and Regional Water Quality Control Board-Central Valley Region. Oakland, California. September 2000.	1; Camanche Res
Mokulmne River	Zinc	EBMUD (East Bay Municipal Utility District). 2001. Unpublished dissolved copper concentration data for the lower Mokelumne River downstream of Camanche Dam, generated as part of EBMUD's NPDES requirements. Provided electronically by Alexander R. Coate (Manger of Regulatory Compliance, EBMUD) to Michelle L. Wood (Environmental Specialist, Central Valley Regional Water Quality Control Board) on August 2, 2001.	1; Camanche Res
Mokulmne River	Zinc	EDAW, Inc. 1992. *Draft EIS/EIR for the Updated Water Supply Management Program, Volume III, Technical Appendices B1 and B2.* Prepared for: East Bay Municipal Utility District. Oakland, California. December 1992.	1; Camanche Res
Mokulmne River	Zinc	Montoya, B., and X. Pan. 1992. *Inactive Mine Drainage in the Sacramento Valley, California.* California Regional Water Quality Control Board, Central Valley Region Report. July 1992.	1; Camanche Res
Mokulmne River	Zinc	SCH EIR. 1996. *Draft EIR for The Penn Mine Site, Long-Term Solution Project.* Prepared for: East Bay Municipal Utility District and Regional Water Quality Control Board-Central Valley Region. SCH EIR No. 95103036.	1; Camanche Res
Mosher Slough	Chlorpyrifos, Diazinon	Fact Sheet	3; Change: General
Mosher Slough	Chlorpyrifos, Diazinon	DeLorme 1998. Northern California Atlas and Gazetteer- Detailed Topographic Maps. 1:150,000 Scale. Fourth Edition. (http://www.delorme.com.)	NA
Mosher Slough	Chlorpyrifos, Diazinon	Horizons Technology, Inc., 1997. Sure! MAPS® RASTER Map Sets (U.S. Geological Survey 7.5' Topographic Quadrangles), Version 2.1.2.	NA
San Carlos Creek	Hg	Fact Sheet	3; Change: New Idrea
San Carlos Creek	Hg	USGS (United States Geological Survey). 1969-1981. Ciervo Mountain (1969), Idria (1969), San Benito Mountain (1981), and Tumey Hills (1971). California 7.5' Topographic Quadrangle, as presented by TopoZone.com (© 2000 Maps a la carte, Inc.). Accessed on March 13, 2001 (http://www.topozone.com/default.asp).	NA
San Carlos Creek	Hg	CRWQCB-CVR. 1971-1995. *Futures Foundation, New Idria Mine File.* Electronic database of all water sampling results for San Carlos Creek and New Idria Mine drainage. Mercury data for water samples collected June 1971 to December 1995.	1; Disk 2
San Carlos Creek	Hg	CRMP (Panoche/Silver Creek Coordinated Resource Management Plan) TRC (Technical Review Committee). 1996. *Draft Water Quality Report.* February 29, 1996.	3; Change: New Idrea
Stanislaus River	Diazinon, GAP, UTX	Fact Sheet	3; Change: General

Waterbody	Pollutant	Sources	Location: Folder #; Tab Title
Stanislaus River	Diazinon, GAP, UTX	USBR (U.S. Bureau of Reclamation). 2001. *U.S. Bureau of Reclamation DataWeb: Power Plants, Dams & Reservoirs.* Accessed on August 22, 2001 (http://dataweb.usbr.gov/).	NA
Stanislaus River	Diazinon, GAP, UTX	USGS (United States Geological Survey). 1987, 1991. *Knights Ferry* (1987) and *Ripon* (1991). California 7.5' Topographic Quadrangles, as presented by TopoZone.com (© 2000 Maps a la carte, Inc.). Accessed on August 22, 2001 (http://www.topozone.com/default.asp).	NA
Tuolumne River	Diazinon	Fact Sheet	3; Change: General
Tuolumne River	GAP, UTX	Fact Sheet	3; Change: General
Tuolumne River	Diazinon, GAP, UTX	USGS (United States Geological Survey). 1987, 1991, 1969. La Grange (1987), Westley (1991), and Brush Lake (1969). California 7.5' Topographic Quadrangles, as presented by TopoZone.com (© 2000 Maps a la carte, Inc.). Accessed on August 23, 2001 (http://www.topozone.com/default.asp).	NA

Documents Supporting Delisting a Waterbody-Pollutant from the 2002 303(d) List

Waterbody	Pollutant	Sources	Location: Folder #; Tab Title
American River, Lower	Group A 2; Pesticides	Fact Sheet	3; Removals
American River, Lower	Group A 2; Pesticides	Davis, J.A., M.D. May, G. Ichikawa, and D. Crane. 2000. Contaminant Concentrations in Fish from the Sacramento-San Joaquin Delta and Lower San Joaquin River, 1998. San Francisco Estuary Institute, Richmond, CA. September 1998	2; Pesticides
American River, Lower	Group A 2; Pesticides	Larry Walker Associates. 2001b. *Sacramento River Watershed Program Annual Monitoring Report: 1999-2000.* Prepared for the Sacramento River Watershed Program by Larry Walker Associates, Davis, California.	3; Removals
American River, Lower	Group A 2; Pesticides	SWRCB-DWQ (State Water Resources Control Board, Division of Water Quality). 1995. *Toxic Substances Monitoring Program: Freshwater Bioaccumulation Monitoring Program: Data Base (Org_Wet).*	1; Disk 1
Grasslands Marshes	Selenium	Grober, L.F. 1999. *Selenium Total Maximum Daily Load for the Grassland Marshes.* California Regional Water Quality Control Board, Central Valley Region.	NA
Salt Slough	Selenium	Grober, L. 2000. *Selenium Total Maximum Daily Load for Salt Slough.* California Regional Water Quality Control Board, Central Valley Region.	NA

Arcade Crk-Cu

B.1.1 Arcade Creek, Copper

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region, (Regional Board) recommends the addition of Arcade Creek to California's Clean Water Act Section 303(d) list due to impairment by copper. Information available to the Regional Board on copper levels in water samples indicates that water quality objectives are not being attained in Arcade Creek. The description of the basis for this determination is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Arcade Creek	**Pollutants/Stressors**	Copper
Hydrologic Unit	519.21	**Sources**	Urban runoff/Storm sewers
Total Waterbody Size	10 miles	**TMDL Priority**	
Size Affected	10 miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	All of Arcade Creek	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	38° 40' 28"	**Upstream Extent Longitude**	121° 13' 58"
Downstream Extent Latitude	38° 36' 11"	**Downstream Extent Longitude**	121° 30' 52"

Watershed Characteristics

The Arcade Creek watershed covers approximately 50 square miles. Arcade Creek proper generally flows from east to west starting near the intersection of Sunrise Boulevard and Greenback Lane and flowing into the Natomas East Main Drainage Canal in Sacramento (Russick, 2001). Watershed elevations range from 20 to about 270 feet above sea level.

Land use is predominately residential and commercial. The entire watershed lies within the urbanized parts of the Sacramento metropolitan area extending from the northeastern corner of the City of Citrus Heights on the east to the Natomas East Main Drain on the west. Flows and water quality in Arcade Creek are characteristic of a stream dominated by urban runoff. Typical dry weather flows at the USGS gauging station at Watt Avenue are less than 3 cubic feet per second (cfs) but may increase rapidly during rainfall events and have exceeded 1,900 cfs.

Water Quality Objectives Not Attained

The United States Environmental Protection Agency (USEPA) California Toxic Rule (CTR) freshwater aquatic life criteria for dissolved copper are not being attained. The CTR Criteria Continuous Concentration (CCC) ranges from 2.7 to 29.3 μg/L and the Criteria Maximum Concentration (CMC) ranges from 3.6 to 49.6 μg/L, depending on hardness. The California DHS numeric primary maximum contaminant level (MCL) to protect drinking water is 1,300 μg/L (Marshack, 2000). Copper data were compared to the hardness adjusted CTR criteria, as well as the drinking water MCL.

Evidence of Impairment

Water samples collected from Arcade Creek by the US Geological Survey (USGS) and the City of Sacramento indicate that Arcade Creek is impaired by copper. These data are summarized in Table B-2, below. The USGS collected water samples from Arcade Creek from February 1996 through April 1998. Of the 28 samples collected by the USGS in that time period, 4 samples (approximately 14 %) exceeded the CTR Criteria Continuous Concentration for dissolved copper and 2 samples (approximately 7%) exceeded CTR Criteria Maximum Concentration (USGS, 2001). The City of Sacramento, as a participant in the Sacramento River Watershed Program (SRWP), collected copper samples from Arcade creek from June 1999 through May 2000. Of the 12 samples collected during that time period[1], 4 samples (approximately 33%) exceeded the CTR Criteria Continuous Concentration for dissolved copper and one sample (approximately 8%) exceeded the CTR Criteria Maximum Concentration (Larry Walker Associates, 2001a). Of the 40 total samples from both of these data sources, 8 (20 %) exceeded the CTR Criteria Continuous Concentration for dissolved copper (Larry Walker Associates, 2001b) and 3 samples (approximately 8%) exceeded the CTR Criteria Maximum Concentration. None of the samples exceeded the USEPA drinking water MCL.

Table B-2. Summary of Copper Concentration Data for Arcade Creek

Data Source	*USGS*	*SRWP*	*Total*
Dates of Sampling	2/96 – 4/98	8/99 – 5/00	2/96 – 5/00
Number of Samples	28	12[a]	40[a]
Median Cu Concentration (µg/L)	4.0	2.3	4.0
Range of Cu Concentrations (µg/L)	1.8-9.0	0.2-9.0	0.2-9.0
Number Above USEPA CCC	4 (14%)	4 (33%)	8 (20%)
Number Above USEPA CMC	2 (7%)	1 (8%)	3 (8%)

[a] There were 13 samples collected by the City of Sacramento for the SRWP. One of the 13 samples from the SRWP data was excluded from this analysis due to a lack of the hardness data needed to assess compliance with Water Quality Standards.

Extent of Impairment

The entire reach of Arcade Creek, from its headwaters to the Natomas East Main Drainage Canal, is considered to be impaired by copper.

Potential Sources

The most likely source of copper to Arcade Creek is urban runoff. Urban runoff has been shown to contain copper from automotive sources (brakes and tires), urban source water and water delivery systems, and atmospheric deposition (Woodward-Clyde, 1992).

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Ground water — Water levels in wells.

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Introduction

These pages provide access to water-resources data collected at approximately 1.5 million sites in all 50 States, the District of Columbia, and Puerto Rico. Online access to this data is organized around the categories listed to the left.

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SACRAMENTO RIVER
WATERSHED
PROGRAM

Annual Monitoring Report: 1999–2000

Prepared for:

Sacramento River Watershed Program

By:

Larry Walker Associates

DRAFT

B. Other Trace Metals

Monitoring results for the Sacramento River Watershed Program (SRWP) and for primary coordinating programs (USGS NAWQA, Sacramento River Coordinated Monitoring Program, City of Redding NPDES monitoring, and Department of Water Resources) are presented and summarized in this section. Data are evaluated for spatial and temporal trends, and summary statistics are also provided in Appendix F. Data are also compared to relevant water quality objectives and to advisory criteria to evaluate attainment and potential impairment of beneficial uses in the watershed. Qualitative comparisons of mass loads from major Delta inputs are used to evaluate the relative importance of Sacramento River watershed trace metals sources to the Delta.

i. Background and Available Data Overview

The sources of data utilized for this report are summarized in Table 10. The monitoring locations for the primary data considered for this report (USGS NAWQA, Sacramento River Coordinated Monitoring Program, City of Redding NPDES monitoring, the California Department of Water Resources, and the Sacramento River Watershed Program) are illustrated in Figure 7.

Table 10. Trace Metals Monitoring Programs In The Sacramento River Watershed

Program	Monitoring Period	Parameters	# of monitoring locations & geographic reference
SRWP	6/98 – 5/00	▪ Total and dissolved As, Cd, Cu, Pb, Zn ▪ Total Cr, Se, Ni, Ag	2 sites: 1 in upper watershed, and 1 in lower watershed
Sacramento River Basin NAWQA (USGS)	2/96 – 4/98	▪ Dissolved As, Cd, Cr, Cu, Pb, Ni, Se, Ag, Zn (and other metals)	12 sites, distributed throughout watershed
Sacramento River CMP (SRCSD)	12/92 – 6/00	▪ Total and dissolved As, Cd, Cr, Cu, Pb, Ni, Se, Ag, Zn	5 sites, on Sacramento and American rivers in Sacramento metropolitan area
City of Redding	1/98–5/00	▪ Total and dissolved As, Cd, Cr, Cu, Pb, Ni, Zn ▪ Total Se, Ag	1 site at Sacramento River below Keswick Dam
SFBay Regional Monitoring Program	1987– 1998	▪ Total and dissolved trace metals in water	18 Bay-Delta sites, including Sacramento River and San Joaquin River at the Delta terminus
Intensive Tributary Monitoring (DWR)	6/98–5/99	▪ Total trace metals in water	Numerous locations in Deer Ck, Mill Ck, Big Chico Ck

ii. Spatial Distribution & Patterns

Data have been evaluated for spatial trends in the Sacramento River mainstem, and for differences between major and minor tributaries and the Sacramento River mainstem. The primary reason for spatial evaluation of concentrations is to help in the detection of sources with higher pollutant concentrations. Typical spatial distributions are described using median concentrations of trace metals. Median data are used for spatial analysis because the median is a representative and relatively stable statistic that represents "typical" concentrations for a water body. (Note that median data are generally not used for evaluation of attainment or potential impairment of beneficial uses in this report, because these evaluations require consideration of the full range of data.) Variability of the data was evaluated by comparing the interquartile range-to-median ratios for each parameter and site (this is a non-parametric equivalent of the coefficient of variation value). Results for the range of data are presented in Figures 8–12 and are discussed below. Summary statistics for trace metals data are presented in Appendix F.

Spatial Distribution of Arsenic.—Typical total arsenic concentrations in the Sacramento River mainstem range from a median of 1.1 µg/L below the Keswick Reservoir discharge to a median of 1.7 µg/L for the Sacramento River at Veterans Bridge. The median total concentration in the American River (0.58 µg/L) is less than one half the median concentration for the Sacramento River at Veterans Bridge, and is responsible for a slight decrease in the concentrations observed for the Sacramento River at Freeport and River Mile 44, where the median concentration is 1.5 µg/L. The median total concentration at Cache Slough near Ryers Ferry (1.6 µg/L) is similar to that in the Sacramento mainstem. Total arsenic concentrations were much higher in the Mill Creek watershed, with medians between 15 µg/L and 69 µg/L. Concentrations in the lower Deer Creek watershed were also higher than the mainstem, with medians near 2 µg/L. Arsenic concentrations in the Big Chico Creek watershed were substantially lower than in the mainstem, with medians ranging from 0.06 – 0.26 µg/L. The variability of total arsenic concentrations was similar at Sacramento River at Veterans Bridge, Freeport, and River Mile 44, with slightly lower variability for the American River, and somewhat more variable in the three smaller tributaries (Mill, Deer, and Big Chico creeks). The highest total arsenic concentrations observed were at Mill Creek at Highway 36 (109 µg/L).

Evaluation of spatial trends in dissolved arsenic are somewhat hampered because the majority of the available data (from the USGS NAWQA program) are below detection at a reporting limit of 1 µg/L. Median concentrations in the Sacramento River mainstem remained relatively consistent between 1 and 1.1 µg/L, with no apparent downstream trend (although it should be noted that these median dissolved data are influenced by the reporting limits for USGS data). It is apparent that dissolved arsenic concentrations in the major tributaries (the Feather, Yuba, and American rivers) are lower than in the Sacramento River mainstem since dissolved arsenic concentrations were not observed to exceed 1 µg/L in any of these tributaries. Median dissolved concentrations in Colusa Basin Drain (2.4 µg/L), Sacramento Slough (4.0 µg/L), and Arcade Creek (2.0 µg/L) were considerably higher than in the mainstem, while median concentrations for Cache Creek and Yolo Bypass were both similar to the mainstem at about the 1 µg/L reporting level. Variability in dissolved arsenic concentrations was difficult to evaluate due to the high percentage of data below reporting limits, but the highest dissolved concentrations observed were at Sacramento Slough, Colusa Basin Drain, and Arcade Creek (6 µg/L at all three sites).Total and dissolved arsenic data are presented in Figure 8.

Spatial Distribution of Cadmium—Median total cadmium concentrations in the Sacramento River mainstem range from a minimum of 0.02 µg/L below the Keswick Reservoir discharge to a maximum of 0.04 µg/L for the Sacramento River at Veterans Bridge. The estimated median total concentration in the American River (below the reporting limit of 0.02 µg/L) is much lower the median concentration for the Sacramento River at Veterans Bridge (0.04 µg/L), and results in a significant decrease in the median concentrations observed for the Sacramento River at Freeport and River Mile 44 (0.03 µg/L at both sites). The median total concentration at Cache Slough near Ryers Ferry (0.02 µg/L) is substantially lower than observed in the Sacramento River mainstem. Total cadmium concentrations were also lower in the Mill Creek, Deer Creek, and Big Chico Creek watersheds, with medians less than 0.01 µg/L. Variability of total cadmium concentrations appears similar at most mainstem and major tributary sites, with somewhat greater variability at Sacramento River below Keswick Reservoir. Variability in the smaller tributary watersheds (Mill, Deer, and Big Chico creeks) could not be assessed due to the proportion of data below reporting limits. The highest single sample total cadmium concentration observed was at Sacramento River at Veterans Bridge (0.74 µg/L).

Evaluation of spatial trends in dissolved cadmium are difficult because most available data are below detection at reporting limits between 1 µg/L and 0.005 µg/L. Median concentrations in the Sacramento River mainstem ranged from a maximum of 0.019 µg/L for the Sacramento River below Keswick to an estimated minimum of less than 0.01 µg/L at Veterans Bridge, Freeport, and River Mile 44 (CMP data, 1994-2000). It is apparent that concentrations in the American River are typically somewhat lower than in the Sacramento River mainstem, but there were insufficient detected data to estimate medians for any of the tributaries (USGS NAWQA data, 1996-98; CMP data, 1994-2000). The highest dissolved cadmium concentrations observed were at Sacramento River below Keswick Reservoir (0.019 µg/L).

Total and dissolved cadmium data are also presented in Figure 9.

Spatial Distribution of Copper—Median total copper concentrations in the Sacramento River mainstem range from a minimum of 2.1 µg/L below the Keswick Reservoir discharge to 3.7 µg/L for the Sacramento River at Veterans Bridge. The median total concentration in the American River (0.8 µg/L) is approximately one quarter the median concentrations for the Sacramento River at Veterans Bridge (3.7 µg/L). The median total concentration at Cache Slough near Ryers Ferry (4.5 µg/L) is higher than observed in the Sacramento mainstem. Total copper concentrations were lower in the Mill Creek, Deer Creek, and Big Chico Creek watersheds, with medians ranging from 0.15–1.7 µg/L. Variability of total copper concentrations was higher at Sacramento River below Keswick (due primarily to lower minimum concentrations), but the highest single sample total copper concentrations observed were at Colusa Basin Drain and Arcade Creek (21.5 and

21.1 µg/L, respectively). Variability in the smaller tributary watersheds (Mill, Deer, and Big Chico creeks) was not markedly different than in the Sacramento River mainstem.

Median dissolved copper concentrations for the available data for the Sacramento River mainstem are very consistent and range between 1.2 µg/L and 1.7 µg/L from the Sacramento River below Keswick to River Mile 44. The median dissolved concentration in the American River at Discovery Park (0.5 µg/L) is less than half the median concentration for the Sacramento River near Hamilton City (1.2 µg/L). Median dissolved concentrations in the other major tributaries (the Feather River and Yuba River) were 1.0 and <1.0 µg/L, respectively. Median dissolved concentrations were clearly higher in the two agricultural drains (Colusa Basin Drain—2.4 µg/L; Sacramento Slough—2.0 µg/L), an urban creek (Arcade Creek, 4.0 µg/L), and the Yolo Bypass (1.4 µg/L). Median dissolved concentrations were lower in Cache Creek (<1 µg/L) than in the mainstem Sacramento River. Variability in dissolved copper concentration data was similar for all sites. The highest individual dissolved copper concentrations observed were at Colusa Basin Drain (8.0 µg/L) and in Arcade Creek (9.0 µg/L).

Total and dissolved copper data are also presented in Figure 10.

Spatial Distribution of Lead—Median total lead concentrations in the Sacramento River mainstem range from a low of 0.05 µg/L below the Keswick Reservoir discharge, to a high of 0.53 µg/L for the Sacramento River at River Mile 44 (CMP data, 1994-2000). There is a substantial increase in total lead concentrations in the Sacramento River between Keswick Reservoir and Veterans Bridge, but median concentrations change little in the lower reach from Veterans Bridge to River Mile 44. The median total concentration in the American River (0.2 µg/L) is less than one half the median concentration for the Sacramento River at Veterans Bridge (0.52 µg/L). The median total concentration at Cache Slough near Ryers Ferry (0.68 µg/L, SRWP data 1998-2000) is slightly higher than observed in the Sacramento mainstem. Total lead concentrations in the Mill Creek, Deer Creek, and Big Chico Creek watersheds were generally lower than in the mainstem, with medians ranging from less than 0.01 to 0.05 µg/L, but maximum concentrations in Mill Creek (1.3–2.6 µg/L) were higher than observed in the mainstem between Keswick and Colusa. Variability of total lead data is not notably different among sites, but the maximum single sample concentrations observed were at Veterans Bridge (7.2 µg/L) and River Mile 44 (3.4 µg/L).

Evaluation of spatial trends in dissolved lead are difficult because a preponderance of available data (primarily from USGS NAWQA and the Sacramento CMP) are below detection at a reporting limit of 1 µg/L. The median dissolved lead concentrations in the Sacramento River below Keswick and near Hamilton City were 0.02 µg/L (SRWP and City of Redding data, 1998-2000), and the median dissolved lead concentration at Cache Slough was 0.07 µg/L (SRWP data, 1998-2000). There were insufficient detected data to calculate medians for other Sacramento River or tributary locations. Variability of dissolved lead data could not be adequately assessed, but the highest single sample dissolved lead concentration observed was at Arcade Creek (1.32 µg/L).

Total and dissolved lead data are also presented in Figure 11.

In general, median dissolved zinc concentrations exhibit a decreasing trend with distance downstream from Keswick Dam. Median dissolved zinc concentrations for the available data for the Sacramento River mainstem range from a high of 2.8 μg/L for the Sacramento River below Keswick, to approximately 1.1 μg/L and <0.5 μg/L for Freeport and River Mile 44, respectively. In the major tributaries to the mainstem, most dissolved zinc data were below the USGS reporting limit (1 μg/L). Median dissolved zinc concentrations in the major agricultural drains (Colusa Basin Drain and Sacramento Slough), Cache Creek, and the Yolo Bypass are also below detection at a reporting limit of 1 μg/L. Arcade Creek stands out with a substantially higher median dissolved zinc concentration of 7.7 μg/L (USGS data, 1996-99). Variability of dissolved zinc data was not notably different among locations, with the exceptions of Cache Slough, and the Sacramento River near Hamilton, which were relatively high compared to the other locations. The highest single sample dissolved zinc concentrations observed were reported for the Sacramento River at Veterans Bridge (23 μg/L) and Freeport (27 μg/L).

Total and dissolved zinc data are also presented in Figure 12.

iii. Temporal Distribution & Patterns

Total trace metals concentrations in the mainstem Sacramento River generally exhibit a strong seasonal pattern (Figure 13). Concentrations typically peak after the early precipitation events and increased river flows of the early wet season, and then decrease steadily through the next wet season. In general, this pattern is consistent with the adsorption of metals to fine-grained particles and the seasonal wash-off, resuspension and transport of these particulates deposited during the dry season. This pattern appears to be consistent for total concentrations of all trace metals at all the mainstem Sacramento River sites monitored between Redding and River Mile 44, and in the major tributaries in the lower watershed (the Feather River, Yuba River, and American River). This pattern in the data is somewhat less distinct for dissolved metals concentrations in the mainstem Sacramento River and the American River. There are insufficient data to assess temporal patterns in dissolved trace metals in other major tributaries because the majority of NAWQA dissolved trace metals concentrations are below detection.

Time series plots of water column trace metal concentrations are also presented in Appendix H of this report.

iv. Attainment of Beneficial Uses and Potential Impairment

Comparisons with water quality criteria: Total and dissolved trace metals concentrations were compared to CTR water quality standards and Central Valley Region Basin Plan objectives (Table 11). Trace metals concentrations in the Sacramento River mainstem and in the American River were rarely observed to exceed CTR standards or other water quality objectives for trace metals. Dissolved concentrations of copper for the American

River at J Street and Arcade Creek exceeded the hardness-adjusted[1] chronic criterion in one sample for each of these locations. Dissolved copper concentrations exceeded the CTR hardness-adjusted chronic criterion (4.4 µg/L as dissolved copper at a median hardness of 37 mg/l as $CaCO_3$) in approximately 10% of the samples from Sacramento River below Keswick location, and exceeded the median hardness-adjusted Basin Plan objective (6.1 µg/L) in one sample from this site (Figures 14a and 14b). Dissolved copper concentrations were not observed to exceed CTR standard values or other applicable water quality objectives in the Sacramento River mainstem from Red Bluff to Freeport. Dissolved copper exceeded the CTR standard in only one sample below Freeport (collected in November 1994 from River Mile 44). It should be noted that CTR chronic criteria are expressed as 4-day average values, and because all samples are essentially instantaneous grabs, actual 4-day average concentrations may not have exceeded the CTR standard.

Concentrations of other trace metals were not observed to exceed CTR standards or Basin Plan objectives at any location. Since dissolved concentrations of metals were not measured in Mill Creek, Deer Creek, and Big Chico Creek, it was not possible to determine whether exceedances of the dissolved metals standards occurred. Longer-term data sets (e.g. Sacramento CMP data, 1992-2000) indicate that total and dissolved trace metals concentrations in the lower Sacramento River (below the confluence with the Feather River) and the American River "always" meet the CTR standards (greater than 99.9% of the time). In summary, trace metal concentrations in the mainstem Sacramento River and major tributaries have been observed to comply with applicable regulatory limits a high percentage of the time, with the exception of dissolved copper concentrations in the Sacramento River below Keswick Reservoir. Compliance statistics with CTR standards and Basin Plan objectives are summarized in Table 12.

What do the data say about attainment of beneficial uses and potential impairment, and how does this compare with any relevant 303(d) listings for parameter and sites?
With the exception of the arsenic criterion, which is based on protection of human health, CTR water quality standards for the trace metals of interest are based on the protection of aquatic life. The CTR standards define what USEPA believes to be "safe levels", rather than toxicity threshold levels. Because these standards are conservative by design (to protect all waters in the United states) and are not reflective of site-specific conditions, exceedances of the criteria are not necessarily predictive of actual impairments of beneficial uses. For the purpose of these evaluations, ambient concentrations that exceed criteria are considered indicators of potential impairment of beneficial uses.

A number of tributary reaches and one mainstem reach in the Sacramento River watershed are included for trace metals on the California 1998 303(d) list (Table 13). Most of these listings are for cadmium, copper, lead, and zinc. There is one listing for arsenic (Kanaka Creek) and one listing for nickel (James Creek). All of the listings are attributed to the effects of mining (resource extraction and mine tailings). There are also

[1] Hardness-adjusted criteria were calculated using the median hardness for the specific monitoring location.

listings for copper, nickel, and selenium for the San Francisco Bay Estuary and the Sacramento-San Joaquin Delta, attributed to a variety of sources. Observed exceedances of CTR dissolved copper standards in the Sacramento River immediately below Keswick Reservoir appears to be consistent with the 303(d) listing for this reach of the Sacramento River. Although this stretch of the Sacramento River is also listed for cadmium and zinc, dissolved concentrations in the Sacramento River below Keswick Reservoir were not observed to exceed or approach CTR hardness-adjusted standards or Basin Plan objectives for these metals (1.2 μg/L and 0.25 μg/L, respectively, as dissolved cadmium; and 59 μg/L and 31 μg/L, respectively, as dissolved zinc).

For the period monitored by the SRWP (1998-2000), NAWQA (1996-98), the Sacramento CMP (1992-2000), and the City of Redding (1998-2000), it appears that aquatic life beneficial uses are not being adversely impacted by trace metals in the mainstem Sacramento River below Red Bluff, in all major tributaries (Feather River, Yuba River, and American River), and in the two major agricultural drain monitored (Colusa Basin Drain and Sacramento Slough). However, in the Sacramento River between Shasta Dam and Red Bluff, dissolved copper concentrations may exceed levels potentially harmful to sensitive aquatic species.

Table 11. **California Toxics Rule Water Quality Standards and Central Valley Region Basin Plan Objectives for Trace Metals.**

	Arsenic, total		Cadmium, dissolved		Chromium, dissolved	Copper, dissolved		Lead, dissolved	Nickel, dissolved	Selenium, total	Silver, dissolved		Zinc, dissolved	
Location	CTR	BP	CTR	BP	CTR	CTR	BP	CTR	CTR	CTR	CTR	BP	CTR	BP
Sacramento River below Keswick	150	10	1.2	0.25	91	4.4	6.1	1.0	26	5	0.84	10	59	31
Sacramento River above Bend Bridge	150	10	1.3	0.28	98	4.8	6.6	1.1	28	5	0.98	10	63	34
Mill Ck at Mouth	150	NA	1.2	0.24	87	4.3	5.9	0.97	25	5	0.78	10	57	30
Mill Ck at Black Rock	150	NA	1.1	0.21	81	3.9	5.4	0.87	23	5	0.65	10	52	27
Mill Ck at Highway 36	150	NA	1.4	0.32	109	5.4	7.5	1.3	31	5	1.23	10	71	38
Deer Creek at Mouth	150	NA	1.7	0.43	133	6.6	9.3	1.7	38	5	1.87	10	87	49
Deer Creek at Upper Diversion Dam	150	NA	1.0	0.19	74	3.6	4.9	0.76	21	5	0.54	10	47	24
Deer Creek at Ponderosa Way	150	NA	1.4	0.3	104	5.1	7.1	1.2	30	5	1.12	10	68	36
Deer Creek below Childs Meadows	150	NA	0.63	0.09	44	2.1	2.7	0.37	12	5	0.18	10	28	13
Big Chico Ck above Mud Ck	150	NA	1.6	0.39	124	6.1	8.6	1.5	36	5	1.60	10	81	45
Mud Ck above Big Chico Ck	150	NA	1.2	0.24	87	4.3	5.9	0.97	25	5	0.78	10	57	30
Big Chico Ck at Chico (Rose Ave.)	150	NA	1.8	0.44	136	6.8	9.6	1.8	39	5	1.96	10	89	50
Big Chico Ck below Five-Mile Rec.	150	NA	1.9	0.49	145	7.2	10	1.9	42	5	2.25	10	96	54
Big Chico Ck at Golf Course	150	NA	1.8	0.46	141	7.0	9.9	1.8	41	5	2.10	10	93	52
Big Chico Ck above Salmon Hole	150	NA	1.8	0.44	136	6.8	9.6	1.8	39	5	1.96	10	89	50
Sacramento River near Hamilton City	150	10	1.4	0.32	107	5.3	7.4	1.3	31	5	1.20	10	70	38
Sacramento River at Colusa	150	10	1.4	NA	104	5.1	10	1.2	30	5	1.12	10	68	100
Sacramento Slough	150	NA	2.7	NA	221	11.2	NA	3.3	65	5	5.42	NA	148	NA
Colusa Basin Drain	150	NA	3.5	NA	288	14.8	NA	4.7	86	5	9.48	NA	194	NA
Yuba River at Marysville	150	NA	0.9	NA	66	3.2	NA	0.66	19	5	0.43	NA	43	NA
Feather River near Nicolaus	150	NA	1.1	NA	77	3.7	NA	0.81	22	5	0.60	NA	50	NA
Sacramento River at Verona	150	10	1.4	NA	107	5.2	10	1.3	31	5	1.18	10	70	100
Sacramento River at Veterans Bridge	150	10	1.5	NA	116	5.7	10	1.4	34	5	1.41	10	76	100
Arcade Ck at Norwood Ave.	150	NA	2.0	NA	154	7.7	NA	2.1	45	5	2.56	NA	102	NA
American River at J Street	150	10	0.7	NA	48	2.3	10	0.42	13	5	0.22	10	30	100
American River at Discovery Park	150	10	0.8	NA	55	2.6	10	0.52	16	5	0.30	10	35	100
Sacramento River at Freeport	150	10	1.3	NA	101	5.0	10	1.2	29	5	1.05	10	66	100
Sacramento River at River Mile 44	150	10	1.4	NA	105	5.2	10	1.2	30	5	1.14	10	68	100
Cache Slough near Ryers Ferry	150	NA	1.7	NA	133	6.6	NA	1.7	38	5	1.87	NA	87	NA

CTR criteria are California Toxic Rule (USEPA 2000) chronic criteria for protection of aquatic life.
CTR criteria for cadmium, chromium, copper, lead, nickel, silver and zinc are adjusted for median hardness.
Basin Plan values are Central Valley Region Basin Plan water quality objectives for the protection of aquatic life.
Basin Plan objectives for cadmium, copper, and zinc are hardness-adjusted for selected locations.
"NA" indicates that there is no applicable criterion.

Table 12. Percent compliance with CTR criteria and Basin Plan objectives.

	Arsenic, total		Cadmium, dissolved		Chromium, dissolved	Copper, dissolved		Lead, dissolved	Nickel, dissolved	Selenium, total	Silver, dissolved		Zinc, dissolved	
Location	CTR	BP	CTR	BP	CTR	CTR	BP	CTR	CTR	CTR	CTR	BP	CTR	BP
Sacramento River below Keswick	100	100	100	100	100	**90**	**99**	100	100	100	100	100	100	100
Sacramento River above Bend Bridge	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Mill Ck at Mouth	100	—	100	100	100	**T>C**	**T>C**	**T>C**	100	100	**T>C**	**T>C**	100	100
Mill Ck at Black Rock	100	—	100	100	100	**T>C**	**T>C**	**T>C**	100	100	**T>C**	**T>C**	100	100
Mill Ck at Highway 36	100	—	100	100	100	**T>C**	**T>C**	**T>C**	100	100	**T>C**	**T>C**	100	100
Deer Creek at Mouth	100	—	100	100	100	100	100	100	100	100	100	100	100	100
Deer Creek at Upper Diversion Dam	100	—	100	100	100	100	100	100	100	100	100	100	100	100
Deer Creek at Ponderosa Way	100	—	100	100	100	100	100	**T>C**	100	100	100	100	100	100
Deer Creek below Childs Meadows	100	—	100	100	100	100	100	100	100	100	100	100	100	100
Big Chico Ck above Mud Ck	100	—	100	100	100	100	100	100	100	100	100	100	100	100
Mud Ck above Big Chico Ck	100	—	100	100	100	100	100	100	100	100	100	100	100	100
Big Chico Ck at Chico (Rose Ave.)	100	—	100	100	100	100	100	100	100	100	100	100	100	100
Big Chico Ck below Five-Mile Rec.	100	—	100	100	100	100	100	100	100	100	100	100	100	100
Big Chico Ck at Golf Course	100	—	100	100	100	100	100	100	100	100	100	100	100	100
Big Chico Ck above Salmon Hole	100	—	100	100	100	100	100	100	100	100	100	100	100	100
Sacramento River near Hamilton City	—	—	100	100	—	100	100	—	—	—	—	—	100	100
Sacramento River at Colusa	100	100	100	NA	100	100	NA	100	100	—	100	NA	100	NA
Sacramento Slough	—	—	—	NA	—	100	NA	100	100	—	100	NA	100	NA
Colusa Basin Drain	100	—	100	NA	100	100	NA	100	100	—	100	NA	100	NA
Yuba River at Marysville	100	—	100	NA	100	100	NA	100	100	—	100	NA	100	NA
Feather River near Nicolaus	100	—	100	NA	100	100	NA	100	100	—	100	NA	100	NA
Sacramento River at Verona	100	100	100	NA	100	100	100	100	100	—	100	100	100	100
Sacramento River at Veterans Bridge	100	100	100	NA	100	100	100	100	100	100	—	—	100	100
Arcade Ck at Norwood Ave.	100	—	100	NA	100	**96**	NA	100	100	—	100	NA	100	NA
American River at J Street	100	100	100	NA	100	**97**	100	100	100	—	100	100	100	100
American River at Discovery Park	100	100	100	NA	100	100	100	100	100	100	—	—	100	100
Sacramento River at Freeport	100	100	100	NA	100	100	100	100	100	100	100	100	100	100
Sacramento River at River Mile 44	100	100	100	NA	100	**99.6**	100	100	100	100	—	—	100	100
Cache Slough near Ryers Ferry	100	—	100	NA	100	100	—	100	100	100	100	NA	100	NA

Values indicate percent of samples that meet applicable water quality criteria or objective.
"NA" indicates that there is no applicable criterion.
"—" indicates that parameter was not monitored at location.
"T>C" total concentration exceeded criterion, but dissolved fraction was not reported
Bold outlined values indicate observed exceedance of water quality criterion.

Table 13. Waterbodies Listed For Trace Metals On California's 1998 303(D) List.

Waterbody	Pollutant	Source	Area affected	Units
Keswick Reservoir	Cadmium, Copper, Zinc	Resource Extraction	200	Acres
Shasta Lake	Cadmium, Copper, Zinc	Resource Extraction	20	Acres
Dolly Creek	Copper, Zinc	Resource Extraction	1	Miles
Horse Creek	Cadmium, Copper, Lead, Zinc	Resource Extraction	2	Miles
Humbug Creek	Copper, Zinc	Resource Extraction	9	Miles
James Creek	Nickel	Resource Extraction	6	Miles
Kanaka Creek	Arsenic	Resource Extraction	1	Miles
Little Backbone Creek	Cadmium, Copper, Zinc	Resource Extraction	1	Miles
Little Cow Creek	Cadmium, Copper, Zinc	Resource Extraction	1	Miles
Little Grizzly Creek	Copper, Zinc	Mine Tailings	10	Miles
Sacramento River (Shasta Dam To Red Bluff)	Cadmium, Copper, Zinc	Resource Extraction	40	Miles
Spring Creek	Cadmium, Copper, Zinc	Resource Extraction	5	Miles
Town Creek	Cadmium, Copper, Lead, Zinc	Resource Extraction	1	Miles
West Squaw Creek	Cadmium, Copper, Lead, Zinc	Resource Extraction	2	Miles
Willow Creek (Whiskeytown Reservoir)	Copper, Zinc	Resource Extraction	3	Miles
Sacramento-San Joaquin Delta	Selenium	Industrial point sources, agriculture, natural sources,	15,000	Acres
Sacramento-San Joaquin Delta and San Francisco Bay Estuary	Copper, Nickel	Municipal point sources, urban runoff, atmospheric deposition	290,000	Acres
Sacramento-San Joaquin Delta and San Francisco Bay Estuary	Selenium.	Agriculture, ground water, industrial point sources, natural sources,	210,000	Acres

v. Mass Load Comparisons

Comparisons of mass load contributions from major Delta inputs could not be adequately evaluated, due to a general lack of appropriate trace metals data. Nearly all of the trace metals data from the USGS NAWQA program are for dissolved trace metals, which are not appropriate for estimation of total mass loads. Total metals concentration data from the Sacramento Coordinated Monitoring Program are adequate for estimating mass loads for some constituents in the Sacramento River near Sacramento, but there are insufficient total metals data for other potentially significant trace metal sources to the Delta, including Cache Creek, Yolo Bypass, the San Joaquin River, the Cosumnes River, and the Mokelumne River. This lack of appropriate data for estimating mass loads can be considered a significant data gap for trace metals of interest in the Delta and San Francisco Bay.

vi. Conclusions and Recommendations

- Aquatic life uses are typically the most sensitive to trace metal concentrations. In comparisons to CTR water quality standards and Basin Plan water quality objectives designed to protect aquatic life, trace metal concentrations in the Sacramento River watershed are generally much lower than these values. The notable exception is that dissolved copper concentrations in individual samples continue to exceed hardness-adjusted CTR chronic standards for copper approximately 10% of the time in the Sacramento River below Keswick Reservoir. This result indicates a potential impact on sensitive aquatic life species in this reach of the Sacramento River.

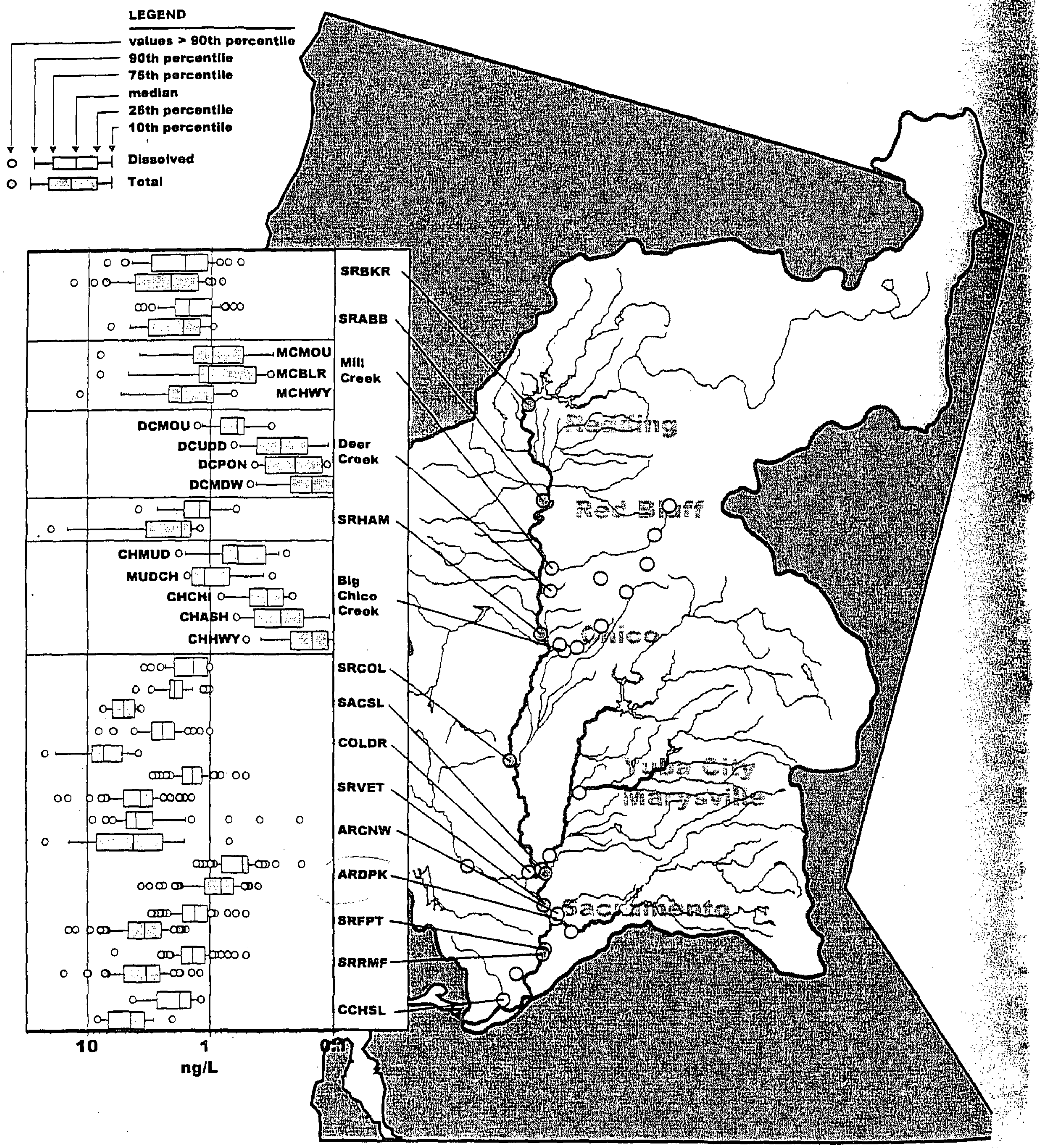


Figure 10. Distribution of Copper in the Sacramento River Watershed Total and Dissolved Copper Concentrations in Water

Summary Statistics: Trace Metals Data

Copper, dissolved

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRBKR	Sacramento River below Keswick	1/20/98	4/18/00	43	42	98%	0.57	7.03	0.9	1.1	1.7	3.0	4.4	0.04
SRABB	Sacramento River above Bend Bridge	2/13/96	5/17/00	39	37	95%	0.569	3.92	1.0	1.0	1.5	2.0	2.4	1
SRHAM	Sacramento River near Hamilton City	6/23/99	5/16/00	13	13	100%	0.596	3.6	0.7	1.0	1.2	1.6	2.3	—
SRCOL	Sacramento River at Colusa	2/28/96	11/16/99	33	31	94%	1	3.4	1.0	1.1	1.4	2.0	2.2	1
SACSL	Sacramento Slough	2/12/96	5/16/00	37	37	100%	1	4	1.4	1.7	2.0	2.1	3.0	—
COLDR	Colusa Basin Drain	2/7/96	5/16/00	40	40	100%	1	8.04	1.7	2.0	2.4	3.0	4.0	—
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	12	44%	1	3	<RL	<RL	<RL	1.2	1.6	1
FRNIC	Feather River near Nicolaus	2/23/96	1/18/00	28	20	71%	0.34	2.1	<RL	<RL	1.0	1.3	2.0	1
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	25	93%	1	2.3	1.0	1.0	1.7	2.0	2.0	1
SRVET	Sacramento River at Veterans Bridge	1/4/94	12/16/98	83	82	99%	0.5	2.9	1.0	1.2	1.4	1.7	2.1	0.5
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	5/17/00	40	40	100%	0.185	9	1.8	3.0	4.0	4.8	6.0	—
ARJST	American River at J Street	3/18/96	4/16/98	26	6	23%	1	2.8	<RL	<RL	<RL	<RL	1.7	1
ARDPK	American River at Discovery Park	1/4/94	9/21/99	80	67	84%	0.179	1.3	<RL	0.5	0.5	0.8	0.9	0.5
SRFPT	Sacramento River at Freeport	1/4/94	12/17/98	113	111	98%	0.5	3	1.0	1.1	1.3	1.7	2.2	0.5
SRRMF	Sacramento River at River Mile 44	1/18/94	12/17/98	76	75	99%	0.625	6	1.0	1.1	1.4	1.7	2.1	0.5
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	1.16	4.21	1.3	1.5	1.8	2.4	3.9	—

Copper, total

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRBKR	Sacramento River below Keswick	1/20/98	4/18/00	39	39	100%	0.06	13.00	1.06	1.32	2.13	4.18	8.94	—
SRABB	Sacramento River above Bend Bridge	6/23/99	5/17/00	12	12	100%	0.93	6.53	0.99	1.27	1.70	3.10	3.82	—
MCMOU	Mill Creek at Mouth	6/23/98	5/19/99	12	11	92%	0.43	7.88	0.44	0.58	0.97	1.35	2.01	0.04
MCBLR	Mill Creek at Black Rock	6/23/98	5/19/99	11	11	100%	0.32	7.88	0.34	0.45	1.05	1.23	2.53	—
MCHWY	Mill Creek at Highway 36	6/23/98	5/19/99	12	12	100%	0.63	11.22	0.69	1.00	1.72	2.14	2.75	—
DCMOU	Deer Creek at Mouth	6/24/98	5/18/99	11	11	100%	0.31	1.25	0.32	0.54	0.61	0.82	1.10	—
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	5/18/99	12	12	100%	0.09	0.63	0.12	0.17	0.27	0.37	0.54	—
DCPON	Deer Creek at Ponderosa Way	6/24/98	5/18/99	8	8	100%	0.11	0.43	0.12	0.13	0.21	0.32	0.42	—
DCMDW	Deer Creek below Childs Meadows	6/24/98	5/18/99	12	10	83%	0.09	0.46	<RL	0.11	0.15	0.22	0.38	0.04
CHMUD	Big Chico Creek above Mud Creek	6/23/98	5/20/99	12	12	100%	0.23	1.77	0.30	0.35	0.56	0.76	1.43	—
MUDCH	Mud Creek above Big Chico Creek	6/23/98	5/20/99	8	8	100%	0.30	1.52	0.44	0.79	1.10	1.35	1.51	—
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	5/20/99	12	12	100%	0.21	0.81	0.23	0.26	0.34	0.45	0.71	—
CHASH	Big Chico Creek above Salmon Hole	6/23/98	5/20/99	12	12	100%	0.08	0.60	0.12	0.18	0.27	0.38	0.59	—
CHHWY	Big Chico Creek at Hwy 32	6/23/98	5/20/99	12	11	92%	0.09	0.50	0.09	0.11	0.15	0.22	0.32	0.04
SRHAM	Sacramento River near Hamilton City	6/23/99	5/16/00	13	13	100%	1.21	18.90	1.31	1.46	1.72	3.32	11.09	—
SACSL	Sacramento Slough	6/22/99	5/16/00	12	12	100%	3.59	7.42	4.06	4.11	5.11	6.19	6.98	—
COLDR	Colusa Basin Drain	6/23/99	5/16/00	13	13	100%	3.81	21.50	4.16	5.27	7.48	8.87	15.42	—
SRVET	Sacramento River at Veterans Bridge	1/4/94	12/16/98	83	83	100%	1.40	16.90	2.43	2.85	3.69	5.14	6.53	—
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/17/00	12	12	100%	0.69	21.10	2.05	2.49	4.29	7.86	10.76	—
ARDPK	American River at Discovery Park	1/4/94	12/16/98	81	78	96%	0.40	3.60	0.52	0.63	0.82	1.10	1.70	0.5
SRFPT	Sacramento River at Freeport	1/4/94	12/17/98	81	81	100%	1.54	14.00	2.01	2.50	3.40	4.86	6.79	—
SRRMF	Sacramento River at River Mile 44	1/18/94	12/17/98	74	74	100%	1.20	15.00	2.13	2.60	3.34	5.15	6.60	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	13	13	100%	2.04	8.29	3.21	3.49	4.47	6.56	8.01	—

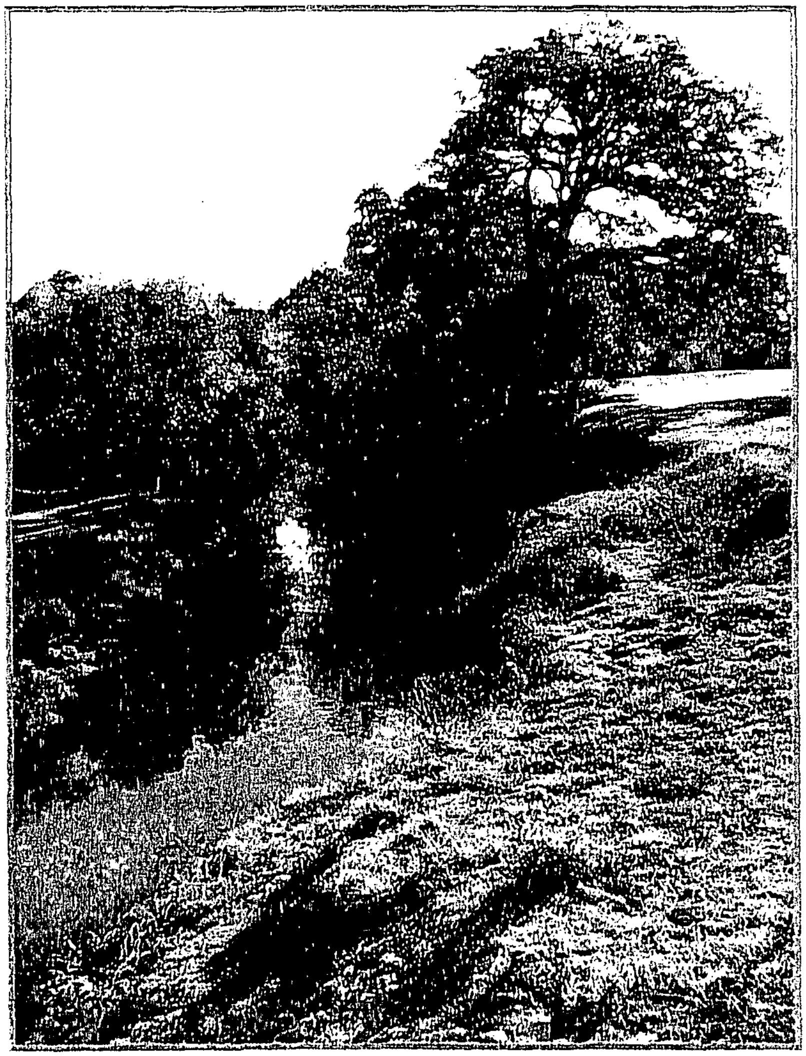
Lead, dissolved

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRBKR	Sacramento River below Keswick	1/20/98	4/18/00	39	30	77%	0.004	0.125	<RL	0.01	0.02	0.04	0.08	0.005
SRABB	Sacramento River above Bend Bridge	2/13/96	7/21/99	29	2	7%	0.015	0.023	<RL	<RL	<RL	<RL	<RL	1
SRCOL	Sacramento River at Colusa	2/28/96	11/16/99	33	1	3%	0.060	0.060	<RL	<RL	<RL	<RL	<RL	1
SACSL	Sacramento Slough	2/12/96	11/16/99	28	3	11%	0.049	0.130	<RL	<RL	<RL	<RL	1.00	1
COLDR	Colusa Basin Drain	2/7/96	8/18/99	30	3	10%	0.038	0.264	<RL	<RL	<RL	<RL	1.00	1
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	1
FRNIC	Feather River near Nicolaus	2/23/96	1/18/00	28	1	4%	0.088	0.088	<RL	<RL	<RL	<RL	<RL	1
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	1
SRVET	Sacramento River at Veterans Bridge	1/4/94	12/16/98	83	20	24%	0.100	0.400	<RL	<RL	<RL	<RL	0.19	0.1
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	7/20/99	30	3	10%	1.040	1.320	<RL	<RL	<RL	<RL	1.00	1
ARJST	American River at J Street	3/18/96	4/16/98	26	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	1
ARDPK	American River at Discovery Park	1/4/94	9/21/99	81	17	21%	0.016	0.500	<RL	<RL	<RL	<RL	0.10	0.1
SRFPT	Sacramento River at Freeport	1/4/94	12/17/98	113	18	16%	0.100	0.500	<RL	<RL	<RL	<RL	1.00	0.1
SRRMF	Sacramento River at River Mile 44	1/18/94	12/17/98	76	16	21%	0.040	0.300	<RL	<RL	<RL	<RL	0.10	0.1
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	11	92%	0.018	0.640	0.02	0.04	0.07	0.21	0.48	0.005

SACRAMENTO
STORMWATER MANAGEMENT PROGRAM

CHARACTERIZATION OF OP PESTICIDES IN SACRAMENTO URBAN RUNOFF AND RECEIVING WATERS



Funded by a CALFED Ecosystem Restoration Grant and the Sacramento Stormwater Program Permittees

November 2001

CHAPTER 3. MONITORING PROJECT SETTING

The monitoring for the Sacramento County Urban Runoff Organophosphate Toxicity Control Program (Sacramento OP Pesticide Project) was conducted from May 1999 through May 2000. The monitoring for this project was established in the November 3, 1998 report, "The Ecological Monitoring and Quality Assurance Project Plan for the Sacramento County Urban Runoff OP Toxicity Control Program" (Ecological Monitoring Plan). Presented in this section of the report are details on the monitoring events, the monitoring sites, and the analyses performed. In addition, information on residential pesticide use that occurred during this period of monitoring will be presented. This information is provided to illustrate the circumstances under which diazinon, chlorpyrifos, and toxicity monitoring was conducted for this project; information that will be used in Chapter 4 when the monitoring results are analyzed.

For the Sacramento OP Pesticide Project, fifteen monitoring events were conducted from May 18, 1999 through May 17, 2000. This includes ten dry weather monitoring events (non-storm events that occurred during the dry and rainy season) and five storm events. Table 3-1 presents information on all of the monitoring events and includes the dates of sampling, type of sites samples, and types of analyses performed. Discussion and further explanation of the information presented in Table 3-1 is provided in the following sections. Figure 3-1 shows the location of the various sites monitored in this study.

MONITORING SITES/DRAINAGE AREAS

The monitoring conducted for this project mainly consisted of water column diazinon and chlorpyrifos analysis of four basic types of water samples—creek, urban runoff, river and rain water. A limited amount of general chemistry and aquatic toxicity monitoring was also performed. For each type of water sampling, the monitoring sites, water source, and their drainage areas are described.

Arcade Creek and Watershed

Arcade Creek was selected as a representative Sacramento urban creek[1]. Five sites were monitored along its length starting with AC-1 as the most downstream site up to AC-5, the furthest upstream site. These monitoring sites are shown on Figure 3-2, a map of the Arcade Creek watershed.

Arcade Creek flows in a westerly direction from its headwaters in Citrus Heights to its confluence with the Natomas East Main Drainage Canal (Natomas East Main Drain) located in

[1] Arcade Creek was selected for this project because a substantial amount of monitoring had already been performed on Arcade Creek including the USGS NAWQA study monitoring (1994 - 1998) and Sacramento River Watershed Program monitoring (1996 to the present). In addition, the project investigator was confident that the creek would contain water throughout the summer (unlike many Sacramento creeks); thus, allowing for twelve straight months of monitoring.

Table 3-1. CALFED Phase I—Summary of Monitoring Events

Date	Event	Arcade Creek Sites	Runoff Sites	Rain Monitoring[a]	River Sites	GC-Diazinon Analysis[b]	GC-Chlorpyrifos Analysis[b]	Toxicity Tests Performed[c]
5/18-5/19/99	DE-1	All	SRS, S111, S152 only[d]		All	X	X	
6/21-6/23/99	DE-2	All	All		All	X	X	
7/19-7/21/99	DE-3	All	All		All	X	X	
8/16-8/18/99	DE-4	All	All		All	X	X	
9/20-9/22/99	DE-5	All	All		All	X	X	
10/18-10/20/99	DE-6	All	All		All	X	X	
10/27-10/28/99	WE-1[e]	All except AC5[f]	All	3 sites	No	X[g]	X[g]	
11/14-11/17/99	DE-7	All	All[h]		All	X[h]	X[h]	Yes
12/13-12/15/99	DE-8	All	All		All	X[g]	X[g]	
1/14-1/16/00	WE-2	All	All	3 sites	All except RM44	X	No	
1/29-1/31/00	WE-3	All	All	4 sites	No	X	No	
2/19-2/21/00	WE-4	All	All	3 sites[i]	No	X	No	Yes
3/21-3/22/00	DE-9	All	All		All	X	No	
4/16-4/18/00	WE-5	All	All	3 sites	All	X	No	Yes
5/16-5/17/00	DE-10	All	All		All	No	No	

Table Notes: [a]Rainfall sampling sites are: S104, S111, AC-5. For WE-3, rain samples at S152 were also collected.

[b]Typically only 3 sites have corresponding GC analyses and those are from either the Runoff or Arcade Creek Sites.

[c]Samples for toxicity tests were collected from Arcade Creek at the AC-2 monitoring site.

[d]Sump 104 could not be sampled for the DE-1 event because the water level was below the sampling tube inlet.

[e]WE-1 is considered the first significant storm event (first-flush) event of the 1999/2000 wet season.

[f]AC-5 creek samples were not collected due to equipment problems.

[g]Urban runoff sample volumes were low. Therefore, samples from S104, S111, and SRS were combined for GC analysis.

[h]New Sigmas began operating at S104, S111 and Strong Ranch for DE-7.

[i]Rainfall samples for WE-4 have slightly different date than other samples (2/16 vs. 2/19 - 2/21).

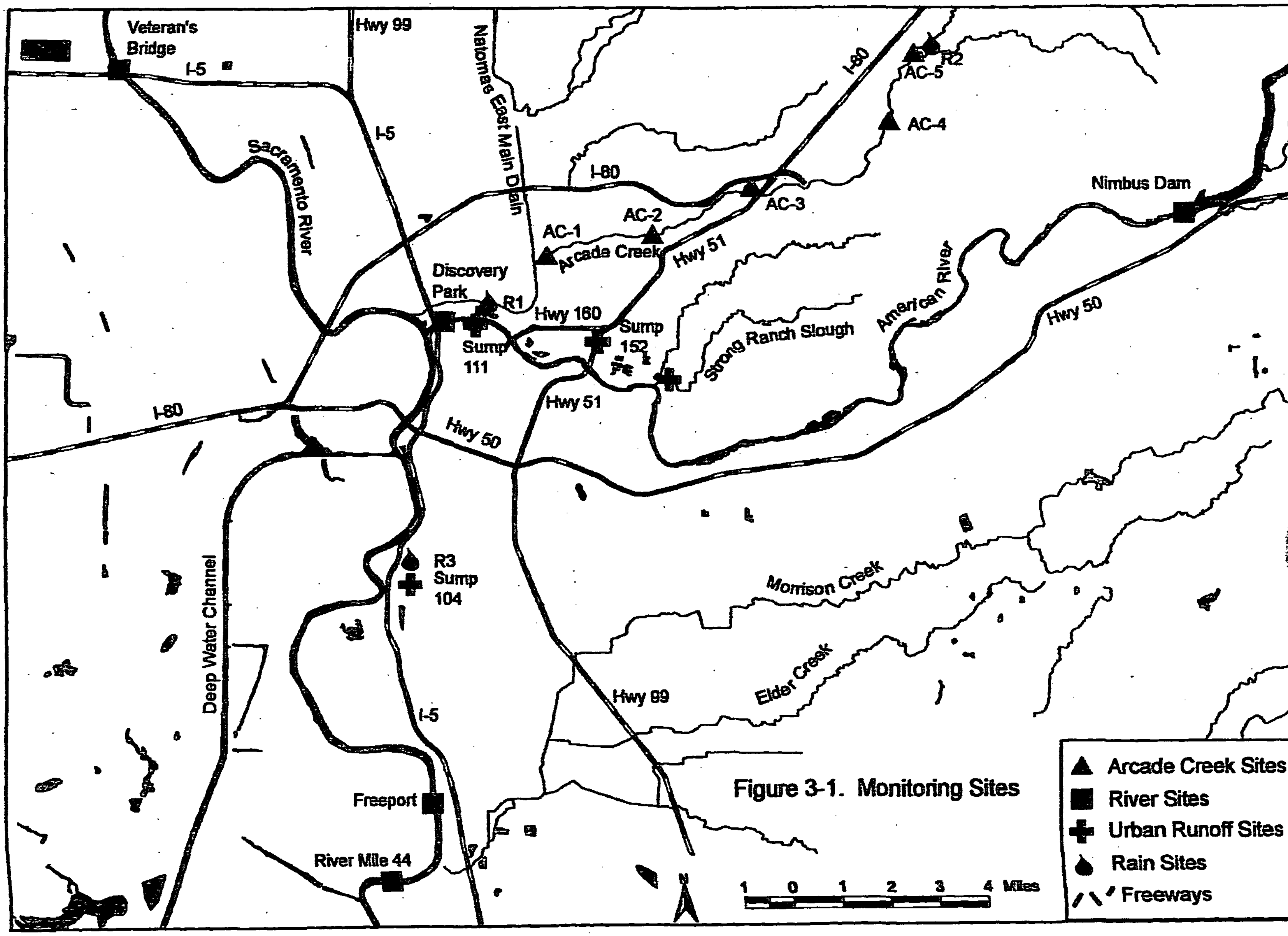


Figure 3-1. Monitoring Sites

the City of Sacramento. From its headwaters to downstream of the Haggin Oaks Golf Course, Arcade Creek is not channelized and even has stretches of riparian woodland along its banks.

Downstream of the golf course, the creek is a trapezoidal, concrete-lined channel with few trees along its banks. Flows along much of the length of Arcade Creek persist year-round though in August and September they taper down to a trickle, less than 1 cubic foot per second (cfs). Presented in Table 3-2 are selected historic flow data for Arcade Creek illustrating the type of flow which occurs in it.

The flow data presented in Table 3-2 indicate that the 12-months of monitoring for this project occurred during an above average wet period. The flow volume breakdown for 1998 indicates that, when considering flow volume in Arcade Creek, over 95-percent is associated with storm runoff. Evaluating years of flow data though indicate that storm flows occur and dissipate rapidly (typically 24 - 36 hours). Thus, most of the time (over 90-percent of the time) a low base flow of 1 - 2 ft^3/sec (cfs) can be found in Arcade Creek (based on a review of USGS 1996, 1998, 1999 WY records).

Table 3-2. Arcade Creek Select Historic Flow Data

Flow Item	Value	Data Source
Annual flow volume for 1996 CY[a]	21,790 acre-ft.[b]	USGS Sacramento River Basin historic hydrologic Records
Annual flow volume for 1997 CY	19,730 acre-ft.	
Annual flow volume for 1998 CY	25,620 acre-ft.	
Annual flow volume for 1999 CY	9,890 acre-ft.	
Annual flow volume for 2000 CY	21,830 acre-ft.	
Flow-volume from storms from 1998[c] water year (WY)	96%	Evaluation of USGS 1998 water year records[d]
Flow-volume from non-storm flows from 1998[c] WY	4%	
Base flow[e]	1 - 2 cfs	Evaluation of historic USGS daily flow records.
Peak flow[e]	2,290 cfs	Occurred in Jan. 2000

[a]: CY: calendar year.
[b]: An acre-foot is a unit of measuring volume of water. One acre-foot is equal in volume to one foot of water on one acre.
[c]: 1998 was a very wet water year. Flows in Arcade Creek were about twice as high as average.
[d]: 1998 records had to be evaluated for the breakdown of storm vs. non-storm flows because the preliminary records for 1999/2000 included some data printout errors; thus, could not be used for this evaluation.
[e]: Measured at USGS flow gage station located at Watt Avenue.

Arcade Creek has a relatively large watershed of 36.4 square miles which includes portions of the City of Sacramento, County of Sacramento, and nearly all of the City of Citrus Heights. The Arcade Creek watershed is essentially fully developed with a diverse mix of land uses. Presented in Table 3-3 is a breakdown of the land uses within Arcade Creek.

Table 3-3. Arcade Creek Watershed Land Use Breakdown

Land Use	Percent of Watershed
Residential	65%
Utilities & Public[a]	14%
Commercial/Industrial	12%
Vacant	4%
Parks	2%
Cemetery	1%
Agricultural/Misc./ Unknown	2%

[a]Utilities & Public includes golf courses.

Noteworthy land uses and activities within the Arcade Creek watershed include three full golf courses[2], three cemeteries, and two major branches of Highway 80 (the "Highway 80 Split" is located in the lower third of the watershed just upstream of AC-3). Overall, the watershed is densely developed with a substantial amount of impervious surface area (e.g., paved surfaces and roof tops) thus leading to artificially high runoff and reduced opportunity for runoff infiltration. Most of the pervious surface area is provided as yards, golf courses, parks, cemeteries, and school grounds; all land uses where pesticides such as diazinon and chlorpyrifos are likely to be applied.

Each of the five Arcade Creek monitoring sites and their drainage areas are described below.

AC-1 Monitoring Site

Location: Norwood Avenue Bridge; 0.8 miles upstream of the mouth of Arcade Creek (where it joins the Natomas East Main Drain). This monitoring site on Arcade Creek is also used by the Sacramento River Watershed Program.

Site and Drainage Basin Description: The monitoring site is located at the base of the Arcade Creek watershed in the Sacramento neighborhood of Del Paso Heights. The immediate neighborhood is a low-income neighborhood with a mix of multi and single-unit residences. The flow in the creek at this location tends to pond and experience lower velocities and longer detention times than upstream sites. The ponding and low velocities can be attributed to the minimal channel slope; beaver dams; and, during high flows, backwater effects from the American River and/or Natomas East Main Drain.

[2] The three full golf courses include Haggin Oaks Municipal Golf Course which has essentially two golf courses (one 18-hole and two 9-hole courses) and the Northridge Country Club.

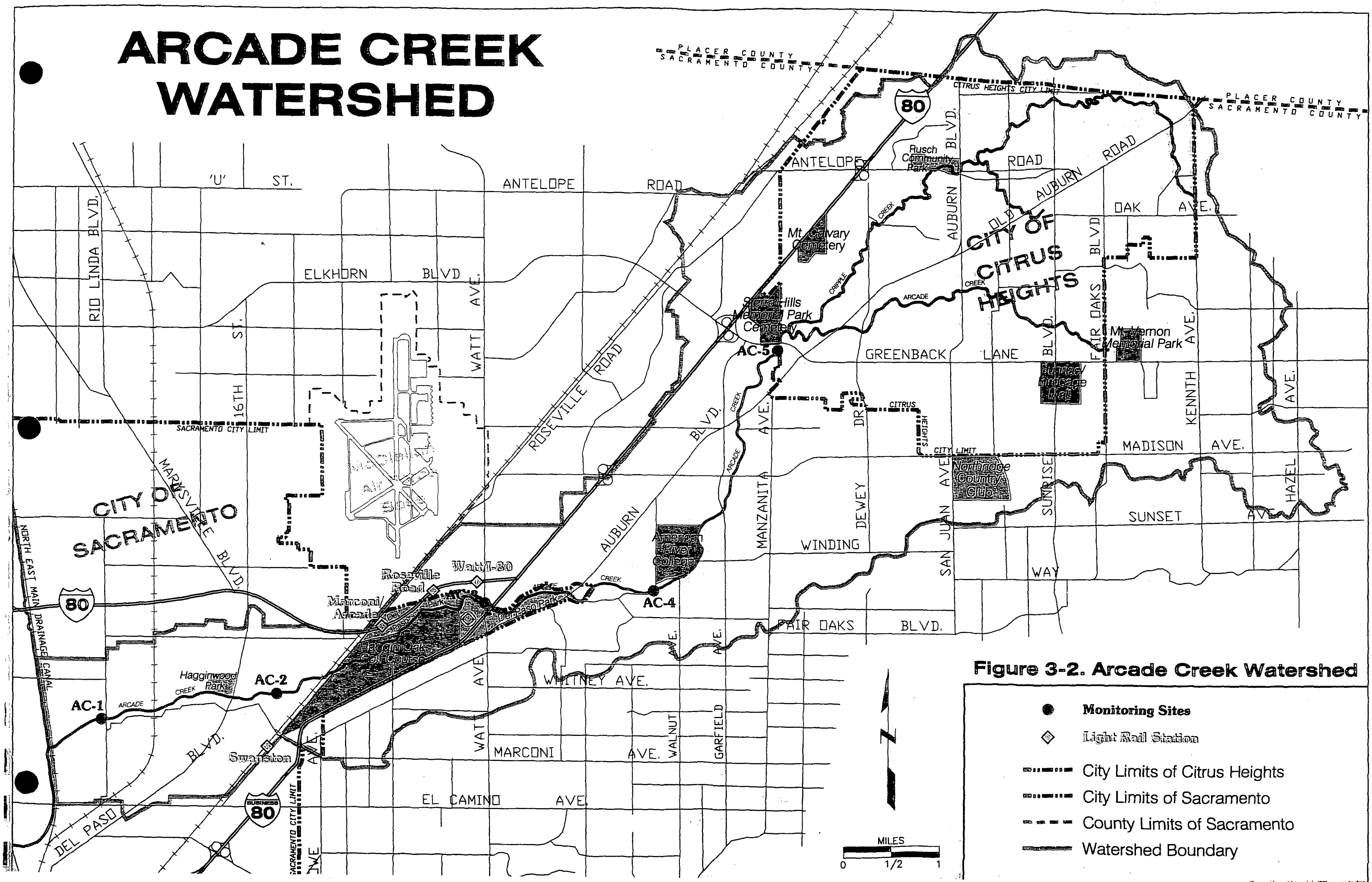


Figure 3-2. Arcade Creek Watershed

SJ County:

Vander Wett - Lone Tree Road X - 0.03 → 4-91
Miranda - Brennan Rd (Red) X (out) 3.03 → 12-96
Anthony Rocha - Brennan Rd X 2.2 → 7-97 (Jimmy Rocha, now Frank Rocha)
Silveira - Brennan Rd X 0.66 → 5-91
Frank Rocha - Lone Tree Rd (out) X NV.
Pete Vanuga - Avena Rd (out) X NV
Art Stumpf - Dodds Rd X NV.
Vander Meullen - Avena Rd (out) X NV.
Frank Faria - Robinson Rd X NV
John Vieira - Lone Tree Road X NV
Bader - Mariposa Rd X 1.82 → 12-97
VanderSchaaf - 12727 Murphy Rd X NV
AKA - Brent Hicks

CENTRAL VALLEY REGIONAL WATER QUALITY CONTROL BOARD

INSPECTION REPORT

12 June 1997

DISCHARGER: Manuel and Maria Miranda

LOCATION & COUNTY: 13942 S. Brennan Road, Escalon, CA 95320

CONTACT(S):

INSPECTION DATE: 5 June 1997

INSPECTED BY: Louis Pratt

ACCOMPANIED BY: Elliot Diringer

OBSERVATIONS AND COMMENTS:

This inspection was conducted in response to finding dairy waste water in Avena Drain at Brennen Road. The inspection revealed that waste water had been applied to the field north of the dairy. Waste water had left the field and discharged into Avena Drain. The electrical conductivity of the waste water in Avena Drain at Brennen Road was 1400 micromhos/cm. There is no provision at the lower end of the field to prevent tail water from discharging into the drain.

Summary:

The dairy is in violation of Waste Discharge Requirements.

LOUIS F. PRATT
Land and Water Resource Specialist

STATE OF CALIFORNIA - Environmental Protection Agency PETE WILSON, Governor

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION
3443 Routier Road, Suite A
Sacramento, CA 95827-3098
PHONE: (916) 255-3000
FAX: (916) 255-3015

12 June 1997

Manuel and Maria Miranda
13942 S. Brennan Road
Escalon, CA 95320

NOTICE OF VIOLATION

An inspection was conducted at your dairy on 5 June in response to finding dairy waste in Avena Drain. A copy of the inspection report is enclosed for your records.

The discharge of waste from your dairy into Avena Drain is a violation of General Waste Discharge Requirements (GWDRs) Order No. 96-270 and is subject to enforcement action.

The Monitoring and Reporting Program (MRP) in you GWDRs requires that you notify the Regional Board by telephone within 72 hours of an off-property discharge of facility waste water containing manure. This notification will be followed by a written report within two weeks. Regional Board staff was not informed by telephone. The written notification is due within two weeks from the date of the discharge. The information required for a written report is outlined in the MRP. Failure to submit a written report of the discharge observed on 5 June is also subject to enforcement action.

If you have any questions, please call Louis Pratt at (916) 255-3110.

ROBERT MATTEOLI
Sr. Water Quality Control Engineer

Enclosure.

cc: David Irey, Deputy District Attorney, Stockton.

LFP.

DEPARTMENT OF FISH AND GAME
FISH AND WILDLIFE
WATER POLLUTION CONTROL LABORATORY

2005 NIMBUS ROAD
RANCHO CORDOVA, CA 95670
PHONE (916) 358-2858 ATSS 8-434-2858 FAX (916) 985-4301

LABORATORY REPORT

Name:	Louis Pratt	**Lab Number:**	L-292-96
Agency:	Water Quality Control Board	**Other Number:**	
Address:	3445 Routier Rd., Suite A	**Date Sampled:**	12-04-96
City:	Sacramento CA 95827	**Date Received:**	12-04-96
		Date Completed:	12-06-96
RE:	Manuel Miranda Dairy	**Index-PCA Code:**	

RESULTS OF CHEMICAL ANALYSIS:

Laboratory Number	Sample Identification	Total Ammonia as N, mg/L	Undissociated Ammonia as NH_3,mg/L
L-292-96	Manuel Miranda Dairy	117	9.03
Reporting Limit		0.05	--

METHOD REFERENCE:

Methods for Chemical Analysis of Water and Wastewater, EPA-600/4-79-020, March 1983, Method 350.3 Ion Selective Electrode.

COST OF ANALYSIS: $32.00

POLLUTION ACTION KIT (IF USED): $110.00 AND HAZMAT SHIPPER (IF USED): $25.00

Deposit recovery costs to Cleanup and Abatement Account with "cost of analysis:" identified separately.

Analyst	Date: 12/20/96	Supervisor	Date: 12-20-96
Chemistry Laboratory Supervisor	Date: 12-20-96		

97 JAN -2 PM

CENTRAL VALL[illegible] REGIONAL WATER QUALITY [illegible]ONTROL BOARD

INSPECTION REPORT

19 December 1997

DISCHARGER: Bader Dairy

LOCATION & COUNTY: 23628 E. Mariposa Road, Escalon, San Joaquin County

CONTACT(S): Mr. Bader

INSPECTION DATE: 12 December 1997

INSPECTED BY: Louis F. Pratt

ACCOMPANIED BY:

OBSERVATIONS AND COMMENTS:

This inspection was conducted in response to finding dairy waste flowing in Avena Drain at Van Allen Road. The inspection revealed a discharge of wastewater from a pasture at the back of the dairy farm into Avena Drain. The rate of flow was approximately 50 gallons per minute. The electrical conductivity of the wastewater at Avena Drain was 1800 micromhos/cm. There was no flow in the drain above the discharge. I spoke with Mr. Bader. He said that he had pumped wastewater out onto the pasture. A sample was taken and submitted to the Fish and Game Water Pollution Laboratory. Photographs were taken.

While at the dairy facility it was noted that water was ponding in the corrals.

SUMMARY:

The dairy is in violation of Sections 22562 a) and 22564 of Subchapter 2, Chapter 7, Division 2, Title 27 of the California Code of Regulations.

LOUIS F. PRATT
Land and Water Resource Specialist

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION
3443 Routier Road, Suite A
Sacramento, CA 95827-3098
Phone (916) 255-3000
FAX (916) 255-3015

FILE w/ cpy

Cal/EPA

Pete Wilson, Governor

22 December 1997

CERTIFIED MAIL
P 037 327 514

Mr. Gustav Bader
Bader Dairy
23662 E. Mariposa Road
Escalon, CA 95320

NOTICE OF VIOLATION

An inspection was conducted at your dairy on 12 December in response to finding dairy wastewater flowing in Avena Drain. A copy of the report is enclosed for your records.

The discharge of waste off of property under your control is a violation of water quality regulations and is subject to enforcement action. Enforcement action may be considered without further notice.

Please submit a written report to this office by **12 January 1998**, outlining steps that you have taken or plan to take to abate the discharge and to bring your dairy into continuous compliance with the regulations. A copy of the applicable regulations is enclosed for your reference..

If you have any questions, please call Louis Pratt at (916) 255-3110.

ROBERT J. MATTEOLI
Senior Water Quality Control Engineer

APPROVED
author
senior Robert J Matteoli

Enclosures.

cc: David Irey, Deputy District Attorney, Stockton.
Western United Dairymen, Modesto.

BIOLOGICAL SIGNIFICANCE

To maintain a healthy aquatic life in freshwater, the California Department of Fish and Game has determined that ammonia levels (measured as NH_3) should not exceed 0.02 mg/L undissociated ammonia. Acute toxicity (96-hr. LC50) of ammonia to various freshwater fish ranges from 0.1 to 4 mg/L (McKee and Wolf 1971).

It is my opinion that the level of undissociated ammonia in sample numbers L-410-97-1 was toxic to aquatic organisms.

REFERENCES:

McKee J.E. and H.W. Wolf. 1971. Water Quality Criteria. Publication 3-A. California State Water Resources Control Board. Sacramento, Ca.

Staff Water Quality Biologist

12/22/97

Date

LFD

DEPARTMENT OF FISH AND GAME
FISH AND WILDLIFE
WATER POLLUTION CONTROL LABORATORY

2005 NIMBUS ROAD
RANCHO CORDOVA, CA 95670
PHONE (916) 358-2858 ATSS 8-434-2858 FAX (916) 985-4301

LABORATORY REPORT

Name:	Louis Pratt	**Lab Number:**	L-410-97
Agency:	Regional Water Quality Control Bd.	**Other Number:**	
Address:	3443 Routier Rd., Suite A	**Date Sampled:**	12-12-97
City:	Sacramento CA 95827-3098	**Date Received:**	12-12-97
		Date Completed:	12-15-97
RE:	Bader Dairy	**Index-PCA Code:**	

RESULTS OF CHEMICAL ANALYSIS:

Sample Identification	Total Dissolved Solids, mg/L	Total Ammonia as N, mg/L	Undissociated Ammonia as NH_3, mg/L
Bader Dairy	935	62.4	1.82
Reporting Limit	10	0.05	--

METHOD REFERENCES:

Methods for Chemical Analysis of Water and Wastewater, EPA-600/4-79-020, March 1983, Method 350.3 Ion Selective Electrode/Calculation.

Standard Methods for the Examination of Water and Wastewater, 17th edition, 1989, American Public Health Association, American Water Works Association, Water Pollution Control Federation, Method 2540C TDS Dried @ 180°C.

97 DEC 26 PM 12:04

cc: David Irey

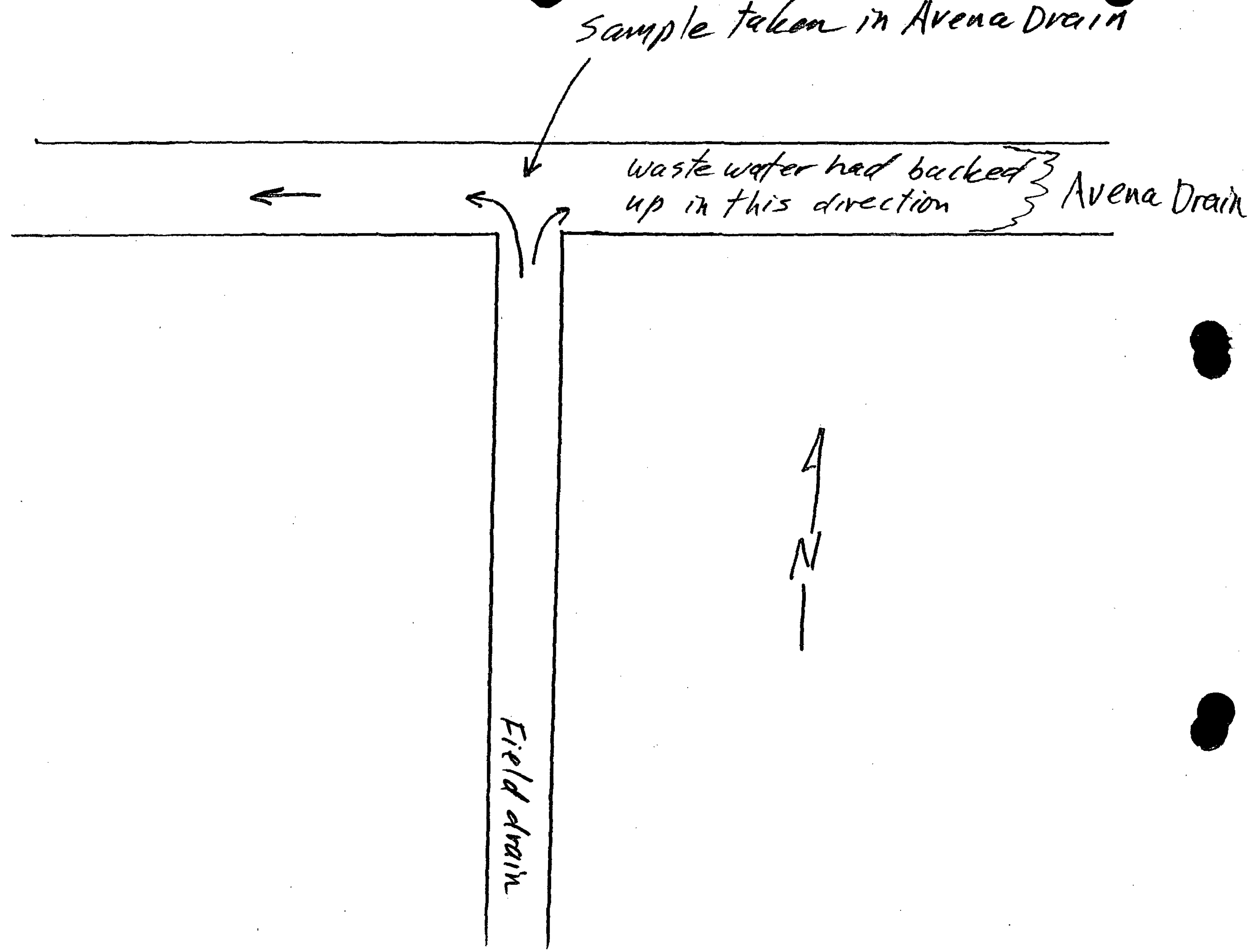
COST OF ANALYSIS: $50.00

POLLUTION ACTION KIT (IF USED): $110.00 AND HAZMAT SHIPPER (IF USED): $25.00

Deposit recovery costs to the Fish and Wildlife Pollution Account with "cost of analysis:" identified separately.

Mirela Martin	12-17-97	B Crane	12-17-97
Analyst	**Date**	**Supervisor**	**Date**
B Crane	12-17-97		
Chemistry Laboratory Supervisor	**Date**		

11-1


Sample taken in Avena Drain
waste water had backed up in this direction
Avena Drain
N
Field drain

CENTRAL VALLEY REGIONAL WATER QUALITY CONTROL BOARD

INSPECTION REPORT

21 May 1991

DISCHARGER: Frank F. Machado Dairy

LOCATION & COUNTY: 14089 S. Brennan Road, Escalon, San Joaquin County

CONTACT(S):

INSPECTION DATE: 15 May 1991 - 0930

INSPECTED BY: Louis F. Pratt

ACCOMPANIED BY:

OBSERVATIONS AND COMMENTS:

This inspection was conducted in response to a complaint alleging a discharge of wastewater from this dairy into Avena Drain. The inspection revealed that wastewater applied to fields ran off the fields into Avena Drain. The wastewater holding pond had been pumped down approximately four feet. Data recorded during the inspection are as follows (electrical conductivity [EC] readings are in micromhos/cm):

Location	EC	pH	Temp	Flow (est)
Wastewater in Avena Drain at the west property line	2400	7.0	63°F	25 gpm
Drain along property line	1400			
Avena Drain at Van Allen Road	900			

Wastewater had been mixed with irrigation water. There was no water in Avena Drain at Brennan Road which is above the dairy. There were no other sources of wastewater to the drain.

A sample of wastewater was taken from Avena Drain at the west property line. The sample was turned over to the Department of Fish and Game for analysis. Wastewater has ponded in a low area in the southeast corner of the property. The ponding has occurred long enough to produce a marsh. The area encompasses several acres, provides habitat for mosquito breeding, and poses a threat to ground water quality.

INSPECTION SUMMARY:

Wastewater pumped onto fields was discharging into Avena Drain. Wastewater which is continuously ponded in a corner produces a threat to water quality.

LOUIS F. PRATT
Land and Water Resource Specialist

LFP:lsb

4-3

WPCL Number L— 176 — 91

Results of Laboratory Analysis:

Sample Description

Cubitainer of dairy waste from Frank Machado Dairy, 14089 Brennary Rd. taken on May 15, 1991.

	pH	undissociated NH_3 as N, mg/L
	7.6	0.66
Detection Limit		0.03

Cost of analysis: $35.00

Sample was acidified with concentrated H_2SO_4 immediately after pH and conductivity were taken.

Method Ref: Standard Methods for the Examination of Water and Wastewater, 17th Edition, 1989, 4500-NH_3 F - Ammonia Selective Electrode Method.

Susan Engeurman 6-12-91 Norman L. Morgan 6-13-91

Analyst Date Supervisor Date

Biological Significance of Analytical Results:

Please contact the Regional Water Quality Biologist for interpretation of analytical results.

91 JUN 14 AM 11:26

Richard J. Hansen 6-13-91

Biologist Date Laboratory Director Date

LFP

RTMENT OF FISH AND GAME

Fish and Wildlife Water Pollution Control Laboratory
Request for Laboratory Analysis

Your attention to completion of this form will allow WPCL chemists and biologists to better serve you. If you have questions regarding any aspect of sampling or the results reported here, please call the appropriate number listed below. Also, if possible, please notify WPCL prior to arrival of samples. Biology Lab (916) 355-0856; Chemistry Lab (916) 355-0794; ATSS 438-XXXX.

Delivered By: ______

Analysis Required: ____ Bioassay   X Chemical

Ammonia

Date Required: ASAP   Region 2

Send Results To:

Name: Dennis DeAnda

Agency: Fish and Game

Address: P.O. Box 30803

City: Stockton, CA   ZIP 95213

For Laboratory Use Only:

WPCL Number: L-176-91

Other Number: ______

Field Number: ______

Received By: S. Sugarman

Date Received: 05/16/91

Date Completed: 06/10/91

Phone (916) 355 — 7040

Copies To: Louis Pratt, RWQCB - Central Valley

Problem Description (pollutant, source, water color, odor, etc.): ______

Water Temp. 63 °F or °C (circle one)   pH 7.0   Dissolved Oxygen ______ mg/L (ppm)

Sample Sources (provide diagram below): Dairy waste from Frank Machado Dairy, 14089 Brennary Rd. (now Silveira Dairy)

Sample Description (include number and size of containers):

____ Pollutant ______
X Water Cubitainer
____ Soil ______
____ Animal ______
Animals were alive ____, dying ____, or dead ____ when collected (Check one).

Suspect Sample May Contain:

____ Heavy metals
____ Petroleum products
____ Fertilizer
X Other (specify) NH3 [illegible]
____ Unknown

Analysis Requested for the Following Reason:

____ Fish and/or wildlife loss (Date of loss ____; Region ____)
____ DFG Code violation (Code Section ____)
____ Suspected or potential problem (explain below)
____ Routine check

ALL MEASUREMENTS ARE APPROXIMATE AND NOT TO SCALE UNLESS STATED (SCALE=)

INDICATE NORTH

1" 2" 3" 4" 5" 6" 7"

FG-1000 (Rev. 4/85)   85 35575

4-1

CENTRAL VALLEY REGIONAL WATER QUALITY CONTROL BOARD

General information

MEMORANDUM

TO: Dairy File, San Joaquin County   DATE 14 Dec 1981

SUBJECT Dairy Waste Complaints from F&G   FROM John Menke

Warden Webb Fisher called and informed me that:

(1) Rocha Dairy (JOHN ROCHA, JR., 23733 E. Mariposa Rd, Escalon) @ Carlton & Mariposa was discharging to Temple Creek. Dairy contact Joe Cardoso.

(2) Tony Freitas of the Morris Dairy (8892 S. Van Allen Rd, Stockton) will pump water from the corral which is draining into Temple Creek @ S Van Allen Rd undercrossing

(3) Pete Vanderwerff Dairy (54754 E. Lone Tree Rd, Escalon) is discharging to the Avena Drain and will be cited.

(4) "Tony Rocha, Jr. Dairy" (JOAQUIN ROCHA, 10408 S. Van Allen Stockton, contact Anthony Jack Rocha) leaks manure water to ditch along Van Allen Rd.

(5) Personnel @ Wagner Dairy (22184 Skiff Rd, Escalon) were cleaning manure from roadside drains. (Accumulation had been observed by Warden Fisher & myself on 8 Dec 81 and I inspected dairy that date — apparent source of discharge was corral runoff).

(6) Tony Luiz Dairy (24333 E Skiff Rd, Escalon) may be source of discharge to area drain. No observed discharge.

1-5

VIOLATION REPORT

Petrus Cornelia Vanderwerff
24659 E Lone Tree
Escalon, Calif. 95320

March 26, 1978

2:00 P. M.

Deposit in Avena Drain dairy manure and wastes

Section 5650 (f) Calif. Fish and Game Code: It is unlawful to depositin, permit to pass into, or place where it can pass into the water of this State any of the following: (f) Any substance or material deleterious to fish, plant life, or bird life.

Pursuant to an investigation into the cause of a severe fish kill in the Lone Tree Slough in its lower reaches, investigation was made to locate the source and cause of the kill.

In checking the lower portions of the slough it appeared to be manure from the color and odor. The water was brown and smelled of manure.

In checking for the sources of the kill this date it was found that the Avena Drain at Jack Tone Rd. had a very substantial flow of manure water in it.

I follwed the drain very carefully all the way upstream to find the exact source. I ascertained that all of the dairys along the drain were not in any manner draining any material into it. I walked several miles along it to come to the exact source of the manure water.

It was found at the end of the Avena Drain at the N/E corner of the lagoon at the Vanderwerff dairy where a considerable amount of manure water, freshly washed from the washing barn, was entering the drain.

A sample of the water and pictures were taken.

Weber G. Fisher

Weber G. Fisher
Fish and Game Warden
Region II

Chronology of Events

21 June 89

'Pete Van der Werff Dairy'

18 Feb '78 — Complaint from DFG listing 4 dairies suspected of discharging in the area drain. While Mr Van der Werff has the capacity to discharge some of his pond threw a tail water water return system, at this time there was no effedence of a discharge.

4 Mar 78 — Fish and wildlife loss report form filed. There was a total fish kill on Lone Tree Slough near French Camp. Three dairys were implicated including that of Mr. Van der Werff.

26 Mar 78 — STAFF LETTER TO DISCHARGER FROM DFG informing him OF HIS violation

10 May '78 — DFG ISSUED CITATIONS TO four dairys - HAD COURT hearings - pospoped

14 Dec '81 — DFG reports that Mr Van der Werff is discharging unto an area drain and will be sited

Dec '81 — SITE inspectors had Discharger explain waste management system and discussed options of his irrigating c̄ lagoon water, evenly distribute wasts in fields and enstall a one-way valve at

2

16 Dec 81 (CONT.) The connection of the tailwater ditch an manure lagoon.

21 Dec '81 Recieved a copy of a violation report from DFG to the Discharger stating that he was releasing manured water into the Avena Drain. This discharge was a result of a faulty gate which has given problems in the past due to lack of proper care and maintence.

22 Dec '81 STAFF letter to DISCHARGER indicating the findings and discussions of the 16 Dec '81 site inspection.

2 July '82 Slide gate & earth berm are in place between tail water and Avena Drain

7 SEPT '82 work in progress on installing a solids separat

28 OCT 82 A Conversation with Discharger reveals his time schedule is falling behind due to delays recieving the solids seperator from the Manufacturer

29 OCT '82 Called Solids Seperator manufactor to notify them Mr. Van de Werff is under court order to improve his waste system.

MEMORANDUM

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD • CENTRAL VALLEY REGION

3443 Routier Road, Suite A
Sacramento, CA 95827-3098

Phone: (916) 255-3000
CALNET: 8-494-30

TO: Rudy Schnagl

FROM: Louis Pratt

DATE: 7 February 1994

SIGNATURE:

SUBJECT: DAIRY WASTE VIOLATIONS

Although precipitation has been well below average for the fall and winter of 1993-1994 there have been many violations in regards to the management of dairy wastewater and runoff. Presence of dairy waste in roadside ditches, drains and creeks is widespread. The following violations have been documents within the past two months:

SAN JOAQUIN COUNTY

Ray Vaz Dairy, WDR's. Dairy wastewater pumped onto a field discharged into Avena Drain.
Vander Meulen Dairy. Dairy wastewater pumped onto a field discharged into Avena Drain.
Frank Machado and Sons Dairy, WDR's. Wastewater and runoff were discharged into McMullen Drain, thence into Walthal Slough.
Tony Dutra Dairy, WDR's pending. Dairy wastewater and runoff discharge into a drain which is tributary to Walthal Slough. The discharge is an ongoing problem and goes on unabated.
Vargas Dairy. Wastewater has discharged into Mariposa Drain.
Silva Bros Dairy, WDR's, ACL. Wastewater was leaving the dairy in three locations along Peltier Road and Pearl Road. The reasons for the discharges are the same one's that brought about the ACL.
S. D. Seifert Dairy, WDR's. Wastewater pumped onto fields discharged into an area drain along Sowels Road near Collier Road. The wastewater could be found north of Liberty Road. The need for improvements was discussed with the owner and the operator a year ago, but no improvements have been made.
Seifert Dairy Farm, WDR's, C&A. Runoff and wastewater were discharged into the roadside ditch along Collier and Dustin Roads, thence into Jahant Slough. The regulations, WDR's and C&A all prohibit the discharge, but it continues unabated.
Van Egmond Dairies, RWD submitted. Runoff from feed storage areas continues to discharge into roadside ditches near the intersection of Liberty and Dustin. This drainage is tributary to Dry Creek
Jack Virtue. The wastewater retention pond overflowed and discharged into the roadside ditch near the intersection of Liberty and Sowels, and continued north in an area drain.
Stockton Dairy, WDR's. The wastewater retention pond overflowed into Temple Creek. Wastewater pumped onto fields discharged into Temple Creek in three locations. Temple Creek contained dairy waste over a distance of over one half mile.
Mariposa Dairy. Wastewater pumped onto a field discharged into Temple Creek near Murphy Road.
Leen De Snayer Dairy, RWD submitted. Runoff from a feed storage area discharges into a

roadside ditch which drains into Sycamore Slough.
Frank Galhano Dairy, WDR's. Dairy wastewater pumped onto fields discharged into Mariposa Drain which is tributary to Temple Creek.
Art Stuyt Dairy, WDR's. Wastewater or runoff from the dairy discharged into Mariposa Drain.
Van De Pol Dairy. Runoff from the dairy discharges into the Highway 120 roadside ditch, thence into an irrigation drain, thence into Lone Tree Creek.

STANISLAUS COUNTY

3H Dairy, RWD, NOI submitted. Wastewater pumped onto a pasture discharged into OID's Union Drain which is tributary to Dry Creek and the Tuolumne River.
Joe Parreira Dairy. Wastewater pumped onto fields discharged into Union Drain near Stoddard Road.
Joe Dotinga Dairy. Wastewater pumped onto a field discharged into Union Drain near Alvarado Road. Runoff from a feed storage area discharges into Union Drain near Workman Road.
Manuel Furtado Dairy. Wastewater had discharged into OID's Kearney Drain, which is tributary to Union Drain.
Julio Serpa Dairy. Wastewater continuously discharges onto neighboring property which is an almond orchard. The neighbor has asked Serpa to stop the discharge, but the problem continues unabated.

SACRAMENTO COUNTY

Manuel Carmo Dairy, WDR's, ACL. Wastewater and corral runoff had discharged into a drain which is tributary to Stone Lake.

SUMMARY

Of the 22 dairies observed in violations which could adversely impact surface water quality, nine have WDR's, two have had ACL's, one is currently subject to a C&A, and three have submitted a RWD and are awaiting WDR's. Most of these dairies have been perennial problems. Lack of a tailwater or wastewater recovery system is the most prevalent cause of the violations. However, resistance or failure to take the simplest steps or make the simplest improvements which would prevent off-property discharges of waste are a significant contribution to the overall problem.

W.. on H. Hickox
Secretary for Environmental Protection

California Regional Water Quality Control Board

Central Valley Region

Steven T. Butler, Chair

Gray Davis
Governor

Sacramento Main Office
Internet Address: http://www.swrcb.ca.gov/~rwqcb5
3443 Routier Road, Suite A, Sacramento, California 95827-3003
Phone (916) 255-3000 • FAX (916) 255-3015

FILE

21 June 2000

CERTIFIED MAIL
Z100 456 074

Art Stuyt Dairy
21812 East Dodds Road
Escalon, CA 95320

NOTICE OF VIOLATION:

On 16 June 2000, Regional Board staff inspected the Art Stuyt Dairy at 21812 East Dodds Road, Escalon, to ascertain compliance with Waste Discharge Requirement Order (WDR's) No. 91-112. A copy of the staff Inspection Report is enclosed for your records.

Regional Board staff has determined that your dairy is in violation of WDR's No. 91-112. Therefore, pursuant to 13267 of the Water Code, please submit to this office by 24 July 2000 a Nutrient and Irrigation Water Management Plan (NIWMP) for your dairy. This plan must show calculated quantity of nutrients in the animal waste produced at your dairy and the nutrient requirements of the cropland where the wastes are applied. The plan should identify the quantity of manure solids that are removed from your dairy on an annual basis and the estimated percentage of nutrients in those solids, but does not need to address nutrient loadings on the off-site cropland where the solids are applied. The plan should also discuss the procedures that you use to apply the wastewater and to control tailwater containing residual manure.

Your Extension Service Dairy Advisor or dairy association field representative should be able to assist you in preparing the NIWMP. I am enclosing a copy of Fact Sheet No. 4 for Dairies "Nutrient and Irrigation Water Management Plans" to assist you in developing your NIWMP.

If you have any questions, please call John Menke at (916)-255-3024 or John Collins at (916)-255-3359.

ROBERT J. MATTEOLI
Senior Water Quality Engineer

APPROVED
author
senior

Enclosure: Inspection Report & Fact Sheet No. 4

The Order also contains provisions requiring that:

*Before the number of animal units is increased above the level stated in the Findings, the Discharger shall submit a Technical Report, which clearly demonstrates that the increase will not be a threat to water quality. The Discharger will use the method described in Attachment B to calculate animal units.

*Prior to the use of any new waste retention ponds, a report completed by a certified engineer or engineering geologist verifying that the excavation meets all requirements of this Order shall be submitted to the Regional Board.

*The Discharger shall report promptly to the Board any material change or proposed change in the character, location, or volume of the discharge.

Because of the noted increase in animal population, a new report of Waste Discharge and a Nutrient Irrigation Water Management Plan need to be requested, and the Waste Discharge Requirements need to be updated.

SUMMARY:

The Art Stuyt Dairy appears to be in violation of Waste Discharge Requirements Order No. 91-112 due to inadequate facility acreage to handle repeated applications of liquid waste and may pose a threat to groundwater.

Approved: [signature] Robert Matteoli

DEPARTMENT OF FISH AND GAME
FISH AND WILDLIFE
WATER POLLUTION CONTROL LABORATORY
2005 NIMBUS ROAD
RANCHO CORDOVA, CA 95670
PHONE (916) 358-2858 ATSS 8-434-2858 FAX (916) 985-4301

LABORATORY REPORT

Name:	Louis Pratt	**Lab Number:**	L- 205-97
Agency:	Regional Water Control Board	**Other Number:**	
Address:	3443 Routier R., Suite A	**Date Sampled:**	7-3-97
City:	Sacramento CA 95827	**Date Received:**	7-3-97
		Date Completed:	7-9-97
RE:		**Index-PCA Code:**	

RESULTS OF CHEMICAL ANALYSIS:

Sample Identification	Total Ammonia As N, mg/L	Undissociated Ammonia As NH_3, mg/L @ 30°C
A. Rocha-Borba Dairy	233	2.2
Reporting Limit	0.05	--

METHOD REFERENCES:

Methods for Chemical Analysis of Water and Wastewater, EPA-600/4-79-020, March 1983, Method 350.3 Ion Selective Electrode.

COST OF ANALYSIS: $22.00

POLLUTION ACTION KIT (IF USED): $110.00 AND HAZMAT SHIPPER (IF USED): $25.00

Deposit recovery costs to Cleanup and Abatement Account with "cost of analysis:" identified separately.

Analyst: [signature] Date: 7/10/97 Supervisor: [signature] Date: 7/10/97

Chemistry Laboratory Supervisor: [signature] Date: 7/10/97

BIOLOGICAL SIGNIFICANCE

To maintain a healthy aquatic life in freshwater, the California Department of Fish and Game has determined that ammonia levels (measured as NH_3) should not exceed 0.02 mg/L undissociated ammonia. Acute toxicity (96-hr. LC50) of ammonia to various freshwater fish ranges from 0.1 to 4 mg/L (McKee and Wolf 1971).

It is my opinion that the level of undissociated ammonia in sample number L-205-97-1 was toxic to aquatic organisms.

REFERENCES:

McKee J.E. and H.W. Wolf. 1971. Water Quality Criteria. Publication 3-A. California State Water Resources Control Board. Sacramento, Ca.

Staff Water Quality Biologist

7/18/97
Date

CENTRAL VALLEY REGIONAL WATER QUALITY CONTROL BOARD

INSPECTION REPORT

15 July 1997

DISCHARGER: Frank and Carol Borba Dairy

LOCATION & COUNTY: 13845 S. Brennan Avenue

CONTACT(S): Frank and Carol Borba, Operators

INSPECTION DATE: 3 and 7 July 1997

INSPECTED BY: Louis Pratt

ACCOMPANIED BY: Robert Matteoli

OBSERVATIONS AND COMMENTS:

This inspection was conducted at the request of Carol Borba. On 1 July, Mrs. Borba reported by telephone that the waste management system at the dairy was not functional, that waste water was accumulating at the facility and may discharge into Avena Drain. At the time of the 3 July inspection, waste water was ponding in the corrals and was discharging into Avena Drain at a rate of approximately 30 gallons per minute. The electrical conductivity (EC) of the waste water discharging into the drain was 4600 micromhos/cm. There was no flow in the drain above the discharge. The EC of the waste water in the drain approximately ½ mile below the discharge was 4200 micromhos/cm.

According to Frank and Carol Borba, there is no cropland with the dairy facility. Waste water generated at the facility must be pumped into waste water retention ponds and then pumped onto adjacent cropland under the control of Mr. Anthony Rocha who leases the dairy facility to Frank and Carol Borba. Corn growing on the adjacent cropland was showing widespread areas of moderate to severe water stress, an indication that irrigation was as much as one week over due.

At the time of the inspections, there was no freeboard in the smaller of the two ponds and only about one foot of freeboard in the larger pond. Also, the sump pump for lifting waste water into the waste water retention ponds had been disconnected. A valve on the flush line from the pond had been closed and locked.

The 7 July inspection revealed that Frank Borba had piled soil along the corral fence to abate the discharge. However, there were no changes or repairs made in the waste management system to render it functional.

Summary: The dairy is in violation of Section 2562 a) of Chapter 15, Division 3, Title 23 of the California Code of Regulations.

LOUIS F. PRATT
Land and Water Resource Specialist

Aqua Drain-
Ammonia

B.1.2 Avena Drain, Ammonia

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region, (Regional Board) recommends the addition of the Avena Drain to California's Clean Water Act Section 303(d) list due to impairment by ammonia. Information available to the Regional Board on ammonia levels indicates that water quality objectives are not being attained. The basis for this recommendation is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Avena Drain	**Pollutants/Stressors**	Ammonia
Hydrologic Unit		**Sources**	Agriculture/Dairies
Total Length	8.5 Miles	**TMDL Priority**	
Size Affected	6.5 Miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	The upper 6.5 miles of Avena Drain	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	37° 50' 05"	**Upstream Extent Longitude**	121° 00' 27"
Downstream Extent Latitude	37° 50' 44"	**Downstream Extent Longitude**	121° 07' 37"

Watershed Characteristics

Avena Drain is a modified natural channel approximately 8.5 miles in length. The Avena Drain is tributary to Lone Tree Creek, which is tributary to the Delta. Storm water runoff (mainly from cropland) and irrigation tail water are the main sources of water. Due to the flow of tail water, the drain is no longer ephemeral during the dry season. Although there are few trees growing along the drain, there is some riparian vegetation.

Water Quality Objectives Not Attained

The narrative objective for toxicity is not being attained in the Avena Drain. The narrative toxicity objective in the Basin Plan states, in part, "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life." The narrative toxicity objective further states that "The Regional Water Board will also consider ... numerical criteria and guidelines for toxic substances developed by the State Water Board, the California Office of Environmental Health Hazard Assessment, the California Department of Health Services, the U.S. Food and Drug Administration, the National Academy of Sciences, the U.S. Environmental Protection Agency, and other appropriate organizations to evaluate compliance with this objective (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/~rwqcb5/bsnplnab.pdf)."

Ammonia levels in Avena Drain frequently exceed the Basin Plan objective for toxicity. To maintain healthy aquatic life in fresh water, the California Department of Fish and Game (CDFG) has determined that ammonia levels (measured as NH_3) should not exceed 0.02 mg/L undissociated ammonia (CRWQCB-CVR, 2001a). Acute toxicity (96 hour LC_{50}) of ammonia to various freshwater fish ranges from 0.1 to 4.0 mg/L (McKee and Wolf, 1971).

Evidence of Impairment

There are 12 dairies that have the potential and propensity to discharge wastewater containing manure into Avena Drain. These discharges arise from the inability to retain wastewater during the winter months, and from irrigation with wastewater during the spring, summer and fall. Over a period of 10 years, samples collected from water entering the drain have shown undissociated ammonia levels ranging from 0.97 to 3.03 mg/L, with an average undissociated ammonia level of 1.73 mg/L (CRWQCB-CVR, 2001a). Samples collected from the drain at Van Allen Road in 1998 contained undissociated ammonia levels of 0.24 and 0.31 mg/L (CRWQCB-CVR, 2001a). A sample taken from the drain near Brennan Avenue in 1999 showed an undissociated ammonia level of 0.54 mg/L (CRWQCB-CVR, 2001a). All of the samples contained undissociated ammonia levels above the CDFG criterion, and all of the samples exceed some to most of the LC_{50}'s for various freshwater fish species.

Extent of Impairment

Avena Drain begins on a dairy farm east of Brennan Avenue in San Joaquin County. Ten of the 12 dairies along the drain are located on the upper 6 ½ miles.

Potential Sources

The source of the ammonia in Avena Drain is from manure carried in dairy wastewater. The samples were taken during known discharges of wastewater.

SJ County:

[illegible] - Lone Tree Road X - 0.03

Miranda - Brennan Rd (Out) (Out) 3.03

Anthony Rocha - Brennan Rd X 2.2 ([illegible] "2 [illegible], now Frank Rocha")

Silveira - Brennan Rd X 0.66

Frank Rocha - Lone Tree Rd (Out) NV

Pete [illegible] - Avena Rd (Out) NV

Art [illegible] - Dodds Rd X NV.

Vander Meullen - Avena Rd (Out) NV

Frank [illegible] - Robinson Rd ?

John Vieva - Lone Tree Road

Bader - Mariposa Rd X 1.82

VanderSchaaf - 12727 Murphy Rd ?

DEPARTMENT OF FISH AND GAME
FISH AND WILDLIFE
WATER POLLUTION CONTROL LABORATORY

2005 NIMBUS ROAD
RANCHO CORDOVA, CA 95670
PHONE (916) 358-2858 ATSS 8-434-2858 FAX (916) 985-4301

LABORATORY REPORT

Name:	Louis Pratt	**Lab Number:**	L- 205-97
Agency:	Regional Water Control Board	**Other Number:**	
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Sample Identification	Total Ammonia As N, mg/L	Undissociated Ammonia As NH_3, mg/L @ 30°C
A. Rocha-Borba Dairy	233	2.2
Reporting Limit	0.05	–

METHOD REFERENCES:

Methods for Chemical Analysis of Water and Wastewater, EPA-600/4-79-020, March 1983, Method 350.3 Ion Selective Electrode.

COST OF ANALYSIS: $22.00

POLLUTION ACTION KIT (IF USED): $110.00 AND HAZMAT SHIPPER (IF USED): $25.00

Deposit recovery costs to Cleanup and Abatement Account with "cost of analysis:" identified separately.

Marla Martin	7/10/97	[signature]	7/10/97
Analyst	**Date**	**Supervisor**	**Date**
[signature]	7/10/97		
Chemistry Laboratory Supervisor	**Date**		

3 -1

BIOLOGICAL SIGNIFICANCE

To maintain a healthy aquatic life in freshwater, the California Department of Fish and Game has determined that ammonia levels (measured as NH_3) should not exceed 0.02 mg/L undissociated ammonia. Acute toxicity (96-hr. LC50) of ammonia to various freshwater fish ranges from 0.1 to 4 mg/L (McKee and Wolf 1971).

It is my opinion that the level of undissociated ammonia in sample number L-205-97-1 was toxic to aquatic organisms.

REFERENCES:

McKee J.E. and H.W. Wolf. 1971. Water Quality Criteria. Publication 3-A. California State Water Resources Control Board. Sacramento, Ca.

Staff Water Quality Biologist

2/18/97
Date

LFP

ARTMENT OF FISH AND GAME

Fish and Wildlife Water Pollution Control Laboratory

Request for Laboratory Analysis

Your attention to completion of this form will allow WPCL chemists and biologists to better serve you. If you have questions regarding any aspect of sampling or the results reported here, please call the appropriate number listed below. Also, if possible, please notify WPCL prior to arrival of samples. Biology Lab (916) 355-0856; Chemistry Lab (916) 355-0794; ATSS 438-XXXX.

Delivered By: ______

Analysis Required: ___ Bioassay X Chemical

Ammonia

Date Required: ASAP Region 2

Send Results To:

Name Dennis DeAnda

Agency Fish and Game

Address P.O. Box 30803

City Stockton, CA ZIP 95213

For Laboratory Use Only:

WPCL Number L-176-91

Other Number ______

Field Number ______

Received By S. Sugarman

Date Received 05/16/91

Date Completed 06/10/91

Phone (916) 355 — 7040

Copies To: Louis Pratt, RWQCB - Central Valley

Problem Description (pollutant, source, water color, odor, etc.): ______

Water Temp. 63 °F or °C (circle one) pH 7.0 Dissolved Oxygen ______ mg/L (ppm)

Sample Sources (provide diagram below): Dairy waste from Frank Machado Dairy, 14089 Brennary Rd. (NOW Silveira Dairy)

Sample Description (include number and size of containers):

- ___ Pollutant ______
- X Water Cubitainer
- ___ Soil ______
- ___ Animal ______

Animals were alive ___, dying ___, or dead ___ when collected (Check one).

Suspect Sample May Contain:

- ___ Heavy metals
- ___ Petroleum products
- ___ Fertilizer
- X Other (specify) NH[illegible]
- ___ Unknown

Analysis Requested for the Following Reason:

- ___ Fish and/or wildlife loss (Date of loss ___; Region ___)
- ___ DFG Code violation (Code Section ___)
- ___ Suspected or potential problem (explain below)
- ___ Routine check

ALL MEASUREMENTS ARE APPROXIMATE AND NOT TO SCALE UNLESS STATED (SCALE=)

INDICATE NORTH

1″ 2″ 3″ 4″ 5″ 6″ 7″

FG-1000 (Rev. 4/85) 85 35575

4-1

WPCL Number L— 176 — 91

Results of Laboratory Analysis:

Sample Description

Cubitainer of dairy waste from Frank Machado Dairy, 14089 Brennary Rd. taken on May 15, 1991.

	pH	undissociated NH_3 as N, mg/L
	7.6	0.66
Detection Limit		0.03

Cost of analysis: $35.00

Sample was acidified with concentrated H_2SO_4 immediately after pH and conductivity were taken.

Method Ref: Standard Methods for the Examination of Water and Wastewater, 17th Edition, 1989, 4500-NH_3 F - Ammonia Selective Electrode Method.

Susan Engleman — Analyst — 6-12-91 (Date)

Norman L. Morgan — Supervisor — 6-13-91 (Date)

Biological Significance of Analytical Results:

Please contact the Regional Water Quality Biologist for interpretation of analytical results.

91 JUN 14 AM 11:26

RECEIVED

Biologist — Date — Richard J. — Laboratory Director — 6-13-91 (Date)

LFP

DEPARTMENT OF FISH AND GAME
FISH AND WILDLIFE
WATER POLLUTION CONTROL LABORATORY

2005 NIMBUS ROAD
RANCHO CORDOVA, CA 95670
PHONE (916) 358-2858 ATSS 8-434-2858 FAX (916) 985-4301

LABORATORY REPORT

Name:	Louis Pratt	**Lab Number:**	L-410-97
Agency:	Regional Water Quality Control Bd.	**Other Number:**	
Address:	3443 Routier Rd., Suite A	**Date Sampled:**	12-12-97
City:	Sacramento CA 95827-3098	**Date Received:**	12-12-97
		Date Completed:	12-15-97
RE:	Bader Dairy	**Index-PCA Code:**	

RESULTS OF CHEMICAL ANALYSIS:

Sample Identification	Total Dissolved Solids, mg/L	Total Ammonia as N, mg/L	Undissociated Ammonia as NH_3, mg/L
Bader Dairy	935	62.4	1.82
Reporting Limit	10	0.05	--

METHOD REFERENCES:

Methods for Chemical Analysis of Water and Wastewater, EPA-600/4-79-020, March 1983, Method 350.3 Ion Selective Electrode/Calculation.

Standard Methods for the Examination of Water and Wastewater, 17th edition, 1989, American Public Health Association, American Water Works Association, Water Pollution Control Federation, Method 2540C TDS Dried @ 180°C.

cc: David Irey

COST OF ANALYSIS: $50.00

POLLUTION ACTION KIT (IF USED): $110.00 AND HAZMAT SHIPPER (IF USED): $25.00

Deposit recovery costs to the Fish and Wildlife Pollution Account with "cost of analysis:" identified separately.

Maria Martin	12-17-97	R B Crane	12-17-97
Analyst	Date	Supervisor	Date
R B Crane	12-17-97		
Chemistry Laboratory Supervisor	Date		

11-1

BIOLOGICAL SIGNIFICANCE

To maintain a healthy aquatic life in freshwater, the California Department of Fish and Game has determined that ammonia levels (measured as NH_3) should not exceed 0.02 mg/L undissociated ammonia. Acute toxicity (96-hr. LC50) of ammonia to various freshwater fish ranges from 0.1 to 4 mg/L (McKee and Wolf 1971).

It is my opinion that the level of undissociated ammonia in sample numbers L-410-97-1 was toxic to aquatic organisms.

REFERENCES:

McKee J.E. and H.W. Wolf. 1971. Water Quality Criteria. Publication 3-A. California State Water Resources Control Board. Sacramento, Ca.

Staff Water Quality Biologist

12/22/94

Date

MEMORANDUM

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD • CENTRAL VALLEY REGION

3443 Routier Road, Suite A
Sacramento, CA 95827-3098

Phone: (916) 255-3000
CALNET: 8-494-3000

TO: Rudy Schnagl

FROM: Louis Pratt

DATE: 7 February 1994

SIGNATURE:

SUBJECT: DAIRY WASTE VIOLATIONS

Although precipitation has been well below average for the fall and winter of 1993-1994 there have been many violations in regards to the management of dairy wastewater and runoff. Presence of dairy waste in roadside ditches, drains and creeks is widespread. The following violations have been documents within the past two months:

SAN JOAQUIN COUNTY

Ray Vaz Dairy, WDR's. Dairy wastewater pumped onto a field discharged into Avena Drain.
Vander Meulen Dairy. Dairy wastewater pumped onto a field discharged into Avena Drain.
Frank Machado and Sons Dairy, WDR's. Wastewater and runoff were discharged into McMullen Drain, thence into Walthal Slough.
Tony Dutra Dairy, WDR's pending. Dairy wastewater and runoff discharge into a drain which is tributary to Walthal Slough. The discharge is an ongoing problem and goes on unabated.
Vargas Dairy. Wastewater has discharged into Mariposa Drain.
Silva Bros Dairy, WDR's, ACL. Wastewater was leaving the dairy in three locations along Peltier Road and Pearl Road. The reasons for the discharges are the same one's that brought about the ACL.
S. D. Seifert Dairy, WDR's. Wastewater pumped onto fields discharged into an area drain along Sowels Road near Collier Road. The wastewater could be found north of Liberty Road. The need for improvements was discussed with the owner and the operator a year ago, but no improvements have been made.
Seifert Dairy Farm, WDR's, C&A. Runoff and wastewater were discharged into the roadside ditch along Collier and Dustin Roads, thence into Jahant Slough. The regulations, WDR's and C&A all prohibit the discharge, but it continues unabated.
Van Egmond Dairies, RWD submitted. Runoff from feed storage areas continues to discharge into roadside ditches near the intersection of Liberty and Dustin. This drainage is tributary to Dry Creek
Jack Virtue. The wastewater retention pond overflowed and discharged into the roadside ditch near the intersection of Liberty and Sowels, and continued north in an area drain.
Stockton Dairy, WDR's. The wastewater retention pond overflowed into Temple Creek. Wastewater pumped onto fields discharged into Temple Creek in three locations. Temple Creek contained dairy waste over a distance of over one half mile.
Mariposa Dairy. Wastewater pumped onto a field discharged into Temple Creek near Murphy Road.
Leen De Snayer Dairy, RWD submitted. Runoff from a feed storage area discharges into a

roadside ditch which drains into Sycamore Slough.

Frank Galhano Dairy, WDR's. Dairy wastewater pumped onto fields discharged into Mariposa Drain which is tributary to Temple Creek.

Art Stuyt Dairy, WDR's. Wastewater or runoff from the dairy discharged into Mariposa Drain.

Van De Pol Dairy. Runoff from the dairy discharges into the Highway 120 roadside ditch, thence into an irrigation drain, thence into Lone Tree Creek.

STANISLAUS COUNTY

3H Dairy, RWD, NOI submitted. Wastewater pumped onto a pasture discharged into OID's Union Drain which is tributary to Dry Creek and the Tuolumne River.

Joe Parreira Dairy. Wastewater pumped onto fields discharged into Union Drain near Stoddard Road.

Joe Dotinga Dairy. Wastewater pumped onto a field discharged into Union Drain near Alvarado Road. Runoff from a feed storage area discharges into Union Drain near Workman Road.

Manuel Furtado Dairy. Wastewater had discharged into OID's Kearney Drain, which is tributary to Union Drain.

Julio Serpa Dairy. Wastewater continuously discharges onto neighboring property which is an almond orchard. The neighbor has asked Serpa to stop the discharge, but the problem continues unabated.

SACRAMENTO COUNTY

Manuel Carmo Dairy, WDR's, ACL. Wastewater and corral runoff had discharged into a drain which is tributary to Stone Lake.

SUMMARY

Of the 22 dairies observed in violations which could adversely impact surface water quality, nine have WDR's, two have had ACL's, one is currently subject to a C&A, and three have submitted a RWD and are awaiting WDR's. Most of these dairies have been perennial problems. Lack of a tailwater or wastewater recovery system is the most prevalent cause of the violations. However, resistance or failure to take the simplest steps or make the simplest improvements which would prevent off-property discharges of waste are a significant contribution to the overall problem.

California Regional Water Quality Control Board

Central Valley Region

Steven T. Butler, Chair

Winston H. Hickox
Secretary for Environmental Protection

Gray Davis
Governor

Sacramento Main Office
Internet Address: http://www.swrcb.ca.gov/~rwqcb5
3443 Routier Road, Suite A, Sacramento, California 95827-3003
Phone (916) 255-3000 • FAX (916) 255-3015

FILE

21 June 2000

CERTIFIED MAIL
Z100 456 074

Art Stuyt Dairy
21812 East Dodds Road
Escalon, CA 95320

NOTICE OF VIOLATION:

On 16 June 2000, Regional Board staff inspected the Art Stuyt Dairy at 21812 East Dodds Road, Escalon, to ascertain compliance with Waste Discharge Requirement Order (WDR's) No. 91-112. A copy of the staff Inspection Report is enclosed for your records.

Regional Board staff has determined that your dairy is in violation of WDR's No. 91-112. Therefore, pursuant to 13267 of the Water Code, please submit to this office by 24 July 2000 a Nutrient and Irrigation Water Management Plan (NIWMP) for your dairy. This plan must show calculated quantity of nutrients in the animal waste produced at your dairy and the nutrient requirements of the cropland where the wastes are applied. The plan should identify the quantity of manure solids that are removed from your dairy on an annual basis and the estimated percentage of nutrients in those solids, but does not need to address nutrient loadings on the off-site cropland where the solids are applied. The plan should also discuss the procedures that you use to apply the wastewater and to control tailwater containing residual manure.

Your Extension Service Dairy Advisor or dairy association field representative should be able to assist you in preparing the NIWMP. I am enclosing a copy of Fact Sheet No. 4 for Dairies "Nutrient and Irrigation Water Management Plans" to assist you in developing your NIWMP.

If you have any questions, please call John Menke at (916)-255-3024 or John Collins at (916)-255-3359.

ROBERT J. MATTEOLI
Senior Water Quality Engineer

APPROVED
author [signature]
senior [signature]

Enclosure: Inspection Report & Fact Sheet No. 4

The Order also contains provisions requiring that:

*Before the number of animal units is increased above the level stated in the Findings, the Discharger shall submit a Technical Report, which clearly demonstrates that the increase will not be a threat to water quality. The Discharger will use the method described in Attachment B to calculate animal units.

*Prior to the use of any new waste retention ponds, a report completed by a certified engineer or engineering geologist verifying that the excavation meets all requirements of this Order shall be submitted to the Regional Board.

*The Discharger shall report promptly to the Board any material change or proposed change in the character, location, or volume of the discharge.

Because of the noted increase in animal population, a new report of Waste Discharge and a Nutrient Irrigation Water Management Plan need to be requested, and the Waste Discharge Requirements need to be updated.

SUMMARY:

The Art Stuyt Dairy appears to be in violation of Waste Discharge Requirements Order No. 91-112 due to inadequate facility acreage to handle repeated applications of liquid waste and may pose a threat to groundwater.

Approved: [signature]

LPP

State of California
DEPARTMENT OF FISH AND GAME

Fish and Wildlife Water Pollution Control Laboratory
Request for Laboratory Analysis

Your attention to completion of this form will allow WPCL chemists and biologists to better serve you. If you have questions regarding any aspect of sampling or the results reported here, please call the appropriate number listed below. Also, if possible, please notify WPCL prior to arrival of samples. Biology Lab (916) 355-0856; Chemistry (916) 355-0794; ATSS 438-XXXX.

Delivered By: Warden Art Ramirez

Analysis Required: ____ Bioassay X Chemical

Date Required: ASAP Region 2

Send Results To:

Name: Wdn. D.E. DeAnda #170

Agency: Fish and Game

Address: P.O. Box 30803

City: Stockton, CA ZIP 95213

For Laboratory Use Only:

WPCL Number: L-111-91

Other Number:

Field Number:

Received By: S. Sugarman

Date Received: 4-23-91

Date Completed: 4-23-91

Phone (916) 355-7040

Copies To: Regional Water Quality Control Board - Central Valley Dist. - L. Pratt

Problem Description (pollutant, source, water color, odor, etc.): Dairy irrigation water running off pasture creating foam in Lone Tree Creek.

Water Temp. 79 (°F) or °C (circle one) pH 7 Dissolved Oxygen N/A mg/L (ppm)

Sample Sources (provide diagram below): Collected at drain falling into Lone Tree Creek Pete Vanderwerf Dairy 24654 Lone Tree Rd. Escalon.

Sample Description (include number and size of containers): Collected 2 1600 hr. - 4-22-91

____ Pollutant

____ Water: Sample collected in poly bottle - refrigerated

____ Soil

____ Animal

Animals were alive ____, dying ____, or dead ____ when collected (Check one).

Suspect Sample May Contain:

____ Heavy metals

____ Petroleum products

____ Fertilizer

X Other (specify) NH_3

____ Unknown

Analysis Requested for the Following Reason:

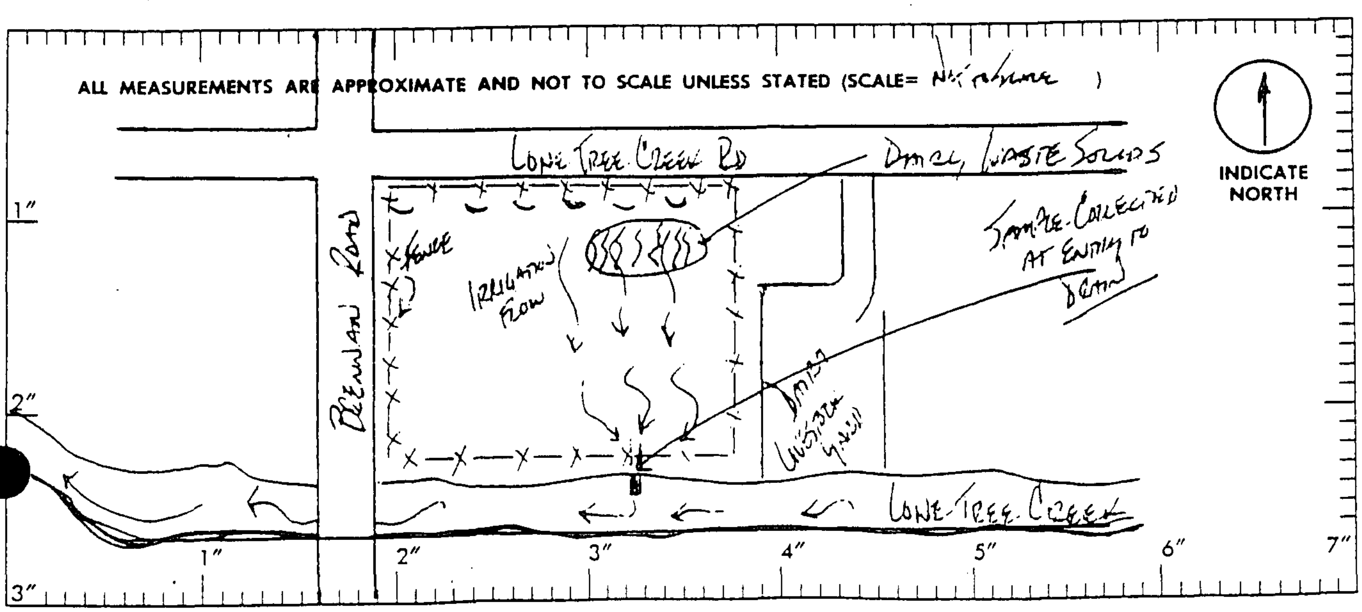
____ Fish and/or wildlife loss (Date of loss ____; Region ____)

X DFG Code violation (Code Section 5650 (f))

X Suspected or potential problem (explain below)

____ Routine check

ALL MEASUREMENTS ARE APPROXIMATE AND NOT TO SCALE UNLESS STATED (SCALE= N/A)



FG-1000 (Rev. 4/85)

85 35575

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WPCL Number L— 111 — 91

Results of Laboratory Analysis:

Sample Description:

One cubitainer of dairy waste taken from Pete Vanderwerf dairy drain falling into Lone Tree Creek, 1600 Hr., 04-22-91.

	pH	Undissociated NH_3 as N, mg/L
Sample	6.9	0.03
Detection Limit	0.01	0.03

Sample was acidified with H_2SO_4 immediately after analysis was completed.

Cost of analysis: $35.00

Method Reference:

Standard Methods for the Examination of Water and Wastewater, 1989, 17th Edition, 4500-NH_3 F, Ammonia Selective Electrode Method.

Analyst	Date	Supervisor	Date
[signature]	5-10-91	[signature]	5-10-91

Biological Significance of Analytical Results:

Please contact the Regional Water Quality Biologist (Jerry Mensch) for interpretation of analytical results.

Biologist	Date	Laboratory Director	Date
		[signature]	5-13-91

Chronology of Events 21 June 89
'Pete Van der Werff Dairy'

18 Feb '76 Complaint from DFG listing 4 dairies suspected of discharging in the area drain. While Mr Van der Werff has the capacity to discharge some of his pond threw a tail water water retorn system, at this time there was no effedence of a discharge.

4 Mar 78 Fish and wildlife loss report form filed There was a Total fish kill on Lone Tree Slough near French Camp. Three dairys were implicated including that of Mr Van der Werff.

26 Mar 78 STAFF LETTER TO DISCHARGER FROM DFG informing him OF HIS violation

10 May '78 DFG ISSUED CITATIONS TO four dairys - HAD COURT hearings - posponed

14 Dec '81 DFG reports that Mr Van der Werff is discharging into an area drain and will be sited

11 Dec '81 SITE Inspectors had Discharger explain waste Management system and discussed options OF his irrigating c̄ Lagoon water, evenly distribute wasts in fields and enstall a one-way valve at

16 Dec '81 (CONT.) The connection of the tailwater ditch in manure lagoon.

21 Dec '81 Recieved a copy of a violation report from DFG to the Discharger stating that he was releasing manured water into the Avena Drain. This discharge was a result of a faulty gate which has given problems in the past due to lack of proper care and maintence.

22 Dec '81 STAFF letter to DISCHARGER indicating the findings and discussions of the 16 Dec '81 site inspection.

2 July '82 Slide gate & earth berm are in place between tail water and Avena Drain.

7 SEPT '82 work in progress on installing a solids separato

28 Oct '82 A Conversation with Discharger reveals his time schedule is falling behind due to delays recieving the solids seperator from the Manufacturer.

29 Oct '82 Called Solids Seperator manufactor to notify them Mr Van de Werff is under court order to improve his waste system.

CENTRAL VALLEY REGIONAL WATER QUALITY CONTROL BOARD

MEMORANDUM

TO: Dairy File, San Joaquin County   DATE 14 Dec 1981

SUBJECT Dairy Waste Complaints from F+G   FROM John Menke

Warden Web Fisher called and informed me that:

(1) Rocha Dairy (JOHN ROCHA, JR., 23733 E. Mariposa Rd, Escalon) @ Carlton & Mariposa was discharging to Temple Creek. Dairy contact Joe Cardoso.

(2) Tony Lima of the Morris Dairy (8892 S. Van Allen Rd, Stockton) will pump water from the corral which is draining into Temple Creek @ S Van Allen Rd undercrossing

(3) Pete Vanderwerff Dairy (54754 E. Lone Tree Rd, Escalon) is discharging to the Avena Drain and will be cited.

(4) "Tony Rocha, Jr. Dairy" (JOAQUIN ROCHA, 10408 S. Van Allen Rd, Stockton, contact Anthony Jack Rocha) leaks manure water to ditch along Van Allen Rd.

(5) Personnel @ Wagner Dairy (22184 Skiff Rd, Escalon) were cleaning manure from roadside drains. (Accumulation had been observed by Warden Fisher + myself on 8 Dec 81, and I inspected dairy that date – apparent source of discharge was corral runoff).

(6) Tony Luiz Dairy (24323 E Skiff Rd, Escalon) may be source of discharge to area drain. No observed discharge.

VIOLATION REPORT

Petrus Cornelia Vanderwerff
24659 E Lone Tree
Escalon, Calif. 95320

March 26, 1978

2:00 P. M.

Deposit in Avena Drain dairy manure and wastes

Section 5650 (f) Calif. Fish and Game Code: It is unlawful to depositin, permit to pass into, or place where it can pass into the water of this State any of the following: (f) Any substance or material deleterious to fish, plant life, or bird life.

Pursuant to an investigation into the cause of a severe fish kill in the Lone Tree Slough in its lower reaches, investigation was made to locate the source and cause of the kill.

In checking the lower portions of the slough it appeared to be manure from the color and odor. The water was brown and smelled of manure.

In checking for the sources of the kill this date it was found that the Avena Drain at Jack Tone Rd. had a very substantial flow of manure water in it.

I follwed the drain very carefully all the way upstream to find the exact source. I ascertained that all of the dairys along the drain were not in any manner draining any material into it. I walked several miles along it to come to the exact source of the manure water.

It was found at the end of the Avena Drain at the N/E corner of the lagoon at the Vanderwerff dairy where a considerable amount of manure water, freshly washed from the washing barn, was entering the drain.

A sample of the water and pictures were taken.

Weber G. Fisher

Weber G. Fisher
Fish and Game Warden
Region II

Owner, Larry Nash brought this in. REM 1 May 1978

KLC 4013

INITIAL REPORT OF FISH AND WILDLIFE LOSS

CAUSE: DISEASE ____ PESTICIDES ____ POLLUTION X OTHERS OR UNKNOWN ____

LOSS: FISH X BIRDS ____ MAMMALS ____

IN: WILD POPULATIONS X INSTALLATION ____

* *

Fish and Game Region 2 County San Joaquin Specific Location Lone Tree (USGS description) Slough Nearest town French Camp

Area affected (miles of stream, acres of lake etc.) 10

Date of First Loss 3-23-78

Loss First Reported By DeGruff (Name) French Camp (Address) On 3-23-78 (Date)

LOSS DUE TO:

____ PESTICIDE (Describe type, rate and purpose of application, size of area treated)

X POLLUTION (Describe type, source, color, odor, etc.) Dairy Wastes Manure

____ DISEASE (Name if known, or symptoms)

____ UNKNOWN (Describe circumstance of loss)

Type of Water (fresh, salt or estuary) Fresh

Severity: Total X Heavy ____ Moderate ____ Light ____

Duration (Hours--days and hours, etc.) of critical effect ____

ANIMAL KILL INFORMATION: (List species and size range. Put estimate number/species in appropriate box.)

Species Killed	Size	1-50	51-100	101-500	501-1000	1000+	10,000+
Carp						X	

EVIDENCE OBTAINED: (To whom did you deliver the samples?)

X Waste sample (Pollutant)

X Water samples Retained

____ Animal samples (fish, birds, mammals)

____ Other (describe)

Name and address of person or firm believed responsible: Morris Dairy, Dochee Dairy and Vanderwerff Dairy-

Name and address of additional witnesses:

3-24-78 (Date of observation) 3-27-78 (Submission of report) Weber G. Fisher (Name of reporter)

* *

FOR REGIONAL OFFICE USE

Other agencies contacted: No

Do you plan additional investigations on this loss? Yes Comments investigate for possible Prosecution

Date 4/3/78 for Regional Manager C. Matthews

FG 406 R-2 1-73

78 13

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LFP.

DEPARTMENT OF FISH AND GAME
FISH AND WILDLIFE
WATER POLLUTION CONTROL LABORATORY

2005 NIMBUS ROAD
RANCHO CORDOVA, CA 95670
PHONE (916) 358-2858 ATSS 8-434-2858 FAX (916) 985-4301

LABORATORY REPORT

Name:	Louis Pratt	**Lab Number:**	L-292-96
Agency:	Water Quality Control Board	**Other Number:**	
Address:	3445 Routier Rd., Suite A	**Date Sampled:**	12-04-96
City:	Sacramento CA 95827	**Date Received:**	12-04-96
		Date Completed:	12-06-96
RE:	Manuel Miranda Dairy	**Index-PCA Code:**	

RESULTS OF CHEMICAL ANALYSIS:

Laboratory Number	Sample Identification	Total Ammonia as N, mg/L	Undissociated Ammonia as NH_3,mg/L
L-292-96	Manuel Miranda Dairy	117	3.03
Reporting Limit		0.05	--

METHOD REFERENCE:

Methods for Chemical Analysis of Water and Wastewater, EPA-600/4-79-020, March 1983, Method 350.3 Ion Selective Electrode.

COST OF ANALYSIS: $32.00

POLLUTION ACTION KIT (IF USED): $110.00 AND HAZMAT SHIPPER (IF USED): $25.00

Deposit recovery costs to Cleanup and Abatement Account with "cost of analysis:" identified separately.

Maida Martin
Analyst

12/20/96
Date

Supervisor

12-20-96
Date

Chemistry Laboratory Supervisor

12-20-96
Date

97 JAN -2 PM 1:03

To maintain a healthy aquatic life in freshwater, the California Department of Fish and Game has determined that ammonia levels (measured as NH_3) should not exceed 0.02 mg/L undissociated ammonia. Acute toxicity (96-hr. LC50) of ammonia to various freshwater fish ranges from 0.1 to 4 mg/L (McKee and Wolf 1971).

It is my opinion that the level of undissociated ammonia in sample number L-292-96-1 was toxic to aquatic organisms.

REFERENCES:

McKee J.E. and H.W. Wolf. 1971. Water Quality Criteria. Publication 3-A. California State Water Resources Control Board. Sacramento, Ca.

Staff Water Quality Biologist

12/20/96
Date

Bacteria

B.1.3 Avena Drain, Pathogens

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region, (Regional Board) recommends the addition of the Avena Drain to California's Clean Water Act Section 303(d) list due to impairment by pathogens. Information available to the Regional Board on pathogen levels indicates that water quality objectives are not being attained. The basis for this recommendation is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Avena Drain	**Pollutants/Stressors**	Pathogens
Hydrologic Unit		**Sources**	Agriculture/Dairies
Total Length	8.5 Miles	**TMDL Priority**	
Size Affected	6.5 Miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	The upper 6.5 miles of Avena Drain	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	37° 50' 05"	**Upstream Extent Longitude**	121° 00' 27"
Downstream Extent Latitude	37° 50' 44"	**Downstream Extent Longitude**	121° 07' 37"

Watershed Characteristics

Avena Drain is a modified natural channel approximately 8.5 miles in length. The Avena Drain is tributary to Lone Tree Creek, which is tributary to the Delta. Storm water runoff (mainly from cropland) and irrigation tail water are the main sources of water. Due to the flow of tail water, the drain is no longer ephemeral during the dry season. Although there are few trees growing along the drain, there is some riparian vegetation.

Water Quality Objectives Not Attained

The narrative objective for toxicity is not being attained for pathogens in the Avena Drain. The narrative toxicity objective in the Basin Plan states, in part, "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life." The narrative toxicity objective further states the " the Regional Water Board will also consider…numerical criteria and guidelines developed by the State Water Board, the California Office of Environmental Health Hazard Assessment, the California Department of Health Services…the U.S. Environmental Protection Agency, and other organizations to evaluate compliance with this objective." The Basin Plan also contains a specific objective for fecal coliform bacteria (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/rwqcb5/bsnplnab.pdf).

Guidelines and criteria have been developed for the protection of human health. The California Department of Health Services (CDHS) has adopted regulations for recreational waters and beaches for single samples of total coliform bacteria of 10,000 Most Probable Number (MPN) per 100 milliliters and of 1,000 MPN per 100 ml for 30-day log mean of sample levels (Title 17 California Code of Regulation section 7958). CDHS has also published draft guidelines that include limits for single samples of *E. coli* of 235 MPN per 100 milliliters (CDHS, July 2000 http://www.dhs.ca.gov/ps/ddwem/beaches/freshwater.htm). USEPA guidelines for bacteria contained in *Ambient Water Quality Criteria for Bacteria* (USEPA, 1986a) state "Based on a statistically sufficient number of samples (generally not less than 5 samples equally spaced over a 30-day period), the geometric mean of the indicated bacterial densities should not exceed one or the other of the following: *E. coli* 126 MPN per 100 ml; or Enterococci 33 MPN per 100 ml." A methodology for determining exceedances based on single samples is also included in the standards.

Evidence of Impairment

There are 12 dairies that have the potential and propensity to discharge wastewater containing manure into Avena Drain. These discharges arise from the inability to retain wastewater during the winter months, and from irrigation with wastewater during the spring, summer and fall.

DeltaKeeper submitted bacteria data for a total of 14 water samples collected from six locations on Avena Drain on five dates between October 2000 and January 2001 (Jennings, 2001). Geometric means of the bacteria counts have been calculated for three locations (Avena Drain at Carrolton road, at Murphy Road, and at Van Allen Road) based on three sampling dates at each location, using the data submitted by DeltaKeeper. The geometric means for *E. coli* at the three locations are 7,743, 949.6, and 6,239 MPN per 100 ml, respectively (all exceeding the USEPA criterion of 126 MPN per 100 ml). Individual *E. coli* measurements for 13 of the 14 samples exceeded the USEPA single sample criterion of 235 MPN per 100 ml.

Extent of Impairment
Avena Drain begins on a dairy farm east of Brennan Avenue in San Joaquin County. Ten of the 12 dairies along the drain are located on the upper 6 ½ miles.

Potential Sources
The source of the pathogens in Avena Drain is most likely from manure carried in dairy wastewater. The samples were taken during known discharges of wastewater

B.1.11 Lower Calaveras River, Pathogens

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region, (Regional Board) recommends the addition of the lower Calaveras River to California's Clean Water Act Section 303(d) list due to impairment by pathogens. Information available to the Regional Board on pathogens levels in the lower reach of the Calaveras River indicates that water quality objectives are not being attained. A description for the basis for this determination is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Lower Calaveras River	**Pollutants/Stressors**	Pathogens
Hydrologic Unit	531.30	**Sources**	Urban runoff, Recreation
Total Waterbody Size	50 miles	**TMDL Priority**	
Size Affected	5 Miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	The lower 5 miles of the Calaveras River (urban Stockton)	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	38° 00' 45"	**Upstream Extent Longitude**	121° 14' 22"
Downstream Extent Latitude	37° 58' 00"	**Downstream Extent Longitude**	121° 22' 04"

Watershed Characteristics

The Delta is characterized by tidal waters with limited flushing flows during the dry seasons. The lower Calaveras River has much of its flow diverted upstream of Stockton and the downstream area is dominated by urban runoff. The lower Calaveras River supports recreational uses, including boating, fishing, water skiing and swimming. The predominant land use in this portion of the watershed is urban. Additionally, there are recreational uses of the waters, including boating facilities near the confluence with the San Joaquin River.

Water Quality Objectives Not Attained

The narrative objective for toxicity is not being attained for pathogens in the lower Calaveras River. The narrative toxicity objective in the Basin Plan states, in part, "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life." The narrative toxicity objective further states the " the Regional Water Board will also consider...numerical criteria and guidelines developed by the State Water Board, the California Office of Environmental Health Hazard Assessment, the California Department of Health Services...the U.S. Environmental Protection Agency, and other organizations to evaluate compliance with this objective." The Basin Plan also contains a specific objective for fecal coliform bacteria (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/rwqcb5/bsnplnab.pdf).

Guidelines and criteria have been developed for the protection of human health. The California Department of Health Services (CDHS) has adopted regulations for recreational waters and beaches for single samples of total coliform bacteria of 10,000 Most Probable Number (MPN) per 100 milliliters and of 1,000 MPN per 100 ml for 30-day log mean of sample levels (Title 17 California Code of Regulation section 7958). CDHS has also published draft guidelines that include limits for single samples of *E. coli* of 235 MPN per 100 milliliters (CDHS, July 2000 http://www.dhs.ca.gov/ps/ddwem/beaches/freshwater.htm). USEPA guidelines for bacteria contained in *Ambient Water Quality Criteria for Bacteria* (USEPA, 1986a) state "Based on a statistically sufficient number of samples (generally not less than 5 samples equally spaced over a 30-day period), the geometric mean of the indicated bacterial densities should not exceed one or the other of the following: *E. coli* 126 MPN per 100 ml; or Enterococci 33 MPN per 100 ml." A methodology for determining exceedances based on single samples is also included in the standards.

Evidence of Impairment

DeltaKeeper submitted bacteria data for water samples collected from two locations on the lower Calaveras River (Jennings, 2001). One sampling location is near the mouth of the river and the other is approximately four miles upstream. A total of 26 samples collected at the upstream location over during 10 months in 2000-2001, and a total of 11 samples collected at the downstream location during seven months in 2000, were analyzed. Geometric means of the bacteria counts have been calculated using the data submitted by DeltaKeeper. The geometric mean for *E. coli* is 322 MPN per 100 ml for samples collected at the upstream location (exceeding the USEPA criterion of 126 MPN per 100 ml). The geometric mean for *E. coli* for samples collected at the downstream location is 76 MPN per 100 ml. However, individual *E. coli* measurements at the downstream site have exceeded the USEPA single sample criterion of 235 MPN per 100 ml.

Extent of Impairment

The lower five miles of the Calaveras River is recommended for listing as impaired due to pathogen contamination. The extent of impairment is extrapolated upstream from the sampling location based on land use patterns. Both sampling locations are within the urban Stockton area. The lower five miles of the Calaveras River have similar land use patterns and it is expected that sampling will show high levels of bacteria in the urban portion of the river.

Potential Sources

In urban settings, the USEPA has identified sources of pathogen pollution to include urban litter, contaminated refuse, domestic pet and wildlife excrement and failing sewer lines (USEPA, 2001a). In their pathogen TMDL Guide, the USEPA states "In a study of bacterial loading in urban streams, Young and Thackston (1999) found that fecal bacteria densities were directly related to the density of housing, population, development, percent impervious area, and domestic animal density. Additionally, recreational areas may have high bacteria counts. This can be due to improper disposal of waste from boats, lack of sanitary facilities in the area of recreation and children in diapers using the water."

B.1.22 Five Mile Slough, Pathogens

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region, (Regional Board) recommends the addition of Five Mile Slough in the Delta to California's Clean Water Act Section 303(d) list due to impairment by pathogens. Information available to the Regional Board on pathogens levels in Five Mile Slough indicates that water quality objectives are not being attained. A description for the basis for this determination is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Five Mile Slough	**Pollutants/Stressors**	Bacteria
Hydrologic Unit	544.00	**Sources**	Urban runoff, Recreation
Total Waterbody Size	1.5 Miles	**TMDL Priority**	
Size Affected	1.5 Miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	From the head of the slough at Alexandria Place to the confluence with Fourteen Mile Slough.	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	38° 00' 51"	**Upstream Extent Longitude**	121° 19' 52"
Downstream Extent Latitude	38° 00' 50"	**Downstream Extent Longitude**	121° 22' 10"

Watershed Characteristics

Five Mile Slough is located in the Delta, extends through urban Stockton from Five Mile Creek, and is bordered by residential housing, schools, a park, and a golf course. The Delta is characterized by tidal waters with limited flushing flows during the dry seasons. Five Mile Slough supports recreational uses, including boating, fishing, and swimming.

Water Quality Objectives Not Attained

The narrative objective for toxicity is not being attained for pathogens in Five Mile Slough. The narrative toxicity objective in the Basin Plan states, in part, "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life." The narrative toxicity objective further states the " the Regional Water Board will also consider…numerical criteria and guidelines developed by the State Water Board, the California Office of Environmental Health Hazard Assessment, the California Department of Health Services…the U.S. Environmental Protection Agency, and other organizations to evaluate compliance with this objective." The Basin Plan also contains a specific objective for fecal coliform bacteria (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/rwqcb5/bsnplnab.pdf).

Guidelines and criteria have been developed for the protection of human health. The California Department of Health Services (CDHS) has adopted total coliform bacteria guidelines, applicable to recreational waters and beaches, of 10,000 Most Probable Number (MPN) per 100 milliliters (ml) for single samples and of 1,000 MPN per 100 ml for 30-day log mean of sample levels (Title 17 California Code of Regulation section 7958). CDHS has also published draft guidelines that include limits for single samples of *E. coli* of 235 MPN per 100 milliliters (CDHS, July 2000 http://www.dhs.ca.gov/ps/ddwem/beaches/freshwater.htm). U.S. EPA guidelines for bacteria are contained in *Ambient Water Quality Criteria for Bacteria* (USEPA, 1986a). The U.S. EPA standards are stated as "Based on a statistically sufficient number of samples (generally not less than 5 samples equally spaced over a 30-day period), the geometric mean of the indicated bacterial densities should not exceed one or the other of the following: *E. coli* 126 MPN per 100 ml; or Enterococci 33 MPN per 100 ml." A methodology for determining exceedances based on single samples is also included in the standards.

Evidence of Impairment

DeltaKeeper submitted bacteria data for Five Mile Slough from two sampling locations (Jennings, 2001). One sampling location (downstream) is near the mouth of the slough (at the confluence with Fourteen Mile Slough) and the other sampling location (upstream) is near the beginning of the constructed portion of the slough (at Alexandria Place), approximately 1.5 miles upstream of the mouth of the slough. A total of 29 samples collected from Five Mile Slough during 10 months in 2000-2001 were analyzed for *E. coli* and total coliform. Geometric means of the bacteria counts have been calculated using the data submitted by DeltaKeeper. The geometric means for *E. coli* and total coliform levels measured at the downstream sampling location are 38 MPN per 100 ml and 8,728 MPN per 100 ml, respectively. However, the sampling at the downstream sampling location was limited to three sampling events (one each month for April 2000, August 2000 and February 2001). One *E. coli* measurement at the downstream site was 244 MPN per 100 ml, which exceeds the CDHS single-sample criterion of 235 MP per 100 ml. The geometric mean for *E. coli* levels measured at the upstream sampling location is 147 MPN per 100 ml, which exceeds the U.S. EPA criterion of 126 MPN per 100 ml.

Extent of Impairment

Regional Board staff recommends listing the entire 1.5 mile-long reach of Five Mile Slough as impaired due to pathogen contamination since both sampling locations are within the urban Stockton area and the entire reach of Five Mile Slough has similar land use patterns.

Potential Sources

In urban settings, the U.S. EPA has identified sources of pathogen pollution to include urban litter, contaminated refuse, domestic pet and wildlife excrement and failing sewer lines (USEPA, 2001a). In their pathogen TMDL Guide, the U.S. EPA states "In a study of bacterial loading in urban streams, Young and Thackston (1999) found that fecal bacteria densities were directly related to the density of housing, population, development, percent impervious area, and domestic animal density. Additionally, recreational areas may have high bacteria counts. This can be due to improper disposal of waste from boats, lack of sanitary facilities in the area of recreation and children in diapers using the water."

B.1.31 Mormon Slough, Pathogens

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region, (Regional Board) recommends the addition of Mormon Slough to California's Clean Water Act Section 303(d) list due to impairment by pathogens. Information available to the Regional Board on pathogens levels in Mormon Slough indicates that water quality objectives are not being attained. A description for the basis for this determination is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Mormon Slough	**Pollutants/Stressors**	Bacteria
Hydrologic Unit	544.00	**Sources**	Urban runoff, Recreation
Total Waterbody Size	6 Miles	**TMDL Priority**	
Size Affected	4 Miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	From the confluence with the Deep Water Channel to the confluence with the Stockton Diverting Canal.	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	37° 57' 25"	**Upstream Extent Longitude**	121° 20' 53"
Downstream Extent Latitude	37° 57' 09"	**Downstream Extent Longitude**	121° 18' 23"

Watershed Characteristics

Mormon Slough is a tributary to the Stockton Deep Water Channel in the Delta. The Delta is characterized by tidal waters with limited flushing flows during the dry seasons. The area around Mormon Slough is highly urbanized and supports recreational uses, including boating, fishing, water skiing and swimming.

Water Quality Objectives Not Attained

The narrative objective for toxicity is not being attained for pathogens in the predominantly urban stretches of various Delta waterways (including Mormon Slough). The narrative toxicity objective in the Basin Plan states, in part, "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life." The narrative toxicity objective further states the " the Regional Water Board will also consider...numerical criteria and guidelines developed by the State Water Board, the California Office of Environmental Health Hazard Assessment, the California Department of Health Services...the U.S. Environmental Protection Agency, and other organizations to evaluate compliance with this objective." The Basin Plan also contains a specific objective for fecal coliform bacteria (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/rwqcb5/bsnplnab.pdf).

Guidelines and criteria have been developed for the protection of human health. Guidelines and criteria have been developed for the protection of human health. The California Department of Health Services (CDHS) has adopted a total coliform bacteria guideline, applicable to recreational waters and beaches, of 10,000 Most Probable Number (MPN) per 100 milliliters for single samples and of 1,000 MPN per 100 ml for 30-day log mean of sample levels (Title 17 California Code of Regulation section 7958). CDHS has also published draft guidelines that include limits for single samples of *E. coli* of 235 MPN per 100 milliliters (CDHS, July 2000 http://www.dhs.ca.gov/ps/ddwem/beaches/freshwater.htm). U.S. EPA guidelines for bacteria are contained in *Ambient Water Quality Criteria for Bacteria* (USEPA, 1986a). The U.S. EPA standards are stated as "Based on a statistically sufficient number of samples (generally not less than 5 samples equally spaced over a 30-day period), the geometric mean of the indicated bacterial densities should not exceed one or the other of the following: *E. coli* 126 MPN per 100 ml; or Enterococci 33 MPN per 100 ml." A methodology for determining exceedances based on single samples is also included in the standards.

Evidence of Impairment
DeltaKeeper submitted bacteria data for Mormon Slough from one sampling location, approximately one mile upstream from the confluence with the Stockton Deep Water Channel (Jennings, 2001). A total of 31 samples collected during 10 months in 2000-2001 were analyzed. The calculated geometric mean for the *E. coli* levels is 1,272 MPN per 100 ml, which exceeds the U.S. EPA criterion of 126 MPN per 100 ml.

Extent of Impairment
Regional Board staff recommends listing the portion of Mormon Slough between the Stockton Deep water Channel and the Stockton Diverting Canal as impaired for pathogens due to bacterial contamination. The entire area around Mormon Slough is urban and has similar land use patterns and it is anticipated that sampling along other portions of Mormon Slough would show similar bacteria levels.

Potential Sources
In urban settings, the U.S. EPA has identified sources of pathogen pollution including urban litter, contaminated refuse, domestic pet and wildlife excrement and failing sewer lines (USEPA, 2001a). In their pathogen TMDL Guide, the U.S. EPA states "In a study of bacterial loading in urban streams, Young and Thackston (1999) found that fecal bacteria densities were directly related to the density of housing, population, development, percent impervious area, and domestic animal density. Additionally, recreational areas may have high bacteria counts. This can be due to improper disposal of waste from boats, lack of sanitary facilities in the area of recreation and children in diapers using the water."

B.1.33 Mosher Slough, Pathogens

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region, (Regional Board) recommends the addition of Mosher Slough in the Delta to California's Clean Water Act Section 303(d) list due to impairment by pathogens. Information available to the Regional Board on pathogens levels in Mosher Slough indicates that water quality objectives are not being attained. A description for the basis for this determination is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Mosher Slough	**Pollutants/Stressors**	Bacteria
Hydrologic Unit	544.00	**Sources**	Urban runoff, Recreation
Total Waterbody Size	5 miles	**TMDL Priority**	
Size Affected	5 miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	From Mosher Creek to the confluence with Bear Creek	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	38° 01' 45"	**Upstream Extent Longitude**	121° 16 45'
Downstream Extent Latitude	38° 02' 35"	**Downstream Extent Longitude**	121° 23' 11"

Watershed Characteristics

Mosher Slough flows through urban portion of Stockton, in the Delta. The Delta is characterized by tidal waters with limited flushing flows during the dry seasons. The lower portion of the slough is near, and is likely also used for, recreational uses including boating, fishing, water skiing and swimming. The predominant land uses in the watershed that encompasses Mosher Slough are agricultural, urban (the city of Stockton), and a deepwater port.

Water Quality Objectives Not Attained

The narrative objective for toxicity is not being attained for pathogens in Mosher Slough. The narrative toxicity objective in the Basin Plan states, in part, "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life." The narrative toxicity objective further states the " the Regional Water Board will also consider...numerical criteria and guidelines developed by the State Water Board, the California Office of Environmental Health Hazard Assessment, the California Department of Health Services...the U.S. Environmental Protection Agency, and other organizations to evaluate compliance with this objective." The Basin Plan also contains a specific objective for fecal coliform bacteria (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/rwqcb5/bsnplnab.pdf).

Guidelines and criteria have been developed for the protection of human health. The California Department of Health Services (CDHS) has adopted a total coliform bacteria guideline, applicable to recreational waters and beaches, of 10,000 Most Probable Number (MPN) per 100 milliliters for single samples and of 1,000 MPN per 100 ml for 30-day log mean of sample levels (Title 17 California Code of Regulation section 7958). CDHS has also published draft guidelines that include limits for single samples of *E. coli* of 235 MPN per 100 milliliters (CDHS, July 2000; http://www.dhs.ca.gov/ps/ddwem/beaches/freshwater.htm). The U.S. EPA guidelines for bacteria are contained in *Ambient Water Quality Criteria for Bacteria* (USEPA, 1986a). The U.S. EPA standards are stated as, "Based on a statistically sufficient number of samples (generally not less than 5 samples equally spaced over a 30-day period), the geometric mean of the indicated bacterial densities should not exceed one or the other of the following: *E. coli* 126 per 100 ml; or Enterococci 33 per 100 ml." A methodology for determining exceedances based on single samples is also included in the standards.

Evidence of Impairment

DeltaKeeper submitted bacteria data for Mosher Slough from three sampling locations (Jennings, 2001). Although geometric means have not been calculated for the data, all 31 samples submitted exceed the CDHS 30 day criterion for total coliform and 29 of the 31 samples exceed the recommended *E. coli* criterion. The measured bacteria densities in the samples were high during the entire sampling period, which includes samples collected during an entire year (May, August, September, October, November, December, January, and February).

Extent of Impairment

Regional Board staff recommends listing Mosher Slough as impaired due to pathogen contamination. The sampling location is within the urban Stockton area. The area around Mosher Slough is heavily urbanized and it is likely that samples collected from other portions of Mosher Slough would show similar high levels of bacteria.

Potential Sources

In urban settings, U.S. EPA has identified sources of pathogen pollution to include urban litter, contaminated refuse, domestic pet and wildlife excrement and failing sewer lines (USEPA, 2001a). In their pathogen TMDL Guide, the U.S. EPA states "In a study of bacterial loading in urban streams, Young and Thackston (1999) found that fecal bacteria densities were directly related to the density of housing, population, development, percent impervious area, and domestic animal density. Additionally, recreational areas may have high bacteria counts. This can be due to improper disposal of waste from boats, lack of sanitary facilities in the area of recreation and children in diapers using the water."

B.1.47 Smith Canal, Pathogens

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region, (Regional Board) recommends the addition of Smith Canal to California's Clean Water Act Section 303(d) list due to impairment by pathogens. Information available to the Regional Board on pathogen levels in the lower reach of the Smith Canal indicates that water quality objectives are not being attained. A description for the basis for this determination is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Smith Canal	**Pollutants/Stressors**	Pathogens
Hydrologic Unit	544.00	**Sources**	Urban runoff, Recreation
Total Waterbody Size	2 miles	**TMDL Priority**	
Size Affected	2 miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	From Yosemite Lake to the confluence with the San Joaquin River	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	37° 58' 03"	**Upstream Extent Longitude**	121° 18' 24"
Downstream Extent Latitude	37° 57' 25"	**Downstream Extent Longitude**	121° 20' 54"

Watershed Characteristics

The Delta is characterized by tidal waters with limited flushing flows during the dry seasons. Smith Canal is located in the Delta and is a tributary to the Stockton Deep Water Channel. The area is highly urbanized and supports recreational uses, including boating, fishing, water skiing and swimming. Additionally, the recreational uses of the waters include a park with a "lake" (Yosemite Lake) at the upper terminus of the canal.

Water Quality Objectives Not Attained

The narrative objective for toxicity is not being attained in Smith Canal. The narrative toxicity objective in the Basin Plan states, in part, "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life." The narrative toxicity objective further states the " the Regional Water Board will also consider...numerical criteria and guidelines developed by the State Water Board, the California Office of Environmental Health Hazard Assessment, the California Department of Health Services...the U.S. Environmental Protection Agency, and other organizations to evaluate compliance with this objective." The Basin Plan also contains a specific objective for fecal coliform bacteria (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/rwqcb5/bsnplnab.pdf).

Guidelines and criteria have been developed for the protection of human health. The California Department of Health Services (CDHS) has adopted a total coliform bacteria guideline, applicable to recreational waters and beaches, of 10,000 Most Probable Number (MPN) per 100 milliliters for single samples and of 1,000 MPN per 100 ml for 30-day log mean of sample levels (Title 17 California Code of Regulation section 7958). CDHS has also published draft guidelines that include limits for single samples of *E. coli* of 235 MPN per 100 milliliters (CDHS, July 2000 http://www.dhs.ca.gov/ps/ddwem/beaches/freshwater.htm). USEPA guidelines for bacteria are contained in *Ambient Water Quality Criteria for Bacteria* (USEPA, 1986a). The USEPA standards are stated as "Based on a statistically sufficient number of samples (generally not less than 5 samples equally spaced over a 30-day period), the geometric mean of the indicated bacterial densities should not exceed one or the other of the following: *E. coli* 126 MPN per 100 ml; or Enterococci 33 MPN per 100 ml." A methodology for determining exceedances based on single samples is also included in the standards.

Evidence of Impairment

DeltaKeeper submitted bacteria data for Smith Canal from three sampling locations (Jennings, 2001). The sampling locations are located at the upper terminus of the canal at Yosemite Lake, approximately one-quarter mile downstream in the canal, and near the mouth of the canal (near Interstate 5 [I-5]). Geometric means have been calculated using the data submitted by DeltaKeeper. The calculated geometric mean for the *E. coli* levels measured in samples collected from the Yosemite Lake location is 919 MPN per 100 ml, which exceeds the USEPA criterion of 126 MPN per 100 ml. The calculated geometric mean for the *E. coli* levels measured in samples collected from the sampling location approximately one-quarter mile downstream from the Yosemite Lake is 6,223 MPN per 100 ml, which also exceeds the USEPA criterion of 126 MPN per 100 ml. The calculated geometric mean for the *E. coli* levels measured in samples collected from the sampling location near I-5 is 88 MPN per 100 ml. However, individual *E. coli* measurements for samples collected from location near I-5 have exceeded the USEPA single sample criterion of 235 MPN per 100 ml and the geometric mean of the measured total coliform levels remains high, at 2,090 MPN per 100 ml.

Extent of Impairment

Regional Board staff recommends listing the entire reach of Smith Canal, including Yosemite Lake at the upper terminus, as impaired for pathogens due to bacterial contamination. Sampling locations are within the urban Stockton area. The entire canal is heavily urbanized and has similar land use patterns. Sampling shows high levels of bacteria in the entire length of Smith Canal.

Potential Sources

In urban settings, the USEPA has identified sources of pathogen pollution to include urban litter, contaminated refuse, domestic pet and wildlife excrement, and failing sewer lines (USEPA, 2001a). In their pathogen TMDL Guide, the USEPA states "In a study of bacterial loading in urban streams, Young and Thackston (1999) found that fecal bacteria densities were directly related to the density of housing, population, development, percent impervious area, and domestic animal density. Additionally, recreational areas may have high bacteria counts. This can be due to improper disposal of waste from boats, lack of sanitary facilities in the area of recreation and children in diapers using the water."

B.1.50 Stockton Deep Water Channel, Pathogens

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region, (Regional Board) recommends the addition of Stockton Deep Water Channel to California's Clean Water Act Section 303(d) list due to impairment by pathogens. Information available to the Regional Board on pathogens levels in Stockton Deep Water Channel indicates that water quality objectives are not being attained. A description for the basis for this determination is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Stockton Deep Water Channel	**Pollutants/Stressors**	Bacteria
Hydrologic Unit	544.00	**Sources**	Urban runoff, Recreation
Total Waterbody Size	2 miles	**TMDL Priority**	
Size Affected	2 miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	All of the channel	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	37° 57' 28"	**Upstream Extent Longitude**	121° 21' 14"
Downstream Extent Latitude	37° 57' 23"	**Downstream Extent Longitude**	121° 17' 34"

Watershed Characteristics

The Stockton Deep Water Channel is located in the Delta and extends through the Port of Stockton into urban Stockton, where it is bordered by residential housing and recreation areas including Weber Point. The Stockton Deep Water Channel supports recreational uses, including boating, fishing, and swimming. The predominant land uses in the area around the Stockton Deep Water Channel are industrial and urban.

Water Quality Objectives Not Attained

The narrative objective for toxicity is not being attained in the Stockton Deep Water Channel. The narrative toxicity objective in the Basin Plan states, in part, "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life." The narrative toxicity objective further states the " the Regional Water Board will also consider...numerical criteria and guidelines developed by the State Water Board, the California Office of Environmental Health Hazard Assessment, the California Department of Health Services...the U.S. Environmental Protection Agency, and other organizations to evaluate compliance with this objective (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/rwqcb5/bsnplnab.pdf)."

Guidelines and criteria have been developed for the protection of human health. The California Department of Health Services (CDHS) has adopted a total coliform bacteria guideline, applicable to recreational waters and beaches, of 10,000 Most Probable Number (MPN) per 100 milliliters for single samples and of 1,000 MPN per 100 ml for 30-day log mean of sample levels (Title 17 California Code of Regulation section 7958). CDHS has also published draft guidelines that include limits for single samples of *E. coli* of 235 MPN per 100 milliliters (CDHS, July 2000 http://www.dhs.ca.gov/ps/ddwem/beaches/freshwater.htm). USEPA guidelines for bacteria are contained in *Ambient Water Quality Criteria for Bacteria* (USEPA, 1986a). The USEPA standards are stated as "Based on a statistically sufficient number of samples (generally not less than 5 samples equally spaced over a 30-day period), the geometric mean of the indicated bacterial densities should not exceed one or the other of the following: *E. coli* 126 MPN per 100 ml; or Enterococci 33 MPN per 100 ml." A methodology for determining exceedances based on single samples is also included in the standards.

Evidence of Impairment

DeltaKeeper submitted bacteria data for the Stockton Deep Water Channel from two sampling locations (Jennings, 2001). One sampling location is at the lower terminus of the channel in McLeod Lake and the other is approximately one mile upstream at Morelli Park. During six months in 2000, 14 samples were collected from each location and analyzed for *E. coli*. Geometric means have been calculated using the data submitted by DeltaKeeper. The calculated geometric mean for *E. coli* in water samples collected from the Morelli Park location is 399 MPN per 100 ml, which exceeds the USEPA criterion of 126 MPN per 100 ml. The calculated geometric mean for *E. coli* in water samples collected from the McLeod Lake location is 287 MPN per 100 ml, which also exceeds the USEPA criterion.

Extent of Impairment

Regional Board staff recommends listing the Stockton Deep Water Channel as impaired due to pathogen contamination. Both sampling locations are within the urban Stockton area, which includes a deep water shipping port. The area around the entire reach of the Stockton Deep Water Channel has similar land use patterns and it is expected that sampling would show similar high levels of bacteria throughout the channel.

Potential Sources

In urban settings, the USEPA has identified sources of pathogen pollution to include urban litter, contaminated refuse, domestic pet and wildlife excrement and failing sewer lines (USEPA, 2001). In their pathogen TMDL Guide USEPA states "In a study of bacterial loading in urban streams, Young and Thackston (1999) found that fecal bacteria densities were directly related to the density of housing, population, development, percent impervious area, and domestic animal density. Additionally, recreational areas may have high bacteria counts. This can be due to improper disposal of waste from boats, lack of sanitary facilities in the area of recreation and children in diapers using the water."

B.1.52 Walker Slough, Pathogens

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region, (Regional Board) recommends the addition of Walker Slough to California's Clean Water Act Section 303(d) list due to impairment by pathogens. Information available to the Regional Board on pathogens levels in the Walker Slough indicates that water quality objectives are not being attained. A description for the basis for this determination is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Walker Slough	**Pollutants/Stressors**	Pathogens
Hydrologic Unit	544.00	**Sources**	Urban runoff, Recreation
Total Waterbody Size	2 Miles	**TMDL Priority**	
Size Affected	2 Miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	Walker Slough	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	37° 54' 57"	**Upstream Extent Longitude**	121° 16' 31"
Downstream Extent Latitude	37° 54' 57"	**Downstream Extent Longitude**	121° 18' 03"

Watershed Characteristics

Walker Slough is located in the Delta and extends between French Camp Slough and Duck Creek. The area is highly urbanized and supports recreational uses, including boating, fishing, water skiing and swimming. The Delta is characterized by tidal waters with limited flushing flows during the dry seasons.

Water Quality Objectives Not Attained

The narrative objective for toxicity is not being attained for pathogens in Walker Slough. The narrative toxicity objective in the Basin Plan states, in part, "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life." The narrative toxicity objective further states the " the Regional Water Board will also consider...numerical criteria and guidelines developed by the State Water Board, the California Office of Environmental Health Hazard Assessment, the California Department of Health Services...the U.S. Environmental Protection Agency, and other organizations to evaluate compliance with this objective." The Basin Plan also contains a specific objective for fecal coliform bacteria (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/rwqcb5/bsnplnab.pdf).

Guidelines and criteria have been developed for the protection of human health. The California Department of Health Services (CDHS) has adopted a total coliform bacteria guideline, applicable to recreational waters and beaches, of 10,000 Most Probable Number (MPN) per 100 milliliters for single samples and of 1,000 MPN per 100 ml for 30-day log mean of sample levels (Title 17 California Code of Regulation section 7958). CDHS has also published draft guidelines that include limits for single samples of *E. coli* of 235 MPN per 100 milliliters (CDHS, July 2000 http://www.dhs.ca.gov/ps/ddwem/beaches/freshwater.htm). USEPA guidelines for bacteria are contained in *Ambient Water Quality Criteria for Bacteria* (USEPA, 1986a). The USEPA standards are stated as "Based on a statistically sufficient number of samples (generally not less than 5 samples equally spaced over a 30-day period), the geometric mean of the indicated bacterial densities should not exceed one or the other of the following: *E. coli* 126 MPN per 100 ml; or Enterococci 33 MPN per 100 ml." A methodology for determining exceedances based on single samples is also included in the standards.

Evidence of Impairment

DeltaKeeper submitted bacteria data for Walker Slough from two sampling locations (Jennings, 2001). Fourteen samples were collected from each location during six months in 2000-2001 and analyzed for *E. coli*. Geometric means of the bacteria counts have been calculated using the data submitted by DeltaKeeper. The calculated geometric mean for *E. coli* in samples collected from the downstream location is 506 MPN per 100 ml, which exceeds the USEPA criterion of 126 MPN per 100 ml. The calculated geometric mean for *E. coli* in samples collected from the upstream location is 1,182 MPN per 100 ml, which also exceeds the USEPA criterion.

Extent of Impairment

Regional Board staff recommends listing the portion of Walker Slough that occurs between French Camp Slough and Duck Creek as impaired for pathogens due to bacterial contamination. The sampling locations are within the urban Stockton area. The area around the entire slough is urbanized and has similar land use patterns. It is expected that samples collected from other portions of Walker Slough would show similar high levels of *E. coli*.

Potential Sources

In urban settings, the USEPA has identified sources of pathogen pollution to include urban litter, contaminated refuse, domestic pet and wildlife excrement and failing sewer lines (USEPA, 2001a). In their pathogen TMDL Guide, the USEPA states "In a study of bacterial loading in urban streams, Young and Thackston (1999) found that fecal bacteria densities were directly related to the density of housing, population, development, percent impervious area, and domestic animal density. Additionally, recreational areas may have high bacteria counts. This can be due to improper disposal of waste from boats, lack of sanitary facilities in the area of recreation and children in diapers using the water."

B.1.53 Wolf Creek, Fecal Coliform

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region, (Regional Board) recommends the addition of Wolf Creek to California's Clean Water Act Section 303(d) list due to impairment by fecal coliform. Information available to the Regional Board on pathogens levels in Wolf Creek indicates that water quality objectives are not being attained. A description for the basis for this determination is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Wolf Creek	Pollutants/Stressors	Fecal Coliform
Hydrologic Unit	516.30	**Sources**	Urban runoff, Recreation, Agriculture
Total Waterbody Size	14.5 miles	**TMDL Priority**	
Size Affected	14.5 miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	All of Wolf Creek	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	39° 12' 56"	**Upstream Extent Longitude**	121° 04' 00"
Downstream Extent Latitude	39° 02' 03"	**Downstream Extent Longitude**	121° 07' 51"

Watershed Characteristics

The Wolf Creek watershed is located in the Sierra Nevada foothills. Wolf Creek runs through the urban area of Grass Valley. The Grass Valley Wastewater Treatment Plant (GVWTP) discharges into Wolf Creek below Grass Valley. Downstream from Grass Valley, the Wolf Creek watershed consists of low-density housing that typically has some associated livestock.

Water Quality Objectives Not Attained

The numeric objective for bacteria is not being attained in Wolf Creek. The bacteria objective in the Basin Plan states, in part, "In waters designated for contact recreation (REC-1), the fecal coliform concentration based on a minimum of not less than five samples for any 30-day period shall not exceed a geometric mean of 200/100 ml, nor shall more than ten percent of the total number of samples taken during any 30-day period exceed 400 /100 ml (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/~rwqcb5/bsnplnab.pdf)." The bacteria objectives are presented in terms of Most Probable Number (MPN) per 100 milliliters (ml). The bacteria objectives were evaluated for Wolf Creek by comparing fecal coliform concentrations measured in Wolf Creek to Basin Plan objectives.

Guidelines and criteria have been developed for the protection of human health. The California Department of Health Services (CDHS) has adopted total coliform bacteria guidelines, applicable to recreational waters and beaches, of 10,000 MPN/100 ml for single samples and of 1,000 MPN/ml for 30-day log means of sample levels (Title 17 California Code of Regulation section 7958). CDHS has also published draft guidelines that include a limit for *E. coli* in single samples of 235 MPN/100 ml (CDHS, July 2000 http://www.dhs.ca.gov/ps/ddwem/beaches/freshwater.htm). The USEPA (USEPA) guidelines for bacteria, contained in *Ambient Water Quality Criteria for Bacteria* (USEPA, 1986a), are stated as "Based on a statistically sufficient number of samples (generally not less than 5 samples equally spaced over a 30-day period), the geometric mean of the indicated bacterial densities should not exceed one or the other of the following: *E. coli* 126 MPN per 100 ml; or Enterococci 33 MPN per 100 ml." A methodology for determining exceedances based on single samples is also included in the standards.

Evidence of Impairment
Waste discharge reports and Regional Board inspection sampling results show elevated coliform levels upstream and downstream of the GVWTP (City of Grass Valley, 2000 and 2001). Geometric means were calculated from 18 sample dates during February 2000 to June 2001. Calculated geometric means for total coliform of 1,491 MPN/100 ml (upstream of the GVWTP) and 1,014 MPN/100 ml (downstream of the GVWTP), exceeding the CDHS recommended criteria of 1,000 MPN/100 ml total coliform. The calculated geometric mean for fecal coliform for samples collected upstream of the GVWTP of 238 MPN/100 ml exceeds the Basin Plan Fecal Coliform objective of 200 MPN/100 ml. The calculated geometric mean for fecal coliform for samples collected downstream of the GVWTP is 102 MPN/100 ml. The fecal coliform counts in seven of 18 monthly samples exceeded the 200 MPN/100 ml fecal coliform criterion and reached 2,300 MPN/100 ml in February 2000 (City of Grass Valley, 2000 and 2001).

Extent of Impairment
Regional Boards staff recommends that the entire Wolf Creek be listed for fecal coliform. Although only the upper reach of Wolf Creek has been monitored for coliform, land use in the lower reach is essentially the same. There are no stream segments that would be likely to have substantially lower pathogen loads.

Potential Sources
In urban settings, the USEPA has identified sources of pathogen pollution to include urban litter, contaminated refuse, domestic pet and wildlife excrement and failing sewer lines (USEPA, 2001a). In their pathogen TMDL Guide, the USEPA states "In a study of bacterial loading in urban streams, Young and Thackston (1999) found that fecal bacteria densities were directly related to the density of housing, population, development, percent impervious area, and domestic animal density.." The TMDL Guide also states "Storm water runoff from urban watersheds might also be a significant source of pathogens, delivering pathogens present in the waste of domestic pets and wildlife and in litter. On-site wastewater systems (septic tanks, cesspools) that are poorly installed, faulty, improperly located, or are in close proximity to waterbodies are potential sources of human pathogens to surface and ground waters...Rural storm water runoff can transport significant loads of bacteria and pathogens from livestock pastures, livestock and poultry feeding facilities, and feedlots. Livestock areas with high concentrations of animal waste contribute pathogens primarily through surface runoff...Wildlife can also contribute pathogen loadings and may be particularly important in the transmission of the protozoan pathogens *Giardia lamblia* and *Cryptosporidium*. Wildlife of concern includes deer, beaver, ducks, and geese. In urban or suburban areas, large populations of deer can provide a significant source of pathogens."

DeltaKeeper

A PROJECT OF SAN FRANCISCO BAYKEEPER

14 May 2001

Mr. Jerry Bruns
Chief, Standards, Policies, and Special Studies Section
Mr. Joe Karkoski
303(d) List Update Coordinator
Central Valley Regional Water Quality Control Board
3443 Routier Road, Suite A
Sacramento, CA 95827-3003

RE: DeltaKeeper Comments on Section 303(d) List Update.

Dear Messrs. Bruns and Karkoski:

Thank you for the opportunity to provide information to support the update of the Section 303(d) List as required by the federal Clean Water Act. These comments are submitted on behalf of DeltaKeeper, WaterKeepers Northern California and the California Sportfishing Protection Alliance. (hereinafter "DeltaKeeper"). DeltaKeeper appreciates the considerable work that staff has accomplished in updating the list of waterbodies that will fail to meet water quality standards even if point sources are regulated.

1. The San Francisco-Sacramento-San Joaquin Bay Delta Estuary has been described as one of the most "invaded" estuaries in the world with respect to introduction of exotic, non-native species. During the last 303(d) update, the San Francisco Regional Board listed San Francisco Bay as impaired because of exotic species. Non-native species are considered a "pollutant" under the federal Clean Water Act. Clearly, the Sacramento-San Joaquin Delta should be listed as impaired, because of exotic species, on the 303(d) list. We reference: Nonindigenous Aquatic Species in a United States Estuary; A Case Study of the Biological Invasions of the San Francisco Bay and Delta; A Report for the United States Fish and Wildlife Service; Andrew N. Cohen and James T. Carlton; 1995. We also reference a number of articles in the Interagency Ecological Program for the Sacramento-San Joaquin Delta Newsletter including: Vol. 13 No. 4, Freshwater Invasion of *Euryemora affinis* and Vol. 13, No. 3, Reproduction in the Chinese Mitten Crabs; Vol. 13, No. 1, Recent Historical Evidence of Centrachid Increases and Tule Perch Decrease in the Delta (p. 23) and Examining the Relative Predation Risks of Juvenile Chinook Salmon in Shallow Habit: The Effect of Submerged Aquatic Vegetation (p. 57); Vol. 12 No. 2, Long-term Trends in Mysid

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Shrimp and Zooplankton; Vol. 12, No. 4, Fall 1999, More Non-indigenous Species? First Records of one Amphipod and Two Isopods in the Delta: Vol. 12, No. 1, What is the Impact of the Introduced Brazilian Waterweed *Egeria densa* to the Delta Ecosystem?; Vol. 10. No 3, neomysis/Zooplankton Abundance; Vol. 10, No. 1, Chinese Mitten Crabs in the Delta; Vol. 9, No. 4, Invasion of the Estuary by Oriental and European Crabs.

2. Recent monitoring has increased our understanding of the magnitude and extent of mercury impairment. The following waterbodies should be added to the list as impaired because of mercury: Consumes River, Mokelumne River, Calaveras River, San Joaquin River, Stanislaus River, Merced River, Tuolumne River, Mud Slough, Lindsey Slough, Minor Slough, Sacramento Ship Channel. We reference 1) Delta Wetlands Restoration and the Mercury Question: Year 2 Findings of the CALFED UC Davis Delta Mercury Study by Darell G. Slotton, Thomas H. Suchanek, and Shaun M. Ayers as reported in IEP Newsletter, Vol. 13, No. 4, Fall 2000 and 2) Contaminant Concentrations in Fish from the Sacramento-San Joaquin Delta and Lower San Joaquin River by Jay A. Davis and Michael D. May, San Francisco Estuary Institute, 1998.

Lake Englebright, Scotts Flat Reservoir, Rollins Reservoir, Lake Combie, Camp Far West Reservoir, and the South Yuba River, Deer Creek and Bear River should be added as impaired because of mercury contamination based on mercury concentrations in fish tissue. We reference; Mercury Bioaccumulation in Fish in a Region Affected by Historic Gold Mining: The South Yuba River, Deer Creek, and Bear River Watersheds, California, 1999 by Jason T. May, Roger L. Hothem, Charles N. Alpers and Matthew A. Law, USGS Open File Report 00-367.

Black Butte Reservoir should be listed as impaired because of mercury contamination based on concentrations in fish tissue. We reference: a) Prevalence of Selected Target Chemical Contaminants in Sport Fish From Two California Lakes: Public health Designed Screening Study, Final Project Report, by Robert K. Brodberg and Gerald A. Pollock, June 1999, Pesticide and Environmental Toxicology Section, Office of Environmental Health Hazard Assessment, Cal. EPA and the Draft Evaluation of Potential Health Effects of eating Fish From Black Butte Reservoir (Glenn and Tehama Counties) and b) Guidelines For Sport Fish Consumption, Pesticide and Environmental Toxicology Section, Office of Environmental Health Hazard Assessment, Cal. EPA.

3. Concentrations of Dieldrin in fish caught in the Sacramento River exceed screening values that led to consumption advisories in San Francisco Bay. Consequently, the Sacramento River should be listed as impaired because of Dieldrin. We reference: Contaminant Concentrations in Fish from the Sacramento-San Joaquin Delta and Lower San Joaquin River by Jay A. Davis and Michael D. May, San Francisco Estuary Institute, 1998.

4. Significant PCB contamination exceeding values that led to consumption advisories in San Francisco Bay has been identified in the Sacramento River, North and South Delta, and Smith

Canal. Extremely high concentrations of PCBs have been documented in Smith Canal. Accordingly, these waterbodies should be listed as impaired. We reference: Contaminant Concentrations in Fish from the Sacramento-San Joaquin Delta and Lower San Joaquin River by Jay A. Davis and Michael D. May, San Francisco Estuary Institute, 1998.

5. Over the last five years, DeltaKeeper has continued monitoring Stockton area waterways following storms. This monitoring continued a Regional Board investigation of urban runoff in 1994-95. Accordingly, the Calaveras River, Smith Canal, Mormon Slough and French Camp Slough should be added as impaired because of diazinon and chlorpyrifos. We reference: Review of the City of Stockton Urban Stormwater Runoff Aquatic Life Toxicity Studies Conducted by the CVRWQCB, DeltaKeeper and the University of California, Davis, Aquatic Toxicology Laboratory between 1994 and 2000 by G. Fred Lee, PhD, DEE and Anne Jones-Lee, PhD, April 2001. This report is attached to these comments.

6. Over the last five years, DeltaKeeper has monitored Stockton area waterways following storms. The data demonstrates that severe, prolonged dissolved oxygen sags occur in local waterways after rainfall. DeltaKeeper staff and volunteers have been trained by CVRWQCB and SWRCB staff and DeltaKeeper's QA/QC has been approved by the SWRCB. Accordingly, Mosher Slough, Five-Mile Slough, the Calaveras River, Smith Canal, Mormon Slough and French Camp Slough should be listed as impaired because of low dissolved oxygen caused by urban runoff. We reference: Dissolved Oxygen Depletion in the Stockton Sloughs, Report prepared for DeltaKeeper by G. Fred Lee & Associates, August 2000. Additional data collected in the Fall of 2000 by DeltaKeeper. This information is attached to these comments. We also reference: Stockton Fish Kills Associated With Urban Storm Runoff: The Role Of Low Dissolved Oxygen, a report prepared for the Regional Water Quality Control Board, June 1998, by Valerie Connor (Regional Board) and Karen Larsen, Kristy Cortright, Pacienca Young, Linda Deanovic and David Hinton (UCD) and Application of Stockton's Water Quality Model to Evaluate Stormwater Impact on Smith Canal, a report prepared for the City of Stockton by Carl W. Chen, Wangteng Tsai, Systech Engineering, February 1999. The Regional Board has a copy of these reports.

7. Over the last year, DeltaKeeper has been monitoring bacteria levels (total coliform and *e-coli*) in local waterways and throughout the Delta. DeltaKeeper staff was trained by USEPA (Richmond Laboratory). Staff and volunteers have been trained by SWRCB staff. CVRWQCB and SWRCB staff have joined DeltaKeeper on several collection trips. SWRCB staff, at the request of CVRWQCB staff, analyzed DeltaKeeper data, collection and analytical methods. Data was found to be acceptable and conservative. Results demonstrate routine exceedance of Region 5 Basin Plan standards, USEPA Ambient Water Quality Criteria for Bacteria, USEPA Great Lakes Freshwater Standard, the California Code of Regulations and proposed bacteria standards by the California Department of Health Services. The data are attached to these comments. Accordingly, Mosher

Slough, Five-Mile Slough, Calaveras River, Smith Canal, Mormon Slough, French Camp Slough, Lower San Joaquin River and Delta waterways should be listed as impaired because of bacteria.

8. Review of the Summary Statistics for Monitoring Data: SRWP, USGS NAWQA, Sacramento River CMP and City of Redding contained in Appendix F of the 1998-99 Annual Monitoring Report of the Sacramento River Watershed Program reveals that copper, lead, zinc, arsenic, nickel, cadmium, turbidity, phosphorus, giardia, iron, manganese, sodium and specific conductance exceed relevant criteria. The Regional Board has a copy of this report.

a. Copper: The Sacramento watershed monitoring data shows that maximum ambient concentration of total copper is 14.5 μg/l. The minimum hardness of the river is 19 mg/l at Freeport. Based on this hardness value, the acute and chronic criteria for copper are 2.8 μg/l and 2.2 μg/l, respectively. These differences become even more significant when compared to ambient concentrations of dissolved metals. The ambient concentration of dissolved copper exceeds both the acute and chronic copper criterion. The Sacramento River has no remaining assimilative capacity for copper - dissolved or total.

b. Lead: The Sacramento watershed monitoring data reveals that the maximum ambient concentration of total lead is 3.0 μg/l and dissolved lead is 0.5 μg/l. The minimum river hardness is 19 mg/l at Freeport. The chronic aquatic life criteria for lead at this hardness value is 0.4 μg/l. The Sacramento River has no remaining assimilative capacity for lead - dissolved or total.

c. Zinc: The Sacramento River monitoring data shows that the maximum ambient concentration of total zinc is 29 μg/l at Freeport (and 52 μg/l at River Mile 44). Dissolved zinc has been reported as high as 27 μg/l. At 19 mg/l hardness, the acute and chronic criteria for zinc are both 29.0 μg/l. These differences become significant when compared to the ambient concentrations of dissolved zinc which, at 27 μg/l, almost exceeds both the acute and chronic criterion of 29 μg/l. Considering that Regional Board studies have established that copper and zinc are additive, there is no question that zinc is present at toxic levels.

d. Arsenic: The Sacramento watershed monitoring data reports that dissolved arsenic concentration at Freeport has been as high as 2.0 μg/l and total arsenic has been found at 3.6 μg/l. Total arsenic is reported as high as 3.07 μg/l at River Mile 44. Arsenic is a bioaccumulative compound and it is inappropriate to adjust to percent dissolved. Arsenic at Freeport and River Mile 44 exceeds the USEPA Integrated Risk Information System (IRIS) Reference Dose as a Drinking Water Level of 2.1 μg/l and various one-in-a-million criteria including; the Cal/EPA Cancer Potency Factor as a Drinking Water Level of 0.023 μg/l, the USEPA IRIS of 0.02 μg/l and the USEPA Drinking Water Health Advisory or SNARL of 0.02 μg/l. The Sacramento River is clearly impaired because of arsenic.

e. Nickel: The Sacramento watershed monitoring data shows that total nickel was detected at Freeport at 18 µg/l and at River Mile 44 at 17 µg/l. Using the EPA conversion factor of 0.998 and a hardness value of 19 mg/l, nickel exceeds the chronic aquatic life criteria.

f. Cadmium: The Sacramento watershed monitoring data reports total cadmium as high as 0.35 µg/l at Freeport and 0.37 µg/l at River Mile 44. Dissolved cadmium concentrations are reported at 0.04 µg/l at both Freeport and River Mile 44, These concentrations exceed the Cal/EPA Cancer Potency Factor as a Drinking Water Level of 0.023 µg/l.

g. Turbidity: The Sacramento watershed monitoring data shows that turbidity of 45.2 NTU at Freeport and 53.4 at River Mile 44 exceed the California Department of Health Services Secondary MCL of 5 NTU and the USEPA Primary MCL of 1.0/0.5/0.3 NTU.

h. Phosphorus: The Sacramento watershed monitoring data demonstrates that phosphorus concentrations at Freeport of 0.21 mg/l (210 µg/l) and 1.09 mg/l (1,090 µg/l) at River Mile 44 exceed the USEPA Integrated Risk Information System (IRIS) Reference Dose as a Drinking Water Level of 0.14 µg/l and the USEPA Drinking Water Health Advisory or Suggested No-Adverse-Response Level (SNARL) for toxicity other than cancer risk of 0.1 µg/l.

i. Giardia. The Sacramento watershed monitoring data shows that concentrations of giardia at Freeport ranged between 9.3 and 30.6 cysts/100 L. We suspect this is above levels that are identified as causing impairment.

j. Coliform: The Sacramento watershed monitoring data shows that total coliform in the American River at Discovery Park exceeds both the fecal and total coliform criteria.

k. Iron and Manganese: The Sacramento watershed monitoring data shows that iron in Arcade Creek of 360 µg/l exceeds the Secondary MCL for iron. Concentrations of dissolved manganese at 106 µg/l exceed the Secondary MCL of 50 µg/l.

l. Sodium: The Sacramento watershed monitoring data shows sodium concentrations at Freeport as high as 11.0 mg/l (11000 µg/l). This concentration exceeds the USEPA Drinking Water Health Advisory or Suggested No-Adverse-Response Level (SNARL) for toxicity other than cancer risk of 2000 µg/l. Indeed, almost all of the monitored waterways (Yuba, Feather Arcade Creek, etc.) exceeded sodium at even the 50th or 75 median percentile.

m. Specific Conductance: Sacramento watershed monitoring shows that Colusa Basin Drain levels of EC ranged as high as 765 µmhos/cm (90th percentile of 714 µmhos/cm) These exceed the agricultural water quality goal of 700 µmhos/cm.

9. Review of the City of Stockton's Ambient Water Quality Monitoring Program on the San Joaquin River (Bowman Road, above the POTW) reveals that copper, lead, arsenic, turbidity, phosphorus, ammonia, coliform and conductivity exceed relevant criteria. Minimum river hardness is 38 mg/l. The Regional Board has a copy of this data.

a. Copper: Total copper concentrations ranged as high as 7.2 µg/l. Other copper concentrations were 7.0 µg/l, 6.4 µg/l, 5.4 µg/l, and 4.5 µg/l. At a hardness of 40 mg/l, the chronic criteria is 4.1 µg/l and the acute criteria is 5.7 µg/l. In fact, in July 1995, the ambient concentration of copper was 7 µg/l at a hardness of 38 mg/l. Using the conversion factor contain in the California Toxics Rule and the State Implementation Plan, the copper concentration exceeds both acute and chronic aquatic life criteria. Consequently, the San Joaquin River has no remaining assimilative capacity for copper.

b. Arsenic: Total arsenic concentrations ranged as high as 4.4 µg/l with other reported levels of 3.7 µg/l and 3.0 µg/l. Arsenic is a bioaccumulative compound and it is inappropriate to adjust to percent dissolved. Arsenic in the San Joaquin River exceeds the USEPA Integrated Risk Information System (IRIS) Reference Dose as a Drinking Water Level of 2.1 µg/l and various one-in-a-million criteria including; the Cal/EPA Cancer Potency Factor as a Drinking Water Level of 0.023 µg/l , the USEPA IRIS of 0.02 µg/l and the USEPA Drinking Water Health Advisory or SNARL of 0.02 µg/l. The San Joaquin River is clearly impaired because of arsenic.

c. Lead: Total lead concentrations ranged as high as 3.5 µg/l. Other lead concentrations are reported at 1.4 µg/l, 1.3 µg/l and 1.2 µg/l. The chronic aquatic life criteria for lead is at a hardness of 40 mg/l is 0.92 µg/l. The San Joaquin River is clearly impaired because of chronic concentrations of lead.

d. Bis (2-ethylhexyl) phthalate: Concentrations of bis (2-ethylhexyl) phthalate were found at 15 µg/l and 23 µg/l. The California Primary MCL is 4 µg/l. The USEPA Primary MCL is 6 µg/l. Various one-in-a-million criteria including; the Cal/EPA Cancer Potency Factor as a Drinking Water Level of 12 µg/l , the USEPA IRIS of 3 µg/l and the USEPA Drinking Water Health Advisory or SNARL of 3 µg/l were exceeded. The San Joaquin River is imparied because of bis (2-ethylhexyl) phthalate.

e. Phosphorus. Total phosphorus concentrations were as high as .39 mg/l (390 µg/l) and .37 mg/l (370 µg/l). Dissolved phosphorus concentrations were as high as 0.29 mg/l (290 µg/l). These exceed the USEPA Integrated Risk Information System (IRIS) Reference Dose as a Drinking Water Level of 0.14 µg/l and the USEPA Drinking Water Health Advisory or Suggested No-Adverse-Response Level (SNARL) for toxicity other than cancer risk of 0.1 µg/l.

f. Conductivity: EC levels at Bowman Road ranged as high as 821 mg/l, 828 mg/l and 1026 mg/l. The specific conductance agricultural goal is 700. We identify EC because it has been suggested that EC impairment on the San Joaquin River doesn't extend to Stockton.

g. Turbidity: Turbidity is reported as 57, 42, 45, 39, etc. Units are reported as mg/l. Frankly, we are not sure how this translates to NTUs, but suspect the turbidity criteria is exceeded.

h. Ammonia: Ammonia was found as high as 1.8 mg/l. San Joaquin River temperatures have been reported as high as 28 C (82.4 F). The pH has been reported as high as 8.22. The San Joaquin River has a reasonable potential to exceed the chronic aquatic life criteria for ammonia.

i. Coliform: As our attached data on total coliform concentrations demonstrates, the river exceeds the criteria for total coliform.

10. The American River (Sacramento County), San Joaquin River, Tuolumne River and Merced River should be listed for simazine. We reference Water Woes; An Analysis of Pesticide Concentrations in California Surface Water by Teresa M. Olle, Stephan Orme and Brad Heavner, California Public Interest Research Group and Pesticide Action Network, 2000. The report was based on an analysis of the Department of Pesticide Regulation's Surface Water Database. Simazine interacts synergistically with OP pesticides and these waterways are already listed for diazinon. The Regional Board has a copy of this report.

11. Avena Drain: Avena Drain receives stormwater runoff and illegal dumping of dairy wastes. Regional Board files are pregnant with data on EC and ammonia concentrations in Avena Drain (check with Louie Pratt). We have attached coliform data showing that the Drain is impaired because of coliform. We have also attached a number of field parameter monitoring data sheets that demonstrate that EC levels are regularly above criteria. Avena Drain must be identified as impaired because EC and coliform concentrations caused by discharges dairy wastes.

12. The Mokelumne River should be listed for unknown toxicity. In 1991-1992 Val Connor (Regional Board staff) and Linda Deavonic (UCD) found unknown toxicity to fathead minnows during part of a Basin Metals Implementation Plan project. That information was report in 1994. More recently, DeltaKeeper found unknown toxicity to fathead minnows during a CalFed funded study of toxicity in the Delta (Sacramento-San Joaquin Delta Toxicity Test Monitoring Report:1998-99. The Final Report For DeltaKeeper by the Aquatic Toxicology Laboratory, University California, Davis). The Regional Board has both of these reports.

During low water cycles, resuspension events in Camanche Reservoir cause high concentrations of metals and turbidity to be discharged into the Lower Mokelumne River. While much has been accomplished in eliminating the major (but not the only) source of metals to Camanche Reservoir, a heavy metal sink behind Camanche Dam remains. The Mokelumne River listings for copper and zinc should be maintained. In addition, the river should be listed for aluminum, cadmium, low dissolved oxygen, turbidity and temperature. During an eight day evidentiary hearing by the State Water Resources Control Board in 1992, East Bay Municipal Utility District was required to provide data on metals sampling in the Mokelumne River. We are including that data, a report on Mokelumne River water quality by State Board staff and the USFWS final briefing document to that hearing. We also reference DFG's Lower Mokelumne River Fisheries Management Plan that is at the Regional Board.

13. Inexplicably, the Pitt River is the only river in the entire Central Valley identified as impaired because of temperature. Yet, inadequate temperature, caused by altered flow regimes and increased loading of high temperature, has been identified as one of the major reasons for the decline of fisheries throughout the Central Valley. Data on inadequate temperatures can be found in numerous documents including, but not limited to; the CalFed EIR/EIS, the Restoration Plan for the Anadromous Fish Restoration Program of the Central Valley Project Improvement Act, the DFG's Lower Mokelumne River Fisheries Management Plan (November 1991), the State Water Board's Bay-Delta Hearing, Mokelumne River and Yuba River Hearing records and various EIR/EISs conducted by the Federal Energy Regulatory Commission including those on the Tuolumne, Mokelumne, Yuba and Feather rivers. Additional evidence can be found in the findings of various Regional Board issued NPDES permits.

For example; the CalFed EIR/EIS states that the mainstem of the San Joaquin River between the Merced River confluence and Vernalis in the fall and spring often exceed stressful or lethal levels for upstream and downstream migrating fall-run chinook salmon. When the Vernalis flow is 5,000 cfs or less in May, water temperatures are at levels of chronic stress. Increased water temperature is identified as one of principal causes of declining chinook salmon populations in the San Joaquin River in the September 1998 EIR/EIS titled Meeting Flow Objectives for the San Joaquin River Agreement 1999-2010 (VAMP Agreement). The City of Stockton's Ambient Water Quality Monitoring Program on the San Joaquin River (in Regional Board files) shows that temperatures during the September migration of chinook salmon reach 74.3 F (23.5 C).

The CalFed EIR/EIS states that "[i]n late April and May, stream temperature often exceeds stressful levels for emigrating smolts (Merced River)" and "[r]esults of the stream temperature modeling study indicate that in May, and at times in late April, smolts emigrating from the Tuolumne River encounter stressful or lethal water temperatures... new schedules will not ease temperature problems,... especially in the lower portion of the river..." and that flows in the Stanislaus River "... exceed critical temperatures for salmon spawning and egg incubation.."

The CalFed EIR/EIS states that in the American River, temperatures in summer and fall are often "above 70 F." With respect to the Sacramento River, the CalFed EIR/EIS observes that high temperatures "cause the loss of many adult salmon and eggs spawned in the river." For Delta channels, the CalFed EIR/EIS observes that "[d]uring spring and fall, Delta channels are used by anadromous fish for migrating between rivers and the Pacific Ocean and are used as rearing areas as well Untimely high water temperatures stress migrating fish by delaying their movement or by causing mortality."

Finding No. 32 of the Sacramento Regional Wastewater Treatment Facility NPDES permit states that "[s]tudies by the National Marine Fisheries Service and the U.S. Bureau of Reclamation have identified the Sacramento Chinook Salmon as a species that is affected by elevated temperatures in the Sacramento River. There are adults and juveniles in portions of the River every month of the year. Juvenile salmon show signs of adverse effects at River temperatures of 65 F. Migration of adults is usually delayed when River temperatures reach 70 F. At 72 F, adult mortality may occur." The February 1998 Thermal Plan Compliance Report by Sacramento Regional County Sanitation District (part of the hearing record) shows that the Sacramento River exceeds 65 F: 49.2% of the time between April-June, 99.9% of the time between July-August and 38.6% of the time between September-November. The report shows that the River exceeds 69 F; 24.5% of the time between April-June, 92.8% of the time between July-August and 18.5% of the time between September-November.

State Water Board Decision 1644, Decision Regarding Protection of Fishery Resources and Other Issues Relating to Diversion and Use of Water From the Lower Yuba River, conclusively establishes that the Yuba River exceeds criteria for temperature. Indeed, the State Board decision states that "[t]he SWRCB recognizes that compliance with requirements to provide suitable water temperatures year-round for all lifestages of chinook salmon and steelhead is not feasible in the lower Yuba River." The Yuba River must be listed as impaired because of temperature to ensure that additional loadings of high temperature do not occur.

Waterbodies that have been identified as having temperatures above acute or stressful levels include, but are not limited to: the San Joaquin River, Stanislaus River, Merced River, Tuolumne River, Calaveras River, Mokelumne River, Bear River, Sacramento River, Yuba River, Feather River, Colusa Basin Drain, American River, Clear Creek and Deer Creek.

During previous 303(d) List updates, Regional Board staff have made only minimal effort to identify waterways impaired by temperature. In previous 303(d) update submittals, resource agencies have identified numerous waterways as impaired because of high temperatures. Virtually all Central Valley waterways below major impoundments are identified Critical Habitat for species listed pursuant to state and federal Endangered Species Acts. Virtually all of these same waterways are identified as having temperatures above levels that are protective of salmonids. Regional Board staff can no longer ignore the enormous degradation cause by excessive temperatures. They must make a concerted effort to identify and list temperature impaired waterways.

14. There are several other waterways that have been identified as impaired during development of NPDES permits. Deer Creek (tributary to the Consumes River) is impaired because of coliform and temperature (see Richard McHenry). Morrison Creek (Sacramento) is impaired because of temperature (see Patricia Leary).

Thank you for this opportunity to comment on the revised 303(d) list update. If you have any questions regarding these comments, please feel free to contact me (209) 464-5090.

Sincerely,

Bill Jennings

29-Aug-00	Paradise Point Marina	**>2,419.2**	79.8
03-Oct-00	Paradise Point Marina	**1,313**	0
07-Aug-00	Pock lane	**>2419.2**	103.9
12-Oct-00	Potato Slough	658.00	0
08-Jun-00	S.J. River at Beach	**>2419.2**	14.8
09-Jun-00	S.J. River at Beach	**>2419.2**	24
11-Sep-00	S.J. River at Beach	**>2419.2**	7.4
30-Nov-00	S.J.R. at Navy Drive	**15,530.70**	**1,723.00**
14-Nov-00	Sacramento R. at Rio Vista Boat Launch	689	3.1
17-Nov-00	San Joaquin River at French Camp Slough	**1,301.00**	20
27-Apr-00	Smith @ I-5	**1413.6**	49.6
10-May-00	Smith @ I-5	**>2419.2**	**727**
06-Jun-00	Smith @ I-5	**>2419.2**	58.3
08-Jun-00	Smith @ I-5	**>2419.2**	57.3
09-Jun-00	Smith @ I-5	**>2419.2**	43.9
21-Jun-00	Smith @ I-5	960.6	44.8
06-Jul-00	Smith @ I-5	**>2419.2**	**285.1**
28-Jul-00	Smith @ I-5	**>2419.2**	86
07-Aug-00	Smith @ I-5	**>2419.2**	43.2
05-Sep-00	Smith @ I-5	**>2419.2**	117.8
10-May-00	Smith @ Pershing	**>2419.2**	**1732.87**
11-Oct-00	Smith @ Pershing	**>48,384**	**34,657.40**
30-Oct-00	Smith @ Pershing	**>120,960**	**6,980**
27-Apr-00	Smith at Yosemite	**1553.07**	49.6
07-Aug-00	Smith at Yosemite	**>2419.2**	**261.3**
14-Aug-00	Smith at Yosemite	**>2419.2**	**410.6**
18-Aug-00	Smith at Yosemite	**>2419.2**	**240**
22-Aug-00	Smith at Yosemite	**>2419.2**	98.8
28-Aug-00	Smith at Yosemite	**>2419.2**	**435.2**
20-Sep-00	Smith at Yosemite	**>2419**	**93**
20-Sep-00	Smith at Yosemite	**>2419.2**	**172.3**
29-Sep-00	Smith at Yosemite	**7,270**	**185**
04-Oct-00	Smith at Yosemite	**4611**	**432**
10-Oct-00	Smith at Yosemite	**>24,192.0**	**12,033.10**
11-Nov-00	Smith at Yosemite	**>24,192.0**	**4,611.00**
21-Nov-00	Smith at Yosemite	**6,867**	**495**
21-Nov-00	Smith at Yosemite	**17,329**	**612**
22-Nov-00	Smith at Yosemite	**>24,192.0**	**2,098.00**
28-Nov-00	Smith at Yosemite	**6,488.00**	41
06-Dec-00	Smith at Yosemite	**>24,192.**	**250**
14-Nov-00	South Fork Mokelumne At Westgate Landing	228	0
14-Nov-00	Sycamore at Guard Rd.	**2,098.00**	**146**
15-Aug-00	Telephone Cut	**>2419.2**	23.1

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Site	Date	Collect time	Sample ID	Start Temp	Start Time	Start Date	End Temp	End Time	End Date	Ratio	Large Wells Total	Small Wells Total	MPN Total	Large Wells E coli	Small Wells E coli	MPN E coli	Northing	Westing
2				Listing of Blanks that were run along with the samples															
3	Blank	10-Jan-00	13:00	COL100101BLNK-MB1	35.00	13:00	10-Jan-00	35.00	8:45	11-Jan-00	20:1	0	0	<20	0	0	<20		
4	Blank	11-Jan-00	17:00	COL110101BLNK-MB1	34.50	17:30	11-Jan-00	34.50	13:30	12-Jan-00	10:1	0	0	<10	0	0	<10		
5	Blank	12-Jan-00	10:45	COL120101BLNK-MB1	35.00	11:30	12-Jan-00	35.00	7:15	13-Jan-01	20:1	0	0	<20	0	0	<20		
6	Blank	23-Oct-00	10:50	COL231000BLNK-MB1	35.00	15:35	23-Oct-00	35.60	13:30	24-Oct-00	10:1	0	0	<10	0	0	<10		
7	Blank	30-Oct-00	16:45	COL301000BLNK-MB1	35.00	16:45	30-Oct-00	35.00	13:00	31-Oct-00	1:1	0	0	<1	0	0	<1		
8	Blank	02-Nov-00	11:25	COL021100BLNK-SH1	35.00	12:25	02-Nov-00	34.50	9:00	03-Nov-00	10:1	0	0	<10	0	0	<10		
9	Blank	07-Nov-00	13:00	COL071100BLNK-MB1	35.00	15:00	07-Nov-00	35.00	13:00	08-Nov-00	10:1	0	0	<10	0	0	<10		
10	Blank	09-Nov-00	12:50	COL091100BLNK-SH1	35.00	14:30	09-Nov-00	35.00	9:30	10-Nov-00	10:1	0	0	<10	0	0	<10		
11	Blank	10-Nov-00	12:00	COL101100BLNK-MB1	35.00	13:00	10-Nov-00	34.50	9:15	11-Nov-00	10:1	0	0	<10	0	0	<10		
12	Blank	11-Nov-00	10:44	COL111100BLNK-MB1	34.00	12:00	11-Nov-00	35.00	8:00	12-Nov-00	10:1	0	0	<10	0	0	<10		
13	Blank	14-Nov-00	12:45	COL141100BLNK-MB1	35.00	13:35	14-Nov-00	35.00	9:30	15-Nov-00	10:1	0	0	<10	0	0	<10		
14	Blank	15-Nov-00	11:20	COL151100BLNK-MB1	35.00	12:30	15-Nov-00	35.00	8:15	16-Nov-00	50:1	0	0	<50	0	0	<50		
15	Blank	16-Nov-00	10:30	COL161100BLNK-SH1	35.00	13:40	16-Nov-00	35.00	9:30	17-Nov-00	10:1	0	0	<10	0	0	<10		
16	Blank	20-Nov-00	10:45	COL201100BLNK-MB1	35.00	12:15	20-Nov-00	35.00	8:00	21-Nov-00	10:1	0	0	<10	0	0	<10		
17	Blank	21-Nov-00	10:25	COL211100BLNK-SH1	35.00	13:05	21-Nov-00	35.00	9:05	22-Nov-00	10:1	0	0	<10	0	0	<10		
18	Blank	22-Nov-00	10:40	COL221100BLNK-MB1	35.00	12:05	22-Nov-00	35.00	8:05	23-Nov-00	10:1	0	0	<10	0	0	<10		
19	Blank	28-Nov-00	11:30	COL281100BLNK-MB1	36.00	14:20	28-Nov-00	35.00	10:20	29-Nov-00	10:1	0	0	<10	0	0	<10		
20	Blank	30-Nov-00	14:00	DAB301100BLNK-MB1	35.00	14:45	30-Nov-00	35.00	10:45	01-Dec-00	10:1	0	0	<10	0	0	<10		
21	Blank	05-Dec-00	15:50	COL051200BLNK-MB1	35.00	16:45	05-Dec-00	35.00	12:45	06-Dec-00	10:1	0	0	<10	0	0	<10		
22	Blank	06-Dec-00	14:50	COL061200BLNK-MB1	35.00	15:30	06-Dec-00	35.00	11:30	07-Dec-00	10:1	0	0	<10	0	0	<10		
23	Blank	08-Jan-01	15:05	COL080101BLNK-MB1	35.00	16:10	08-Jan-01	35.00	12:00	09-Jan-01	10:1	0	0	<10	0	0	<10		
24	Blank	24-Jan-01	13:10	COL240101BLNK-MB1	35.00	14:00	24-Jan-01	35.00	9:30	25-Jan-01	10:1	0	0	<10	0	0	<10		
25	Blank	25-Jan-01	11:40	COL250101BLNK-MB1	35.00	13:20	25-Jan-01	35.00	9:00	26-Jan-01	10:1	0	0	<10	0	0	<10		
26	Blank	27-Jan-01	11:45	COL270101BLNK-MB1	34.00	12:00	27-Jan-01	35.00	8:00	28-Jan-01	10:1	0	0	<10	0	0	<10		
27	Blank	10-Feb-01	12:45	COL100201BINK-LC1	35.00	14:20	10-Feb-01	35.00	10:20	11-Feb-01	20:1	0	0	<20	0	0	<20		
28	Blank	11-Feb-01	13:20	COL110201BLNK-LC1	35.00	14:00	11-Feb-01	35.00	10:00	12-Feb-01	20:1	0	0	<20	0	0	<20		
29	Blank	02-Mar-01	15:38	COL020201BLNK-LC1	35.00	16:30	02-Mar-01	35.00	13:00	03-Mar-01	20:1	0	0	<20	0	0	<20		
30	Blank	14-Mar-01	15:15	COL140301BLNK-LC1	35.00	15:40	14-Mar-01	35.00	9:50	15-Mar-01	20:1	0	0	<20	0	0	<20		
31	Blank	20-Mar-01	12:40	COL200301BLNK-LC1	35.00	12:45	20-Mar-01	35.00	10:30	21-Mar-01	10:1	0	0	<20	0	0	<20		
32	Blank	26-Mar-01	13:30	COL260301BLNK-LC1	35.00	17:30	26-Mar-01	35.00	13:30	27-Mar-01	20:1	0	0	<20	0	0	<20		
33	Blank	12-Apr-01	13:25	COL120401BLNK-LC1	35.00	17:00	12-Apr-01	35.00	13:00	13-Apr-01	20:1	0	0	<1	0	0	<1		
34	Blank	21-Apr-01	15:50	COL210401BLNK-LC1	35.00	16:30	21-Apr-01	35.00	12:30	22-Apr-01	20:1	0	0	<20	0	0	<20		
35	Blank @ Turner Cut	21-Mar-01	11:00	COL210301BLNK-LC1	35.00	13:30	21-Mar-01	35.00	10:30	22-Mar-01	20:1	0	0	<20	0	0	<20		
36																			

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Site	Date	Collect Time	Sample ID	Start Temp	Start Time	Start Date	End Temp	End Time	End Date	Ratio	Large Wells Total	Small Wells Total	MPN Total	Large Wells E coli	Small Wells E coli	MPN E coli	Northing	Westing
37				List of Urban Sites around Stockton, CA															
38	Calaveras River @ DeltaKeeper's Dock	12-Apr-00	15:49	COL120400CLVR-SF	35.00	16:00	12-Apr-00	35.00	10:00	13-Apr-00	1:1	49	32	686.7	21	9	38.6		
39	Calaveras River @ DeltaKeeper's Dock	26-Apr-00	9:30	COL260400CLVR-RK	36.00	15:09	26-Apr-00	35.00	9:21	27-Apr-00	1:1	49	48	>2419.2	48	12	193.5		
40	Calaveras River @ DeltaKeeper's Dock	27-Apr-00	9:40	COL270400CLVR-RK	35.00	11:50	27-Apr-00	35.00	8:20	28-Apr-00	1:1	49	46	1986.28	9	1	10.1		
41	Calaveras River @ DeltaKeeper's Dock	10-May-00	18:00	COL100500CLVR-RK	35.00	18:20	10-May-00	35.00	14:30	11-May-00	1:1	49	48	>2419.2	31	3	51.2		
42	Calaveras River @ DeltaKeeper's Dock	24-May-00	10:49	COL240500CLVR-RK	36.00	11:15	24-May-00	35.50	8:30	25-May-00	1:1	49	48	>2419.2	49	15	261.3		
43	Calaveras River @ DeltaKeeper's Dock	01-Jun-00	11:10	COL010600CLVR-RK	35.00	11:30	01-Jun-00	35.00	7:10	02-Jun-00	1:1	49	48	>2419.2	31	11	65.1		
44	Calaveras River @ DeltaKeeper's Dock	21-Jun-00	15:15	COL210600CLVR-JF1	35.00	15:30	21-Jun-00	35.00	10:00	22-Jun-00	1:1	49	48	>2419.2	29	3	46.6		
45	Calaveras River @ DeltaKeeper's Dock	28-Jul-00	12:00	COL280700CLVR-JL1	35.00	12:30	28-Jul-00	35.00	9:30	29-Jul-00	1:1	49	48	>2419.2	24	5	75.3		
46	Calaveras River @ DeltaKeeper's Dock	18-Aug-00	14:49	COL180800CLVR-MB	35.00	15:00	18-Aug-00	35.00	11:30	19-Aug-00	1:1	49	48	>2419.2	21	0	26.5		
47	Calaveras River @ DeltaKeeper's Dock	12-Sep-00	11:20	COL120900CLVR-MB1	36.00	11:35	12-Sep-00	35.50	9:30	13-Sep-00	1:1	49	48	>2419.2	31	3	51.2		
48	Calaveras River @ DeltaKeeper's Dock	03-Oct-00	12:38	COL031000CLVR-MB1	35.00	13:52	03-Oct-00	34.50	10:00	04-Oct-00	10:1	47	17	2063	7	2	96	37*58.134'	121*21.337'
49	Calaveras River @ UOP footbridge	14-Aug-00	11:52	COL140800CLVR-JF1	35.50	13:40	14-Aug-00	35.00	9:40	15-Aug-00	1:1	49	48	>2419.2	42	8	107.6	37*58.884	121*18.841'
50	Calaveras River @ UOP footbridge	22-Aug-00	14:11	COL220800CLVR-JL	35.00	16:00	22-Aug-00	34.60	13:00	23-Aug-00	1:1	49	48	>2419.2	47	17	206.3		
51	Calaveras River @ UOP footbridge	28-Aug-00	11:40	COL280800CLVR-MB1	34.50	13:15	28-Aug-00	35.50	9:15	29-Aug-00	1:1	49	48	>2419.2	48	22	298.7		
52	Calaveras River @ UOP footbridge	20-Sep-00	10:55	COL200900CLVR-MB1	36.00	14:00	20-Sep-00	35.00	11:00	21-Sep-00	1:1	49	48	>2419.2	40	10	98.5		
53	Calaveras River @ UOP footbridge	20-Sep-00	10:55	COL200900CLVR-MB	35.00	13:30	20-Sep-00	35.00	13:30	21-Sep-00	1:1	outside	lab	>2419.2	outside	lab	50		
54	Calaveras River @ UOP footbridge	04-Oct-00	11:55	COL041000CLVR-MB1	35.50	13:30	04-Oct-00	35.00	9:30	05-Oct-00	10:1	49	30	6131	9	1	109	37*58.883'	121*18.838'
55	Calaveras River @ UOP footbridge	11-Oct-00	10:00	COL111000CLVR-DW1	35.00	14:00	11-Oct-00	35.00	9:30	12-Oct-00	20:1	49	48	>48384	49	45	34657.4		
56	Calaveras River @ UOP footbridge	19-Oct-00	15:55	COL191000CLVR-MB1	35.50	17:20	19-Oct-00	35.00	15:30	20-Oct-00	10:1	49	41	12033.1	6	2	84	37*58.882'	121*18.839'
57	Calaveras River @ UOP footbridge	30-Oct-00	14:59	COL301000CLVR-LC1	35.00	16:45	30-Oct-00	35.00	13:00	31-Oct-00	50:1	49	48	>120960	37	14	4670	37*58.884'	121*18.845'
58	Calaveras River @ UOP footbridge	11-Nov-00	11:00	COL111100CLVR-MB1	34.00	12:00	11-Nov-00	35.00	8:00	12-Nov-00	10:1	49	37	9208	9	2	120	37*58.878'	121*18.835'
59	Calaveras River @ UOP footbridge	21-Nov-00	9:30	COL211100CLVR-SH2	35.00	13:00	21-Nov-00	35.00	9:00	22-Nov-00	10:1	49	30	6131	7	3	107	37*58.888'	121*18.843'
60	Calaveras River @ UOP footbridge	21-Nov-00	9:30	COL211100CLVR-SH1	35.00	13:05	21-Nov-00	35.00	9:05	22-Nov-00	10:1	49	33	7270	3	0	31	37*58.888'	121*18.843'
61	Calaveras River @ UOP footbridge	28-Nov-00	11:50	COL281100CLVR-SH1	36.00	14:20	28-Nov-00	35.00	10:20	29-Nov-00	10:1	49	46	19862.8	14	0	185	37*58.884'	121*18.842'
62	Calaveras River @ UOP footbridge	06-Dec-00	13:40	COL061200CLVR-MB1	35.00	15:30	06-Dec-00	35.00	11:30	07-Dec-00	10:1	42	6	988	1	0	10	37*58.881'	121*18.838'
63	Calaveras River @ UOP footbridge	08-Jan-01	14:10	COL080101CLVR-MB1	35.00	16:10	08-Jan-01	35.00	12:00	09-Jan-01	10:1	49	48	>24192	49	12	2249	37*58.880'	121*18.843'
64	Calaveras River @ UOP footbridge	11-Jan-01	16:15	COL110101CLVR-MB1	34.50	17:30	11-Jan-01	34.50	13:30	12-Jan-01	10:1	49	48	>24192	41	9	1014		
65	Calaveras River @ UOP footbridge	24-Jan-01	12:10	COL240101CLVR-MB1	35.00	14:00	24-Jan-01	35.00	9:30	25-Jan-01	10:1	49	48	>24192	44	34	2507	37*58.875'	121*18.838'
66	Calaveras River @ UOP footbridge	10-Feb-01	11:40	COL100201CLVR-LC1	35.00	14:20	10-Feb-01	35.00	10:20	11-Feb-01	20:1	49	48	>48384	31	3	1024		
67	Calaveras River @ UOP footbridge	11-Feb-01	12:05	COL110201CLVR-LC1	35.00	14:00	11-Feb-01	35.00	10:00	12-Feb-01	20:1	49	48	>48384	35	14	1694		
68	Calaveras River @ UOP footbridge	05-Mar-01	14:32	COL050301CLVR-LC1	35.00	17:30	05-Mar-01	35.00	15:00	06-Mar-01	20:1	49	46	39725.6	49	23	8212		
69	Calaveras River @ UOP footbridge	14-Mar-01	13:07	COL140301CLVR-LC1	35.00	15:40	14-Mar-01	35.00	9:50	15-Mar-01	20:1	27	5	900	2	0	40		
70	Calaveras River @ UOP footbridge	20-Mar-01	10:27	COL200301CLVR-LC1	35.00	12:45	20-Mar-01	35.00	10:30	21-Mar-01	10:1	49	17	2909	6	0	63		
71	Calaveras River @ UOP footbridge	26-Mar-01	14:12	COL260301CLVR-LC1	35.00	17:30	26-Mar-01	35.00	13:30	27-Mar-01	20:1	49	48	>48384	39	8	1768	37*58.885'	121*18.840'
72	Calaveras River @ UOP footbridge	12-Apr-01	9:30	COL120401CLVR-LC1	35.00	17:00	12-Apr-01	35.00	13:00	13-Apr-01	20:1	49	36	17328	4	1	104		
73	Calaveras River @ UOP footbridge	21-Apr-01	13:12	COL210401CLVR-LC1	35.00	16:30	21-Apr-01	35.00	12:30	22-Apr-01	20:1	49	48	48384	31	11	1302		
74	Calaveras River @ UOP footbridge	07-Aug-01	13:06	COL070800CLVR-JL1	35.00	15:38	07-Aug-01	35.00	12:00	08-Aug-00	1:1	49	48	>2419.2	40	9	95.9	37*58.877'	121*18.838'
75	Five-Mile Slough @ Alexandria	26-Apr-00	13:30	COL260400FVML-RK	36.00	15:09	26-Apr-00	35.00	9:21	27-Apr-00	1:1	49	47	2419.17	19	1	24.6		
76	Five-Mile Slough @ Alexandria	07-Aug-00	12:45	COL070800FVML-JL2	35.00	15:38	07-Aug-00	35.00	12:00	08-Aug-00	1:1	49	48	>2419.2	12	2	15.8	38*00.744'	121*20.399'
77	Five-Mile Slough @ Alexandria	02-Feb-01	13:26	COL020201FVML-LC1	35.00	16:30	02-Feb-01	35.00	13:00	03-Feb-01	20:1	49	30	12262	11	0	244		
78	Five-Mile Slough @ Plymouth	10-May-00	15:10	COL100500FVML-RK	35.00	15:30	10-May-00	35.00	14:30	11-May-00	1:1	49	48	>2419.2	48	27	378.4		
79	Five-Mile Slough @ Plymouth	07-Aug-00	12:28	COL070800FVML-JL1	35.00	15:38	07-Aug-00	35.50	12:00	08-Aug-00	1:1	49	47	2419.17	22	4	33.6	38*00.829'	121*21.159'
80	Five-Mile Slough @ Plymouth	14-Aug-00	11:29	COL140800FVML-JF1	35.50	13:40	14-Aug-00	35.00	9:40	15-Aug-00	1:1	49	48	>2419.2	30	2	47.1	38*00.830'	121*21.160'
81	Five-Mile Slough @ Plymouth	18-Aug-00	14:00	COL180800FVML-JL	35.50	15:00	18-Aug-00	35.50	11:30	19-Aug-00	1:1	49	48	>2419.2	5	0	5.2		
82	Five-Mile Slough @ Plymouth	22-Aug-00	13:50	COL220800FVML-JL	35.00	16:00	22-Aug-00	34.60	13:00	23-Aug-00	1:1	49	47	2419.17	7	4	7.4		
83	Five-Mile Slough @ Plymouth	28-Aug-00	11:15	COL280800FVML-MB1	34.50	13:00	28-Aug-00	35.00	9:15	29-Aug-00	1:1	49	48	>2419.2	34	4	61.3		
84	Five-Mile Slough @ Plymouth	20-Sep-00	10:25	COL200900FVML-MB1	36.00	14:00	20-Sep-00	35.00	11:00	21-Sep-00	1:1	49	48	>2419.2	9	1	10.9		
85	Five-Mile Slough @ Plymouth	04-Oct-00	11:25	COL041000FVML-MB1	35.00	13:30	04-Oct-00	35.00	9:30	05-Oct-00	10:1	49	48	>24192	0	0	<10	38*00.824'	121*21.178'
86	Five-Mile Slough @ Plymouth	10-Oct-00	16:30	COL101000FVML-MB1	35.50	17:10	10-Oct-00	35.00	13:10	11-Oct-00	10:1	49	48	>24192	49	40	11198.5		
87	Five-Mile Slough @ Plymouth	11-Oct-00	9:30	COL111000FVML-DW1	35.00	14:00	11-Oct-00	35.00	9:30	12-Oct-00	20:1	49	48	>48384	49	48	>48384	38*00.824'	121*21.234
88	Five-Mile Slough @ Plymouth	19-Oct-00	15:30	COL191000FVML-MB1	35.50	17:20	19-Oct-00	35.00	15:30	20-Oct-00	10:1	49	38	9804	15	3	211	38*00.823'	121*21.226'
89	Five-Mile Slough @ Plymouth	30-Oct-00	14:20	COL301000FVML-MB1	35.00	16:45	30-Oct-00	35.00	13:00	31-Oct-00	50:1	49	42	64982.5	13	2	855	38*00.826'	121*21.229'
90	Five-Mile Slough @ Plymouth	11-Nov-00	10:35	COL111100FVML-MB1	34.00	12:00	11-Nov-00	35.00	8:00	12-Nov-00	10:1	48	23	3130	2	0	20	38*00.824'	121*21.219'
91	Five-Mile Slough @ Plymouth	21-Nov-00	9:10	COL211100FVML-SH1	35.00	13:05	21-Nov-00	35.00	9:05	22-Nov-00	10:1	36	5	697	2	0	20	38*00.823'	121*21.234'

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Site	Date	Collect Time	Sample ID	Start Temp	Start Time	Start Date	End Temp	End Time	End Date	Ratio	Large Wells Total	Small Wells Total	MPN Total	Large Wells E. coli	Small Wells E. coli	MPN E. coli	Northing	Westing
92	Five-Mile Slough @ Plymouth	21-Nov-00	9:10	COL211100FVML-SH2	35.00	13:00	21-Nov-00	35.00	9:00	22-Nov-00	10:1	36	7	738	0	0	<10	38*00.823'	121*21.234'
93	Five-Mile Slough @ Plymouth	28-Nov-00	10:40	COL281100FVML-SH1	36.00	14:20	28-Nov-00	35.00	10:20	29-Nov-00	10:1	23	3	341	0	0	<10	38*00.821'	121*21.231'
94	Five-Mile Slough @ Plymouth	05-Dec-00	16:05	COL051200FVML-MB1	35.00	16:45	05-Dec-00	35.00	12:45	06-Dec-00	10:1	27	3	419	0	0	<10	38*00.825'	121*21.232'
95	Five-Mile Slough @ Plymouth	08-Jan-01	13:15	COL080101FVML-MB1	35.00	16:10	08-Jan-01	35.00	12:00	09-Jan-00	10:1	49	48	>24192	49	33	7270	38*00.819'	121*21.233'
96	Five-Mile Slough @ Plymouth	10-Jan-01	16:30	COL100101FVML-MB1	35.00	17:30	10-Jan-01	35.00	13:30	11-Jan-00	10:1	49	48	>24192	49	46	19862		
97	Five-Mile Slough @ Plymouth	24-Jan-01	11:45	COL240101FVML-MB1	35.00	14:00	24-Jan-01	35.00	9:30	25-Jan-01	10:1	49	48	>24192	24	7	416.0	38*00.826'	121*21.163'
98	Five-Mile Slough @ Plymouth	27-Jan-01	10:15	COL270101FVML-MB1	34.00	12:00	27-Jan-01	35.00	8:00	28-Jan-01	10:1	49	22	3873	12	1	146	38*00.829'	121*21.160'
99	Five-Mile Slough @ Plymouth	10-Feb-01	11:15	COL100201FVML-LC1	35.00	14:20	10-Feb-01	35.00	10:20	11-Feb-01	20:1	49	40	22397	9	0	196		
100	Five-Mile Slough @ Plymouth	11-Feb-01	11:45	COL110201FVML-LC1	35.00	14:00	11-Feb-01	35.00	10:00	12-Feb-01	20:1	49	42	15996	29	2	896		
101	Five-Mile Slough @ Plymouth	05-Mar-01	13:57	COL050301FVML-LC1	35.00	17:30	05-Mar-01	35.00	15:00	06-Mar-01	20:1	49	47	48383.4	24	2	34.5		
102	Five-Mile Slough @ Plymouth	14-Mar-01	12:34	COL140301FVML-LC1	35.00	15:40	14-Mar-01	35.00	9:50	15-Mar-01	20:1	49	37	18416	16	5	500		
103	Five-Mile Slough @ Plymouth	20-Mar-01	10:00	COL200301FVML-LC1	35.00	12:45	20-Mar-01	35.00	10:30	21-Mar-01	10:1	48	21	2851	1	0	10		
104	Five-Mile Slough @ Plymouth	26-Mar-01	13:40	COL260301FVML-LC1	35.00	17:30	26-Mar-01	35.00	13:30	27-Mar-01	20:1	49	48	>48384	43	10	2356		
105	Five-Mile Slough @ Plymouth	12-Apr-01	10:15	COL120401FVML-LC1	35.00	17:00	12-Apr-01	35.00	13:00	13-Apr-01	20:1	49	42	25993	2	2	82		
106	Five-Mile Slough @ Plymouth	21-Apr-01	12:31	COL210401FVML-LC1	35.00	16:30	21-Apr-01	35.00	12:30	22-Apr-01	20:1	49	48	48,384	41	14	2320		
107	McCleod Lake	24-Aug-00	10:22	COL240800MCCL-DW1	35.00	12:00	24-Aug-00	35.50	9:00	25-Aug-00	1:1	49	48	>2419.2	17	2	22.8		
108	McCLeod Lake	05-Oct-00	10:35	COL051000MCCL-SH1	35.00	12:00	05-Oct-00	35.00	9:15	06-Oct-00	10:1	47	10	1607	2	0	20	37*57.305	121*17.670
109	McCLeod Lake	19-Oct-00	11:35	COL191000MCCL-MB1	35.00	12:30	19-Oct-00	35.00	8:00	20-Oct-00	10:1	49	27	5172	8	0	86	37*57.326'	121*17.680'
110	McCLeod Lake	23-Oct-00	12:00	COL231000MCCL-MB1	35.00	15:35	23-Oct-00	35.60	13:30	24-Oct-00	10:1	49	47	24191.7	12	7	216	37*57.387	121*17.590'
111	McCLeod Lake	29-Oct-00	7:10	COL291000MCCL-MB1	35.00	7:40	29-Oct-00	35.00	5:20	30-Oct-00	50:1	49	48	>120960	30	5	2600		
112	McCLeod Lake	29-Oct-00	7:10	COL291000MCCL-MB2	35.00	7:40	29-Oct-00	35.00	5:20	30-Oct-00	50:1	49	48	>120960	32	6	2955		
113	McCLeod Lake	31-Oct-00	10:15	COL311000MCCL-SH1	35.00	13:00	31-Oct-00	35.00	10:40	01-Nov-00	50:1	49	48	>120960	30	2	2355	37*57.354'	121*17.579
114	McCLeod Lake	30-Nov-00	9:15	COL301100MCCL-MB1	35.00	11:50	30-Nov-00	35.00	9:00	01-Dec-00	10:1	49	34	7701	14	2	185	37*57.332'	121*17.572'
115	McCLeod Lake	02-Feb-01	14:20	COL020201MCCL-LC1	35.00	16:30	02-Feb-01	35.00	13:00	03-Feb-01	20:1	49	48	>48384	49	17	5818		
116	McCLeod Lake	07-Mar-01	10:20	COL070301MCCL-LC1	35.00	13:15	07-Mar-01	35.00	10:30	08-Mar-01	20:1	49	38	19608	28	1	790		
117	McCLeod Lake	15-Mar-01	12:20	COL150301MCCL-LC1	35.00	14:30	15-Mar-01	35.00	9:30	16-Mar-01	20:1	49	31	12976	5	0	104		
118	McCLeod Lake	22-Mar-01	11:00	COL220301MCCL-LC1	35.00	12:50	22-Mar-01	35.00	9:50	23-Mar-01	10:1	30	1	439	1	0	10		
119	McCLeod Lake	26-Mar-01	14:55	COL260301MCCL-LC1	35.00	17:30	26-Mar-01	35.00	13:30	27-Mar-01	20:1	49	48	>48384	43	11	2422	37*57.367	121*17.564'
120	McCLeod Lake	12-Apr-01	10:10	COL120401MCCL-LC1	35.00	17:00	12-Apr-01	35.00	13:00	13-Apr-01	20:1	49	30	12262	3	1	82		
121	Morelli Park	12-Oct-00	15:50	COL121000MRLL-MB1	35.00	17:30	12-Oct-00	35.00	13:30	13-Oct-00	20:1	49	48	>48384	49	44	31061.4	37*57.173'	121*18.386'
122	Morelli Park	13-Oct-00	12:00	COL131000MRLL-MB1	35.00	13:55	13-Oct-00	35.00	10:00	14-Oct-00	20:1	49	48	>48384	49	38	19608	37*57.181'	121*18.385'
123	Morelli Park	14-Oct-00	16:50	COL141000MRLL-MB1	35.00	17:20	14-Oct-00	35.00	14:45	15-Oct-00	20:1	49	47	48384	34	10	1456		
124	Morelli Park	15-Oct-00	9:30	COL151000MRLL-MB1	35.00	9:30	15-Oct-00	35.00	7:00	16-Oct-00	20:1	49	41	24066.2	27	4	870		
125	Morelli Park	17-Oct-00	16:30	COL171000MRLL-MB1	33.50	17:25	17-Oct-00	36.00	14:45	18-Oct-00	10:1	49	43	14136	21	1	278	37*57.183'	121*18.358'
126	Morelli Park	29-Oct-00	7:00	COL291000MRLL-MB1	35.00	7:40	29-Oct-00	35.00	5:20	30-Oct-00	50:1	49	48	>120960	29	3	2320		
127	Morelli Park	31-Oct-00	10:40	COL311000MRLL-SH1	35.00	13:00	31-Oct-00	35.00	10:40	01-Nov-00	50:1	49	17	14545	7	0	350	37*57.179'	121*18.388'
128	Morelli Park	10-Nov-00	11:45	COL101100MRLL-MB1	35.00	13:00	10-Nov-00	34.50	9:15	11-Nov-00	10:1	47	17	2063	5	0	52	37*57.143'	121*18.369'
129	Morelli Park	30-Nov-00	9:30	COL301100MRLL-MB1	35.00	11:50	30-Nov-00	35.00	9:00	01-Dec-00	10:1	29	5	496	4	0	41	37*57.184'	121*18.381'
130	Morelli Park	02-Feb-01	14:40	COL020201MRLL-MB1	35.00	16:30	02-Feb-01	35.00	13:00	03-Feb-01	20:1	49	10	4092	17	0	406		
131	Morelli Park	07-Feb-01	10:45	COL070201MRLL-LC1	35.00	13:15	07-Feb-01	35.00	10:30	08-Feb-01	20:1	49	19	6510	16	3	452		
132	Morelli Park	15-Mar-01	12:45	COL150301MRLL-LC1	35.00	14:30	15-Mar-01	35.00	9:30	16-Mar-01	20:1	27	6	930	3	0	62		
133	Morelli Park	22-Mar-01	10:30	COL220301MRLL-LC1	35.00	12:50	22-Mar-01	35.00	9:50	23-Mar-01	10:1	18	1	231	0	1	10		
134	Morelli Park	12-Apr-01	10:25	COL120401MRLL-LC1	35.00	17:00	12-Apr-01	35.00	13:00	13-Apr-01	20:1	49	19	6,510	3	0	62		
135	Mormon Slough @ Lincoln	06-Jun-00	10:55	COL060600MRMN-RK	36.00	11:30	06-Jun-00	35.50	9:30	07-Jun-00	1:1	49	48	>2419.2	17	1	21.6		
136	Mormon Slough @ Lincoln	08-Jun-00	10:42	COL080600MRMN-RK	35.00	11:45	08-Jun-00	35.00	9:00	09-Jun-00	1:1	49	48	>2419.2	24	2	34.5		
137	Mormon Slough @ Lincoln	09-Jun-00	10:55	COL090600MRMN-RK1	35.00	11:45	09-Jun-00	35.00	9:30	10-Jun-00	1:1	49	48	>2419.2	15	0	17.5		
138	Mormon Slough @ Lincoln	07-Aug-00	14:05	COL070800MRMN-JL1	35.00	15:38	07-Aug-00	35.00	12:00	08-Aug-00	1:1	49	48	>2419.2	21	10	40	37*56.862'	121*17.787'
139	Mormon Slough @ Lincoln	14-Aug-00	12:30	COL140800MRMN-JF1	35.50	13:40	14-Aug-00	35.00	9:40	15-Aug-00	1:1	49	48	>2419.2	49	20	344.8	37*56.862'	121*17.790'
140	Mormon Slough @ Lincoln	18-Aug-00	14:30	COL180800MRMN-JF	35.50	15:00	18-Aug-00	35.00	11:30	19-Aug-00	1:1	49	48	>2419.2	49	31	648.8		
141	Mormon Slough @ Lincoln	22-Aug-00	14:38	COL220800MRMN-JL	35.00	16:00	22-Aug-00	34.60	13:00	23-Aug-00	1:1	49	48	>2419.2	49	30	613.1		
142	Mormon Slough @ Lincoln	28-Aug-00	12:15	COL280800MRMN-LC1	34.50	13:15	28-Aug-00	35.00	9:15	29-Aug-00	1:1	49	48	>2419.2	49	19	325.5		
143	Mormon Slough @ Lincoln	20-Sep-00	11:45	COL200900MRMN-MB1	36.00	14:00	20-Sep-00	35.00	11:00	21-Sep-00	1:1	49	48	>2419.2	38	4	74.9		
144	Mormon Slough @ Lincoln	29-Sep-00	11:25	COL290900MRMN-MB1	35.00	12:20	29-Sep-00	35.00	8:06	30-Sep-00	10:1	49	46	19862.8	31	5	546		
145	Mormon Slough @ Lincoln	04-Oct-00	12:30	COL041000MRMN-MB1	35.50	13:30	04-Oct-00	35.00	9:30	05-Oct-00	10:1	49	36	8664	14	0	161	37*56.869'	121*17.794'
146	Mormon Slough @ Lincoln	11-Oct-00	10:40	COL111000MRMN-DW1	35.00	14:00	11-Oct-00	35.00	9:30	12-Oct-00	20:1	49	48	>48384	49	48	>48384	37*56.872'	121*17.789'

1	Site	Date	Collect time	Sample ID	Start Temp	Start Time	Start Date	End Temp	End Time	End Date	Ratio	Large Wells Total	Small Wells Total	MPN total	Large Wells E. coli	Small Wells E. coli	MPN E. coli	Northing	Westing
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
147	Mormon Slough @ Lincoln	19-Oct-00	16:25	COL191000MRMN-MB1	35.50	17:20	19-Oct-00	35.00	15:30	20-Oct-00	10:1	49	48	>24192	40	10	9850	37*56.862'	121*17.788'
148	Mormon Slough @ Lincoln	30-Oct-00	15:43	COL301000MRMN-MB1	35.00	16:45	30-Oct-00	35.00	13:00	31-Oct-00	50:1	49	48	>120,960	49	35	40820	37*56.865'	121*17.785'
149	Mormon Slough @ Lincoln	11-Nov-00	11:20	COL111100MRMN-MB1	34.00	12:00	11-Nov-00	35.00	8:00	12-Nov-00	10:1	49	46	19862.8	35	3	624	37*56.861'	121*17.792'
150	Mormon Slough @ Lincoln	21-Nov-00	10:10	COL211100MRMN-SH1	35.00	13:05	21-Nov-00	35.00	9:05	22-Nov-00	10:1	49	29	5794	13	1	160	37*56.862'	121*17.790'
151	Mormon Slough @ Lincoln	21-Nov-00	10:10	COL211100MRMN-SH2	35.00	13:00	21-Nov-00	35.00	9:00	22-Nov-00	10:1	49	28	5475	11	3	156	37*56.862'	121*17.790'
152	Mormon Slough @ Lincoln	22-Nov-00	10:35	COL221100MRMN-MB1	35.00	12:05	22-Nov-00	35.00	8:05	23-Nov-00	10:1	49	48	>24192	49	48	>24192	37*56.865'	121*17.791'
153	Mormon Slough @ Lincoln	06-Dec-00	14:30	COL061200MRMN-MB1	35.00	15:30	06-Dec-00	35.00	11:30	07-Dec-00	10:1	45	15	1576	12	1	146	37*56.861'	121*17.784'
154	Mormon Slough @ Lincoln	08-Jan-01	14:45	COL080101MRMN-MB1	35.00	16:10	08-Jan-01	35.00	12:00	09-Jan-01	10:1	49	48	>24192	49	35	8164	37*56.863'	121*17.784'
155	Mormon Slough @ Lincoln	11-Jan-01	16:40	COL110101MRMN-MB1	34.50	17:30	11-Jan-01	34.50	13:30	12-Jan-01	10:1	49	48	>24192	49	28	5475		
156	Mormon Slough @ Lincoln	24-Jan-01	12:45	COL240101MRMN-MB1	35.00	14:00	24-Jan-01	35.00	9:30	25-Jan-01	10:1	49	48	>24192	49	31	6488	37*56.865'	121*17.791'
157	Mormon Slough @ Lincoln	02-Feb-01	14:55	COL020201MRMN-LC1	35.00	16:30	02-Feb-01	35.00	13:00	03-Feb-01	20:1	49	48	>48384	49	43	28272		
158	Mormon Slough @ Lincoln	10-Feb-01	12:35	COL100201MRMN-LC1	35.00	14:20	10-Feb-01	35.00	10:20	11-Feb-01	20:1	49	48	>48384	49	13	4718		
159	Mormon Slough @ Lincoln	11-Feb-01	13:00	COL110201MRMN-LC1	35.00	14:00	11-Feb-01	35.00	10:00	12-Feb-01	20:1	49	48	>48384	48	23	6260		
160	Mormon Slough @ Lincoln	05-Mar-01	15:23	COL050301MRMN-LC1	35.00	17:30	05-Mar-01	35.00	15:00	06-Mar-01	20:1	49	48	>48384	49	30	12262		
161	Mormon Slough @ Lincoln	14-Mar-01	13:51	COL140301MRMN-LC1	35.00	15:40	14-Mar-01	35.00	9:50	15-Mar-01	20:1	49	43	28272	49	15	5226		
162	Mormon Slough @ Lincoln	20-Mar-01	11:05	COL200301MRMN-LC1	35.00	12:45	20-Mar-01	35.00	10:30	21-Mar-01	10:1	49	38	9804	47	11	1664		
163	Mormon Slough @ Lincoln	26-Mar-01	15:13	COL260301MRMN-LC1	35.00	17:30	26-Mar-01	35.00	13:30	27-Mar-01	20:1	49	48	>48384	49	32	13734		
164	Mormon Slough @ Lincoln	12-Apr-01	10:45	COL120401MRMN-LC1	35.00	17:00	12-Apr-01	35.00	13:00	13-Apr-01	20:1	49	48	48,384	19	6	623		
165	Mormon Slough @ Lincoln	21-Apr-01	13:55	COL210401MRMN-LC1	35.00	16:30	21-Apr-01	35.00	12:30	22-Apr-01	20:1	49	48	48,384	49	48	48384		
166	Mosher Slough @ Kelley Dr.	08-May-00	14:30	COL080500MSHR-RK	36.00	15:30	08-May-00	35.50	13:30	09-May-00	1:1	49	48	>2419.2	49	41	236.1		
167	Mosher Slough @ Kelley Dr.	24-May-00	14:45	COL240500MSHR-RK	35.50	15:15	24-May-00	35.50	10:30	25-May-00	1:1	49	48	>2419.2	49	24	435.2		
168	Mosher Slough @ Kelley Dr.	07-Aug-00	12:11	COL070800MSHR-LC1	35.00	15:38	07-Aug-00	35.00	12:00	08-Aug-00	1:1	49	48	>2419.2	45	9	131.3	38*01.954'	121*21.811'
169	Mosher Slough @ Kelley Dr.	14-Aug-00	11:13	COL140800MSHR-JF1	35.50	13:40	14-Aug-00	35.00	11:40	15-Aug-00	1:1	49	48	>2419.2	49	26	488.4	38*01.953'	121*21.809'
170	Mosher Slough @ Kelley Dr.	18-Aug-00	13:50	COL180800MSHR-JL	35.50	15:00	18-Aug-00	35.00	11:30	19-Aug-00	1:1	49	48	>2419.2	43	17	143		
171	Mosher Slough @ Kelley Dr.	22-Aug-00	13:39	COL220800MSHR-JL	35.00	16:00	22-Aug-00	34.60	13:00	23-Aug-00	1:1	49	48	>2419.2	43	13	124.6		
172	Mosher Slough @ Kelley Dr.	28-Aug-00	11:57	COL280800MSHR-LC1	34.50	13:15	28-Aug-00	35.00	9:15	29-Aug-00	1:1	49	48	>2419.2	49	16	275.5		
173	Mosher Slough @ Kelley Dr.	20-Sep-00	10:00	COL200900MSHR-MB1	36.00	14:00	20-Sep-00	35.00	11:00	21-Sep-00	1:1	49	48	>2419.2	49	31	648.8		
174	Mosher Slough @ Kelley Dr.	04-Oct-00	11:05	COL041000MSHR-MB1	35.50	13:30	04-Oct-00	35.00	9:30	05-Oct-00	10:1	49	44	15530.7	24	0	317	38*01.952'	121*21.812'
175	Mosher Slough @ Kelley Dr.	19-Oct-00	15:10	COL191000MSHR-MB1	35.50	17:20	19-Oct-00	35.00	15:30	20-Oct-00	10:1	49	42	12996.5	24	4	373	38*01.954'	121*21.806'
176	Mosher Slough @ Kelley Dr.	11-Nov-00	10:25	COL111100MSHR-MB1	34.00	12:00	11-Nov-00	35.00	8:00	12-Nov-00	10:1	49	48	>24192	15	1	187	38*01.952'	121*21.774'
177	Mosher Slough @ Kelley Dr.	21-Nov-00	8:50	COL211100MSHR-SH1	35.00	13:05	21-Nov-00	35.00	9:05	22-Nov-00	10:1	44	16	1497	14	5	221	38*01.950'	121*21.810'
178	Mosher Slough @ Kelley Dr.	21-Nov-00	8:50	COL211100MSHR-SH2	35.00	13:00	21-Nov-00	35.00	9:00	22-Nov-00	10:1	49	15	2613	10	2	132	38*01.950'	121*21.810'
179	Mosher Slough @ Kelley Dr.	22-Nov-00	9:50	COL221100MSHR-MB1	35.00	12:05	22-Nov-00	35.00	8:05	23-Nov-00	10:1	49	48	>24192	49	48	>24192	38*01.954'	121*21.809'
180	Mosher Slough @ Kelley Dr.	28-Nov-00	11:20	COL281100MSHR-SH1	36.00	14:20	28-Nov-00	35.00	10:20	29-Nov-00	10:1	48	10	1789	7	1	85	38*01.958'	121*21.808'
181	Mosher Slough @ Kelley Dr.	05-Dec-00	15:45	COL051200MSHR-MB1	35.00	16:45	05-Dec-00	35.00	12:45	06-Dec-00	10:1	45	16	1624	9	1	109	38*01.951'	121*21.807'
182	Mosher Slough @ Kelley Dr.	08-Jan-01	13:00	COL080101MSHR-MB1	35.00	16:10	08-Jan-01	35.00	12:00	09-Jan-01	10:1	49	48	>24192	49	23	4106	38*01.953'	121*21.808'
183	Mosher Slough @ Kelley Dr.	11-Jan-01	15:55	COL110101MSHR-MB1	34.50	17:30	11-Jan-01	34.50	13:30	12-Jan-01	10:1	49	48	>24192	49	28	3968	38*01.953'	121*21.810'
184	Mosher Slough @ Kelley Dr.	24-Jan-01	11:30	COL240101MSHR-MB1	35.00	14:00	24-Jan-01	35.00	9:30	25-Jan-01	10:1	48	48	10111	47	24	2700	38*01.950'	121*21.804'
185	Mosher Slough @ Kelley Dr.	10-Feb-01	11:00	COL100201MSHR-LC1	35.00	14:20	10-Feb-01	35.00	10:20	11-Feb-01	20:1	49	48	>48384	41	8	1974		
186	Mosher Slough @ Kelley Dr.	11-Feb-01	11:30	COL110201MSHR-LC1	35.00	14:00	11-Feb-01	35.00	10:00	12-Feb-01	20:1	49	48	>48384	42	3	2402		
187	Mosher Slough @ Mariner's Dr.	11-Oct-00	9:10	COL111000MSHR-DW1	35.00	14:00	11-Oct-00	35.00	9:30	12-Oct-00	20:1	49	48	>48384	49	47	>48383.	38*01.951'	121*21.889'
188	Mosher Slough @ Mariner's Dr.	30-Oct-00	13:32	COL301000MSHR-LC1	35.00	16:45	30-Oct-00	35.00	13:00	31-Oct-00	50:1	49	48	>120960	34	9	3540	38*01.951'	121*21.889'
189	Mosher Slough @ Mariner's Dr.	05-Mar-01	13:38	COL050301MSHR-LC1	35.00	17:30	05-Mar-01	35.00	15:00	06-Mar-01	20:1	49	48	>48384	49	31	12976		
190	Mosher Slough @ Mariner's Dr.	14-Mar-01	11:58	COL140301MSHR-LC1	35.00	15:40	14-Mar-01	35.00	9:50	15-Mar-01	20:1	44	9	2446	1	0	20		
191	Mosher Slough @ Mariner's Dr.	20-Mar-01	9:40	COL200301MSHR-LC1	35.00	12:45	20-Mar-01	35.00	10:30	21-Mar-01	10:1	49	31	6488	16	6	262		
192	Mosher Slough @ Mariner's Dr.	26-Mar-01	13:10	COL260301MSHR-LC1	35.00	17:30	26-Mar-01	35.00	13:30	27-Mar-01	20:1	49	48	>48384	49	48	>48384	38*01.953'	121*21.886'
193	Mosher Slough @ Mariner's Dr.	12-Apr-01	10:28	COL120401MSHR-LC1	35.00	17:00	12-Apr-01	35.00	13:00	13-Apr-01	20:1	49	48	>48384	30	8	1142		
194	Mosher Slough @ Mariner's Dr.	21-Apr-01	12:02	COL210401MSHR-LC1	35.00	16:30	21-Apr-01	35.00	12:30	22-Apr-01	20:1	49	48	>48384	49	27	10344		
195	Mosher Slugh @ Sandman Park	09-May-00	15:30	COL090500MSHR-RK	35.50	16:00	09-May-00	35.00	13:30	10-May-00	1:1	49	48	>2419.2	49	24	435.2		
196	Mosher Slugh @ Sandman Park	12-Jun-00	15:30	COL120600MSHR-RK	35.00	14:00	12-Jun-00	35.00	12:45	13-Jun-00	1:1	49	48	>2419.2	48	17	238.2		
197	Smith Canal @ I-5	27-Apr-00	10:55	COL270400SMTH-RK2	35.00	11:50	27-Apr-00	35.50	8:20	28-Apr-00	1:1	49	43	1413.6	29	5	49.6		
198	Smith Canal @ I-5	10-May-00	16:30	COL100500SMTH-RK1	35.00	18:20	10-May-00	35.00	14:30	11-May-00	1:1	49	48	>2419.2	49	33	727		
199	Smith Canal @ I-5	06-Jun-00	10:35	COL060600SMTH-RK1	36.00	11:30	06-Jun-00	35.50	9:30	07-Jun-00	1:1	49	48	>2419.2	33	4	58.3		
200	Smith Canal @ I-5	08-Jun-00	10:10	COL080600SMTH-RK1	35.00	11:45	08-Jun-00	35.50	9:00	09-Jun-00	1:1	49	48	>2419.2	32	5	57.3		
201	Smith Canal @ I-5	09-Jun-00	10:15	COL090600SMTH-RK1	35.00	11:45	09-Jun-00	35.50	9:30	10-Jun-00	1:1	49	48	>2419.2	30	1	43.9		

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Site	Date	Collect Time	Sample ID	Start Temp	Start Time	Start Date	End Temp	End Time	End Date	Ratio	Large Wells Total	Small Wells Total	MPN Total	Large Wells E. coli	Small Wells E. coli	MPN E. coli	Northing	Westing
202	Smith Canal @ I-5	21-Jun-00	12:30	COL210600SMTH-JF1	35.50	14:00	21-Jun-00	35.00	10:00	22-Jun-00	1:1	48	47	960.6	29	2	44.8		
203	Smith Canal @ I-5	06-Jul-00	10:35	COL060700SMTH-JF	35.00	12:00	06-Jul-00	35.00	9:45	07-Jul-00	1:1	49	48	>2419.2	48	21	285.1		
204	Smith Canal @ I-5	28-Jul-00	11:30	COL280700SMTH-JL1	35.00	12:30	28-Jul-00	35.00	9:30	29-Jul-00	1:1	49	48	>2419.2	39	7	86		
205	Smith Canal @ I-5	07-Aug-00	13:49	COL070900SMTH-JL1	35.00	15:38	07-Aug-00	35.50	12:00	08-Aug-00	1:1	49	48	>2419.2	29	1	43.2	37*57.635'	121*20.105'
206	Smith Canal @ I-5	05-Sep-00	11:20	COL050900SMTH-MB1	35.00	12:00	05-Sep-00	35.00	9:10	06-Sep-00	1:1	49	48	>2419.2	43	10	117.8		
207	Smith Canal @ Pershing Ave.	10-May-00	17:00	COL100500SMTH-RK2	35.00	18:20	10-May-00	35.50	14:30	11-May-00	1:1	49	48	>2419.2	49	45	1732.87		
208	Smith Canal @ Pershing Ave.	11-Oct-00	10:20	COL111000SMTH-DW1	35.00	14:00	11-Oct-00	35.00	9:30	12-Oct-00	20:1	49	48	>48,384	48	45	34657.4	37*57.981'	121*18.826'
209	Smith Canal @ Pershing Ave.	30-Oct-00	15:26	COL301000SMTH-MB1	35.00	16:45	30-Oct-00	35.00	12:45	31-Oct-00	50:1	49	48	>120960	45	11	6980	37*57.980'	121*18.827
210	Smith Canal @ Pershing Ave.	02-Feb-01	13:55	COL020201SMTH-LC1	35.00	16:30	02-Feb-01	35.00	13:00	03-Feb-01	20:1	49	48	>48384.0	48	10	3578		
211	Smith Canal @ Yosemite Lake	27-Apr-00	10:45	COL270400SMTH-RK1	35.00	11:50	27-Apr-00	35.50	8:20	28-Apr-00	1:1	49	44	1553.07	29	5	49.6		
212	Smith Canal @ Yosemite Lake	08-Jul-00	12:11	COL140800SMTH-LC1	35.50	13:40	08-Jul-00	35.50	11:00	08-Aug-00	1:1	49	48	>2419.2	49	23	410.6	37*58.078	121*18.078
213	Smith Canal @ Yosemite Lake	07-Aug-00	13:22	COL070800SMTH-JL1	35.00	15:38	07-Aug-00	35.50	12:00	08-Aug-00	1:1	49	48	>2419.2	49	15	261.3	37*58.067	121*18.406'
214	Smith Canal @ Yosemite Lake	18-Aug-00	14:15	COL180800SMTH-JF	35.50	15:00	18-Aug-00	35.50	11:30	19-Aug-00	1:1	49	48	>2419.2	47	21	240		
215	Smith Canal @ Yosemite Lake	22-Aug-00	14:24	COL220800SMTH-JL	35.00	16:00	22-Aug-00	34.60	13:00	23-Aug-00	1:1	49	48	>2419.2	42	5	98.8		
216	Smith Canal @ Yosemite Lake	28-Aug-00	11:55	COL280800SMTH-LC1	34.50	13:15	28-Aug-00	35.00	9:15	29-Aug-00	1:1	49	48	>2419.2	49	24	435.2		
217	Smith Canal @ Yosemite Lake	20-Sep-00	11:10	COL200900SMTH-MB1	36.00	14:00	20-Sep-00	35.00	11:00	21-Sep-00	1:1	49	48	>2419.2	47	12	172.3		
218	Smith Canal @ Yosemite Lake	29-Sep-00	11:45	COL290900SMTH-MB1	35.00	12:20	29-Sep-00	35.00	8:06	30-Sep-00	10:1	49	33	7270	14	2	185		
219	Smith Canal @ Yosemite Lake	04-Oct-00	12:10	COL041000SMTH-MB1	35.50	13:30	04-Oct-00	35.00	9:30	05-Oct-00	10:1	49	25	4611	29	1	432	37*58.077'	121*18.422'
220	Smith Canal @ Yosemite Lake	10-Oct-00	15:45	COL101000SMTH-MB1	35.50	17:10	10-Oct-00	35.00	13:10	11-Oct-00	10:1	49	48	>24192	49	41	12033.1		
221	Smith Canal @ Yosemite Lake	19-Oct-00	16:10	COL191000SMTH-MB1	35.50	17:20	19-Oct-00	35.00	15:30	20-Oct-00	10:1	49	47	24191.7	46	13	1616	37*58.077'	121*18.414'
222	Smith Canal @ Yosemite Lake	11-Nov-00	11:10	COL111100SMTH-MB1	34.00	12:00	11-Nov-00	35.00	8:00	12-Nov-00	10:1	49	48	>24,192.	49	25	4611	37*58.077'	121*18.416'
223	Smith Canal @ Yosemite Lake	21-Nov-00	9:55	COL211100SMTH-SH2	35.00	13:00	21-Nov-00	35.00	9:00	22-Nov-00	10:1	49	45	17329	29	12	612	37*58.079'	121*18.418'
224	Smith Canal @ Yosemite Lake	21-Nov-00	9:55	COL211100SMTH-SH1	35.00	13:05	21-Nov-00	35.00	9:05	22-Nov-00	10:1	49	32	6867	31	2	495	37*58.079'	121*18.418'
225	Smith Canal @ Yosemite Lake	22-Nov-00	10:25	COL221100SMTH-MB1	35.00	12:05	22-Nov-00	35.00	8:05	23-Nov-00	10:1	49	48	>24192	48	14	2098	37*58.077'	121*18.416'
226	Smith Canal @ Yosemite Lake	28-Nov-00	11:50	COL281100SMTH-SH1	36.00	14:20	28-Nov-00	35.00	10:20	29-Nov-00	10:1	49	31	6488	4	0	41	37*58.078'	121*18.418'
227	Smith Canal @ Yosemite Lake	06-Dec-00	14:05	COL061200SMTH-MB1	35.00	15:30	06-Dec-00	35.00	11:30	07-Dec-00	10:1	49	48	>24192	16	5	250	37*58.078'	121*18.416'
228	Smith Canal @ Yosemite Lake	08-Jan-01	14:30	COL080101SMTH-MB1	35.00	16:10	08-Jan-01	35.00	12:00	09-Jan-01	10:1	49	48	>24192	49	43	14136	37*58.075'	121*18.416'
229	Smith Canal @ Yosemite Lake	10-Jan-01	16:45	COL100101SMTH-MB1	35.40	17:30	10-Jan-01	35.00	13:30	11-Jan-01	10:1	49	48	>24192	49	29	5794		
230	Smith Canal @ Yosemite Lake	24-Jan-01	12:30	COL240101SMTH-MB1	35.00	14:00	24-Jan-01	35.00	9:30	25-Jan-01	10:1	49	48	>24192	46	14	1669	37*58.078'	121*18.419'
231	Smith Canal @ Yosemite Lake	27-Jan-01	10:50	COL270101SMTH-MB1	34.00	12:00	27-Jan-01	35.00	8:00	28-Jan-01	10:1	49	48	>24192	49	15	2613	37*58.078'	121*18.420'
232	Smith Canal @ Yosemite Lake	10-Feb-01	12:22	COL100201SMTH-LC1	35.00	14:20	10-Feb-01	35.00	10:20	11-Feb-01	20:1	49	48	>48384	40	12	2078		
233	Smith Canal @ Yosemite Lake	11-Feb-01	12:20	COL110201SMTH-LC1	35.00	14:00	11-Feb-01	35.00	10:00	12-Feb-01	20:1	49	48	>48384	44	9	2446		
234	Smith Canal @ Yosemite Lake	05-Mar-01	14:50	COL050301SMTH-LC1	35.00	17:30	05-Mar-01	35.00	15:00	06-Mar-01	20:1	49	48	>48384	49	46	39725.6		
235	Smith Canal @ Yosemite Lake	14-Mar-01	13:29	COL140301SMTH-LC1	35.00	15:40	14-Mar-01	35.00	9:50	15-Mar-01	20:1	45	14	3058	6	1	148		
236	Smith Canal @ Yosemite Lake	20-Mar-01	10:47	COL200301SMTH-LC1	35.00	12:45	20-Mar-01	35.00	10:30	21-Mar-01	10:1	49	23	4106	8	0	86		
237	Smith Canal @ Yosemite Lake	26-Mar-01	14:36	COL260301SMTH-LC1	35.00	17:30	26-Mar-01	35.00	13:30	27-Mar-01	20:1	49	48	>48384	49	28	10950	37*58.076'	121*18.412'
238	Smith Canal @ Yosemite Lake	12-Apr-01	9:50	COL120401SMTH-LC1	35.00	17:00	12-Apr-01	35.00	13:00	13-Apr-01	20:1	49	48	>48,384	28	1	820		
239	Smith Canal @ Yosemite Lake	21-Apr-01	13:31	COL210401SMTH-LC1	35.00	16:30	21-Apr-01	35.00	12:30	22-Apr-01	20:1	49	48	>48,384	49	46	39725.6		
240	Walker Slough @ Manthey Rd.	11-Oct-00	11:00	COL111000WLKR-DW1	35.00	14:00	11-Oct-00	35.00	9:30	12-Oct-00	20:1	49	48	>48384	49	23	8212	37*55.019'	121*17.490'
241	Walker Slough @ Manthey Rd.	30-Oct-00	16:05	COL301000WLKR-MB1	35.00	16:45	30-Oct-00	35.00	13:00	31-Oct-00	50:1	49	48	>120960	43	11	6055	37*55.018'	121*17.491
242	Walker Slough @ Manthey Rd.	06-Dec-00	14:45	COL061200WLKR-MB1	35.00	15:30	06-Dec-00	35.00	11:30	07-Dec-00	10:1	25	3	379	3	0	31	37*55.015'	121*17.480'
243	Walker Slough @ Manthey Rd.	08-Jan-01	15:00	COL080101WLKR-MB1	35.00	16:10	08-Jan-01	35.00	12:00	09-Jan-01	10:1	49	48	>24192	49	13	2359	37*55.012'	121*17.490'
244	Walker Slough @ Manthey Rd.	11-Jan-01	16:55	COL110101WLKR-MB1	34.50	17:30	11-Jan-01	34.50	13:30	12-Jan-01	10:1	49	48	>24192	49	23	4106		
245	Walker Slough @ Manthey Rd.	24-Jan-01	13:00	COL240101WLKR-MB1	35.00	14:00	24-Jan-01	35.00	9:30	25-Jan-01	10:1	49	48	>2419.2	41	5	906.0	37*55.004'	121*17.497'
246	Walker Slough @ Manthey Rd.	10-Feb-01	12:35	COL100201WLKR-LC1	35.00	14:20	10-Feb-01	35.00	10:20	11-Feb-01	20:1	49	48	>48384	17	3	480		
247	Walker Slough @ Manthey Rd.	11-Feb-01	13:15	COL110201WLKR-LC1	35.00	14:00	11-Feb-01	35.00	10:00	12-Feb-01	20:1	49	48	>48384	47	14	3700		
248	Walker Slough @ Manthey Rd.	05-Mar-01	16:28	COL050301WLKR-LC1	35.00	17:30	05-Mar-01	35.00	15:00	06-Mar-01	20:1	49	48	>48384	49	44	31061.4		
249	Walker Slough @ Manthey Rd.	14-Mar-01	14:13	COL140301WLKR-LC1	35.00	15:40	14-Mar-01	35.00	9:50	15-Mar-01	20:1	45	8	2548	11	0	244		
250	Walker Slough @ Manthey Rd.	20-Mar-01	11:23	COL200301WLKR-LC1	35.00	12:45	20-Mar-01	35.00	10:30	21-Mar-01	10:1	49	17	2909	8	0	86		
251	Walker Slough @ Manthey Rd.	26-Mar-01	15:35	COL260301WLKR-LC1	35.00	17:30	26-Mar-01	35.00	13:30	27-Mar-01	20:1	49	48	>48384	49	17	5818		
252	Walker Slough @ Manthey Rd.	12-Apr-01	11:00	COL120401WLKR-LC1	35.00	17:00	12-Apr-01	35.00	13:00	13-Apr-01	20:1	49	33	14,540	6	2	168		
253	Walker Slough @ Manthey Rd.	21-Apr-01	14:14	COL210401WLKR-LC1	35.00	16:30	21-Apr-01	35.00	12:30	22-Apr-01	20:1	49	48	>48384	23	3	682		
254	Walker Slough @ Turnpike Rd.	04-May-00	17:30	COL040500WLKR-RK	35.00	17:30	04-May-00	35.50	11:30	05-May-00	1:1	49	48	>2419.2	49	14	248		
255	Walker Slough @ Turnpike Rd.	07-Aug-00	14:20	COL070800WLKR-JL1	35.00	15:38	07-Aug-00	35.50	12:00	08-Aug-00	1:1	49	48	>2419.2	49	22	387.3	37*55.015'	121*17.416'
256	Walker Slough @ Turnpike Rd.	14-Aug-00	12:47	COL140800WLKR-JF1	35.50	13:40	14-Aug-00	35.50	10:00	15-Aug-00	1:1	49	48	>2419.2	47	23	259.5	37*55.030'	121*17.423'

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Site	Date	Collect time	Sample ID#	Start Temp	Start Time	Start Date	End Temp	End Time	End Date	Ratio	Large Wells Total	Small Wells Total	MPN total	Large Wells E coli	Small Wells E coli	MPN E coli	Northing	Westing
257	Walker Slough @ Turnpike Rd.	18-Aug-00	14:45	COL188900WLKR-JF	35.50	15:00	18-Aug-00	35.50	11:30	19-Aug-00	1:1	49	48	>2419.2	49	37	920.8		
258	Walker Slough @ Turnpike Rd.	22-Aug-00	15:05	COL228000WLKR-JL	35.00	16:00	22-Aug-00	34.60	13:00	23-Aug-00	1:1	49	48	>2419.2	44	12	133.2		
259	Walker Slough @ Turnpike Rd.	28-Aug-00	12:30	COL280800WLKR-MB1	34.00	13:15	28-Aug-00	35.00	9:15	29-Aug-00	1:1	49	48	>2419.2	49	19	325.5		
260	Walker Slough @ Turnpike Rd.	20-Sep-00	12:00	COL200900WLKR-MB1	36.00	14:00	20-Sep-00	35.00	11:00	21-Sep-00	1:1	49	48	>2419.2	49	21	365.4		
261	Walker Slough @ Turnpike Rd.	04-Oct-00	12:45	COL041000WLKR-MB1	35.50	13:30	04-Oct-00	35.00	9:30	05-Oct-00	10:1	49	48	>24192	23	3	341	37*55.017'	121*17.422'
262	Walker Slough @ Turnpike Rd.	10-Oct-00	16:09	COL101000WLKR-MB1	35.50	17:10	10-Oct-00	35.00	13:10	11-Oct-00	10:1	49	48	>24192	49	46	19862.8		
263	Walker Slough @ Turnpike Rd.	19-Oct-00	16:40	COL191000WLKR-MB1	35.50	17:20	19-Oct-00	35.00	15:30	20-Oct-00	10:1	49	47	24191.7	42	10	1106	37*55.017'	121*17.419'
264	Walker Slough @ Turnpike Rd.	11-Nov-00	11:30	COL111100WLKR-MB1	34.00	12:00	11-Nov-00	35.00	8:00	12-Nov-00	10:1	49	35	8164	19	0	233	37*55.013'	121*17.425'
265	Walker Slough @ Turnpike Rd.	21-Nov-00	10:25	COL211100WLKR-SH2	35.00	13:00	21-Nov-00	35.00	9:00	22-Nov-00	10:1	49	16	2755	4	0	41	37*55.015'	121*17.423'
266	Walker Slough @ Turnpike Rd.	21-Nov-00	10:25	COL211100WLKR-SH1	35.00	13:05	21-Nov-00	35.00	9:05	22-Nov-00	10:1	49	13	2359	10	0	110	37*55.015'	121*17.423'
267	Walker Slough @ Turnpike Rd.	28-Nov-00	13:15	COL281100WLKR-SH1	36.00	14:20	28-Nov-00	35.00	10:20	29-Nov-00	10:1	49	22	3873	5	0	52	37*55.017'	121'17.420'
268																			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Site	Date	Collect time	Sample ID	Start Temp	Start Time	Start Date	End Temp	End Time	End Date	Ratio	Large Wells Total	Small Wells Total	MPN Total	Large Wells E. coli	Small Wells E. coli	MPN E. coli	Northing	Westing
269	Listing of sites outside Stockton, CA																		
270	Avena Drain @ Avena Rd.	10-Jan-01	12:00	COL100101AVND-SH1	35.00	13:00	10-Jan-01	35.00	8:45	11-Jan-01	20:1	49	48	>48384	49	48	>48384		
271	Avena Drain @ Avena Rd.	12-Jan-01	10:30	COL120101AVND-MB1	35.00	11:30	12-Jan-01	35.00	7:15	13-Jan-01	20:1	49	48	>48384	49	40	22397		
272	Avena Drain @ Brennan Rd.	03-Nov-00	12:00	COL031100AVND-MB1	33.50	13:00	03-Nov-00	35.00	9:00	04-Nov-00	100:1	49	48	>241920	3	1	410		
273	Avena Drain @ Carrolton Rd.	25-Oct-00	10:55	DRY251000AVND-MB3	35.50	12:05	25-Oct-00	35.00	9:05	26-Oct-00	1:1	49	48	>2419.2	49	48	>2419.2		
274	Avena Drain @ Carrolton Rd.	08-Nov-00	11:00	DRY081100AVND-MB2	35.00	12:30	08-Nov-00	35.00	8:30	09-Nov-00	100:1	49	48	>241920	46	12	15650	37°50.781'	121°04.316'
275	Avena Drain @ Carrolton Rd.	12-Jan-01	10:15	DRY120101AVND-MB1	35.00	11:30	12-Jan-01	35.00	7:15	13-Jan-01	20:1	49	48	>48384	49	30	12262		
276	Avena Drain @ Jack Tone Rd.	25-Oct-00	10:30	DRY251000AVND-MB1	35.50	12:05	25-Oct-00	35.00	9:05	26-Oct-00	1:1	49	48	>2419.2	49	45	1732.87		
277	Avena Drain @ Jack Tone Rd.	03-Nov-00	10:50	DRY031100AVND-MB1	33.50	13:00	03-Nov-00	35.00	9:00	04-Nov-00	100:1	49	22	38730	7	0	740		
278	Avena Drain @ Murphy Rd.	25-Oct-00	10:45	DRY251000AVND-MB2	35.50	12:05	25-Oct-00	35.00	9:05	26-Oct-00	1:1	49	48	>2419.2	49	48	>2419.2		
279	Avena Drain @ Murphy Rd.	03-Nov-00	11:05	DRY031100AVND-MB2	33.50	13:00	03-Nov-00	35.00	9:00	04-Nov-00	100:1	49	48	>241920	23	4	3540		
280	Avena Drain @ Murphy Rd.	08-Nov-00	10:45	DRY081100AVND-MB1	35.00	12:30	08-Nov-00	35.00	8:30	09-Nov-00	100:1	49	43	141360	1	0	100	37°51.049'	121°06.513'
281	Avena Drain @ Van Allen Rd.	03-Nov-00	11:45	COL031100AVND-MB2	33.50	13:00	03-Nov-00	35.00	9:00	04-Nov-00	100:1	49	48	>241920	22	7	3770		
282	Avena Drain @ Van Allen Rd.	08-Nov-00	11:30	COL081100AVND-MB1	35.00	12:30	08-Nov-00	35.00	8:30	09-Nov-00	100:1	49	47	241917	12	0	1350	37°50.272'	121°03.209'
283	Avena Drain @ Van Allen Rd.	12-Jan-01	10:35	COL120101AVND-MB2	35.00	11:30	12-Jan-01	35.00	7:15	13-Jan-01	20:1	49	48	>48384	49	37	18416		
284	Bear Creek @ I-5	08-Jan-01	12:50	COL080101BRCR-MB1	35.00	16:10	08-Jan-01	35.00	12:00	09-Jan-01	10:1	20	6	328	3	0	31	38°02.610'	121°22.249'
285	Bear Creek @ Thornton Rd.	05-Dec-00	15:20	COL051200BRCR-MB1	35.00	16:45	05-Dec-00	35.00	12:45	06-Dec-00	10:1	49	27	5172	27	0	374		
286	Bear Creek @ Thornton Rd.	12-Apr-01	10:00	COL120401BRCR-LC1	35.00	17:00	12-Apr-01	35.00	13:00	13-Apr-01	20:1	49	23	8,212	0	0	<20		
287	Beaver Slough @ Blossom Road	14-Nov-00	12:40	COL141100BVRS-MB1	35.00	13:35	14-Nov-00	35.00	9:30	15-Nov-00	10:1	22	3	323	0	0	0	38°12.307'	121°26.845'
288	Bethany Reservoir State Rec. Area	07-Nov-00	11:40	COL071100BTHN-MB1	35.00	15:00	07-Nov-00	35.00	13:00	08-Nov-00	10:1	45	10	1354	17	0	203	37°46.866'	121°36.953'
289	Bethel Island @ Bethel Harbor	09-Nov-00	11:30	COL091100BTHL-SH1	35.00	14:30	09-Nov-00	35.00	9:30	10-Nov-00	10:1	13	2	171	2	0	20	38°02.035'	121°37.236'
290	Bethel Island @ Frank's Cove	09-Nov-00	12:15	COL091100BTHL-SH4	35.00	14:30	09-Nov-00	35.00	9:30	10-Nov-00	10:1	19	5	298	4	0	41	38°01.295'	121°36.569'
291	Bethel Island @ Russo's Marina	09-Nov-00	11:50	COL091100BTHL-SH3	35.00	14:30	09-Nov-00	35.00	9:30	10-Nov-00	10:1	13	2	171	2	0	20	38°02.035'	121°37.236'
292	Bethel Island @ Russo's Marina	09-Nov-00	11:50	COL091100BTHL-SH2	35.00	14:30	09-Nov-00	35.00	9:30	10-Nov-00	10:1	16	1	201	1	0	10	38°02.035'	121°37.236'
293	Buckley Cove	25-Apr-00	10:15	COL250400BCKL-JF	34.00	12:20	25-Apr-00	35.00	8:10	26-Apr-00	1:1	49	40	1119.85	34	2	57.6		
294	Buckley Cove	02-May-00	12:03	COL020500BCKL-RK1	35.50	13:30	02-May-00	35.50	9:30	03-May-00	1:1	49	45	1732.87	24	3	35.9		
295	Buckley Cove	13-Jun-00	11:40	COL130600BCKL-JF1	35.00	13:00	13-Jun-00	35.00	11:00	14-Jun-00	1:1	49	48	>2419.2	38	8	88.4		
296	Buckley Cove	09-Aug-00	14:15	COL090800BCKL-JL2	35.00	16:30	09-Aug-00	35.50	13:40	10-Aug-00	1:1	49	48	>2419.2	29	4	48	37°58.633'	121°22.476'
297	Buckley Cove	09-Aug-00	12:30	COL090800BCKL-JL1	35.00	16:30	09-Aug-00	35.50	13:40	10-Aug-00	1:1	49	47	2419.17	27	8	49.6	37°58.639'	121°22.476'
298	Buckley Cove	18-Sep-00	10:20	COL180900BCKL-MB1	35.00	12:00	18-Sep-00	35.00	9:00	19-Sep-00	1:1	49	47	2419.17	24	0	31.7		
299	Buckley Cove	10-Nov-00	11:15	COL101100BCKL-MB1	35.00	13:00	10-Nov-00	34.50	9:15	11-Nov-00	10:1	44	5	1086	2	2	41	37°58.637'	121°22.505'
300	Devil's Isle	12-Oct-00	11:45	COL121000DVLS-MB1	35.00	15:10	12-Oct-00	35.00	11:10	13-Oct-00	20:1	28	5	944	1	0	20	38°05.507'	121°29.514'
301	Disappointment Slough	29-Aug-00	11:50	COL290800DSPP-MB1	35.00	14:00	29-Aug-00	35.50	10:00	30-Aug-00	1:1	49	48	>2419.2	24	0	31.7	38°02.670'	121°26.834'
302	Disappointment Slough	29-Aug-00	12:00	COL290800DSPP-MB2	35.00	14:00	29-Aug-00	35.50	10:00	30-Aug-00	1:1	49	47	2419.17	21	13	44.1	38°02.496'	121°26.697'
303	Disappointment Slough	29-Aug-00	12:15	COL290800DSPP-MB3	35.00	14:00	29-Aug-00	35.50	10:00	30-Aug-00	1:1	49	47	2419.17	6	2	8.2	38°02.527'	121°26.357'
304	Dredger cut	15-Aug-00	11:40	COL150800DRDG-JL1	35.00	14:20	15-Aug-00	34.50	10:30	16-Aug-00	1:1	49	48	>2419.2	30	9	58.8	38°05.220'	121°24.327'
305	Duck Creek @ Pock Lane	07-Aug-00	14:38	COL070800DCKC-JL	35.00	15:38	07-Aug-00	35.00	12:00	08-Aug-00	1:1	49	48	>2419.2	40	12	103.9	37°55.621'	121°14.636'
306	Duck Creek @ Pock Lane	12-Apr-01	11:30	COL120401DCKC-LC1	35.00	17:00	12-Apr-01	35.00	13:00	13-Apr-01	20:1	45	9	2,626	0	0	<20		
307	Dutch Slough @ Bethel Island	09-Nov-00	12:25	COL091100DTCH-SH1	35.00	14:30	09-Nov-00	35.00	9:30	10-Nov-00	10:1	28	5	472	0	0	<10	38°00.781'	121°38.468'
308	Fourteen Mile Slough	04-Jul-00	13:20	COL040700FRTN-BJ	35.50	16:45	04-Jul-00	35.50	14:30	05-Jul-00	1:1	49	48	>2419.2	45	16	162.4		
309	Fourteen Mile Slough	16-Jul-00	10:35	COL160700FRTN-BJ	35.00	14:30	16-Jul-00	35.50	12:00	17-Jul-00	1:1	49	48	>2419.2	37	4	71.2		
310	Fourteen Mile Slough	09-Aug-00	13:09	COL090800FRTN-JL1	35.00	16:30	09-Aug-00	35.50	13:40	10-Aug-00	1:1	49	48	>2419.2	25	2	35	38°00.803'	121°23.038'
311	Fourteen Mile Slough	09-Aug-00	14:51	COL090800FRTN-JL2	35.00	16:30	09-Aug-00	35.50	13:40	10-Aug-00	1:1	49	48	>2419.2	17	4	25.3	38°00.807	121°23.041
312	Fourteen Mile Slough	12-Sep-00	10:54	COL120900FRTN-MB1	36.00	11:35	12-Sep-00	35.00	9:30	13-Sep-00	1:1	49	48	>2419.2	31	4	52.9		
313	Fourteen Mile Slough	21-Sep-00	11:01	COL210900FRTN-MB1	35.50	12:45	21-Sep-00	35.00	9:00	22-Sep-00	1:1	49	48	>2419.2	18	2	24.3	37°59.802'	121°24.643'
314	Fourteen Mile Slough	02-Nov-00	11:15	COL021100FRTN-MB1	35.00	12:25	02-Nov-00	34.50	9:00	03-Nov-00	10:1	49	14	2481	5	0	52	37°59.809'	121°24.631'
315	Fourteen-Mile Slough @ Feather River Dr.	06-Dec-00	13:15	COL061200FRTN-MB1	35.00	15:30	06-Dec-00	35.00	11:30	07-Dec-00	10:1	22	2	309	6	1	74	37°59.731'	121°21.007'
316	Fourteen-Mile Slough @ Feather River Dr.	08-Jan-01	13:55	COL080101FRTN-MB1	35.00	16:10	08-Jan-01	35.00	12:00	09-Jan-01	10:1	49	24	4350	16	2	213	37°59.729'	121°21.010'
317	Fourteen-Mile Slough @ Feather River Dr.	12-Apr-01	10:15	COL120401FRTN-LC1	35.00	17:00	12-Apr-01	35.00	13:00	13-Apr-01	20:1	49	27	10344	1	0	20		
318	French Camp Slough	11-Sep-00	10:15	COL110900FRNC-MB1	35.00	14:00	11-Sep-00	35.00	10:00	12-Sep-00	1:1	49	48	>2419.2	49	18	307.6	37°55.071'	121°18.917'
319	French Camp Slough	26-Sep-00	10:10	COL260900FRNC-MB1	35.00	12:30	26-Sep-00	35.00	9:00	27-Sep-00	10:1	49	44	15530.7	20	2	226	37°55.112'	121°19.009
320	French Camp Slough	09-Oct-00	10:50	COL091000FRNC-MB1	35.00	12:40	09-Oct-00	34.50	10:00	10-Oct-00	10:1	49	41	12033.1	29	5	496	37°55.116'	121°19.010'
321	French Camp Slough	31-Oct-00	11:05	COL311000FRNC-SH1	35.00	13:00	31-Oct-00	35.00	10:40	01-Nov-00	20:1	46	10	7335	0	0	0	37°55.217'	121°19.133'
322	Grant Line Canal	07-Nov-00	13:00	COL071100GRNT-MB1	35.00	15:00	07-Nov-00	35.00	13:00	08-Nov-00	10:1	40	3	809	2	1	30	37°49.152'	121°27.029'
323	Haven Acres	19-Sep-00	12:15	COL190900HVNC-MB1	35.00	14:00	19-Sep-00	35.00	10:00	20-Sep-00	1:1	49	48	>2419.2	6	0	6.3	37°51.030'	121°19.316'

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Site	Date	Collect time	SampleID	Start Temp	Start Time	Start Date	End Temp	End Time	End Date	Ratio	Large Wells Total	Small Wells Total	MPN Total	Large Wells E coli	Small Wells E coli	MPN E coli	Northing	Westing
324	Herman & Helens	04-Jul-00	14:48	COL040700HRMN-BJ	35.00	16:45	04-Jul-00	35.00	14:30	05-Jul-00	1:1	49	48	>2419.2	16	2	21.3		
325	Herman & Helens	12-Oct-00	13:29	COL131000HRMN-MB2	35.00	15:10	12-Oct-00	35.00	11:10	13-Oct-00	20:1	22	4	672	0	0	0	38°03.540'	121°30.061'
326	Herman & Helens	12-Oct-00	13:29	COL121000HRMN-MB1	35.00	15:10	12-Oct-00	35.00	11:10	13-Oct-00	20:1	18	7	614	0	0	0	38°03.540'	121°30.061'
327	Herman & Helens	14-Oct-00	16:20	COL141000HRMN-MB1	35.00	17:20	14-Oct-00	35.00	14:45	15-Oct-00	20:1	49	39	20924.8	30	2	942		
328	Herman & Helens	13-Nov-00	11:30	COL131000HRMN-MB1	35.00	13:55	13-Nov-00	35.00	10:00	14-Nov-00	20:1	25	2	728	2	0	40	38°03.634'	121°29.993'
329	King Island Resort	10-Mar-00	11:00	COL031000KNGS-SH1	35.00	13:52	10-Mar-00	34.50	10:00	10-Apr-00	10:1	35	7	703	0	0	<1	38°03.306'	121°27.548'
330	King Island Resort	13-Jun-00	10:57	COL130600KNGS-JF1	35.00	13:00	13-Jun-00	35.00	10:00	14-Jun-00	1:1	49	40	1119.85	4	0	4.1		
331	King Island Resort	04-Jul-00	14:45	COL040700KNGS-BJ	35.00	14:25	04-Jul-00	35.50	16:45	05-Jul-00	1:1	49	38	980.4	10	3	14.3		
332	King Island Resort	29-Aug-00	11:25	COL290800KNGS-MB1	35.00	14:00	29-Aug-00	35.00	9:15	30-Aug-00	1:1	49	43	1413.6	16	2	21.3		
333	King Island Resort	17-Oct-00	15:15	COL171000KNGS-MB1	33.50	17:25	17-Oct-00	36.00	14:45	18-Oct-00	10:1	20	7	341	2	1	30	38°03.295'	121°27.567'
334	Lazy M Marina	07-Nov-00	11:15	COL071100LZYM-MB1	35.00	15:00	07-Nov-00	35.00	13:00	08-Nov-00	10:1	44	17	1541	1	4	50	37°56.223'	121°36.214'
335	Lincoln Village West	25-Apr-00	11:00	COL250400LNVW-JF	34.00	12:20	25-Apr-00	35.00	8:10	26-Apr-00	1:1	49	29	579.4	23	4	58.5		
336	Lincoln Village West	02-May-00	12:35	COL020500LNVW-RK1	35.50	13:30	02-May-00	35.00	9:30	03-May-00	1:1	49	42	1299.65	38	20	113.9		
337	Lincoln Village West	24-May-00	10:45	COL240500LNVW-RK	35.10	11:30	24-May-00	35.00	8:45	25-May-00	1:1	49	42	1299.65	19	5	29.8		
338	Lincoln Village West	01-Jun-00	10:30	COL010600LNVW-RK	35.00	11:30	01-Jun-00	35.00	7:10	02-Jun-00	1:1	49	45	1732.87	44	13	137.4		
339	Lincoln Village West	13-Jun-00	10:14	COL130600LNVW-JF1	35.00	13:00	13-Jun-00	35.00	10:00	14-Jun-00	1:1	49	47	2419.17	49	21	365.4		
340	Lincoln Village West	21-Jun-00	11:31	COL210600LNVW-JF	35.50	14:00	21-Jun-00	35.00	10:00	22-Jun-00	1:1	49	41	1203.31	38	8	83.9		
341	Lincoln Village West	30-Jun-00	10:50	COL300600LNVW-JF	35.50	12:00	30-Jun-00	35.00	9:45	01-Jul-00	1:1	49	45	1732.87	20	3	28.8		
342	Lincoln Village West	04-Jul-00	13:45	COL040700LNVW-BJ	35.00	16:45	04-Jul-00	35.00	14:30	05-Jul-00	1:1	49	48	>2419.2	49	10	125.9		
343	Lincoln Village West	16-Jul-00	10:50	COL160700LNVW-BJ	35.00	14:30	16-Jul-00	35.00	12:00	17-Jul-00	1:1	49	44	1553.07	35	11	78.4		
344	Lincoln Village West	29-Aug-00	10:24	COL290800LNVW-MB1	35.00	12:30	29-Aug-00	35.00	9:00	30-Aug-00	1:1	49	48	>2419.2	36	8	75.9		
345	Lincoln Village West	12-Sep-00	10:36	COL120900LNVW-MB1	36.00	11:35	12-Sep-00	35.00	9:30	13-Sep-00	1:1	49	37	920.8	19	7	32.4		
346	Lincoln Village West	21-Sep-00	10:36	COL210900LNVW-MB1	35.50	12:45	21-Sep-00	35.00	9:00	22-Sep-00	1:1	49	48	>2419.2	48	17	238.2	38°00.008'	121°22.185'
347	Lincoln Village West	03-Oct-00	11:54	COL031000LNVW-MB1	35.00	13:52	03-Oct-00	34.50	10:00	04-Oct-00	10:1	49	25	4611	5	0	52		
348	Lincoln Village West	02-Nov-00	10:45	COL021100LNVW-SH1	35.00	12:25	02-Nov-00	34.50	9:00	03-Nov-00	10:1	45	11	1396	4	1	52	37°59.963'	121°22.190'
349	Lincoln Village West	10-Nov-00	10:40	COL101100LNVW-MB1	35.00	13:00	10-Nov-00	34.50	9:15	11-Nov-00	10:1	48	16	2282	6	2	84	38°00.009'	121°22.185'
350	Lincoln Village West	30-Nov-00	10:15	COL301100LNVW-MB1	35.00	11:50	30-Nov-00	35.00	9:00	01-Dec-00	10:1	22	6	364	2	1	30	38°00.078'	121°22.181'
351	Lincoln Village West	25-Jan-01	11:36	COL250101LNVW-MB1	35.00	13:20	25-Jan-01	35.00	9:00	26-Jan-01	10:1	25	3	379	8	0	86	38°00.077'	121°22.201'
352	Lost Isle	30-Jun-00	10:30	COL030600LSTS-JF	35.50	12:00	30-Jun-00	35.00	9:45	01-Jul-00	1:1	49	48	>2419.2	18	1	23.1		
353	Lost Isle	04-Jul-00	13:25	COL040700LSTS-BJ	35.00	16:45	04-Jul-00	35.00	14:30	05-Jul-00	1:1	49	45	1732.87	32	9	64.5		
354	Lost Isle	17-Oct-00	15:45	COL171000LSTS-MB1	33.50	17:25	17-Oct-00	36.00	14:45	18-Oct-00	10:1	43	10	117.8	1	0	10	37°59.964'	121°27.012'
355	Mokelumne River @ B & W Marina	14-Nov-00	11:10	COL141100MKLM-MB1	35.00	13:35	14-Nov-00	35.00	9:30	15-Nov-00	10:1	30	13	657	3	0	31	38°07.640'	121°34.792'
356	Mossdale Marina	19-Sep-00	11:45	COL190900MSSD-MB1	35.00	14:00	19-Sep-00	35.00	10:00	20-Sep-00	1:1	49	48	>2419.2	14	0	16.1	37°47.185'	121°18.446'
357	Oakwood lake	19-Sep-00	11:20	COL190900OKWD-MB1	35.00	14:00	19-Sep-00	35.00	10:00	20-Sep-00	1:1	49	47	2419.17	16	2	21.3		
358	Old River @ Heinbockle Harbor	07-Nov-00	13:10	COL071100OLDR-MB1	35.00	15:00	07-Nov-00	35.00	13:00	08-Nov-00	10:1	49	32	6867	3	0	31	37°48.292'	121°26.976'
359	Old River @ Holland Riverside	09-Nov-00	12:50	COL091100OLDR-SH1	35.00	14:30	09-Nov-00	35.00	9:30	10-Nov-00	10:1	21	0	265	3	0	31	37°58.352'	121°34.928'
360	Old River @ Rock Barrier	16-Nov-00	9:50	COL161100OLDR-SH1	0.57	0:00	16-Nov-00	0.40	0:00	17-Nov-00	10:1	46	10	1467	1	1	20	37°48.469'	121°19.672
361	Old River @ Rock Barrier	16-Nov-00	9:50	COL161100OLDR-SH2	0.54	0:00	16-Nov-00	0.38	0:00	17-Nov-00	10:1	49	16	2755	4	0	41	37°48.469'	121°19.672
362	Old River @ Stewart Rd.	16-Nov-00	10:25	COL161100OLDR-SH4	35.00	13:00	16-Nov-00	35.00	9:00	17-Nov-00	10:1	49	22	3873	1	0	10	37°48.874'	121°22.893
363	Old River @ Stewart Rd.	16-Nov-00	10:25	COL161100OLDR-SH3	35.00	13:40	16-Nov-00	35.00	9:30	17-Nov-00	10:1	43	8	1112	2	0	20	37°48.874'	121°22.893
364	Paradise Cut @ Paradise Cut Road	16-Nov-00	10:45	COL161100PRDS-SH2	35.00	13:00	16-Nov-00	35.00	9:00	17-Nov-00	10:1	49	15	2613	3	1	41	37°48.068'	121°22.039'
365	Paradise Cut @ Paradise Cut Road	16-Nov-00	10:45	COL161100PRDS-SH1	35.00	13:40	16-Nov-00	35.00	9:30	17-Nov-00	10:1	37	7	776	5	1	63	37°48.068'	121°22.039'
366	Paradise Point Marina	04-Jul-00	14:10	COL040700PRDS-BJ	35.00	16:45	04-Jul-00	35.00	14:30	05-Jul-00	1:1	49	48	>2419.2	8	0	8.6		
367	Paradise Point Marina	16-Jul-00	11:35	COL160700PRDS-BJ	35.00	14:30	16-Jul-00	35.00	12:00	17-Jul-00	1:1	49	45	1732.87	9	0	9.8		
368	Paradise Point Marina	15-Aug-00	11:06	COL150800PRDS-JL1	35.00	14:20	15-Aug-00	35.00	10:30	16-Aug-00	1:1	49	48	>2419.2	14	3	19.7	38°02.671'	121°25.166'
369	Paradise Point Marina	29-Aug-00	12:30	COL290800PRDS-MB1	35.00	14:00	29-Aug-00	35.50	10:00	30-Aug-00	1:1	49	48	>2419.2	37	8	79.8		
370	Paradise Point Marina	03-Oct-00	11:26	COL031000PRDS-SH1	35.00	13:52	03-Oct-00	34.50	10:00	04-Oct-00	10:1	45	9	1313	0	0	0	38°02.576'	121°25.043'
371	Potato Slough	12-Oct-00	12:05	COL121000PTTS-MB1	35.00	15:10	12-Oct-00	35.00	11:10	13-Oct-00	20:1	17	10	658	0	0	0	38°05.045'	121°32.293'
372	Sacramento River @ Rio Vista Boat Launch	14-Nov-00	10:45	COL141100SCRM-MB1	35.00	13:35	14-Nov-00	35.00	9:30	15-Nov-00	10:1	34	8	689	3	0	3.1	38°09.267'	121°41.403'
373	San Joaquin River @ Beach	08-Jun-00	10:35	COL080600SNJQ-RK1	35.00	11:45	08-Jun-00	35.00	9:00	09-Jun-00	1:1	49	48	>2419.2	13	0	14.8		
374	San Joaquin River @ Beach	09-Jun-00	10:55	COL090600SNJQ-RK1	35.00	11:45	09-Jun-00	35.00	9:30	10-Jun-00	1:1	49	48	>2419.2	17	3	24		
375	San Joaquin River @ Beach	11-Sep-00	10:00	COL110900SNJQ-MB1	35.00	14:00	11-Sep-00	35.00	10:00	12-Sep-00	1:1	49	48	>2419.2	7	0	7.4		
376	San Joaquin River @ Confluence of French Camp Slough	23-Oct-00	11:03	COL231000SNJQ-MB2	35.00	15:35	23-Oct-00	35.60	13:30	24-Oct-00	10:1	49	36	8660	13	1	160	37°55.217'	121°19.128'

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Site	Date	Collect Time	Sample ID	Start Temp	Start Time	Start Date	End Temp	End Time	End Date	Ratio	Large Wells Total	Small Wells Total	MPN Total	Large Wells E. coli	Small Wells E. coli	MPN E. coli	Northing	Westing
377	San Joaquin River @ Confluence of French Camp Slough	17-Nov-00	10:30	COL171100SNJQ-MB1	35.00	11:45	17-Nov-00	35.50	8:45	18-Nov-00	10:1	42	16	1301	2	0	20	37°55.213'	121°19.129'
378	San Joaquin River @ MUD Downstream	05-Sep-00	10:35	COL050900SNJQ-MB2	35.00	12:10	05-Sep-00	35.00	9:10	06-Sep-00	1:1	49	48	>2419.2	42	11	113.7		
379	San Joaquin River @ MUD Downstream	11-Sep-00	10:30	COL110900SNJQ-MB2	35.00	12:15	11-Sep-00	35.00	9:00	12-Sep-00	1:1	49	48	>2419.2	29	0	41.6	37°56.353'	121°20.611'
380	San Joaquin River @ MUD Downstream	19-Sep-00	12:45	COL190900SNJQ-MB1	35.00	13:30	19-Sep-00	35.00	9:30	20-Sep-00	1:1	49	48	>2419.2	29	2	44.8		
381	San Joaquin River @ MUD Downstream	09-Oct-00	11:15	COL091000SNJQ-MB3	34.00	12:40	09-Oct-00	34.50	10:00	10-Oct-00	10:1	49	47	24191.7	5	3	84	37°56.498'	121°20.748
382	San Joaquin River @ MUD Downstream	31-Oct-00	11:25	COL311000SNJQ-SH3	35.00	13:00	31-Oct-00	35.00	10:30	01-Nov-00	20:1	49	24	8704	10	4	310	37°56.572'	121°20.708'
383	San Joaquin River @ MUD Downstream	17-Nov-00	10:55	COL171100SNJQ-MB4	35.00	11:45	17-Nov-00	35.00	8:45	18-Nov-00	10:1	40	9	959	2	0	20	37°56.530'	121°20.758'
384	San Joaquin River @ MUD Downstream	17-Nov-00	10:55	COL171100SNJQ-MB3	35.00	11:45	17-Nov-00	35.00	8:45	18-Nov-00	10:1	44	13	1374	2	1	30	37°56.530'	121°20.758'
385	San Joaquin River @ MUD Outfall	24-May-00	9:58	COL240500SNJQ-RK1	36.00	11:15	24-May-00	35.50	8:30	25-May-00	1:1	49	48	>2419.2	27	7	48.1		
386	San Joaquin River @ MUD Outfall	17-Aug-00	11:03	COL170800SNJQ-JL1	35.00	11:25	17-Aug-00	35.00	10:30	18-Aug-00	1:1	49	48	>2419.2	11	0	12.2	37°56.130'	121°19.860'
387	San Joaquin River @ MUD Outfall	24-Aug-00	10:57	COL240800SNJQ-DW1	35.00	12:13	24-Aug-00	35.00	8:50	25-Aug-00	1:1	49	48	>2419.2	24	4	37.3	37°58.293'	121°20.146'
388	San Joaquin River @ MUD Outfall	26-Sep-00	10:40	COL260900SNJQ-DR1	35.00	12:30	26-Sep-00	35.00	9:00	27-Sep-00	10:1	49	45	17328.7	6	0	63	37°56.295'	121°20.159
389	San Joaquin River @ MUD Outfall	09-Oct-00	11:10	COL091000SNJQ-MB2	34.00	12:40	09-Oct-00	34.50	10:00	10-Oct-00	10:1	49	47	24191.7	6	1	74	37°56.283'	121°20.136'
390	San Joaquin River @ MUD Outfall	23-Oct-00	10:45	COL231000SNJQ-MB1	35.00	15:35	23-Oct-00	35.60	13:30	24-Oct-00	10:1	49	39	10462.4	2	0	20	37°56.307'	121°20.150
391	San Joaquin River @ MUD Outfall	31-Oct-00	11:15	COL311000SNJQ-SH2	35.00	13:00	31-Oct-00	35.00	10:30	01-Nov-00	20:1	49	24	8704	3	0	60	37°56.283'	121°20.146'
392	San Joaquin River @ MUD Outfall	31-Oct-00	11:15	COL311000SNJQ-SH1	35.00	13:00	31-Oct-00	35.00	10:30	01-Nov-00	20:1	49	16	5510	1	1	40	37°56.283'	121°20.146'
393	San Joaquin River @ MUD Outfall	17-Nov-00	10:45	COL171100SNJQ-MB2	35.00	11:45	17-Nov-00	35.50	8:45	18-Nov-00	10:1	47	19	2224	2	0	20	37°56.289'	121°20.137'
394	San Joaquin River @ MUD Outfall	15-Mar-01	11:50	COL150301SNJQ-LC1	35.00	14:30	15-Mar-01	35.00	9:30	16-Mar-01	20:1	21	4	636	2	0	40		
395	San Joaquin River @ MUD Upstream	24-May-00	10:03	COL240500SNJQ-RK2	36.00	11:15	24-May-00	35.50	8:30	25-May-00	1:1	49	48	>2419.2	32	3	53.8		
396	San Joaquin River @ MUD Upstream	05-Sep-00	10:30	COL050900SNJQ-MB1	35.00	12:10	05-Sep-00	35.00	9:10	06-Sep-00	1:1	49	48	>2419.2	40	9	95.9		
397	San Joaquin River @ MUD Upstream	09-Oct-00	11:00	COL091000SNJQ-MB1	34.00	12:40	09-Oct-00	34.50	10:00	10-Oct-00	10:1	49	46	19862.8	5	0	52	37°55.780'	121°19.675'
398	San Joaquin River @ Navy Drive	30-Nov-00	9:45	COL301100SNJQ-MB1	35.00	11:50	30-Nov-00	35.00	9:00	01-Dec-00	10:1	49	44	15530.7	47	12	1723	37°56.803'	121°20.314'
399	San Joaquin River @ Port	17-Oct-00	18:15	COL171000SNJQ-MB1	33.50	17:25	17-Oct-00	36.00	14:45	18-Oct-00	10:1	49	42	12996.5	5	0	52	37°57.054'	121°20.143'
400	South Fork Mokelumne @ Westgate	14-Nov-00	11:35	COL141100MKLM-MB2	35.00	13:35	14-Nov-00	35.00	9:30	15-Nov-00	10:1	17	2	228	0	0	<10	38°07.390'	121°39.544'
401	Sycamore @ Guard Rd.	14-Nov-00	12:00	COL141100SYCM-MB1	35.00	13:35	14-Nov-00	35.00	9:30	15-Nov-00	10:1	48	14	2098	12	1	146	38°08.270'	121°25.276'
402	Telephone Cut	15-Aug-00	12:16	COL150800TLPH-JL1	35.00	14:20	15-Aug-00	34.50	10:30	16-Aug-00	1:1	49	48	>2419.2	18	1	23.1	38°04.346'	121°23.552'
403	Temple @ Mariposa	15-Nov-00	10:45	DRY151100TMPL-MB1	35.00	12:30	15-Nov-00	35.00	8:15	16-Nov-00	50:1	44	5	5430	0	0	<50	37°52.710'	121°05.226'
404	Tiki Lagun	22-Aug-00	11:20	COL220800TKLG-JL1	35.00	16:00	22-Aug-00	35.50	13:00	23-Aug-00	1:1	49	47	2419.17	6	0	6.3	37°58.700'	121°28.406'
405	Tiki Lagun	14-Sep-00	10:43	COL140900TKLG-SP1	35.00	12:00	14-Sep-00	36.00	10:00	15-Sep-00	1:1	49	43	1413.6	9	1	9.8		
406	Tiki Lagun	02-Oct-00	11:13	COL021000TKLG-MB2	35.00	12:45	02-Oct-00	35.00	9:05	03-Oct-00	10:1	46	17	1842	2	0	20	37°58.877'	121°28.383'
407	Tiki Lagun	02-Oct-00	11:02	COL021000TKLG-MB1	35.00	12:45	02-Oct-00	35.00	9:05	03-Oct-00	10:1	43	10	1178	4	0	41	37°58.702'	121°28.411'
408	Tiki Lagun	22-Mar-01	11:00	COL210301TKLG-LC-1	35.00	13:30	22-Mar-01	35.00		23-Mar-01	20:1	37	5	1466	0	0	<20		
409	Tinsley isle	16-Jul-00	12:40	COL160700TNSL-BJ	35.00	14:30	16-Jul-00	35.00	12:00	17-Jul-00	1:1	49	45	1732.87	28	10	55.2		
410	Tower Park	13-Oct-00	10:40	COL131100TWRP-MB1	35.00	13:55	13-Oct-00	35.00	10:00	14-Oct-00	20:1	40	3	1618	3	0	62	38°06.593'	121°29.998'
411	Tower Park	14-Oct-00	15:55	COL141000TWRP-MB1	35.00	17:20	14-Oct-00	35.00	14:45	15-Oct-00	1:1	49	48	>2419.2	49	18	307.6	38°06.593'	121°30.000'
412	Turner Cut	22-Aug-00	11:30	COL220800TRNR-JL1	35.00	16:00	22-Aug-00	35.50	13:00	23-Aug-00	1:1	49	48	>2419.2	8	1	9.7	37°58.870'	121°28.393'
413	Turner Cut	14-Sep-00	10:54	COL140900TRNR-SP1	35.00	12:00	14-Sep-00	36.00	10:00	15-Sep-00	1:1	49	48	>2419.2	11	1	13.4		
414	Turner Cut	14-Sep-00	11:00	COL140900TRNR-SP2	35.00	12:00	14-Sep-00	36.00	10:00	15-Sep-00	1:1	49	46	1986.28	12	1	14.6		
415	Turner Cut	02-Oct-00	10:48	COL021000TRNR-MB1	35.00	12:45	02-Oct-00	35.00	9:05	03-Oct-00	10:1	44	8	1187	2	0	20	37°58.997'	121°28.350'
416	Turner Cut	21-Mar-01	11:15	COL210301TRNR-LC1	35.00	13:30	21-Mar-01	35.00	10:30	22-Mar-01	20:1	35	3	1248	0	0	<20		
417	Vacant Lot	12-Oct-00	16:05	COL121000VCNT-MB1	35.00	17:30	12-Oct-00	35.00	13:30	13-Oct-00	20:1	49	48	>48384	49	37	18416	37°57.167'	121°18.127'
418	Weber Point	12-Oct-00	16:30	COL121000WBRP-MB1	35.00	17:30	12-Oct-00	35.00	13:30	13-Oct-00	20:1	49	48	>48384	49	16	5510	37°57.221'	121°17.553'
419	Whiskey Slough Harbor	22-Aug-00	10:53	COL220800WHSK-JL1	35.00	16:00	22-Aug-00	35.50	13:00	23-Aug-00	1:1	49	48	>2419.2	15	2	19.9	37°56.134'	121°25.956'
420	Whiskey Slough Harbor	02-Oct-00	10:40	COL021000WHSK-MB1	35.00	12:45	02-Oct-00	35.00	9:05	03-Oct-00	1:1	45	16	1624	7	0	74	37°56.127'	121°25.949'
421	White Slough	12-Oct-00	11:20	COL121000WHTS-MB1	35.00	15:10	12-Oct-00	35.00	11:10	13-Oct-00	20:1	23	4	708	1	0	20	38°04.124'	121°27.602
422	Windmill Cove	02-May-00	12:00	COL020500WNDM-RK1	35.50	13:30	02-May-00	35.50	9:30	03-May-00	1:1	49	46	1986.27	38	6	79.4		
423	Windmill Cove	01-Jun-00	10:15	COL010600WNDM-RK	35.00	11:30	01-Jun-00	35.50	7:10	02-Jun-00	1:1	49	48	>2419.2	31	5	54.6		
424	Windmill Cove	13-Jun-00	9:47	COL130600WNDM-JF1	35.00	13:00	13-Jun-00	35.00	10:00	14-Jun-00	1:1	49	48	>2419.2	48	18	248.9		
425	Windmill Cove	21-Jun-00	11:10	COL210600WNDM-JF1	35.50	14:00	21-Jun-00	35.00	10:00	22-Jun-00	1:1	49	48	>2419.2	26	3	39.9		
426	Windmill Cove	30-Jun-00	10:15	COL030600WNDM-JF	35.50	12:00	30-Jun-00	35.00	9:45	01-Jul-00	1:1	49	48	>2419.2	48	20	272.3		
427	Windmill Cove	04-Jul-00	15:35	COL040700WNDM-MB	35.00	16:45	04-Jul-00	35.00	14:30	05-Jul-00	1:1	49	48	>2419.2	47	12	172.3		
428	Windmill Cove	06-Jul-00	11:05	COL060700WNDM-JF	35.00	12:00	06-Jul-00	35.00	12:00	07-Jul-00	1:1	49	48	>2419.2	39	7	86		
429	Windmill Cove	16-Jul-00	10:20	COL160700WNDM-BJ	35.00	14:30	16-Jul-00	35.00	12:00	17-Jul-00	1:1	49	48	>2419.2	47	21	240		
430	Windmill Cove	28-Jul-00	10:30	COL280700WNDM-JL1	35.00	12:30	28-Jul-00	35.00	9:30	29-Jul-00	1:1	49	48	>2419.2	48	14	209.8		

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Site	Date	Collect time	Sample ID#	Start Temp	Start Time	Start Date	End Temp	End Time	End Date	Ratio	Large Wells Total	Small Wells Total	MPN total	Large Wells E. coli	Small Wells E. coli	MPN E. coli	Northing	Westing
431	Windmill Cove	09-Aug-00	14:30	COL090800WNDM-JL2	35.00	16:30	09-Aug-00	35.50	13:40	10-Aug-00	1:1	49	48	>2419.2	10	0	11	37°59.361'	121°24.551'
432	Windmill Cove	09-Aug-00	12:45	COL090800WNDM-JL1	35.00	16:30	09-Aug-00	35.50	13:40	10-Aug-00	1:1	49	48	>2419.2	12	2	14.6	37°59.357'	121°24.550'
433	Windmill Cove	15-Aug-00	13:12	COL150800WNDM-JL1	35.00	14:20	15-Aug-00	35.50	10:30	16-Aug-00	1:1	49	48	>2419.2	22	3	32.3	39°59.358'	121°24.545'
434	Windmill Cove	22-Aug-00	12:00	COL220800WNDM-JL1	35.00	16:00	22-Aug-00	34.60	13:00	23-Aug-00	1:1	49	47	2419.17	8	0	8.6	37°59.334	121°24.559'
435	Windmill Cove	18-Sep-00	10:00	COL180900WNDM-	35.00	12:30	18-Sep-00	35.00	9:00	19-Sep-00	1:1	49	45	1732.87	5	0	5.2		
436	Windmill Cove	02-Oct-00	11:35	COL021000WNDM-	35.00	12:45	02-Oct-00	35.00	9:05	03-Oct-00	1:1	47	25	2809	1	0	10	37°59.359'	121°24.555'
437	Windmill Cove	02-Nov-00	11:25	COL021100WNDM-SH1	35.00	12:25	02-Nov-00	34.50	9:00	03-Nov-00	10:1	48	19	2602	3	1	41	37°59.407'	121°24.521'
438	Windmill Cove	20-Nov-00	10:00	COL201100WNDM-	35.00	12:15	20-Nov-00	35.00	8:00	21-Nov-00	10:1	49	22	3873	30	9	588	37°59.354'	121°24.553'
439	Windmill Cove	25-Jan-01	10:50	COL250101WNDM-	35.00	13:20	25-Jan-01	35.00	9:00	26-Jan-01	10:1	14	1	173	0	1	10	37°59.417'	121°24.516'
440	Windmill Cove	07-Mar-01	11:00	COL070301WNDM-LC1	35.00	13:15	07-Mar-01	35.00	10:30	08-Mar-01	20:1	49	9	3912	17	1	406		
441	Windmill Cove	21-Mar-01	10:35	COL210301WNDM-LC1	35.00	13:30	21-Mar-01	35.00	10:30	22-Mar-01	20:1	49	33	14540	12	0	270		
442																			

	Total		Fecal		
Date	R-1	R-2	R-1	R-2	
8-Feb-2000					
9-Feb-2000	1059 MPN/100 ml	2300 MPN/100 ml	209 MPN/100 ml	2300 MPN/100 ml	
10-Feb-2000					
7-Mar-2000					
8-Mar-2000	1300 MPN/100 ml	500 MPN/100 ml	300 MPN/100 ml		
9-Mar-2000					
4-Apr-2000		1400 MPN/100 ml	30 MPN/100 ml	7 MPN/100 ml	
2-May-2000					
3-May-2000	1700 MPN/100 ml	2800 MPN/100 ml	500 MPN/100 ml	80 MPN/100 ml	
4-May-2000					
27-Jun-2000					
28-Jun-2000	1300 MPN/100 ml		1700 MPN/100 ml	300 MPN/100 ml	
29-Jun-2000	900 MPN/100 ml	500 MPN/100 ml	2400 MPN/100 ml	220 MPN/100 ml	RB staff collection
26-Jul-2000	220 MPN/100 ml	300 MPN/100 ml	50 MPN/100 ml	130 MPN/100 ml	
22-Aug-2000					
23-Aug-2000	281 MPN/100 ml	500 MPN/100 ml	30 MPN/100 ml	30 MPN/100 ml	
24-Aug-2000					
19-Sep-2000					
20-Sep-2000	3000 MPN/100 ml	2200 MPN/100 ml	3000 MPN/100 ml	230 MPN/100 ml	
21-Sep-2000					
17-Oct-2000					
18-Oct-2000	24000 MPN/100 ml	7000 MPN/100 ml	800 MPN/100 ml	300 MPN/100 ml	
19-Oct-2000					
14-Nov-2000					
15-Nov-2000	3000 MPN/100 ml	800 MPN/100 ml	300 MPN/100 ml	300 MPN/100 ml	
16-Nov-2000					
12-Dec-2000					
13-Dec-2000	2800 MPN/100 ml	900 MPN/100 ml	500 MPN/100 ml	80 MPN/100 ml	
14-Dec-2000					
9-Jan-2001	2300 MPN/100 ml	1300 MPN/100 ml	230 MPN/100 ml	23 MPN/100 ml	
6-Feb-2001					
7-Feb-2001	500 MPN/100 ml	300 MPN/100 ml	50 MPN/100 ml	30 MPN/100 ml	
8-Feb-2001					
6-Mar-2001					
7-Mar-2001	5000 MPN/100 ml	1300 MPN/100 ml	140 MPN/100 ml	50 MPN/100 ml	

8-Mar-2001					
3-Apr-2001					
4-Apr-2001	1600 MPN/100 ml	1600 MPN/100 ml	80 MPN/100 ml	50 MPN/100 ml	
5-Apr-2001					
2-May-2001	1100 MPN/100 ml	2300 MPN/100 ml	17 MPN/100 ml	50 MPN/100 ml	
26-Jun-2001	1600 MPN/100 ml	80 MPN/100 ml	2400 MPN/100 ml	240 MPN/100 ml	(R-1 fecal = >2400) RB staff collected
27-Jun-2001	800 MPN/100 ml	2300 MPN/100 ml	130 MPN/100 ml	130 MPN/100 ml	

For period beginning 1 February 2000 and ending 30 June 2001:

Minimum	220 MPN/100 ml	80 MPN/100 ml	17 MPN/100 ml	7 MPN/100 ml
Maximum	24000 MPN/100 ml	7000 MPN/100 ml	3000 MPN/100 ml	2300 MPN/100 ml
>200	17	17	10	6
>400	15	15	6	1
	18	18	19	18

Bear Crk- Hg

B.1.4 Bear Creek, Mercury

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region (Regional Board) recommends the addition of Bear Creek to California's Clean Water Act Section 303(d) list due to impairment by mercury. Information available to the Regional Board on mercury levels in water indicates that water quality objectives are not being attained in Bear Creek. The description for the basis for this determination is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Bear Creek	**Pollutants/Stressors**	Mercury
Hydrologic Unit	513.20	**Sources**	Resource extraction (abandoned mines)
Total Waterbody Size	27 miles	**TMDL Priority**	
Size Affected	15 miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	From the unnamed creeks to Cache Creek	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	39° 05' 18"	**Upstream Extent Longitude**	122° 24' 57"
Downstream Extent Latitude	38° 55' 35"	**Downstream Extent Longitude**	122° 19' 59"

Watershed Characteristics

Bear Creek is in Colusa County, east of Clear Lake. The creek is approximately 39 miles long from its headwaters (just north of Indian Valley Reservoir) to its confluence with Cache Creek (Foe and Croyle, 1998; Montoya and Pan, 1992). It receives water from numerous tributaries, including Sulfur Creek (the largest tributary) and Hamilton Creek.

The Bear Creek watershed receives inflow from several mines, including the Sulfur Creek Mining District. Six inactive mercury mines are located in the Bear Creek watershed: Elgin Mine along the upper West Fork tributary of Sulfur Creek, Rathburn Mercury Mine along an unnamed tributary to Bear Creek, and Central, Wide Awake, Empire, and Manzanita mines along the main stem of Sulfur Creek (Montoya and Pan, 1992; Foe and Croyle, 1998). In addition, the area has several active geothermal springs that also may be sources of mercury (Foe and Croyle, 1998). These waters flow directly into Bear Creek, impacting the water quality.

Water Quality Objectives Not Attained

The United States Environmental Protection Agency (USEPA) California Toxic Rule (CTR) criterion for mercury is not being attained. The California Toxics Rule (CTR) lists a criterion of 50 nanograms per liter (ng/L, or parts per trillion [ppt]) of mercury for freshwater sources of drinking water (for human consumption of water and/or aquatic organisms) (USEPA, 2000a).

Evidence of Impairment

Water quality data indicates that Bear Creek is impacted by mercury. Water samples were collected on thirteen days between April 1996 and February 1998. Four locations were sampled along Bear Creek: (1) at Culvert Road (above the confluence with any of the unnamed creeks or Sulfur or Hamilton Creeks), (2) between the confluence of Hamilton and Sulfur Creeks (below the confluence with the unnamed and Hamilton Creeks and above the confluence with Sulfur Creek), (3) at Highway 20 (downstream from the confluence with Sulfur Creek and above the confluence with Thompson Creek), and (4) just upstream from the confluence with Cache Creek (the furthest downstream point). Table B-2 summarizes the data.

Table B-2. Summary of Mercury Concentrations in Bear Creek[a]

Sampling Location	Number	Range in	Percent of Samples

(Listed from upstream to downstream)	of Samples	Concentrations (Total Hg, ng/L)	with Mercury Concentrations above USEPA Criterion (50 ng/L)
1. At Culver Road	2	13.29 – 30.09	0%
2. Between Hamilton and Sulfur Creeks	3	62.65 – 254.0	100%
3. Highway 20	2	328.2 – 1,595.9	100%
4. Just upstream of Cache Creek	12	18.53 – 1,290.2	67%

[a] Data from Foe and Croyle (1998).

Table B-2 indicates that above the unnamed creeks (sampling location #1), mercury concentrations are relatively low. By sampling location #2, mercury concentrations increase to levels above the CTR criterion. This indicates that mercury enters Bear Creek at or above Hamilton Creek, most likely at the unnamed creek that passes along Rathburn Mercury Mine. The levels of mercury increase between locations #2 and #3, by approximately 50 times, indicating that high levels of mercury enter Bear Creek at Sulfur Creek. Below Sulfur Creek, mercury concentrations decrease due to the inflow of additional water. Water quality data indicate that mercury enters Bear Creek primarily from Sulfur Creek and, to a lesser degree, from the unnamed upstream creeks and possibly other creeks.

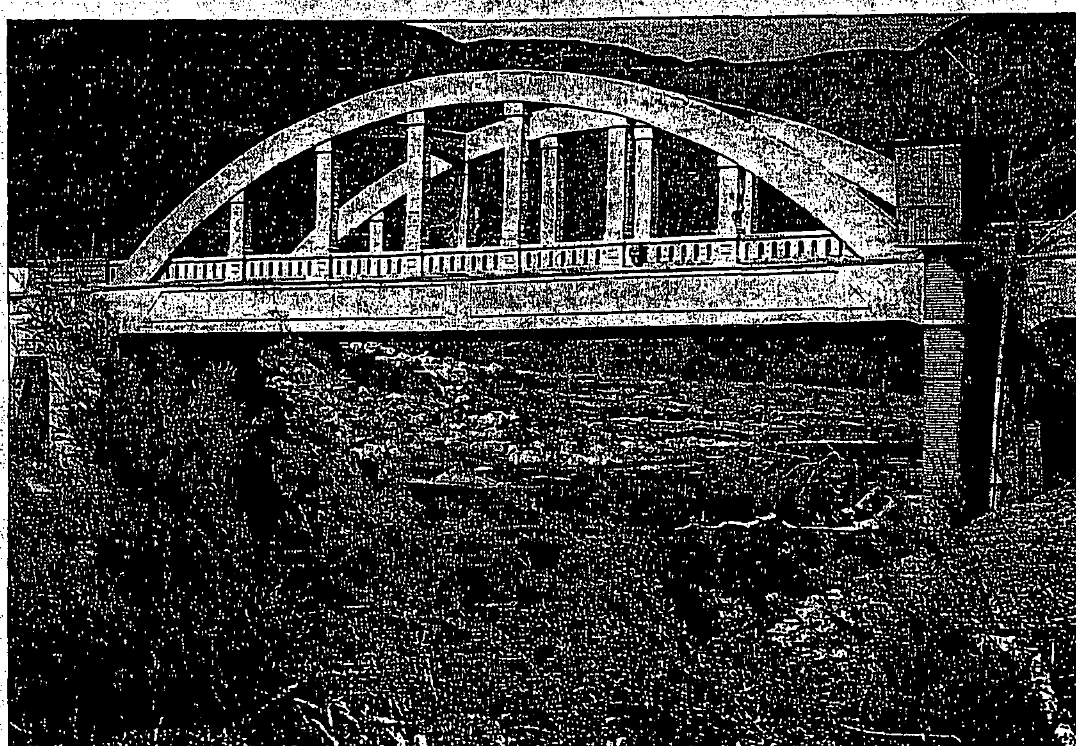
Extent of Impairment

Water quality data indicate that mercury concentrations exceed the criteria at or above Hamilton Creek, most likely beginning at the unnamed creek that passes along Rathburn Mercury Mine. This indicates that, although Sulfur Creek probably contributes the most mercury, Bear Creek is listed as impaired from its confluence with the unnamed creek that flows along Rathburn Mercury Mine to its confluence with Cache Creek.

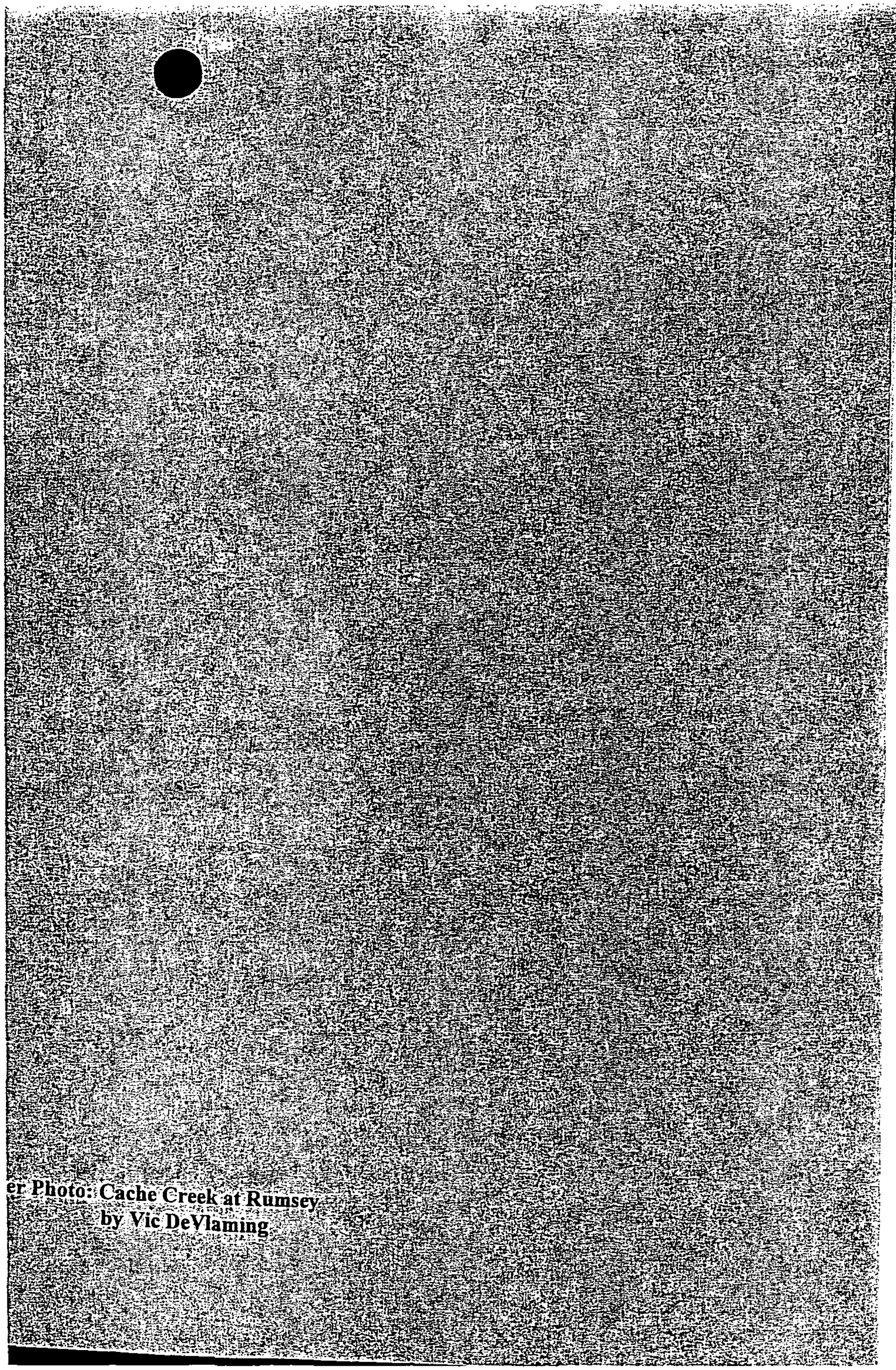
Potential Sources

The primary source of mercury is resource extraction (abandoned mines) from the mines located in the Sulfur Creek watershed and along the unnamed creek upstream from Bear Creek.

MERCURY CONCENTRATIONS AND LOADS FROM THE SACRAMENTO RIVER AND FROM CACHE CREEK TO THE SACRAMENTO-SAN JOAQUIN DELTA ESTUARY



June 1998



er Photo: Cache Creek at Rumsey
by Vic DeVlaming

California Regional Water Quality Control Board
Central Valley Region

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observed. In contrast, almost all mercury/TSS values measured in the Yolo Bypass in January 1995 varied between 0.12 and 0.20 (Figure 9). This is similar to ratios measured on 10 March in the upper Basin, confirming that much of the water, mercury, and sediment present in the Bypass originated from there.

In conclusion, the mercury observed at Greene's Landing during the large March storm likely originated from the Feather and American River watersheds while most of the sediment and mercury from the upper Sacramento River should have been transported down the Yolo Bypass. The source(s) of the elevated concentrations of mercury in the upper Sacramento River between Woodsen Bridge and Ord Ferry are not known. However, likely candidate source(s) are one or more of the small east and westside tributary creeks which appear to have contributed much of the water volume.

Cache Creek Basin Elevated mercury concentrations in the Yolo Bypass on 10 and 11 January (696 and 553 ng/l) suggested a possible local source (Figure 8). All local inputs, except the Sacramento River, were sampled on at least one occasion during two succeeding storms (Table 9). An accurate assessment of the contribution of the Sacramento River is impossible to make at its discharge point into the Bypass as the Sacramento and Feather Rivers and the Sutter Bypass all join immediately upstream (Figure 1) and are not well mixed upon discharge through the weir. Therefore, each of the three tributaries was sampled individually. The highest concentrations of mercury were consistently observed in Cache Creek (Table 9) suggesting that the watershed might be a major source of mercury.

A follow-up study was initiated in the Cache Creek Basin upon obtaining these results. The study had three objectives. First, confirm that the Basin was a major source of mercury during another water year. Second, measure mercury concentrations seasonally in the lower Basin to determine the extent of the exceedance of U.S. EPA criteria and to ascertain bulk mercury transport from the watershed. Finally, identify, if exceedances of U.S. EPA criteria were observed, the principal source(s) of the metal.

Studies conducted between 1996-1998 confirmed that Cache Creek was a major source of mercury. A correlation was noted between total mercury concentration at Road 102 and flow immediately upstream at the Town of Yolo ($R^2 = 0.83$;Figure 11). This relationship was employed to estimate both the frequency of exceedance of U.S. EPA criteria in the lower watershed and to determine bulk mercury exports.

Frequency of exceedance of criteria The frequency of exceedance of the U.S. EPA 12 ng/l mercury criteria was estimated for the lower Cache Creek Basin from the correlation between concentration and flow (Figure 11) and from reported daily discharge rates at the Town of Yolo. Results have been summarized by month for a critically dry (1994), and two wet (1995 and 1996) Sacramento Basin water year types (Table 10). A Sacramento Basin water year categorization was employed as no similar standard is available for the Coast Range and precipitation conditions in the Sacramento watershed are thought to be sufficiently similar to those in Cache Creek to provide a general indication of the relative amount of annual precipitation and water runoff.

The correlation suggests that the U.S. EPA recommended mercury criteria of 12 ng/l is predicted to be exceeded when Cache Creek flows are greater than 100 CFS (Figure 11). Flows of this magnitude occur in the lower Basin about 3 and 35-40 percent of the time during critically dry and wet water year types (Table 10). Months during wet years with a high frequency of exceedance are January through April while during the 1994 dry year only the month of February was sufficiently wet. The results emphasize the importance of storm runoff during wet winters in producing exceedances of the U.S. EPA criteria in the lower Basin.

Loads Cache Creek is diverted into an area called the Settling Basin before discharge to the Yolo Bypass (Figure 2). Purpose of the Settling Basin is to trap suspended sediment and help maintain the capacity of the Bypass to transport large volumes of Sacramento River flood water during storm events. The Settling Basin is periodically dredged to maintain its depth and settling capacity. The concentration of mercury and TSS entering (Road 102, site 2) and leaving (Spillway, site 1) the Settling Basin were compared on 16 occasions to ascertain the settling efficiency of the impoundment. The results suggest that the Settling Basin acts as a sink, trapping about half the mercury and sediment entering it at flows greater than 730 CFS (Table 11). In contrast, the Basin exports three to four times the amount of material entering it at discharge rates less than 150 CFS.

Bulk mercury loads from the Cache Creek watershed to the Settling Basin were estimated for three water years. Loads were calculated by multiplying the reported daily flow at the Town of Yolo by the correlation of mercury concentration and flow (Figure 11) and summing by day over the water year. The results suggest that the watershed exported 0.6, and 221-980 kg/yr of mercury during a critically dry and two wet Sacramento River water year types (Table 10). The majority of the load was transported during the months of January to March in wet years.

Bulk mercury export to the Yolo Bypass from the Settling Basin was also estimated for the three water years. Loads were calculated by multiplying the estimated daily load transported into the Settling Basin by either 0.5 or 3.2 depending on whether the flow rate was greater or less than 730 CFS and again summing by day over the water year. The results suggest that the Cache Creek Settling Basin exported 1.2 and 114-495 kg/yr of mercury during a critically dry and two wet water years (Table 10). The results demonstrate, as with the exceedance of U.S. EPA criteria, the importance of wet winters in mobilizing and transporting mercury from the Basin into the Estuary.

To place these loads in perspective, it is estimated that the Sacramento watershed[9] is about 23 times larger than Cache Creek. In water year 1995 the Sacramento watershed is estimated to

[9]The Sacramento watershed is about 16 million acres while the Cache Creek Basin is only 0.7 million (Basin Plan; Sorenson and Elliott, 1981).

have exported 640 kg of mercury (Larry Walker and Associates, 1997). The Larry Walker estimate excluded all Coast Range inputs to the Yolo Bypass. By comparison, Cache Creek is estimated to have exported 980 kg to the Settling Basin or 1.5 times that of the much larger Sacramento watershed. About half of this mercury was trapped in the Settling Basin while the remainder was exported to the Yolo Bypass.

Hydrologic Mercury Loading Patterns The third objective of the Cache Creek study was to attempt to determine major local sources of mercury. The main area of interest was the 81-mile reach between Clear Lake and the Settling Basin (Figure 2). Within this area the watershed is naturally divided into three sub-basins: the north and south forks and Bear Creek. All three water bodies flow year round. The north and south forks flows are controlled by dams at Indian Valley and at Clear Lake, respectively with winter storm runoff being trapped in both reservoirs for release during irrigation season. Annual irrigation storage from the two impoundments may be as much as 393,000 acre-feet with Clear Lake providing 80% of the water[10] (Sorensen and Elliott, 1981). Bear Creek has no major dams.

The upper Cache Creek basin (above Rumsey) is largely undeveloped chaparral and shrub oak habitat and is primarily used as rangeland. Large areas are highly erosive. The gradient of the Creek in the 33 mile reach between Clear Lake and Rumsey is steep, dropping an average of 22 ft/mile (Sorensen and Elliott,1981). This drop is sufficient to ensure good sediment transport during all but the lowest flow periods.

There are three inactive mercury mining districts in the upper Basin (Figure 2). The Clear Lake District includes Sulfur Bank Mine, an EPA superfund site. The second mining district is Sulfur Creek. This district includes the Elgin, Empire, Abbot and Wide Awake mines. These drain predominately to Bear Creek. Finally, the Knoxville District is located in both the Putah and Cache Creek watersheds. Reed mine is part of the Knoxville District and is the site of the McLaughlin gold mine. The Homestake Mining Company constructed Davis Creek Reservoir as a local water source for the McLaughlin mine and remediated much of the Reed Mine site to reduce off-site movement of mercury. Lake Davis Reservoir has been documented to trap and settle as much as 200-300 kg/yr of mercury eroding off the inactive Reed Mine (Slotton, 1991;Reuter *et al*., 1996). Lake Davis drains into Davis Creek which is tributary to Cache Creek above the confluence of Bear Creek.

The lower Basin (downstream of Rumsey) is intensively farmed with row, orchard and rice cultivation being the major agricultural activities. An inflatable dam is constructed each irrigation season at Capay and water diverted into the Winters and Adams Canals. During peak irrigation much of Cache Creek below Capay Dam is dry with only small intermittent ponded areas where the groundwater table is high. The stream bed is broad and flat, dropping an average

[10]Actual releases during the 1996 and 1997 irrigation season from Clear Lake were 359,774 and 130,750 acre-feet. Similarly, the releases from Indian Valley were 36,162 and 101,322 acre-feet.

of 6 ft/mile during the 30 miles between Capay Dam and the Bypass. The broad flat floodplain ensures continuous erosion and redeposition of sediment during all but the highest flows. Several tailwater irrigation return flows enter above the town of Yolo providing some discharge from the lower basin to the Yolo Bypass during the dry season. This occurred during much of this study.

Thirteen mercury surveys were conducted during two hydrologic cycles in an attempt to characterize mercury concentrations and loads and to identify sources. The strategy involved sampling each of the three subbasins near their confluence with the main stem Creek to determine their relative importance. Once the general seasonal mercury loading patterns were ascertained, then intensive sampling was conducted in subbasins responsible for the majority of the load to determine sources.

Three distinct mercury loading patterns were noted. These have been classified according to the time period when they were most commonly observed: irrigation season; non-irrigation non-precipitation runoff; and precipitation runoff events. Each is described below.

Irrigation season Three surveys were conducted during the April through October irrigation season (Table 12). The 11 June 1996 survey is thought typical and is presented graphically in Figure 12. Overall, the irrigation season is the time period of the lowest mercury and sediment transport in the Basin. As previously mentioned, the source of most of the irrigation water is from Clear Lake and so it is not surprising that most of the suspended sediment and mercury also originates from here. Presumably, the source of the mercury in Clear Lake is from Sulfur Bank Mine. During the irrigation season most of the flow in the Creek is diverted at Capay Dam for agriculture. Mercury and suspended sediment loads in the diverted water are either deposited on farmland or passed through as irrigation tailwater. A much smaller volume of water, predominately irrigation return flow, is present at Road 102. Interestingly, during our surveys this return water always contained higher mercury and suspended sediment concentrations than the water exported at Capay Dam. Presumably the source of the mercury is from erosion off cultivated fields and from remobilization of sediment deposited in the lower Creek bed. An exception to the almost total diversion of upstream water at Capay Dam occurred on 4 April 1996 (Table 12). This survey was conducted immediately after a series of late spring rainstorms (Figure 13a) and no water was needed for irrigation. Therefore, diversion water was being allowed to flow downstream. Also, no rain runoff was visible in the small creeks in the lower watershed. Consequently, the flow rate was constant down Cache Creek (Table 12). A large increase in mercury load was still noted between Rumsey and Road 102 suggesting that much of the sediment and mercury being transported during irrigation season at Road 102 might result from the remobilization of material previously deposited in the lower creek bed.

An advantage of load calculations is that the loads in a watershed must be additive for conservative elements like total mercury and sediment unless large amounts of deposition and remobilization occur. The steepness of the upper watershed should preclude significant deposition. Therefore, variance in mercury and sediment loads in the upper Basin may best be

considered an indication of the reliability of the load estimates. Major potential sources of error are inaccuracies in either measuring mercury concentrations, flow or in collecting representative field samples for an accurate assessment of loads. The latter is probably the major source of error in this study as single subsurface grab samples were employed. In general, the data suggest that mercury load estimates during the irrigation season are accurate to within a factor of two or three. For example, 37 grams of mercury were reported to have been exported from a combination of Clear Lake and the North Fork on 11 June 1996 (Figure 12;Table 12) but only 24 g/day were measured 24 miles downstream at the confluence of the Bear and Cache Creek. Bear Creek added an additional gram for a total of 25 g/day but only 12 g/day were measured 9 miles downstream at Rumsey. Most of the water was diverted at Capay Dam so the small mercury load at Road 102 probably results from the remobilization of bedload material. The inaccuracy in load estimates is greater than would be expected from replicate field mercury samples but the error in the loads is assumed to be real as no evidence of mercury field contamination was observed in the mercury quality assurance and quality control program.

Examination of the mercury loading estimates (Table 12) indicate that transport in the upper basin during the six month irrigation season is on the order of 10-50 g/day. Exports from the lower watershed to the Settling Basin are usually less because of diversions at Capay Dam. Exceptions are on the few occasions, such as 4 April 1996, when irrigation releases upstream are high but no diversion at Capay Dam occurred. It must be emphasized, though, that these irrigation loads estimates are based upon only a few measurements and more surveys are needed to confirm these results.

Comparison of mercury concentrations with recommended U.S. EPA criteria demonstrate few exceedances of the 12 ng/l criteria in the upper basin during irrigation season except on Bear Creek (Table 12). All Bear Creek values exceeded the 12 ng/l limit except on 29 September 1997. On 29 September Bear Creek mercury concentrations were 8.65 ng/l. Much less dissolved mercury data is available (Table 12). No value exceeded the proposed California Toxics Rule value of 50 ng/l. Only concentrations on Bear Creek appear to routinely be greater than the recommended National Toxics Rule concentration of 1.8 ng/l. More dissolved mercury data is needed from throughout the watershed to better establish baseline concentrations.

The ratio of mercury/TSS varied, except for Bear Creek, between 0.2 and 0.7 ppm dry weight for the upper watershed (Table 12). Sediment mercury concentrations for Bear Creek were about an order of magnitude higher (4.2-8.4) suggesting, like the mercury water concentration data, that Bear Creek is the most contaminated of the three drainages.

Non-precipitation runoff Irrigation ceases in October and baseline flows from Clear Lake and Indian Valley Reservoirs drop to 3-7 and 10 CFS, respectively. Bear Creek always appears to discharge a small amount of water (0.5-2 CFS). These three flows plus groundwater seepage result in an almost continuous discharge of water as far downstream as Capay Dam whereupon Creek flow becomes intermittent. The first large rain storms in California typically occur in December. Bear Creek and the North Fork have more of their watershed located below reservoirs than does the South Fork. Therefore, these two contribute most of the initial flow. As precipitation continues, Clear Lake and Indian Valley Reservoir levels rise and both impoundments begin to release water. Typical runoff from the North and South Fork are of about equal magnitude during late winter and early spring. Bear Creek, having a much smaller watershed, has less discharge.

No mercury surveys were undertaken between the end of irrigation and the beginning of the rainy season as little mercury was thought to be transported during these low flow conditions. The 27 February 1996 event was taken after a seven day dry period (Figure 13a). About half an inch of rain fell in the late afternoon but no runoff was visible during sampling. The flow was about equally divided between the North and South forks, however, the North Fork contributed about ten times as much mercury and suspended sediment (Table 13;Figure 14). Mercury and suspended sediment loads appear to steadily increase downstream with loads at Road 102 being about 1.5 times larger than at Rumsey. The increase in mercury loads downstream again suggest remobilization of bedload material below Rumsey.

The accuracy of non-irrigation season mercury loads are not known as insufficient measurements were made. Therefore, it is assumed that the reliability of the measurements are similar to those obtained during the irrigation season which were estimated to be within a factor of 2 to 3 of the true value. If correct, mercury loads from the upper basin during winter non-storm periods may be on the order of 100 to 1,000 g/day. This is about 10 to 20 times more mercury than was believed exported during irrigation season. Again, the load estimates are based upon few measurements. More sampling is needed to confirm these values.

Comparison of instream mercury concentrations with the U.S. EPA criteria demonstrate that all values collected in the watershed exceed 12 ng/l (Table 13). Some concentrations from the lower basin are greater than the recommended criteria by at least two orders of magnitude. No dissolved mercury data was collected.

Like during the irrigation season, the ratio of Hg/TSS varied between 0.2 and 0.4 ppm dry weight. The only exception was Bear Creek with ratios of 1.5 to 3.8 ppm. The higher ratios in Bear Creek again suggest runoff from a more mercury enriched environment.

Precipitation Runoff The third loading pattern was observed during and immediately after large storms. Storm-induced mercury runoff is the least frequent of the three load patterns and only occurred after sufficient rain had fallen in the watershed to saturate the soil profile and induce sheet runoff. The 1996 and 1997 water years were classified as wet in the Sacramento watershed and about 4-10 major rainstorms occurred per year as evidenced by short term increases in Cache Creek flow at Rumsey (Figure 13a,b). The frequency of storm runoff was higher in 1998, a third wet year (Figure 13c).

Eight storm surveys were conducted (Table 14). Load estimates during rainfall periods were emphasized as the mercury loading patterns at the Settling Basin suggested that these might be

critical events to understand. Results of the 21 February 1996 event are presented in Figure 15. Both the source and volume of flow during storm events is highly variable. Early in the season reservoirs are low and the majority of water is from overland runoff, mostly originating from the Bear and from the North Fork watersheds. The relative contribution from Bear Creek is greatest at this time. Later in the season flows are a combination of reservoir discharge and overland runoff. Typically, late season flows are much larger and are dominated by reservoir discharge from the North and South Forks.

Only one early storm-season event was sampled (23 December 1996). The event was unique in that Bear Creek contributed about half of the flow and a large part of the mercury load in the upper Basin. During all other events, most of the flow was from the North and South Forks. On these occasions the major source of mercury originated from a section of Creek located downstream of the confluence of the North and South Forks but above Bear Creek (Figure 15; Table 14). This section of Cache runs through an inaccessible portion of canyon. Throughout the study period, the canyon accounted for more than 90% of the mercury load above Rumsey[11]. The only exception was during the early (23 December 1996) and late (2 and 3 April 1996) storm season when the contribution from the canyon was 30-50% of the load above Rumsey. The fact that large loads only appear to be present in the canyon after large storms suggest that the source(s) may be one or more ephemeral streams that only discharge then.

The largest mercury loads were exported from the upper Basin after storms. For example, 25,128-63,558 g/day of mercury were estimated to have been transported past Rumsey on 26 January 1997 (Table 14). The load is equivalent to between 3-35 years of irrigation season runoff or between 25-600 days of winter non-storm runoff. Obtaining precise estimates of both the frequency and magnitude of these events is important. However, good estimates of either are beyond the scope of this study. The 1996 to 1998 rainfall data suggest, though, that large storms with several days of runoff may occur multiple times during wet years. Estimates of the amount of mercury transported in the upper basin during these occasions varied between 14,000-63,000 g/day (Table 14). As on other occasions, concern exists about the accuracy of the estimates. Replicate field samples were taken on 2 April 1996 and again on 26 January 1997 to provide an indication of the repeatability of the mercury load measurements (Table 14). These estimates, similar to that seen during the irrigation season, appear to vary by a factor of 2-3 suggesting that the true export value may range between 5,000 and 180,000 g/day. The upper value is likely high as repeated measurements 19 miles downstream at Capay on 26 January (when 63,000 g/day mercury was measured at Rumsey) demonstrate an upper value of 92,000 g/day. The latter value is also consistent with loading estimates at Road 102[12]. Therefore, mercury transport in the

[11]Canyon loads were determined by subtracting the sum of the loads from the North and South Forks from those at site 6.

[12]The maximum mercury concentration observed in this study was about 2,000 ng/l at around 20,000 CFS (Figure 11). This is equivalent to about

upper Basin, unless much larger rainstorms occur than were measured in this study, are likely to be on the order of 5,000-100,000 g/day.

Comparison of instream mercury concentrations with the recommended U.S. EPA criteria demonstrate that all values obtained in the Basin, accept at Clear Lake and during the late storm season on the North Fork, exceeded the recommended value of 12 ng/l (Table 14). Mercury concentrations in Clear Lake appear to be near 12 ng/l. On three occasions the recorded value was greater than the recommended criteria while in two instances it was below it. Mercury concentrations on the North Fork on 2 and 3 April were 4.34 and 2.59 ng/l. All other values measured in the Basin were above the criteria with some concentrations from Rumsey and Capay exceeding it by more than two orders of magnitude. As on other occasions, little dissolved data was collected. No value exceeded the California Toxics Rule concentration of 50 ng/l. In contrast, all numbers, except for 2 April 1996 at site 6, were above the National Toxics Rule value of 1.8 ng/l. The dissolved mercury concentration on 2 April at site 6 was 1.67 ng/l. As noted before, much more data is needed to adequately characterize dissolved mercury concentrations in Cache Creek.

The ratio of Hg/TSS is important during storms as that is when most of the sediment is moved in the basin. Bear Creek, as during other times, consistently exported mercury enriched sediment (range 1.9-12.7 ppm dry weight). However, unlike on other occasions, mercury concentrations in sediment at site 6 on Cache Creek were also often elevated. The highest concentrations were measured on occasions with the greatest flow (21, 22, 23 February 1996 and 26 January 1997). The mercury/TSS ratio on these dates varied between 1.8-14.5 ppm. On these occasions the elevated ratio was often maintained downstream suggesting that the unknown canyon source(s) were dominating suspended sediment mercury concentrations. Exceptions were on 21 and 23 February 1996 when high sediment values were only observed at site 6.

To summarize, three general mercury loading patterns were observed in Cache Creek: summer irrigation, winter non-storm runoff, and winter storm-runoff events. The irrigation season occurs during the seven-month period between April and October. Mercury export rates from the upper basin were on the order of 10-50 g/day with most of the metal coming from Clear Lake. Mercury export from the lower Basin is usually much less as most of the water (and mercury) is diverted for irrigation. The winter non-runoff period is the next most common event occurring between November and March. This study was characterized by wet winters. Mercury export rates from the upper Basin were on the order of 100-1000 g/day. Much of the mercury appeared to originate from the North Fork of Cache Creek. Finally, storm mercury export periods were least common and occurred with a frequency of 4-10 times per year. All subbasins exported significant amounts of mercury but the majority of the metal appeared to come from the Cache Creek canyon downstream of the confluence of the North and South forks but above the Bear Creek inflow. Storm mercury export rates were on the order of 5,000-100,000 g/day. Overall,

100,000 g/day.

infrequent storm runoff events account for the majority of the mercury exported from the Basin.

Sources Five intensive surveys were conducted during storms to attempt to identify major sources of mercury in each sub basin. Three were in Bear Creek and in the North Fork and two were float trips down the inaccessible section of Cache Creek canyon between the confluence of the North and South Forks and Bear Creek (Figure 2). There was insufficient time during these trips to collect flow data for each tributary so calculations of loads were impossible. Instead, the strategy consisted of sampling above, in and below tributaries to ascertain whether they might enhance or dilute instream mercury and suspended sediment concentrations. The drainage area of each tributary was estimated to provide a rough indication of potential storm runoff volumes. Results are summarized below by each sub-basin: Bear Creek, North Fork, the canyon area including Harley Gulch, and lower Cache Creek .

Bear Creek Sulfur Creek appeared to be the major source of mercury in Bear Creek (Figure 16). Sulfur Creek is the largest tributary to Bear Creek and drains a 10 square mile area including the inactive Central, Wide Awake, Elgin, and Manzanita mercury mines. The drainage also has several active geothermal springs which may also be sources of mercury. Mercury concentrations in Sulfur Creek on 26 January 1997 and on 2 February 1998 were 5,316 and 11,421 ng/l[13] (Table 15). These concentrations were sufficient to increase downstream mercury concentrations in Bear Creek four to sixfold. The ratio of mercury to suspended solids also support the hypothesis that Sulfur Creek was a major source of sediment contaminated mercury. The ratio varied between 16.1-22.4 ppm dry weight. Addition of this sediment to Bear Creek resulted in a four to five fold increase in the ratio downstream for Bear Creek at the Highway 20 bridge.

A more limited survey was undertaken on 16 February 1998. Mercury concentrations were about 32 times higher in Sulfur Creek (1,964 ng/l) than upstream on Bear Creek (Table 15). No downstream measurements were made so it is not known how much this increased downstream Bear Creek mercury concentrations.

The data also suggest the possibility of a second mercury source(s) between where Bear Valley Road first crosses the Bear (site 16) and Sulfur Creek (Figure 16). Instream mercury concentrations increased seven to ninefold on 26 January 1997 and on 2 February 1998 in this four mile stretch. Three small unsampled creeks drain the northern portion of the Sulfur Creek mercury mining district. One, an unnamed creek, flows past the Rathburn mercury mine. More work is needed to identify the source of mercury in this stretch of Bear Creek.

North Fork On 26 February 1997 Indian Valley Reservoir was discharging 10 cfs but flows at the Highway 20 bridge were estimated at 3,500 cfs (Table 17). Mercury concentrations increased from 21 ng/l at Indian Valley to 125 ng/l at Highway 20 suggesting a large mercury input in the

[13]Dissolved mercury concentrations were 52 and 76 ng/l on both dates, respectively.

12 mile reach[14]. Mercury concentrations decreased downstream of here to 104 ng/l at the confluence of the South Fork implying that there were no additional large inputs. Much of the flow above Highway 20 came from Wolf and Long Valley Creeks (Figure 17), consistent with their large drainage areas. Mercury was detected in both but not at a sufficiently high concentration to explain the results observed at Highway 20.

On 2 February 1998 ten cfs was again discharged from Indian Valley Reservoir and about 2,000 cfs was present at Highway 20 (Table 15). Mercury concentrations doubled between Chalk Mountain (Site 21, two miles downstream of Indian Valley Dam) and Highway 20, again suggesting the presence of a large input(s) between the two locations[15]. Benmore Canyon and Grizzly Creek were sampled in addition to Wolf and Long Valley Creeks. Wolf and Long Valley were again found to carry insufficient mercury to account for the increase observed downstream at Highway 20. In contrast, Benmore and Grizzly Creeks transported 2,149 and 3,022 ng/l of mercury, respectively. Both drain seven to eight-square mile watersheds on the western slope of the Sulfur Creek mercury mining district. These two had large flows and appeared to explain much of the increase in mercury observed at Highway 20. The two were also found to transport large amounts of suspended sediment (14,000-16,000 mg/l) and this may explain the large increase in TSS observed at Highway 20.

A follow up survey was conducted on 16 February 1998 (Table 15). Mercury concentrations in Benmore and Grizzly Creeks were 9-12 times greater than immediately upstream on the North Fork confirming that these two watersheds are major sources of mercury during rainstorms.

The ratio of mercury/TSS was uniformly low in the North Fork (0.1-0.3 ppm dry weight, Table 15). Similarly, low concentrations were observed in Benmore and Grizzly Creeks. These values are in contrast to the ratios measured on Sulfur Creek (16-22 ppm) suggesting that much of the mercury in the North Fork may originate from sheet erosion off the steep slopes characteristic of this portion of the watershed. A detailed assessment should be undertaken in Benmore and Grizzly Creeks to determine the source of the mercury and the feasibility of controlling local erosion.

<u>Harley Gulch</u> Harley Gulch is the only tributary to the inaccessible portion of the Cache Creek canyon that can be accessed by car for sampling. This portion of Cache Creek has previously been shown to be responsible for most of the mercury exported from the watershed during storms. The western branch of Harley Gulch drains a 0.6 square mile portion of watershed that includes the Abbott and Turkey Run Mines. The eastern gulch drains about 2.1 square miles of the southern portion of the Sulfur Creek mining district. Both halves join immediately below

[14]Mercury loads for the North Fork at Indian Valley Dam and at Highway 20 were 0.5 and 1,072 g/day, respectively.

[15]Mercury loads for the North Fork at Chalk Mountain and for HWY 20 were 12 and 5,325/6,759 g/day.

Highway 20 before dropping into the canyon. Harley Gulch appears to be ephemeral with significant flow only after rainstorms.

On 2 February 1998 Harley Gulch west was found to be discharging 359,448 ng/l of mercury (Table 15). The eastern portion of the Gulch had the larger flow but a lower mercury concentration (925 ng/l).

Both streams were resampled two weeks later on 16 February. Harley Gulch west had a mercury concentration of 146,039 ng/l confirming that it is a major source of mercury during storms.

The ratio of mercury/TSS was also high on both occasions (53.6 and 27 ppm dry weight) demonstrating that the Gulch drains a highly enriched mercury environment.

<u>Cache Creek Canyon</u> Two float trips were taken down the Cache Creek canyon to sample tributaries and attempt to determine the source of the large mercury loads observed leaving the area during storms. Both runs were largely inconclusive as they occurred after moderate rainstorms. Only Harley Gulch consistently had elevated concentrations but on both occasions these were insufficient to increase the downstream concentration on Cache Creek.

The first trip occurred on 2 April 1996 after 1.5 inches of rain fell over two days at Indian Valley Reservoir (Figure 13a). Most of the initial water volume was from Clear Lake with Cache Creek flow doubling by the confluence of the Bear (Table 16). Mercury concentrations rose steadily from 12.18 ng/l at Clear Lake to 17.63/23.58 above the Bear (Figure 18). Mercury loads tripled from 30 g/day at Clear Lake to 82-110 g/day above the confluence of the Bear. Only Harley Gulch had a greater concentration than Cache Creek, though the addition of mercury from the Gulch was insufficient to increase instream concentrations. Most of the increase in mercury concentration in Cache Creek appeared to occur downstream of Davis Creek but above the Bear. There are no tributaries in this reach suggesting the possibility that much of the increase in mercury load may have come from resuspension of bedload.

The second float trip was on 16 January 1998. This trip was again after a series of moderate rainstorms (Figure 13c). On this occasion most of the discharge was (visually) from the North Fork although no flow estimates were made. After the North and South Forks mixed, mercury concentrations were stable at 51-52 ng/l down canyon. Only Stemple (103.8 ng/l) and Harley Gulch (78.47) had higher concentrations than Cache Creek.

The ratio of mercury/TSS in the Cache Creek canyon on both float trips varied between 0.1-0.2 ppm dry weight (Table 16). Interestingly, elevated sediment mercury levels were observed on both trips in all tributaries except Stemple and Rocky Creeks suggesting the possibility that many of these tributaries might export sediment with elevated mercury concentrations during storm events. Particularly important may be Davis Creek because of its large watershed[16] and the fact that it previously carried mercury contaminated runoff from the Reed Mine. Contaminated sediment may have settled in flatter portions of the Creek to be eroded later during high flows.

Additional sampling is needed in the canyon area to conclusively identify the source of the elevated mercury loads. This information is essential so that remediation studies can be undertaken to determine whether mercury loads during storms may be reduced.

Lower Watershed Periodic increases in mercury concentration were noted in Cache Creek below Rumsey. Not known was whether these resulted from tributary inputs or remobilization of bedload material. Most of the tributary inputs are located between Rumsey and Capay Dam (Figure 18). On 2 February 1998 all seven inputs between Capay and Rumsey were sampled (Table 15). Mercury concentrations increased from 74.40 ng/l at Rumsey to 391.5 ng/l at Capay Dam. However, all seven tributaries had lower mercury concentrations than Cache Creek at Rumsey suggesting that each was acting as a dilution flow. The source of the mercury downstream of Rumsey appears to be from remobilization of bedload material.

Bioavailability Mercury loads to the Sacramento-San Joaquin Delta Estuary are of concern because of fish advisories. Mercury is a potent human neurotoxin with developing fetuses and small children being most at risk (White *et al.*, 1995). The principal route of human exposure is through consumption of mercury contaminated fish. This study has identified Cache Creek as a source of bulk mercury and confirmed the observations of Larry Walker and Associates (1997) and Alpers (personal communication) that the Feather, American and upper Sacramento Rivers are also major sources.

Factors which promote mercury accumulation in fish tissue are not well understood. However, mercury is known to biomagnify in the aquatic food chain with top predator fish often having a million times more mercury, on a per weight basis, than ambient water concentrations (Wiener and Spry, 1995). Methyl mercury is the primary form accumulating in the aquatic food chain and over ninety percent of the mercury in fish tissue is the neurologically important organic species (Bloom, 1995b). Conversion of inorganic to organic mercury is primarily controlled by sediment microorganisms, mostly sulfur reducing bacteria. Bulk water or sediment mercury concentrations are not by themselves well correlated with mercury fish tissue concentrations (Gilmour, 1995; Slotton, personal communication). Other factors which appear to influence the conversion rate of inorganic to organic mercury include the amount of organic matter and redox potential of the sediment, the oxidation state of the mercury, and water temperature, pH, alkalinity and salinity (Gilmour, 1994).

[16] The drainage area below Davis Creek Reservoir was estimated at 9.2 square miles.

The aquatic environment of the Sierra Nevada is very different from that of the Coast Range and this may affect local bioavailability. Sierra streams originate from snow melt in granitic watersheds. They are colder, more oligotrophic and have lower alkalinity and hardness than Coast Range water which drains from uplifted, low elevation, marine sedimentary material. In addition, the oxidation state of the mercury imported into the Sierras was in an elemental form. The faster moving, oxic Sierra Nevada waters are not a strongly reducing environment and most of that mercury should have remained in an oxidized state. In contrast, most of the bulk mercury present in the Coast Range is cinnabar (mercuric sulfide) which was formed underground at high temperature and pressure[17] (Pickthorn, 1993). As a result, local bioavailability of Coast Range mercury may be very different from that deposited in the Sierra Nevada Mountains. Furthermore, the relative bioavailability of both forms may change upon transport into the estuary. Neither the primary locations of methyl mercury production nor the principal factors controlling methylation rates are yet known for any waterway in California. Determining these should be a primary focus of future aquatic mercury research. In addition, emphasis should be placed upon ascertaining the relative bioavailability of mercury derived from the coastal range and from the Sierra Nevada mountains and whether decreases in loads from either would reduce fish tissue levels in the Rivers and Estuary.

Mercury concentrations in aquatic invertebrates and fish in the historic gold mining region of the Sierra Nevada Mountains have been evaluated by Slotton *et al.* (1997a). Concentrations of mercury in aquatic indicator organisms increased in a predictable fashion with increasing trophic level. A clear signature of mine derived mercury was found associated with the most intensively worked river stretches. Mercury concentrations were lower in non mined areas of the Feather and American Rivers. While sample sizes were small, fish tissue levels in Englebright Reservoir on the Yuba River and in other Foothill Reservoirs exceed the National Academy of Sciences guideline of 0.5 ppm and approach the U.S. Food and Drug Administrations Action Level of 1.0 ppm to protect human health. Larry Walker and Associates (1997) recommended that a comprehensive fish sampling study be performed in Sierra Foothill Reservoirs to determine the human health risk posed by consumption of these fish.

Foothill reservoirs have been found to operate as sinks for both bioavailable and sediment associated inorganic mercury (Slotton et al, 1997a; Larry Walker and Associates, 1997). Significantly lower levels of mercury were found in aquatic organisms below reservoirs as compared to concentrations both in and above them. Similarly, these studies showed that bulk loads of mercury entering foothill reservoirs were greater than the amounts exported. This suggests that the reservoirs in gold mining districts may act as interceptors of mercury, trapping and preventing downstream transport to the Estuary. This may explain the smaller than expected

[17] A small amount of elemental mercury may also be present naturally in the mercury deposits (Pemberton, 1983) and more may have been formed and left around mine retorts as a result of the conversion of cinnabar (Hg^{+2}) to elemental mercury (Hg^{0}).

loads measured in both the American and Feather Rivers by this study and by Larry Walker and Associates (1997). The mercury loads now present after storms in Sierra rivers may primarily result from resuspension of bedload material located below dams.

In the spring of 1996 benthic invertebrate samples were collected in the upper Cache Creek basin to determine bioavailability (Slotton *et al.*, 1997b). The most elevated samples were associated with known mercury mine drainage including Sulfur Creek, Harley Gulch, and Davis Creek. These invertebrate concentrations were much higher than any observed in comparable samples from the Sierra Nevada Mountains. The highly localized nature of the contamination was demonstrated by lower tissue concentrations in adjacent streams without mercury mining activity. Invertebrate tissue concentrations decreased with increasing distance from mine areas. Similar phenomena have been noted at Mt Diablo Mercury Mine in the Coast Range (Slotton *et al.* 1996) and at Sulfur Bank Mine in Clear Lake (Suchanek *et al.* 1997).

Invertebrates were collected at five locations along the upper mainstem Creek between Clear Lake Dam and Rumsey and at two sites on the North Fork between the Highway 20 bridge and the confluence with the South Fork (Figure 2). No data was collected in the lower watershed. Tissue concentrations were similar at all seven locations and were comparable to the highest values observed in the Sierra Nevada Mountains. The results suggest that, while Cache Creek invertebrate tissue concentrations are high, much of the large bulk mercury loads observed in the present study may not be highly bioavailable while in the upper watershed. No information is available on the bioavailability of Cache Creek mercury once transported into the Estuary, although cinnabar deposits from mine wastes in both the Philippines and in the Tyrrhenian Sea have been reported to be transformed to bioavailable forms upon release in the marine environment (Benoit *et al.*, 1994; Baldi and Bargagli, 1982; Baldi *et al.*, 1987;89; Barghigiani *et al.*, 1986).

Yolo County contracted with U.C. Davis to determine mercury levels in Cache Creek fish (Davis, 1998). Sixty-four fish from twelve species were collected in the lower watershed. Most were small (<0.5 kg). However, 20 percent (13 fish) of these had tissue concentrations above the National Academy of Science guideline of 0.5 ppm. Two were above the U.S. Food and Drug Administration action level of 1.0 ppm to protect human health. While sample sizes were small, white crappie, squawfish, and small mouth bass had the highest tissue levels. These averaged 0.49, 0.5 and 0.94 ppm wet weight, respectively. Similar to the Sierras, a comprehensive fish tissue and fish consumption study should be undertaken in Cache Creek to evaluate the potential risk to the public of consuming local fish. The study should be conducted in cooperation with the Office of Environmental Health Hazard Assessment and the Yolo County Health Department to ensure that health advisories are posted, if necessary.

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Table 12. Summary of the movement of mercury and sediment (TSS) loads in the Cache Creek Basin during selected dates in the 1996 and 1997 irrigation season. See Figure 2 for site locations.

Date	Location (Site #)	Hg (dissolved) ng/l	Hg (total) ng/l	TSS (mg/l)	Hg/TSS (ppm)	Flow (cfs)	Hg load (g/d)	TSS load (t/day)
4-4-96	Clear Lake (10)		5.41	18.7	0.3	2,200	29	101
	North Fork (8)		2.25			< 100	1[1]	
	Cache Ck (6)		4.19/5.53[2]	19.9	0.2	2,014	21/27	98
	Bear Ck (5)		20.11	2.4	8.4	259	13	2
	Rumsey (4)		7.83	31.0	0.3	2,273	44	97
4-4-96	Rd 102 (2)		34.41	106.3	0.3	2,110	178	549
6-11-96	Clear Lake (10)		11.06	17.8	0.6	775	36	28
	North Fork (8)		2.40/2.82[2]	3.82	0.7	< 100	1[1]	1[1]
	Cache Ck (6)	1.11	13.49	25.4	0.5	732	24	46
	Bear Ck (5)	7.85	18.37	19.2	4.2	18	1	0
	Rumsey (4)		6.70	26.3	0.3	750	12	48
6-11-96	Rd 102 (2)		16.19	36.4	0.4	52	2	5

[1]Assumes a flow of 100 cfs.
[2]Duplicate field measurement.

Table 12 (Continued)

Date	Location (Site #)	Hg (dissolved) ng/l	Hg (total) ng/l	TSS (mg/l)	Hg/TSS (ppm)	Flow (cfs)	Hg load (g/d)	TSS load (t/day)
6-11-97	Clear Lake (10)		4.08/3.34[2]	20.0	0.2	512	5/4	25
	North Fork (8)		broke	9.0		150[3]		6
	Cache Ck (6)	0.50	5.62/4.60[2]	18.0	0.2	662	16/13	29
	Bear Ck (5)	5.55	20.01/18.70[2]	12.0		6	1/0	0
	Rumsey (4)		5.13	19.0	0.3	668	8	31
	Capay Dam (3)		5.68	25.0	0.2	668	9	41
6-11-97	Rd 102 (2)		6.80	25.0	0.3	122	2	7

[1]Assumes a flow of 100 cfs.
[2]Duplicate field measurement.
[3]Estimated by subtracting the flow at site 6 from that at the Clear Lake Dam

Table 13. Summary of the movement of mercury and sediment (TSS) loads in the Cache Creek Basin on 27 February 1996 during a winter non storm period. See Figure 2 for site locations.

Date	Location (Site #)	Hg (dissolved) ng/l	Hg (total) ng/l	TSS (mg/l)	Hg/TSS (ppm)	Flow (cfs)	Hg load (g/d)	TSS load (t/day)
2-27-96	Clear Lake (10)		7.38	22.1	0.3	1,920	35	104
	North Fork (8)		57.28	194.7	0.3	2,450	343	1,167
	Cache Ck (6)		28.81	190.5	0.2	4,761	336	2,219
	Bear Ck (5)		52.61	13.8	3.8	110	14	4
	Rumsey (4)		35.26	208.2	0.2	4,871	420	2,482
2-27-96	Rd 102 (2)		90.34	352.2	0.3	4,460	986	3,844

[1]Assumes a flow of 100 cfs.

Table 14. Movement of mercury and sediment (TSS) loads in the Cache Creek Basin during storms in 1996, 1997, and 1998

Date	Location (Site #)	Hg dissolve (ng/l)	Hg total (ng/l)	TSS (mg/l)	Hg/TSS (ppm)	Flow (cfs)	Hg load (g/d)	TSS load (t/day)
2-21-96	Clear Lake (10)		17.53	67.2	0.3	2,220	95	365
	North Fork (8)		67.19	516.0	0.2	3,900	641	4,924
	Cache Ck (6)		1,112.48	608	1.8	9,095	24,759	13,531
	Bear Ck (5)		758.59	349	2.2	891	1,653	761
	Rumsey (4)		1,296.09	1,244.2	0.1	9,986	31,670	30,403
2-21-96	Rd 102 (2)		940.82	2,556.8	0.1	9,580	22,054	59,937
2-22-96	Clear Lake (10)		10.04	21.3	0.5	2,350	58	123
	North Fork (8)		37.43	241.1	0.2	3,400	311	2,005
	Cache Ck (6)		2,228.16	352.5	6.3	5,462	29,780	4,711
	Bear Ck (5)		128/125	71.0	1.9	404	127/123	70
	Rumsey (4)		1,132.99	374.6	3.5	5,866	18,990	5,377
2-22-96	Rd 102 (2)		336.52	836.67	1.2	7,270	5,987	14,884
2-23-96	Clear Lake (10)		10.64	24.6	0.4	2,120	55	128
	North Fork (8)		25.01	175.6	0.1	3,250	199	1,397
	Cache Ck (6)		3,938.62	272.0	14.5	5,602	53,991[3]	3,732
	Bear Ck (5)		65.43	29.3	2.2	331	53	24
	Rumsey (4)		987.12	300.7	0.3	5,933	14,331	4,366
2-23-96	Rd 102 (2)		258.17			5,830	3,683	

[1]Field replicates. [2]Assumes flow = 100 cfs. [3]This value is likely high as much smaller loads were observed at Rumsey.

Table 14. (Continued)

Date	Location (Site #)	Hg dissolved (ng/l)	Hg Total (ng/l)	TSS (mg/l)	Hg/TSS (ppm)	Flow (cfs)	Hg load (g/d)	TSS load (t/day)
4-2-96	Clear Lake (10)		12.18	46.4	0.3	956	29	109
	North Fork (8)		4.34	16.6	0.3	< 100	1.0[2]	4[1]
	Cache Ck (6)	1.67	17.63/23.58[1]	108.5	0.2	1,906	82/110	506
	Bear Ck (5)	22.90	61.65/64.50[1]	23.0	2.8	170	26/25	10
	Rumsey (4)		30.77	106.3	0.3	2,076	156	540
4-2-96	Rd 102 (2)		256.56	1,327.3	0.2	2,310	1450	7,503
4-3-96	Clear Lake (10)		12.0	45.1	0.3	1,950	57	2.5
	North Fork (8)		2.59	75	0.3	< 100	1[2]	2[2]
	Cache Ck (6)		21.94	119.3	0.2	1,999	107	584
	Bear Ck (5)		21.84	1.7	12.7	54	3	0
	Rumsey (4)		15.85	77.2	0.2	2,053	80	388
4-3-96	Rd 102 (2)		61.77	177.1	0.4	2,050	310	888
12-23-96	Clear Lake (10)		12.09	<5.0		7.0	0.2	
	North Fork (8)		8.13	23	0.4	< 100	2.0[2]	10
	Cache Ck (6)		25.82	91	0.3	228	14	14
	Bear Ck (5)		109.76	46	2.4	140	38	16
	Rumsey (4)		121.76	420	0.3	369	110	378
	Capay Dam (3)		53.66	93	0.6	369	48	84
12-23-96	Rd 102 (2)		8.29	20	0.4	106	2	5

Table 14. (Continued).

Date	Location (Site #)	Hg dissolved (ng/l)	Hg total (ng/l)	TSS (mg/l)	Hg/TSS (ppm)	Flow (cfs)	Hg load (g/d)	TSS load (t/day)
1-26-97	South Fork (9)		34.85	195	0.2	3,790	316	1,808
	North Fork (7)		104.3	935	0.1	3,500	893	8,007
	Cache Ck (6)		no sample					
	Bear Ck (5)	7.72	1,290.2	670	1.9	500[3]	1,578	819
	Rumsey (4)	5.04	1,142/2,886[1]	1,650	0.7/1.8	9,000	25,128/ 63,558	36,337
	Capay (3)		3,004/4,196[1]	2,250	1.3/1.9	9,000	66,157/ 92,408	49,551
1-26-97	Rd 102 (2)		1,295	1,900	0.7	19,800	62,743	92,056
2-2-98	South Fork (9)							
	North Fork (7)	6.81	1,381/1,088					
	Cache Ck (6)							
	Bear Ck (5)	9.53	984					
	Rumsey (4)							
2-2-98	Rd 102 (2)	4.38	469					

[1]Field replicates. [2]Assumes flow = 100 cfs.

Table 15. Summary of mercury monitoring to locate sources during storms. Sulfur Creek was identified as the major mercury source in Bear Creek, Benmore and Grizzly Creeks in the North Fork, and Harley Gulch in the Canyon section of Cache Creek.

Date	Location (site #)	Area (Mile^2)[1]	Hg (ng/l)	TSS (mg/l)	Hg/TSS (ppm)	Flow (cfs)	Hg Load (g/d)	TSS Load (t/d)
	Bear CREEK							
1-26-97	Culvert (16)	48.2	30.09	290	0.1			
	Above Sulfur Ck (14)		254.0	300	0.9			
	Sulfur Creek (13)	10.1	5,316.4	320	16.1			
	Hwy 20 (12)		1,595.9	415	3.9			
	Cache (5)		1,290.2	670	1.9			
	North FORK.							
	Indian Valley Dam (22)		20.84	33	0.6	10	0.5	0.9
	Chalk Mt. (21)	4.0	23.49	50	0.5	10	0.6	4.2
	Wolf Creek (20)	18.7	24.24	135	0.2			
	Long Valley (19)	37.6	54.35	1400	0.0			
	Hwy 20 (8)		125.2	1,050	0.1	~3,500	1,072	8,972
	N.F. confluence (7)		104.3	935	0.1	3,500	893	8,007
	S.F. confluence (9)	14.8	34.18	195	0.2	3,790	316	1,800
1-26-97	Rumsey (4)		1,141/ 2,886.7	1,650	0.7/ 1.8	9,000	25,128/ 63,558	36,337

[1]Estimated area of watershed draining through sampling site. In the case of reservoirs includes to dam face.

Table 15. (Continued).

Date	Location (site #)	Area (miles^2)	Hg (ng/l)	TSS (mg/l)	Hg/TSS (ppm)	Flow (cfs)	Hg Load (g/d)	TSS Load (t/day)
	BEAR CREEK							
2-2-98	Culvert (16)	48.2	13.29	400	0.0			
	Above Sulfur (14)		89.20	300	0.3			
	Sulfur Creek (13)	10.1	8,401.7/ 1,142.1[2]	510	16.5/ 22.4			
	Hwy 20 (12)		328.2	240	1.4			
	Thompson (11)	6.2	142.0	990	0.1			
	Above Cache (5)		142/ 984[2]	95	1.5/ 10.4			
	NORTH FORK.							
	Chalk Mt. (21)	4.0	501.7	2,100	0.2	10	12	51
	Wolf Creek (20)	18.7	55.37	670	0.1			
	Long Valley (19)	37.6	209.5	1,500	0.1			
	Benmore Cyn (18)	7.4	2,149.7	14,000	0.1			
	Grizzly Creek (17)	8.0	3,022.5	16,000	0.2			
2-2-98	Hwy 20 (8)		1,381/ 1,088[2]	4,500	0.3/ 0.2	~2,000	6,759/ 5,325	22,023

Table 15. (Continued).

Date	Location (site #)	Area (miles²)	Hg (ng/l)	TSS (ng/l	Hg/TSS (ppm)	Flow (cfs)	Hg Load (g/d)	TSS Load (t/day)
	CACHE CANYON							
2-2-98	Harley G.East (31b)	2.1	925.2	3,800	0.2			
	Harley G. West (31a)	0.6	359,448	6,700	53.6			
	LOWER CANYON							
	Rumsey (4)		74.40	300	0.3	4,958	903	
	Rumsey Canyon (23)	1.1	12.29	64	0.2			
	Johnson Canyon (24)	3.9	50.31	100	0.5			
	Cross-Hamilton (25)	12.9	12.48	70	0.2			
	Angus-Black Mt.(26)	11.1	15.46	99	0.2			
	McKinney-Smith (27)	9.3	14.67	78	0.2			
	Mossy Creek (28)	14.5	18.06	130	0.1			
	Taylor-Chimney (29)	24.3	12.71	90	0.1			
	Capay (3)		391.5	1,470	0.3			
2-2-98	Rd. 102 (2)		469.2/ 570.5	1,500	0.3/ 0.4	7,040	8.082/ 9,828	25,840

²Field replicates.

Table 15. (Continued).

Date	Location (site #)	Area (miles²)	Hg (ng/l)	TSS (mg/l)	Hg/TSS (ppm)	Flow (cfs)	Hg Load (g/d)	TSS Load (t/day)
2-16-98	**BEAR CREEK**							
	Above Sulfur (14)		62.65	66	0.9			
	Sulfur Creek (13)	10.1	1,964.7	140	14.0			
	CACHE CANYON							
	Harley G.East(31b)	2.1	58.93	110	0.5			
	Harley G.West(31a)	0.6	146,039	5,400	27.0			
	NORTH FORK.							
	Chalk Mt. (21)	4.0	86.31	290	0.3			
	Benmore Cyn (18)	7.4	749.2	4,800	0.2			
2-16-98	Grizzly Creek (17)	8.0	1,108.9	6,800	0.2			

Table 16. Summary of mercury concentrations in the Cache Creek Canyon during float trips.

Date	Location (site #)	Area (Mile^2)	Hg (ng/l)	TSS (mg/l)	Hg/TSS (ppm)	Flow (cfs)	Hg Load (g/d)	TSS Load (t/day)
4-2-96	Clear Lake Dam (10)		12.18	46.4	0.3	956	29	109
	North Fork Hwy 20 (8)		4.34	16.6	0.3	<100	1[1]	4[1]
	North Fork above confluence (7)		3.93	20.5	0.2	<100	1[1]	5[1]
	South Fork above confluence (9)	14.8	12.90	70.0	0.2	95.6	30.2	163
	Stemple Creek (30)	2.6	1.88	5.4	0.4			
	Harley Gulch (31)	5.1	29.47	1.8	16.3			
	Rocky Creek (32)	14.8	11.46	29.3	0.4			
	Cache Creek below Rocky Creek (33)		13.17	69.3	0.2			
	Judge Davis Creek (35)	2.4	1.74	1.3	1.3			
	Bushy Creek (36)	3.1	2.53	0.8	3.2			
	Petrified Canyon (37)	1.3	2.44	0.3	8.1			
	Trout Creek (38)	2.9	5.21	1.1	4.7			
4-2-96	Cache Creek below Trout Creek (39)		14.76	78.0	0.2			

[1]Assumes a flow of 100 cfs.

Table 16. (Continued)

Date	Location (site #)	Area (Mile^2)	Hg (ng/l)	TSS (mg/l)	Hg/TSS (ppm)	Flow (cfs)	Hg Load (g/d)	TSS Load (t/day)
4-2-96	Crack Canyon (40)	3.4	1.72	3.6	0.5			
	Cache Creek below Crack Cyn (41)		14.41	83.8	0.2			
	Davis Ck @ Davis Lake (42a)		12.42/11.38[1]	3.5	3.6/3.3			
	Davis Creek (42)	9.2	8.58	3.2	2.7			
	Cache below Davis Creek (43)		14.41	84.0	0.2			
	Cache above Bear Creek[2] (6)		17.63/23.58	108.5	0.2	1906	82/110	506
	Cache above Bear Creek[3] (6)		18.37	86.8	0.2	1906	86	405
	Bear Creek[2] (5)		61.65/64.50	23.0	2.8	170	26/25	10
	Rumsey[2] (4)		30.77	106.0	0.3	2076	156	540
4-2-96	Rd. 102[2] (2)		256.56	1327.3	0.2	2310	1450	7503

[1]Replicate field sample.
[2] Car sampling crew (see Table 14)
[3]Float trip sampling crew.

Table 16. (Continued).

Date	Location (site #)	Area (miles^2)	Hg (ng/l)	TSS (mg/l)	Hg/TSS (ppm)	Flow (cfs)	Hg load (g/d)	TSS load (t/d)
1-16-98	North Fork (7)		61.02	446	0.1			
	South Fork (9)		32.46	189.0	0.2			
	Stemple Ck (30)	2.6	103.8	1023	0.1			
	Harley G. (31)	5.1	78.47	47.3	1.7			
	Rocky Creek (32)	14.8	31.78	174.5	0.2			
	Cache below Jack(34)		51.35	472.0	0.1			
	Judge Davis (35)	2.4	2.73	1.9	1.4			
	Bushy Creek (36)	3.1	2.95	2.3	1.3			
	Petrified Ck(37)	1.3	1.51	2.6	0.6			
	Trout Creek (38)	2.9	2.04	2.7	0.8			
	Cache below Trout(39)		52.89	488	0.1			
	Crack Creek (40)	3.4	2.42	3.0	0.8			
	Davis Creek (42)	9.2	4.59	2.3	2.0			
	Cache below Davis(43)		51.65	445	0.1			
	Bear Creek (5)		98.41	62.0	1.6			
1-16-98	Rumsey (4)					1507		

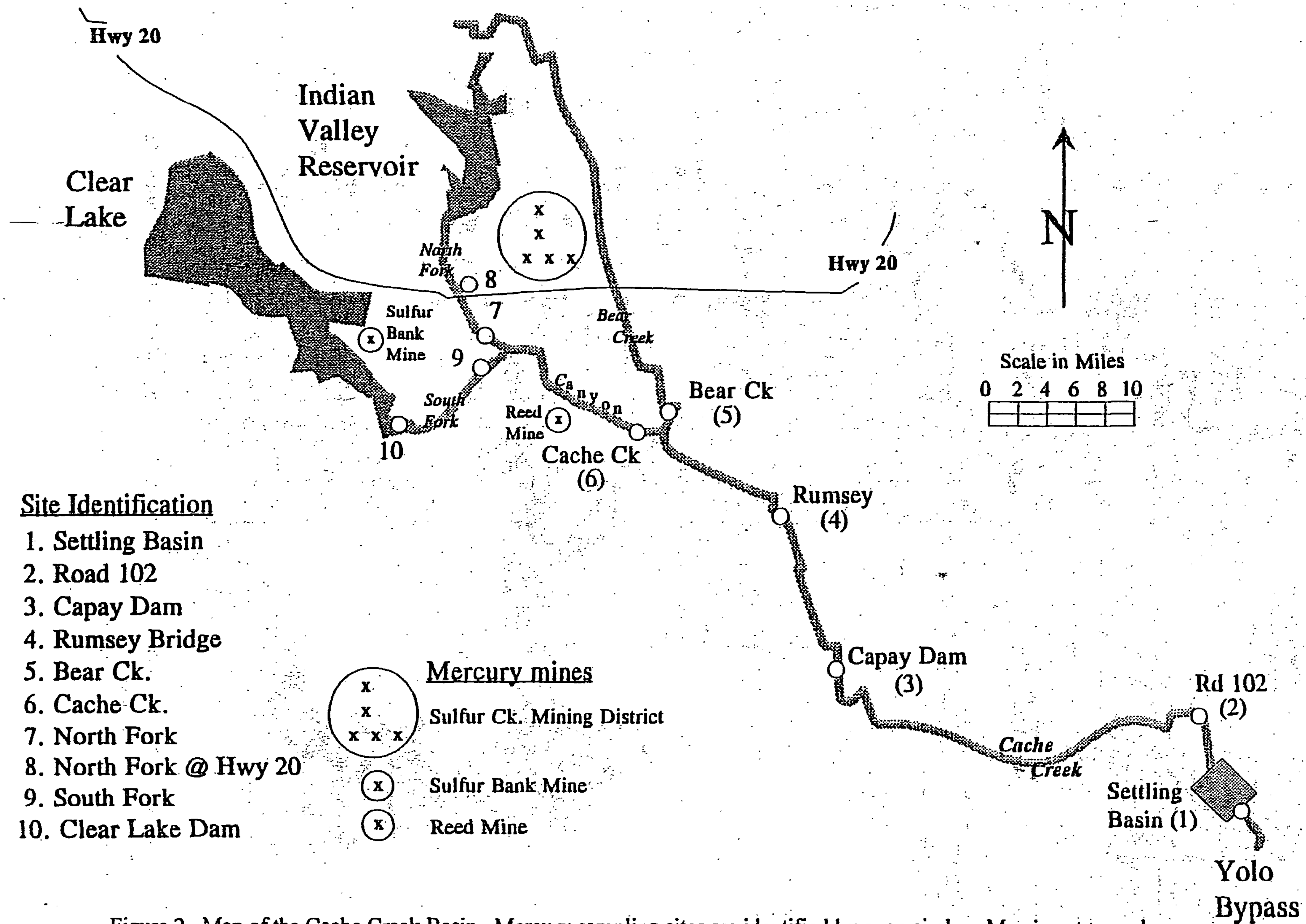
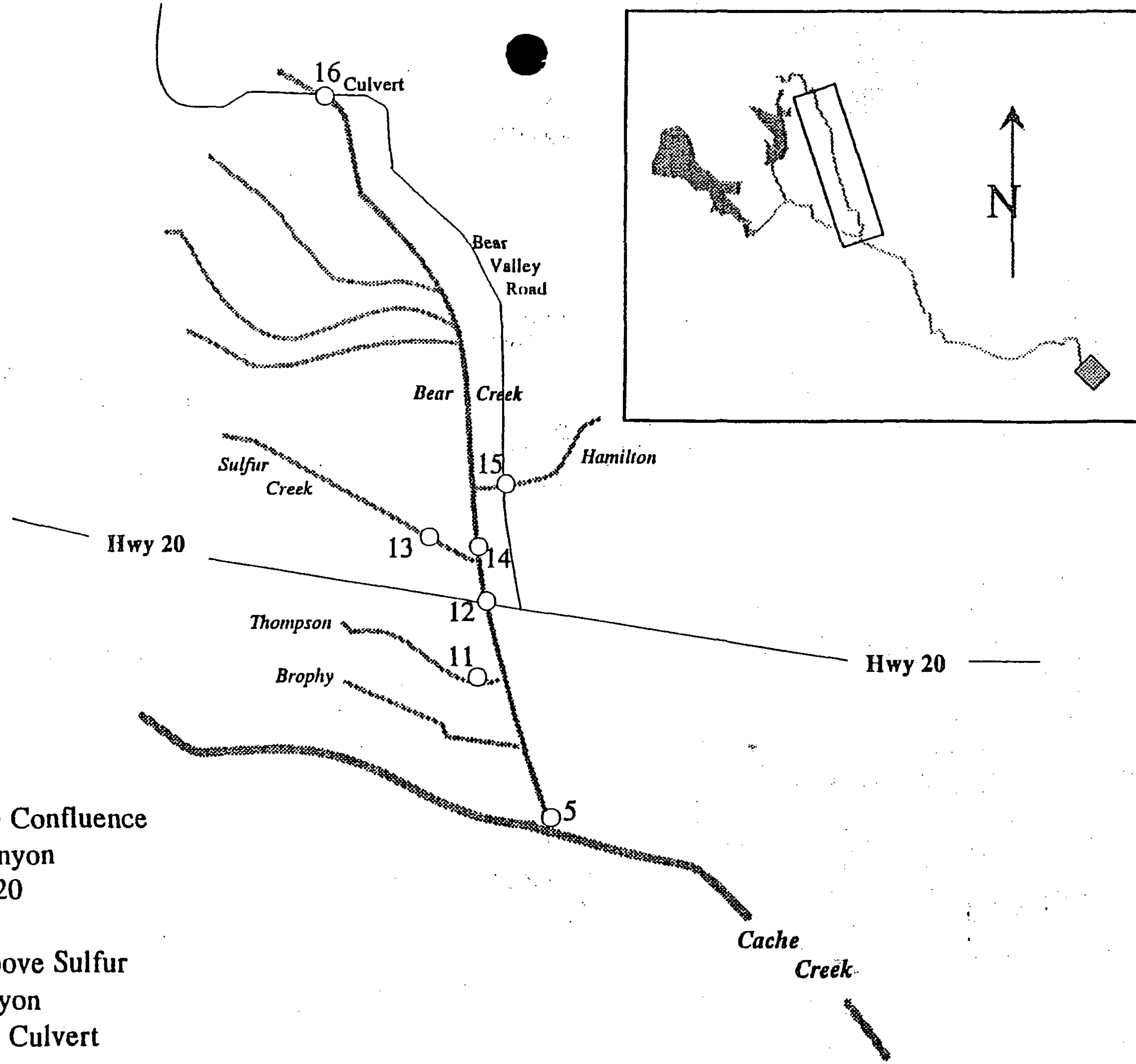


Figure 2. Map of the Cache Creek Basin. Mercury sampling sites are identified by open circles. Map is not to scale.

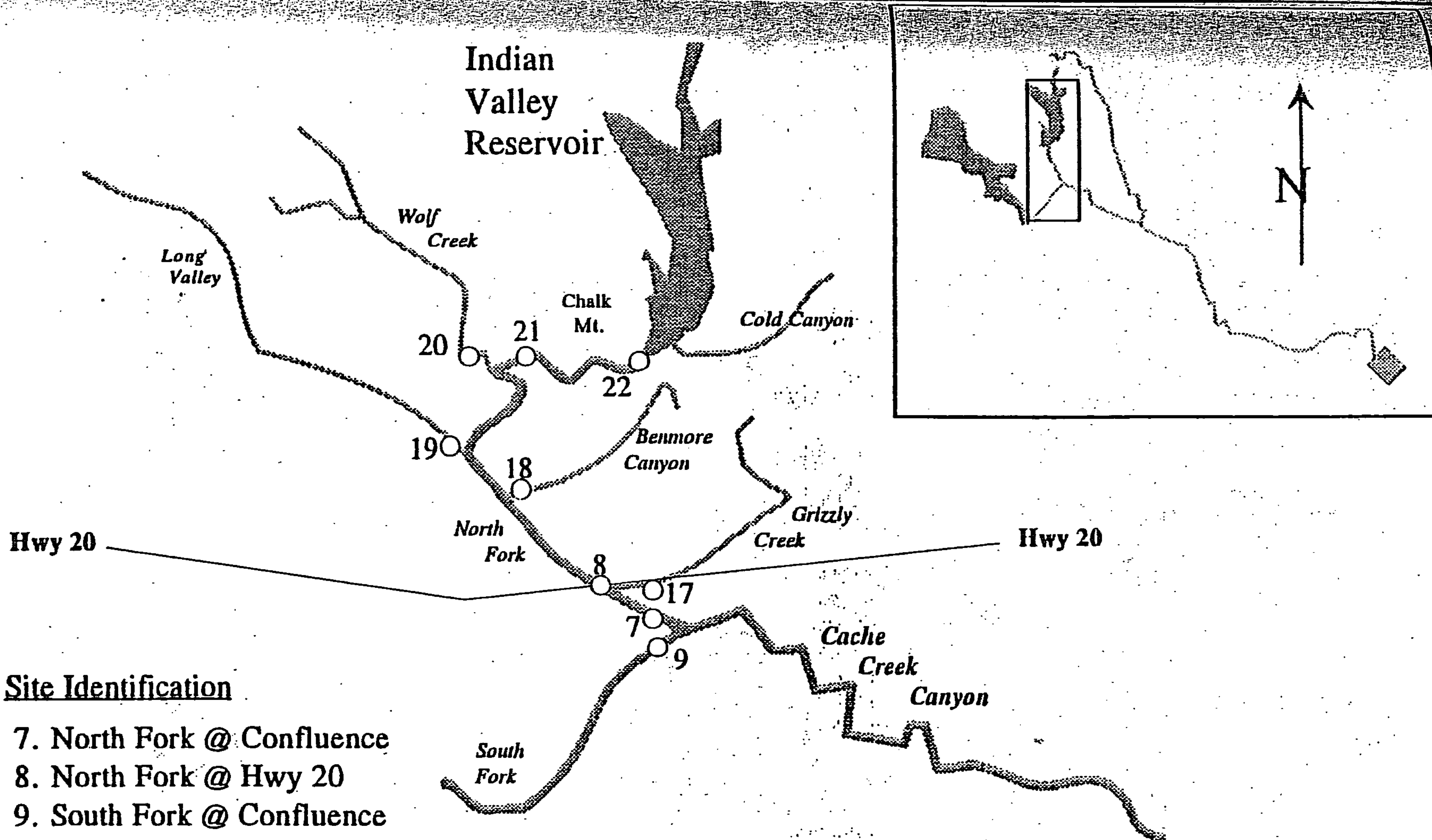


<u>Site Identification</u>

5. Bear Creek @ Confluence
11. Thompson Canyon
12. Bear @ Hwy 20
13. Sulfur Creek
14. Bear Creek above Sulfur
15. Hamilton Canyon
16. Bear Creek @ Culvert

Figure 16. Location of sampling sites to identify mercury sources in Bear Creek. Map not to scale.

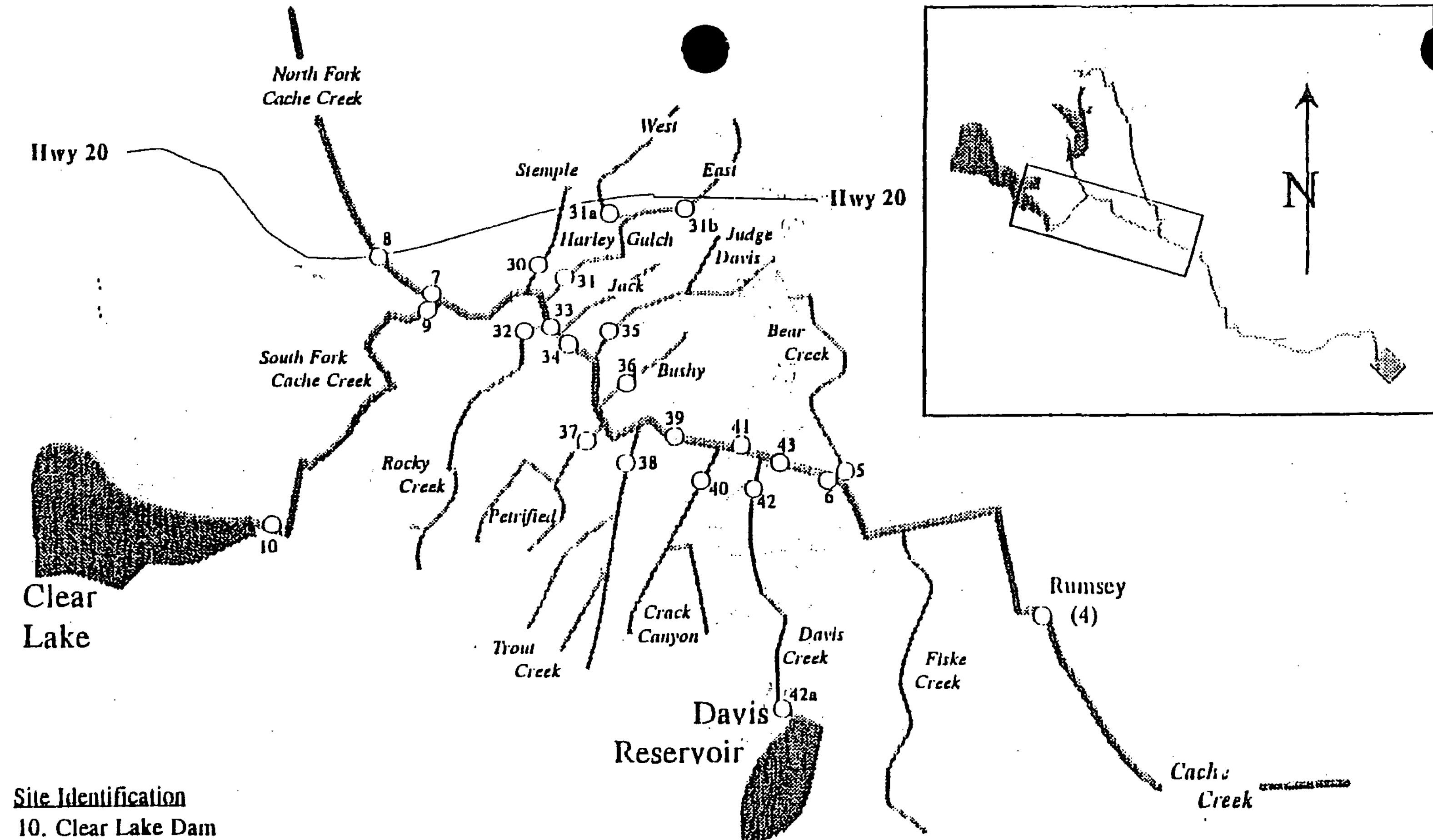
Figure 16. Location of sampling sites to identify mercury sources in Bear Creek. Map not to scale.



Site Identification

7. North Fork @ Confluence
8. North Fork @ Hwy 20
9. South Fork @ Confluence
17. Grizzly Creek
18. Benmore Creek
19. Long Valley
20. Wolf Creek
21. North Fork @ Chalk Mt.
22. Indian Valley Dam

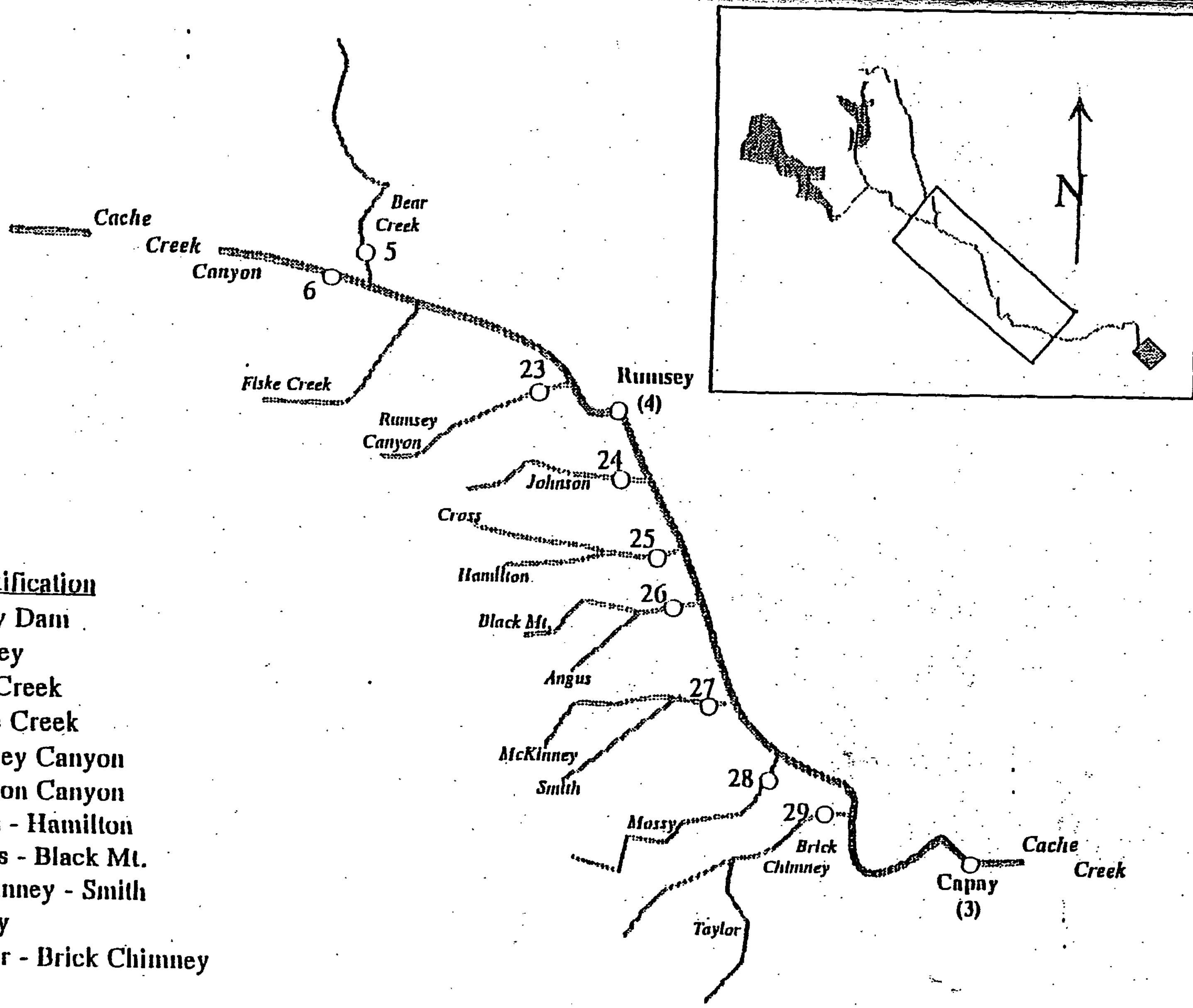
Figure 17. Location of sampling sites to identify mercury sources in the North Fork of Cache Creek. Map is not to scale.



Site Identification

10. Clear Lake Dam
9. South Fork @ Confluence
7. North Fork @ Confluence
8. North Fork @ Hwy 20
30. Stemple Creek
31. Harley Gulch
31a. West Harley Gulch
31b. East Harley Gulch
32. Rocky Creek
33. Cache Creek below Rocky Creek
34. Cache Creek below Jack Creek
35. Judge Davis Creek
36. Bushy Creek
37. Petrified
38. Trout Creek
39. Cache Creek below Trout
40. Crack Canyon
41. Cache Creek below Crack Canyon
42. Davis Creek
42a. Davis Creek below Davis Lake
43. Cache Creek below Davis Creek
6. Cache Creek above Bear Creek
5. Bear Creek above Cache Creek
4. Rumsey

Figure 18. Location of sampling sites to identify mercury sources in the Cache Creek Canyon between the confluence of the North and South Forks and Bear Creek. Map is not to scale.



<u>Site Identification</u>

3. Capay Dam
4. Rumsey
5. Bear Creek
6. Cache Creek
23. Rumsey Canyon
24. Johnson Canyon
25. Cross - Hamilton
26. Angus - Black Mt.
27. McKinney - Smith
28. Mossy
29. Taylor - Brick Chimney

Figure 19. Location of sampling sites to identify mercury sources in lower Cache Creek. Map is not to scale.

Cache Creek Studies

Putah Creek. Sampled collected in mid channel off Road 104 bridge outside of El Macero.

Willow Slough. Sample collected in mid channel off Road 102 bridge outside of Davis.

Colusa Basin Drain. Sample collected in mid channel off Road 99E bridge outside of Knight's Landing.

Settling Basin (site 1). Sample collected at discharge from Settling Basin. Site is approached off Main Street in Woodland on dirt road just prior to entering the Yolo Bypass. Low flow samples collected immediately downstream of block house; high flow samples collected from south side of spillway.

Road 102 (site 2). Bank sample collected immediately downstream on west side of Creek adjacent to the Road 102 bridge.

Capay Dam (site 3). Sample collected from west bank immediately upstream of Capay Dam.

Rumsey (site 4). Sample collected from west side of channel of Rumsey bridge.

Bear Creek (site 5). Sample collected by wading into creek immediately upstream of confluence with Cache Creek.

Cache Creek (site 6). Sample collected by fording Bear Creek and walking several hundred yards upstream on Cache. Sample collected by wading into North side of Creek.

North Fork Confluence (site 7). Sample collected by wading into the North Fork about a 100 yards above the confluence with the South Fork.

North Fork @ HWY 20 (site 8). Sample collected during low flows by wading into Creek at Bridge; during high flows from west bank under bridge.

South Fork Confluence (site 9). Sample collected by wading into the South Fork about a 100 yards above the confluence with the North Fork.

Clear Lake Dam (site 10). Sample collected from the bank about 100 yards downstream of Dam on north side of Creek.

Thompson Creek (site 11). Thompson Creek is tributary to Bear Creek. Sample collected by wading into Thompson Creek about 100 yards upstream of the confluence.

<u>Bear Creek at HWY 20 (site 12)</u>. Sample collected by wading to Creek about 100 yards downstream of bridge.

<u>Sulfur Creek (site 13)</u>. Sample collected by wading into the Creek about 100 yards upstream of its confluence with Bear Creek.

<u>Bear above Sulfur Creek (site 14)</u>. Sample collected from bank about 100 yards above the confluence with Sulfur Creek.

<u>Hamilton Creek (site 15).</u> Hamilton Creek is tributary to Bear Creek. Sample collected from culvert under the Bear Valley Road.

<u>Bear Creek at Culvert (site 16)</u>. Sample collected immediately downstream of where Bear Valley Road first crosses Bear Creek.

<u>Grizzly Creek (site 17)</u>. Grizzly Creek is tributary to the North Fork. Sample collected from bank about 300 yards above the confluence with the North Fork.

<u>Benmore Canyon (site 18)</u>. Benmore is tributary to the North Fork. Sample collected from north bank about 100 yards before its confluence with the North Fork.

<u>Long Valley Creek (site 19)</u>. Long Valley Creek is tributary to the North Fork. Sample collected immediately above the Long Valley Road bridge.

<u>Wolf Creek (site 20)</u>. Wolf Creek is tributary to the North Fork. Sample collected from bank above Spring Creek bridge Road.

<u>Chalk Mountain (site 21).</u> Chalk Mountain is on North Fork about 2 miles below Indian Valley dam. Sample collected at Chalk Mountain Road bridge.

<u>Indian Valley Dam (site 22)</u>. Sample collected by wading into creek immediately below Indian Valley Dam.

<u>Rumsey Canyon (site 23)</u>. Rumsey Canyon is tributary to lower Cache Creek. Sample collected by wading into Creek at HWY 16 bridge.

<u>Johnson Creek (site 24)</u>. Johnson Creek is tributary to lower Cache Creek. Sample collected by wading into Creek at HWY 16 bridge.

<u>Cross-Hamilton (site 25)</u>. Cross-Hamitlon is tributary to lower Cache Creek. Sample collected by wading into Creek at HWY 16 bridge.

<u>Black Mountain-Angus Creeks (site 26)</u>. Black Mountain-Angus Creeks is tributary to lower

Cache Creek. Sample collected by wading into Creek at HWY 16 bridge.

<u>McKinney-Smith (site 27)</u>. Mckinney-Smith is tributary to lower Cache Creek. Sample collected by wading into Creek at HWY 16 bridge.

<u>Mossy Creek (site 28)</u>. Mossy Creek is tributary to lower Cache Creek. Sample collected by wading into Creek at HWY 16 bridge.

<u>Taylor-Brick Chimney Creek (site 29)</u>. Taylor-Brick Chimney is tributary to lower Cache Creek. Sample collected by wading into Creek at HWY 16 bridge.

<u>Stemple Creek (site 30)</u>. Stemple Creek is tributary to Cache Creek. Sample collected by floating Cache Creek and collecting sample about a 100 yards above the Creek's confluence with Cache.

<u>Harley Gulch (site 30)</u>. Harley Gulch is tributary to Cache Creek. Sample collected by floating Cache Creek and collecting sample about a 100 yards above the Creek's confluence with Cache.

<u>Harley Gulch West (Site 31a)</u>. Harley Gulch West drains the Abbott and Turkey Run Mines. Sample collected from south side of HWY 20 immediately before creek joins the east branch.

<u>Harley Gulch East (site 31b)</u>. Sample collected from south side of HWY 20 immediately before creek joins the west branch.

<u>Rocky Creek (site 32)</u>. Rocky Creek is tributary to Cache Creek. Sample collected by floating Cache Creek and collecting sample about a 100 yards above the Creek's confluence with Cache.

<u>Cache Creek below Rocky Creek (site 33)</u>. Sample collected from mid channel several hundred yards downstream of Rocky Creek.

<u>Cache Creek below Jack Creek (site 34)</u>. Sample collected from mid channel several hundred yards downstream of Jack Creek.

<u>Judge Davis Creek (site 35)</u>. Judge Davis Creek is tributary to Cache Creek. Sample collected by floating Cache Creek and collecting sample about a 100 yards above the Creek's confluence with Cache.

<u>Bushy Creek (site 36)</u>. Bushy Creek is tributary to Cache Creek. Sample collected by floating Cache Creek and collecting sample about a 100 yards above the Creek's confluence with Cache.

<u>Petrified Creek (site 37).</u> Petrified Creek is tributary to Cache Creek. Sample collected by floating Cache Creek and collecting sample about a 100 yards above the Creek's confluence with Cache.

Trout Creek (site 38). Trout Creek is tributary to Cache Creek. Sample collected by floating Cache Creek and collecting sample about a 100 yards above the Creek's confluence with Cache.

Cache Creek below Trout Creek (site 39). Sample collected by boat from mid channel several hundred yards downstream of Trout Creek.

Crack Canyon (site 40). Crack Canyon is tributary to Cache Creek. Sample collected by floating Cache Creek and collecting sample about a 100 yards above the Creek's confluence with Cache.

Cache Creek below Crack Canyon (site 41). Sample collected by boat from mid channel several hundred yards downstream of Crack Canyon.

Davis Creek (site 42). Davis Creek drains the old Reed mercury mine and is tributary to Cache Creek. Sample collected by floating Cache Creek and collecting sample about a 100 yards above the Creek's confluence with Cache.

Davis Reservoir Dam (site 42a). Davis Creek was impounded at Davis Reservoir to provide water for Homestake Mining Company. Davis Creek drains the old Reed mercury mine. Sample collected from immediately below the dam.

Cache Creek below Davis Creek (site 43). Sample collected by boat from mid channel several hundred yards downstream of Davis Creek.

Date	Location (Site #)	Order (Upstream to Downstream)	Hg (total) ng/L	Hg (total) ppb	Comment	F&C Table #
12/23/96	Rumsey (4)	11	121.76	0.122	Storms	14
2/23/96	Rumsey (4)	11	987.12	0.987	Storms	14
2/22/96	Rumsey (4)	11	1132.99	1.133	Storms	14
2/21/96	Rumsey (4)	11	1296.09	1.296	Storms	14
1/26/97	Rumsey (4)	11	2886.7	2.887	Storms	14
6/11/97	Capay Dam (3)	12	5.68	0.006	Irrigation Season	12
12/23/96	Capay Dam (3)	12	53.66	0.054	Storms	14
2/2/98	Capay Dam (3)	12	391.5	0.392	Storms	15
1/26/97	Capay Dam (3)	12	4196	4.196	Storms	14
6/11/97	Road 102 (2)	13	6.8	0.007	Irrigation Season	12
12/23/96	Road 102 (2)	13	8.29	0.008	Storms	14
6/11/96	Road 102 (2)	13	16.19	0.016	Irrigation Season	12
4/4/96	Road 102 (2)	13	34.41	0.034	Irrigation Season	12
4/3/96	Road 102 (2)	13	61.77	0.062	Storms	14
2/27/96	Road 102 (2)	13	90.34	0.090	Winter Non Storm	13
4/2/96	Road 102 (2)	13	256.56	0.257	Storms	14
2/23/96	Road 102 (2)	13	258.17	0.258	Storms	14
2/22/96	Road 102 (2)	13	336.52	0.337	Storms	14
2/2/98	Road 102 (2)	13	570.5	0.571	Storms	15
2/21/96	Road 102 (2)	13	940.82	0.941	Storms	14
1/26/97	Road 102 (2)	13	1295	1.295	Storms	14
4/4/96	Bear Creek (5)	10.5	18.53	0.019	Irrigation Season	12
6/11/96	Bear Creek (5)	10.5	20.01	0.020	Irrigation Season	12
6/11/97	Bear Creek (5)	10.5	20.11	0.020	Irrigation Season	12
2/27/96	Bear Creek (5)	10.5	21.84	0.022	Storms	14
2/[illegible]6	Bear Creek (5)	10.5	52.61	0.053	Winter Non Storm	13
2/2[illegible]6	Bear Creek (5)	10.5	64.5	0.065	Storms	14
2/23/96	Bear Creek (5)	10.5	65.43	0.065	Storms	14
4/2/96	Bear Creek (5)	10.5	98.41	0.098	Float Trip	16
4/3/96	Bear Creek (5)	10.5	109.79	0.110	Storms	14
12/23/96	Bear Creek (5)	10.5	128	0.128	Storms	14
1/26/97	Bear Creek (5)	10.5	758.59	0.759	Storms	14
2/2/98	Bear Creek (5)	10.5	984	0.984	Storms	14
1/16/98	Bear Creek (5)	10.5	1290.2	1.290	Storms	14

Bear & Butte

& Jack- Pest.

B.1.5 Lower Bear River, Diazinon

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region, (Regional Board) recommends the addition of the lower Bear River to California's Clean Water Act Section 303(d) list due to impairment by diazinon. Information available to the Regional Board on diazinon levels indicates that water quality objectives are not being attained. The basis for this recommendation is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Lower Bear River	**Pollutants/Stressors**	Diazinon
Hydrologic Unit	516.33	**Sources**	Agriculture
Total Length	18 miles	**TMDL Priority**	
Size Affected	18 miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	From Camp Far West Reservoir to the mouth of the Bear River.	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	39° 08' 02"	**Upstream Extent Longitude**	120° 57' 14"
Downstream Extent Latitude	39° 01' 52"	**Downstream Extent Longitude**	121° 01' 48"

Watershed Characteristics

The Bear River basin comprises more than 232,800 acres. Water uses include recreation, agriculture, municipal, and others. The Bear River basin is bounded by the Yuba River basin on the north, the Little Truckee River basin on the east, and the American River basin on the south. The headwaters are located in the Sierra Nevada snowfields at elevations ranging up to 9,100 feet above sea level. The lower section of the Bear River flows from Camp Far West Reservoir to its confluence with the Feather River south of Marysville. Extensive acreage in this lower part of the watershed is used to grow almonds and stone fruits, especially south of the Bear River downstream from State Highway 65.

Water Quality Objectives Not Attained

The narrative objectives for pesticides and toxicity are not being attained for diazinon in the Bear River. The narrative objective for pesticides states, "No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses." The narrative toxicity objective in the Basin Plan states, in part, "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life." The narrative toxicity objective further states that "The Regional Water Board will also consider ... numerical criteria and guidelines for toxic substances developed by the State Water Board, the California Office of Environmental Health Hazard Assessment, the California Department of Health Services, the U.S. Food and Drug Administration, the National Academy of Sciences, the U.S. Environmental Protection Agency, and other appropriate organizations to evaluate compliance with this objective (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/~rwqcb5/bsnplnab.pdf)." The California Department of Fish and Game (CDFG) has established freshwater numeric acute (1-hour average) and chronic (4-day average) criteria for diazinon of 0.08 µg/L and 0.05 µg/L, respectively, for the protection of aquatic life (Siepmann and Finlayson, 2000).

Evidence of Impairment

Between 1994 and 2000, two studies analyzed a total of 14 ambient water samples collected in the Bear River at Berry Road for diazinon. The results indicate that the CDFG chronic criteria was exceeded 29% of the time overall and the acute criteria was exceeded 21% of the time. Samples were collected during the dormant spray season. Table B-2 summarizes the available data.

Table B-2. Summary of Diazinon Concentrations in Lower Bear River

Data Source	Sample Years	Number of Sample Dates	Range of Diazinon Concentrations	Criteria[a]			Number of Sample Dates Equal to or Above Criteria	Percent of Sample Dates Equal to or Above Criteria
Holmes *et al*, 2000	1994	8	nd - 0.14 µg/L	Chronic	0.05	µg/L	2	25%
				Acute	0.08	µg/L	2	25%
Dileanis *et al*, 2000	2000	6	nd - 0.195 µg/L	Chronic	0.05	µg/L	1	17%
				Acute	0.08	µg/L	1	17%
Summary	1994 & 2000	14	nd – 0.195 µg/L	Chronic	0.05	µg/L	3	21%
				Acute	0.08	µg/L	3	21%

[a] CDFG water quality criteria for the protection of aquatic life (Siepmann and Finlayson, 2000)
nd = not detected

Extent of Impairment
The lower Bear River runs for approximately eighteen miles between Camp Far West Reservoir and its confluence with the Feather River. Samples were collected at Berry Road near the confluence of the Bear and Feather Rivers. The lower section of the Bear River watershed contains extensive acreage of almond and stone fruit orchards. Diazinon is commonly used as a dormant spray on almonds and stonefruits during the winter months, and these applications are the most likely source of diazinon in the lower Bear River. Grasshopper and Yankee Sloughs, and Dry Creek flow into the lower Bear River, and these tributaries also drain orchard lands and are likely to contribute diazinon to the lower Bear River.

Potential Sources
The almond and stone fruit orchards are the most likely sources of diazinon runoff to the lower Bear River, therefore, agriculture has been identified as the source of diazinon.

B.1.8 Butte Slough, Diazinon

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region, (Regional Board) recommends the addition of Butte Slough to California's Clean Water Act Section 303(d) list due to impairment by diazinon. Information available to the Regional Board on concentrations of these pesticides indicates that water quality objectives are not being attained. The basis for this recommendation is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Butte Slough	**Pollutants/Stressors**	Diazinon
Hydrologic Unit	520.30	**Major Sources**	Agriculture
Total Length	7.5 miles	**TMDL Priority**	
Size Affected	7.5 miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	The entire slough	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	39° 11' 55"	**Upstream Extent Longitude**	121° 55' 42"
Downstream Extent Latitude	39° 08' 53"	**Downstream Extent Longitude**	121° 50' 18"

Watershed Characteristics

The drainage basin of Butte Slough lies east of the Sacramento River, south of Big Chico Creek, and north of the Sutter Buttes. Natural streams in the area either originate in the Sierra foothills or are former flood channels for the Sacramento River. Historically, all the streams were ephemeral and only carried runoff or flood flows for two to four months of the year. As these channels reached the low-lying areas along the east side of the Sacramento River, they branched into numerous sloughs and meandering waterways, creating extensive wetland habitat. All flows converged in the southwest corner of the basin and drained into Butte Slough (Chilcott, 1992).

Currently, the majority of the low-lying land within this basin is in rice production, and the sloughs and channels have been extensively reconstructed to carry irrigation water. Almond and stonefruit orchards, pasture, and rangeland dominate the uplands along the northern and eastern edges of the basin. However, important wetland habitat still exists in the basin, including the Butte Sink and the Gray Lodge Waterfowl Management Area, just north of the Sutter Buttes.

Butte Slough begins near the confluence of Butte Creek and the Sacramento River, and flows approximately 7.5 miles before it empties into the Sutter Bypass, just south of State Highway 20. Butte Slough receives large volumes of agricultural runoff during winter storm events and during rice field releases in April and May. During the summer irrigation season for orchard crops, Butte Slough is dominated by agricultural return flows (Chilcott, 1992).

The interconnected waterway and wetland system that includes Butte Creek, Butte Sink, Butte Slough, and the Sutter Bypass are part of the main migration corridor for spring-run salmon, and also provide habitat for numerous other aquatic and wetland species, particularly waterfowl. The Nature Conservancy and several reclamation districts and irrigation companies have formed the Lower Butte Creek Project to reduce fish passage and entrainment problems because of this waterway's key habitat values (NCWA, 2001; http://norcalwater.org/lower_butte_creek_project.htm).

Water Quality Objectives Not Attained

The narrative objectives for pesticides and toxicity are not being attained for diazinon in Butte Slough. The narrative objective for pesticides states, "No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses." The narrative toxicity objective in the Basin Plan states, in part, "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life." The narrative toxicity objective further states that "The Regional Water Board will also consider ... numerical criteria and guidelines for toxic substances developed by the State Water Board, the California Office of

Environmental Health Hazard Assessment, the California Department of Health Services, the U.S. Food and Drug Administration, the National Academy of Sciences, the U.S. Environmental Protection Agency, and other appropriate organizations to evaluate compliance with this objective (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/~rwqcb5/bsnplnab.pdf)." The California Department of Fish and Game (CDFG) has established freshwater numeric acute (1-hour average) and chronic (4-day average) water quality criteria for diazinon of 0.08 µg/L and 0.05 µg/L, respectively, for the protection of aquatic life (Siepmann and Finlayson, 2000).

Evidence of Impairment
Table B-2 summarizes the results from two key studies conducted by the Regional Board (Holmes *et al*, 2000) and the US Geological Survey (Dileanis *et al*, 2001). Samples were collected from Butte Slough at Lower Pass Road during January and February in each year.

Table B-2. Summary of Diazinon Concentrations in Butte Slough

Data Source	Sample Years	Number of Sample Dates	Range of Diazinon Concentrations	Criteria[a]		Number of Sample Dates Equal to or Above Criteria	Percent of Sample Dates Equal to or Above Criteria
Holmes *et al*, 2000	1994	28	nd to 1.0 µg/L	chronic	0.05 µg/L	20	71%
				acute	0.08 µg/L	18	64%
Dileanis *et al*, 2000	2000	9	nd to 0.082 µg/L	chronic	0.05 µg/L	0	0%
				acute	0.08 µg/L	1	11%
Summary	1994 & 2000	37	nd to 1.0 µg/L	chronic	0.05 µg/L	20	54%
				acute	0.08 µg/L	18	49%

[a] CDFG water quality criteria for the protection of aquatic life (Siepmann and Finlayson, 2000)
nd = not detected

Extent of Impairment
Butte Slough extends for approximately six miles, from the confluence of Butte Creek and the Sacramento River to the Sutter Bypass. Samples were collected at one site only, at Lower Pass Road near Meridian. However, the Butte Slough watershed contains extensive acreage of almonds and stonefruits, and Butte Slough receives substantial amounts of runoff from these orchards during winter storm events. Therefore, the entire six miles are proposed for listing on the 303(d) list.

Potential Sources
Diazinon is commonly used as a dormant spray on almonds and stonefruits during the winter months, and these applications are the most likely source of diazinon in Butte Slough.

B.1.9 Butte Slough, Molinate

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region (Regional Board) recommends the addition of Butte Slough to California's Clean Water Act Section 303(d) list due to impairment by molinate. Information available to the Regional Board on concentrations of this pesticide indicates that water quality objectives are not being attained. The basis for this recommendation is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Butte Slough	**Pollutants/Stressors**	Molinate
Hydrologic Unit	520.30	**Major Sources**	Agriculture
Total Length	7.5 miles	**TMDL Priority**	
Size Affected	7.5 miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	The entire slough	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	39° 11' 55"	**Upstream Extent Longitude**	121° 55' 42"
Downstream Extent Latitude	39° 08' 53"	**Downstream Extent Longitude**	121° 50' 18"

Watershed Characteristics

The drainage basin of Butte Slough lies east of the Sacramento River, south of Big Chico Creek, and north of the Sutter Buttes. Natural streams in the area either originate in the Sierra foothills or are former flood channels for the Sacramento River. Historically, all the streams were ephemeral and only carried runoff or flood flows for two to four months of the year. As these channels reached the low-lying areas along the east side of the Sacramento River, they branched into numerous sloughs and meandering waterways, creating extensive wetland habitat. All flows converged in the southwest corner of the basin and drained into Butte Slough (Chilcott, 1992).

Currently, the majority of the low-lying land within this basin is in rice production, and the sloughs and channels have been extensively reconstructed to carry irrigation water. The uplands along the northern and eastern edges of the basin are dominated by almond and stonefruit orchards, pasture, and rangeland. However, important wetland habitat still exists in the basin, including the Butte Sink and the Gray Lodge Waterfowl Management Area, just north of the Sutter Buttes.

Butte Slough begins near the confluence of Butte Creek and the Sacramento River, and flows approximately 7.5 miles before it empties into the Sutter Bypass, just south of State Highway 20. Butte Slough receives large volumes of agricultural runoff during winter storm events and during rice field releases in April and May. During the summer irrigation season for orchard crops, Butte Slough is dominated by agricultural return flows (Chilcott, 1992).

The interconnected waterway and wetland system that includes Butte Creek, Butte Sink, Butte Slough , and the Sutter Bypass are part of the main migration corridor for spring-run salmon, and also provide habitat for numerous other aquatic and wetland species, particularly waterfowl. The Nature Conservancy and several reclamation districts and irrigation companies have formed the Lower Butte Creek Project to reduce fish passage and entrainment problems because of this waterway's key habitat values (NCWA, 2001. http://norcalwater.org/lower_butte_creek_project.htm).

Water Quality Objectives Not Attained

The narrative objective for pesticides and toxicity are not being attained for molinate in Butte Slough. The narrative objective for pesticides states, "No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses." The narrative objective for toxicity states, "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life." The narrative toxicity objective further states "The Regional Water Board will also consider…numerical criteria and guidelines for toxic substances developed by the State Water Board, the California Office of Environmental Health Hazard Assessment, the California Department of Health Services, the U.S. Food and Drug Administration, the National Academy of Sciences, the U.S. Environmental Protection Agency, and other appropriate organizations to evaluate compliance with this objective." (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/rwqcb5/bsnplnab.pdf). The California Department of Fish and Game (CDFG) molinate criterion to protect aquatic life is 13 μg/L (reference).

Evidence of Impairment

Between 1994 and 2000, multiple studies analyzed a total of 99 ambient water samples collected in Butte Slough at Lower Pass Road for molinate. Samples were generally collected during the time period of application of molinate to rice (generally May and June). Seven of 99 samples (about 7%) exceeded the CDFG aquatic life protection criterion for molinate of 13 μg/L (Harrington, 1990).

Table B-2. Summary of Molinate Concentrations in Butte Slough

Data Source	Sample Years	Number of Sample Dates	Range of Molinate Concentrations	Criterion[a]	Number of Sample Dates Equal to or Above Criteria	Percent of Sample Dates Equal to or Above Criteria
Holmes *et al*, 2000	1994	16	nd - 0.15 μg/L	13 μg/L	0	0%
Gorder and Lee, 1995	1995	17	nd - 8.5 μg/L	13 μg/L	0	0%
Gorder *et al*, 1996	1996	19	nd - 15.7 μg/L	13 μg/L	5	26%
CDPR, 1997	1997	17	nd - 16.42 μg/L	13 μg/L	2	12%
Gorder and Newhart, 1998	1998	17	nd - 12.17 μg/L	13 μg/L	0	0%
Newhart and Bennett, 1999	1999	7	nd – 9.0 μg/L	13 μg/L	0	0%
Newhart *et al*, 2000	2000	6	nd - 11.5 μg/L	13 μg/L	0	0%
Summary	1994 - 2000	99	nd - 16.42 μg/L	13 μg/L	7	7%

[a] CDFG water quality criterion for the protection of aquatic life (Harrington, 1990)
nd = not detected

Extent of Impairment

Butte Slough extends approximately 7.5 miles, from the confluence of Butte Creek and the Sacramento River to the Sutter Bypass. Samples were collected from one site only, at Lower Pass Road near Meridian. However, the Butte Slough watershed contains extensive rice acreage, and Butte Slough flows are frequently dominated by runoff from these fields, particularly during April and May. Therefore, the entire 7.5 miles is proposed for listing on the 303(d) list. The most likely source of molinate is from rice fields draining into the Butte Slough waterways.

Potential Sources

Molinate is applied on rice fields to control broad-leaved and grassy weeds (WHO, 1993). Agricultural runoff from rice fields and drift of molinate during aerial application onto rice fields contributes to surface water contamination adjacent rice fields (California Rice Commission, 2001). The occurrence of molinate in Butte Slough water column samples indicates that the most likely source of molinate is from agriculture, specifically rice fields.

B.1.25 Jack Slough, Diazinon

Summary of Proposed Actions

The California Regional Water Quality Control Board, Central Valley Region (Regional Board) recommends the addition of the Jack Slough to California's Clean Water Act Section 303(d) list due to impairment by diazinon. Information available to the Regional Board on diazinon levels in Jack Slough indicates that water quality objectives are not being attained. A description for the basis for this determination is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Jack Slough	**Pollutants/Stressors**	Diazinon
Hydrologic Unit	515.40	**Sources**	Agriculture
Total Waterbody Size	17 miles	**TMDL Priority**	
Size Affected	13 miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	13 miles	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	39° 14' 59"	**Upstream Extent Longitude**	121° 29' 01"
Downstream Extent Latitude	39° 10' 06"	**Downstream Extent Longitude**	121° 35' 24"

Watershed Characteristics

Located in the Feather River watershed, Jack Slough originates in the foothills of northern Yuba County and flows south/southwest to its confluence with the Feather River, northwest of Marysville. Jack Slough meanders as a natural channel, through riparian zones, in the upstream portion of the watershed and is channelized in the downstream portion of the watershed, where intensive agriculture and year-round irrigation management occurs. In the Sacramento Valley, land use adjacent Jack Slough is predominately agriculture with rice fields located near the upper part of Jack Slough drainage and dense fruit and nut orchards located near the lower part of Jack Slough drainage.

Water Quality Objectives Not Attained

The narrative objectives for pesticides and toxicity are not being attained for diazinon in Jack Slough. The narrative objective for pesticides states, "No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses." The narrative toxicity objective in the Basin Plan states "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life." It further states that "The Regional Water Board will also consider ... numerical criteria and guidelines for toxic substances developed by the State Water Board, the California Office of Environmental Health Hazard Assessment, the California Department of Health Services, the U.S. Food and Drug Administration, the National Academy of Sciences, the U.S. Environmental Protection Agency, and other appropriate organizations to evaluate compliance with this objective...As a minimum, compliance with this objective...shall be evaluated with a 96-hour bioassay (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/~rwqcb5/bsnplnab.pdf)." The California Department of Fish and Game (CDFG) has established freshwater numeric acute (1-hour average) and chronic (4-day average) criteria for diazinon of 0.08 µg/L and 0.05 µg/L, respectively, for the protection of aquatic life (Siepmann and Finlayson, 2000).

Evidence of Impairment

Between 1994 and 2000, the Regional Board and the USGS monitoring studies analyzed a total of 26 ambient water samples collected in Jack Slough, during rain events, for diazinon. Overall, 26 out of 26 samples (100%) exceeded the CDFG chronic water quality criteria of 0.05 parts per billion (ppb) and the acute water quality criteria of 0.08 ppb in January and February, coinciding with the orchard dormant spray season. Pollutant concentrations in ambient water samples collected from Jack Slough ranged up to more than 22 times the CDFG chronic water quality criteria. Table B-2 summarizes the available data.

Table B-2. Summary of Diazinon Concentrations in Jack Slough

Data Source	Sample Years	Number of Sample Dates	Range of Diazinon Concentrations	Criteria		Number of Sample Dates Equal to or Above Criteria	Percent of Sample Dates Equal to or Above Criteria
Holmes *et al*, 2000	1994	9	0.137 - 0.803 µg/L	Chronic	0.05 µg/L	9	100%
				Acute	0.08 µg/L	9	100%
Dileanis *et al*, 2000	2000	10	0.116 – 0.727 µg/L	Chronic	0.05 µg/L	10	100%
				Acute	0.08 µg/L	10	100%
Summary	1994 & 2000	19	0.116 – 0.803 µg/L	Chronic	0.05 µg/L	19	100%
				Acute	0.08 µg/L	19	100%

[a] CDFG water quality criteria for the protection of aquatic life (Siepmann and Finlayson, 2000)

Extent of Impairment
Based on California Department of Pesticide Regulation preliminary 2000 Pesticide Use Report (PUR) data, diazinon use (primarily on peach, prune and cherry trees and less on walnut trees) occurs as far as 11 miles upstream from the Regional Board and USGS Jack Slough monitoring study sites (near Highway 70), where 100% of the collected ambient water samples equaled or exceeded CDFG acute and chronic water quality criteria during the orchard dormant spray season. Therefore, diazinon impairment in Jack Slough is likely to extend approximately 11 miles upstream from the two monitoring study sites and also approximately 2 miles downstream from the monitoring study sites, prior to the confluence of Jack Slough and the Feather River.

Potential Sources
Agriculture is the predominant land use near Jack Slough, specifically fruit and nut orchards and rice fields. Diazinon is applied to orchards, primarily during the dormant spray season to control pests. Seasonal rainfall events in the Sacramento Valley coincide with the orchard dormant spray season and, as a result, residual diazinon migrates with surface runoff from orchards and enters Jack Slough during winter rainstorms. Irrigation return water can also transport diazinon to Jack Slough. Since agriculture is the predominant land use near Jack Slough and diazinon is the primary pesticide used on nearby orchards, the main source of diazinon in Jack Slough is likely from agriculture, particularly from orchards during the orchard dormant spray season.

Chapter 3

Water Quality in Relation to Rice Farming

Introduction

The purpose of this chapter is to document the water quality issues associated with rice production in California. The background material for this chapter was the white paper *Water Use for Rice Farming in California* (CH2M HILL, 1992). New information pertaining to recent initiatives, regulations, monitoring results, and other water quality issues are also reviewed and documented in this chapter.

Rice Farming's Influence on Water Quality

Because rice is farmed in standing water, the importance of good farming practice to water quality is evident. However, water quality problems associated with other crops and locales, such as soil erosion and sediment transport, saline drainage waters, and high concentrations of trace elements (e.g., selenium, molybdenum, arsenic) in subsurface drainage, are typically not a problem with rice farming. The generally slow rate of flow through rice fields and the controlled rate of water release tend to avoid significant soil erosion. Also, because much of the water used to irrigate rice fields initially has a low salt concentration, and there is little possibility for salt accumulation in a continuously flooded system, salt concentrations in return flows are usually relatively low. Trace element concentrations in return flows are also low for the same reasons, and perhaps because Sacramento Valley basin soils do not contain elevated concentrations of trace elements.

The major potential water quality challenge for rice farmers is the need to achieve acceptably low pesticide concentrations in return flow, which is a problem shared with other sectors of agriculture. Therefore, this chapter discusses the following:

- Pest management by rice farmers, including water management to achieve water quality goals
- Criteria and performance goal development
- Water quality management and compliance with performance goals

Pest Management by Rice Farmers

Virtually all agricultural crops require the farmer to control weeds, diseases, and insects, as well as other animal pests. Rice is no exception. When alternative methods are available, farmers choose among control methods according to available information, crop loss potential, regulatory controls, level of effectiveness, cost, and environmental impact. The effectiveness of chemical methods of pest control in rice allow for profitable production with the help of relatively few registered pesticides.

Insecticides and herbicides are commonly applied at some phase of rice production to manage pests. The use of these chemicals is intended to control damaging pests and competing plant species. However, if not properly managed, they can cause deleterious effects to nontarget animals and plants and jeopardize human health. For these reasons, environmental regulatory agencies such as the United States Environmental Protection Agency (U.S. EPA) and the California State Water Resources Control Board (SWRCB) through the Central Valley Regional Water Quality Control Board (RWQCB) formulate water quality criteria, river basin plans, and goals for the protection of aquatic life and human health. The California Department of Pesticide Regulation (DPR) is the lead agency for pesticide regulation in California. DPR is required by California law to register and regulate the use of pesticides and protect public health and safety by providing environ mentally sound pest management. These criteria, standards, goals, and regulations govern pesticide use by the rice farmer so as to meet the dual goals of effective pest management and environmental integrity.

Animal Pest Management

The primary animal pests of rice in California are tadpole shrimp, crayfish, rice water weevil, leaf miner, midges, army worms, and leafhoppers. Several chemicals can be applied to control these pests and minimize damage. Common insecticides used on specific-target rice pests in California and their regulatory status are presented in Table 3-1.

Table 3-1

Insecticides Used in Rice Cultivation in California

Chemical Name	Target Pest	Status
Carbofuran	Rice water weevil	Registered, restricted use
Malathion	Midges	Registered, restricted by label
Methyl parathion	Tadpole shrimp, midges	Registered, restricted use
Copper sulfate	Tadpole shrimp	Registered, restricted by label

Malathion and copper sulfate are the only fully registered insecticides with no special restrictions for California rice. The DPR has placed restrictions on the other commonly used insecticides. Restrictions may include holding time limits for discharge water, a permit from the County Agricultural Commissioner to possess or use the pesticide, and limitation of the land area that can be treated. Carbofuran's registration has been extended through the 1996 growing season; however, it will not be renewed for 1997. Growers will nevertheless be able to use available stocks of carbofuran during 1997.

The most intense period of insect and invertebrate pest management is the period between sowing the rice seed and the stand establishment. Carbofuran, used for control of rice water weevil, is applied prior to field flooding or within the first 6 weeks of stand establishment. Other insecticides (malathion, methyl parathion, and copper sulfate) for controlling tadpole shrimp and rice seed midges are also applied in the initial stages of stand development to avoid economic losses of the crop.

Weed Pest Management

The most widely practiced form of weed control is cultural, which does not involve herbicides. Flooding of rice fields is universal in California, and it is the most effective way to control many weeds. Tillage before rice planting can also be helpful. Timely planting and rapid establishment of rice plants at the proper spacing suppresses weeds by eliminating the space and light that weeds need to grow. California rice farmers are proficient at these techniques of controlling weeds, having perfected efficient methods for planting rice directly onto flooded fields. However, several aquatic weeds can still grow under continuously flooded conditions, so further efforts by the farmer are necessary.

At a somewhat greater cost, other nonchemical control measures are available. A small market for organically grown rice has supported the efforts of some farmers in developing these methods to a great extent. Crop rotation with fallow or nonflooded crops, such as corn or beans, is helpful in some instances because it provides time for some of the seeds shed by the previous seasons' aquatic weeds to die off. This can be expensive because most good rice soils are difficult to farm economically with other crops, and the farmer must own or lease equipment to farm the other crops. Maintaining a deeper flood on the field helps suppress weeds, but requires higher levees as well as additional management and water.

At a relatively lower cost, farmers can control weeds with a variety of selective herbicides (chemicals that, at a prescribed concentration, kill weeds but not rice). A number of effective chemicals have been used by rice farmers over the years. Some have been found to harm other crop plants (MCPA and propanil), or are too mobile in groundwater and surface water (bentazon), and some have been or are being removed from use. Corresponding restrictions for use have been imposed. To avoid conflict with sensitive crops, propanil and MCPA use has been geographically restricted. Bentazon use has been forbidden. Other herbicides are organic compounds that break down over time, do not have mobility or toxicity problems, and have associated management practices that have been developed to ensure that they do not pollute water supplies.

The management practices minimizing the deleterious effects of rice herbicides are based on the following general approach:

- Define acceptable concentrations for the protection of human health and aquatic wildlife resources.
- Reduce concentrations in waterways to levels at or below acceptable concentrations by applying herbicides at appropriate rates or allowing time for their breakdown within the rice field before any water is released into waterways.

Herbicides used in California rice production and their regulatory status are presented in Table 3-2. Triclorpyr is a new herbicide available for use in the 1996 growing season.

Herbicides are applied during various stages of the growth cycle of the rice plant. Molinate can be applied from preflooding through initial tillering (sprouting of multiple stems from each plant). Thiobencarb can be applied at post- emergence through initial tillering. MCPA is applied from tiller initiation through panicle initiation (Flint, et al., 1992).

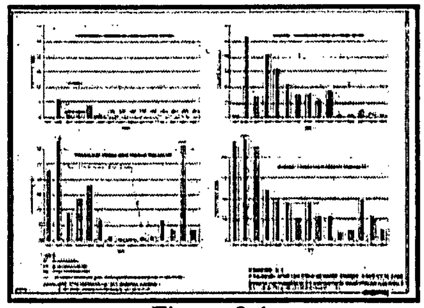


Figure 3-1
Trends For Sacramento River and Colusa Drain Herbicide Standards and Peak Levels

Figure 3-1 indicates the evolution of water quality criteria and performance goals for molinate and thiobencarb from 1981 through 1995. As knowledge has been gained about the sensitivity of fish species, the California Department of Fish and Game (CDFG) has required lower maximum levels of molinate and thiobencarb in agricultural drains. Research on rice water and weed management, as well as rapid adoption of the new technologies by rice farmers, are aimed at meeting this challenge of protecting water quality. The rice farmers' success in this regard is discussed in the Water Quality Monitoring and Compliance with Performance Goals section.

Table 3-2

Herbicides Used in Rice Cultivation in California

Chemical Name	Target Pest	Status
Bensulfuron methyl	Broadleaf, sedges	Registered, restricted by label
Molinate	Grass weeds	Registered, restricted use
Thiobencarb	Broadleaf, sedges, grass weeds	Registered, restricted use
MCPA	Broadleaf, sedges	Registered, restricted use
2,4,D	Broadleaf, sedges	Registered, restricted use
Fenoxaprop	Broadleaf	Registered, restricted by label
Propanil	Broadleaf, sedges, grass	Registered, restricted use
Triclorpyr	Boadleaf	Registration under public notice

Bensulfuron methyl and fenoxaprop are currently the only fully registered herbicides without any special restrictions for California rice. However, weed resistance to bensulfuron methyl has developed, and this has reduced its usefullness in California rice production. Use of MCPA and 2,4,D is limited to certain areas because these chemicals can damage other types of crops.

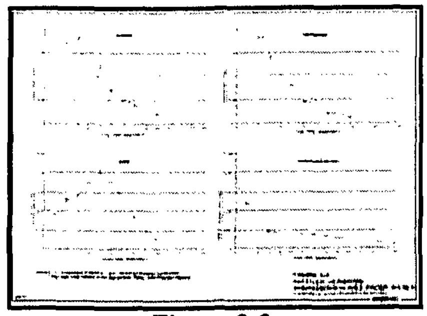


Figure 3-2
Rates of Herbicide Breakdown in Rice Paddy Water

The pesticides used in rice production are broken down by natural mechanisms. A principal mechanism is biodegradation. When rice fields are flooded, oxygen flow into the soil is greatly reduced. Below the surface half-inch of soil, microbes rapidly deplete oxygen and begin to seek other compounds for respiration, including sulfur, nitrogen, iron, and manganese. This layering creates a wide range of chemical and microbial conditions that are ideal for breaking down organic compounds like rice herbicides. The extent of destruction depends on how fast these conditions are created and how long they exist. Microbes work well at high water temperatures that are favored by relatively little inflow of fresh, cool irrigation water. Reducing or eliminating flow out of the rice field keeps herbicide in the field where microbes in the soil and the water can degrade it over time. Figure 3-2 shows that after 7 to 10 days, herbicide concentrations are reduced by 80 to 90 percent for all but MCPA. Nevertheless, MCPA levels in return flow have not been a problem.

Several methods have been developed to retain water on flooded fields to aid in herbicide breakdown. Chapter 2 describes the closed and conventional systems and presents a breakdown of the percentage of rice acreage using each system within the rice producing counties.

Prior to 1980, water retention by the closed or conventional systems was rare. Installation of recirculation systems for substantial acreage is an indication of the commitment of rice farmers' resources to water quality (see Chapter 2). For example, the increase in holding times for tailwaters containing molinate from 4 days (post-application) in 1983 to the current (1996) practice of 28 days and the encouragement of tailwater recycling practices have contributed to the reduction in molinate loadings to receiving waters in the Sacramento River Basin. A provision of the rice pesticide control program allows emergency releases of pesticide-treated tailwaters prior to the standard holding times (with authorization from the county agricultural commissioner). This program provision has resulted in concerns about the impacts of these releases on surface-water quality downstream of these discharges. A study conducted by the RWQCB in 1991 determined that only 0.8 percent of total rice acreage was granted emergency releases in 1991. However, the RWQCB calculated that these releases accounted for approximately 15 percent of the molinate measured at the Colusa Basin Drain. These findings resulted in restriction of emergency release authorizations unless no other options are available (RWQCB, 1992).

In 1992, the RWQCB requested that the DPR conduct a program to reduce the drift of rice pesticides during aerial application, which contributes to rice pesticides in surface waters adjacent to rice fields. The 1994 program has specific provisions for reducing the effects of aerial drift on water quality. These provisions are based on drift control measures outlined in Section 6460 of Title 3 of the California Code of Regulations, and include additional measures to prevent drift by increasing the average size of spray droplets. The provisions also prohibited application to sites immediately upwind of waterways and to all sites when wind speeds are greater than 5 miles per hour (DPR, 1994). Drift provisions for 1995 were the same as in

1994; however, special attention was given to prevent aerial deposition to sweat ditches during application. Aerial drift provisions for 1996 will remain the same (DPR, 1995).

Other 1992 RWQCB pesticide management recommendations requested DPR to incorporate the practice of sealing weir boxes and field drain structures with canvas to minimize leakage of rice field water during holding periods (RWQCB, 1992). These management recommendations should provide additional benefits in limiting pesticide concentrations in drains and ultimately in the Sacramento River. In 1994, pesticide users were required to prevent seepage of field water through the field's weir box by securing the box with plastic and mounding soil in front of each weir box (DPR, 1994). Field inspectors noted that the new 1994 provision requiring mounding of soil in front of each field's drain box was a valuable enforcement tool.

Criteria and Performance Goal Development

Beginning in May 1980, and on a yearly basis through 1983, over 65,000 carp, catfish, black bass, and crappie died in rice field drain waters in the Sacramento Valley (Hill et al., 1991). At approximately the same time, monitoring studies found that thiobencarb concentrations as low as 1 g/L resulted in increases in water taste complaints from people whose drinking water originated in the Sacramento River downstream of the rice field agricultural drains.

As a result of the fish loss events in the early 1980s, CDFG conducted investigations that indicated that the fish losses resulted from molinate poisoning (SWRCB, 1990). By implementation of increased holding times for irrigation waters containing molinate, no additional fish losses have been documented since June 1983.

Monitoring studies in the early 1980s by the RWQCB determined that molinate, carbofuran, malathion, and methyl parathion were present in rice field drains in concentrations that could cause a threat to aquatic life. As a result of the fish losses and the monitoring results through the early 1980s, the DPR initiated the Rice Pesticide Control Program in 1984 to manage and regulate the discharge of pesticides from rice fields.

Findings by CDFG and RWQCB further moved the SWRCB to contract for scientific studies to develop a toxicity database and to suggest limits for pesticide levels in the Valley's rivers and agricultural drains.

A review of information on toxicity of molinate and thiobencarb was conducted by the SWRCB (1990). This review was used to develop specific water quality criteria and performance goals for those herbicides. The CDFG has also recently completed hazard assessments for the insecticides carbofuran, malathion, and methyl parathion. The results of these investigations support the RWQCB recommended performance goals on the basis of studies by the CDFG laboratory and a review of the toxicity literature (Finlayson, pers. comm., 1992). Presently, the performance goals for the five rice pesticides are only targets and are not enforceable.

In 1990, the RWQCB amended *The Water Quality Control Plan* (Basin Plan) for the Central Valley Region. The Basin Plan prohibited the discharge of irrigation return flows containing molinate, thiobencarb, carbofuran, malathion, and methyl parathion unless a RWQCB-approved management practice is followed. Proposed management practices are intended to control pesticide concentrations in return flows from rice fields so that specific performance goals are met. The RWQCB is currently working on amendments to the existing Basin Plan that would establish enforceable water quality objectives by 1997.

The DPR continues to submit yearly rice pesticide control program results and proposed management practices for these pesticides to meet the RWQCB performance goals. Irrigation water-holding times, guidelines for emergency releases, and voluntary limits on acreage treated are examples of current rice pesticide management practices.

Water Quality Monitoring and Compliance with Performance Goals

Since the early 1980s, major accomplishments have been made in reducing the pesticide and herbicide concentrations in rice field drains. Through voluntary and regulatory programs, the Sacramento Valley rice growers have been successful in significantly reducing the total pesticide loadings into the major drains and the Sacramento River. As a result of these reductions in rice pesticide loadings, residuals are well below public health criteria (no known instances of a threat to human health have been experienced). Potential threats to aquatic life should be further minimized by ongoing efforts to improve water quality.

The RWQCB is charged with protection of water quality in California's rice growing region. This has included enforcement of primary water quality criteria for protection of public health and secondary criteria for water quality, and taste and odor. These criteria are established by the U.S. EPA and the California Department of Health Services (DHS). The CDFG is similarly responsible for protection of fish and wildlife resources. These agencies define safe levels of pollutants, including pesticides, in California's waters and also monitor these pollutants to ensure compliance.

As a result of fish kills in the early 1980s, the DPR (formerly a part of the California Department of Food and Agriculture), the City of Sacramento, RWQCB, and CDFG began intensive monitoring of rice pesticides in the Sacramento Valley. These studies included sampling of agricultural drains, the Sacramento River, and fish tissues in both the drains and the river. These monitoring activities have resulted in the establishment of the current water quality objectives and performance goals for maximum concentrations of pesticides in the surface waters of the Sacramento River Basin. The 1996 performance goals for carbofuran, malathion, molinate, methyl parathion, and thiobencarb are 0.4 g/L, 0.1 g/L 10.0 g/L, 0.13 g/L, and 1.5 g/L, respectively (RWQCB, 1994). Seven water quality objectives for pesticides have been defined in the 1994 Basin Plan. Following is a summary of these objectives:

- Pesticides shall not be present in concentrations that adversely affect beneficial uses.

- Discharges shall not result in pesticide concentrations in bottom sediments or aquatic life that adversely affect beneficial uses.

- Total identifiable persistent chlorinated hydrocarbon pesticides shall not be present in the water column at concentrations detectable within the accuracy of analytical methods.

- Pesticide concentrations shall not exceed the lowest levels technically and economically achievable.

- Waters designated for use as domestic or municipal supply shall not contain concentrations of pesticides in excess of maximum contaminant levels set by the California Code of Regulations.

- Waters designated for use as domestic or municipal supply shall not contain concentrations of thiobencarb in excess of 1.0 g/L.

Since the early 1980s, rice pesticide and herbicide concentrations have been significantly reduced in both the Sacramento River and the Basin agricultural drains. These reductions have been achieved through continued monitoring of study results, setting of performance goals and water quality objectives, research into rice tailwater management practices, and innovations in rice cultivation practices.

The total herbicide load (molinate and thiobencarb) carried by the Sacramento River dropped from approximately 40,000 pounds in 1982 to less than 125 pounds in 1992 (California Environmental Protection Agency, 1992). In 1993, the molinate load (thiobencarb was not detected in the Sacramento River) carried by the Sacramento River increased to approximately 4,200 pounds, but then decreased again in 1994 to approximately 240 pounds. Figure 3-3 shows the mass loading to the Sacramento River from 1982 to 1995. Weather conditions may explain some of the variations in the peak concentrations and mass loadings. For example, the dissipation rate of some pesticides increases with increasing temperature. Warm weather in May of 1987 and 1992 may explain the low molinate concentrations and mass loading to the Sacramento River during those years. On the other hand, the cool, wet conditions in May of 1990 and June of 1993 may explain the higher levels occurring during those years.

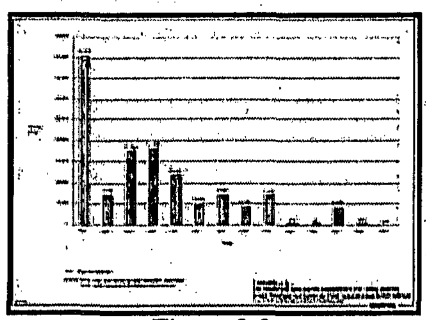


Figure 3-3
Estimated Mass Transport of Molinate and Thiobencarb in the Sacramento River 3-10

Seasonal peak levels of two herbicides over the past 15 years are shown in Figure 3-1. Water and weed management systems have changed greatly during this period. Resulting levels of molinate and thiobencarb in the Sacramento River have been below limits established to protect water quality and public health and have generally declined throughout the monitored period (1982 to 1995). Levels of thiobencarb have been below the secondary public health level (taste) since 1986.

Peak levels in the Colusa Basin Drain have also declined (to less than 10 percent of pre-1985 levels). This water is virtually all return flow, mostly from rice fields. Relevant RWQCB goals in this drain are for the protection of fish.

Since 1982, the molinate concentrations in the Colusa Basin Drain at Highway 20 have decreased from a peak of 357 g/L in 1981 to 25 g/L in 1995 (Figure 3-1). This has resulted in the reduction of molinate concentrations at the City of Sacramento's water intake from a high of 16 g/L in 1982 to 0.16 g/L in 1995, a decrease in concentration of approximately 99 percent (UC Coop. Ext., 1991, DPR, 1995). Drought during the early 1990s resulted in low flows, increasing concentrations of herbicides (Figure 3-1). No Ordram has been detected in the City's drinking water (Cal EPA, 1992). Molinate goals were met between 1986 and 1989, and in 1991.

Molinate goals were exceeded in 1990 as a result of significant reductions in performance goals (from 90 g/L in 1989 to 30 g/L in 1990) and drought-related low flows in the drains and rivers.

Thiobencarb goals were met between 1983 and 1991; however, peak levels were above the performance goals between 1992 and 1995. Performance goals have become significantly more stringent, from 24 g/L in 1989 to 1.5 g/L in 1991. Thiobencarb concentrations at the City of Sacramento's water intake from 1982 to 1995 have also declined. From peak concentrations of 3 to 4 g/L in 1985, the concentration of thiobencarb at the City's intake was less than 1.0 g/L from 1986 to 1995.

The water-holding requirements in the Sacramento Valley in 1995 were adequate to meet performance goals during 1995 and will not be adjusted in 1996. (DPR, 1995).

In lab tests associated with monitoring of rice field drainwater by the CDFG Pesticide Investigations Unit, pesticide levels in the Colusa Basin Drain have not been shown to be toxic. Evidence and experimental data suggest that declines in the striped bass populations in the San Francisco Bay-Delta Estuary since the mid-1970s are probably not a result of rice pesticide use in the Sacramento Valley (Finlayson, pers. comm., 1992).

Conclusions

The California rice industry continues to invest in crop, land, and water management practices that result in reliably high water quality. Their sensitive location in California's water supply network has obliged rice growers to take a proactive approach to water quality. The results demonstrate to other irrigators and industries the potential value of this approach.

The significant reduction in pesticide inputs into the Sacramento River is, "...one of the most successful water pollution control programs in the United States. It has taken concerted effort by numerous state and local agencies and creative implementation by the rice industry to make this happen." *(William Crooks, RWQCB's Executive Officer)*

The following sections present the justification for ratings of the rice industry's performance relative to the environmental value of water quality.

Overall performance of rice relative to water quality values is good. This positive performance is primarily due to irrigation methods that control return flow (surface water flow back to rivers) and limit subsurface drainage discharge, to the capability of rice fields to degrade pesticides, to rice fields' capability to retain plant nutrients, and to low sediment delivery from rice fields. Alternative land uses influence water quality by land drainage, nutrient and pesticide application, machinery spills, home maintenance, and municipal and industrial water use.

Fertilization

Fertilization associated with alternative land uses (including other crops and urban development) generally results in higher levels of nutrients being discharged to waterways than rice farming. Nitrogen use by rice can be extremely efficient since nitrogen remains primarily in the ammoniac form in flooded fields. (This form is far less mobile in soil than the nitrate form dominating non-flooded soils.) Also, phosphorus moves primarily with eroding soil, which is minimal under rice cultivation. Runoff from urban and commercial developments, another alternative land use, can contain significant amounts of nitrogen from lawn over-fertilization, and phosphorus attached to eroding soil (from building sites and the like).

Topdressing of nitrogen in rice, while not shown to cause significant nitrogen loading of surface waters, is nevertheless less efficient than application before planting. Topdressing is not practiced on all fields and is used to supply only a portion of the annual nitrogen requirement where it is practiced. Because rice can require mid-season fertiliza tion, the practice is expected to continue.

Irrigation

Holding water within rice fields for herbicide breakdown is positive relative to the limited drainage management options available with other crops. This level of protection is difficult to achieve with other, non-flooded crops.

Flood maintenance of rice is compared with surface irrigation of other crops on similar lands, and to municipal and industrial water use by urban developments. The influence of irrigation on surface-water and groundwater quality is considered.

Water percolating to groundwater beneath upland (non-flooded) crops can have substantially higher salinity than the irrigation water. This is less pronounced for flood irrigated rice. Also, there is less mobile nitrate nitrogen in the rooted soil of a rice field is lower than in the rooted layer of upland crops. This is a direct result of flooding. Therefore, groundwater recharged through rice fields is of high quality relative to recharge through upland crop fields.

Surface-water quality is generally degraded by higher temperatures and concentrations of salinity, trace elements, nutrients, and organic pollutants. Water returning to the river from any irrigated crop or wastewater treatment plant is commonly warmer than the water in the river, warming the river where this flow reenters. To irrigate other crops on this land, much of the land would probably require artificial subsurface drainage that is not required for rice. Since much of the existing acreage devoted to rice production has saline, shallow groundwater, the salinity of this drainage would greatly exceed that of surface drainage currently found in the Sacramento Valley. Trace element and nutrient concentrations in such drainage would be higher than in return flow from rice fields, and could also degrade water quality. The wetland chemistry of a rice field is also an ideal environment for degradation of organic compounds, such as herbicides and pesticides. These conditions are exclusively present in continuously flooded fields. Flood irrigation avoids environmental degradation associated with warm, saline, nutrient-rich drainage, yet does contribute warm, relatively non-saline return flow. The influence of rice irrigation on water quality therefore compares favorably with irrigation of alternative crops.

Pest Control

Animal (including insect) pest control requires less intensive effort in rice than in many alternative crops. The amount applied, and the resulting levels in the drainage, are significantly lower than for alternative crops.

In most rice fields, a combination of cultural (non-chemical) and chemical weed control is employed. Tillage and flood irrigation are clean technologies in the sense that no pesticides are required. Herbicides are also employed to control weeds, which can otherwise significantly depress crop yields. The focus of regulatory attention on herbicides has made water quality at times the "Achilles heel" of rice farming, and at other times their greatest success. Under current water management systems, herbicide impacts on surface- water quality are minimal, less than or comparable to those associated with alternative crops or urbanization. Continued investment in environmentally acceptable means of weed control should lead to continuing improvement.

Rice farmers can take advantage of naturally rapid herbicide degradation in flooded rice fields: from 80 to 90 percent in 7 to 10 days for most of the registered herbicides. This is due partly to innovations by rice farmers that enable them to retain water in their rice fields after herbicide application. Water retention provides sufficient time for herbicide degrada tion to affect most of the applied chemical, so that released water is of acceptable quality. Performance goals for rice herbicides in the Sacramento River and the Colusa Basin Drain (an agricultural water conveyance facility) have gradually been lowered to extremely low levels. Nevertheless, since 1985, no peformance goals for a rice herbicide has been exceeded for the Sacramento River, and a significant reduction in concentrations in the Colusa Basin Drain has been achieved. These achievements have resulted from extensive and costly research by the rice industry and its collaborators.

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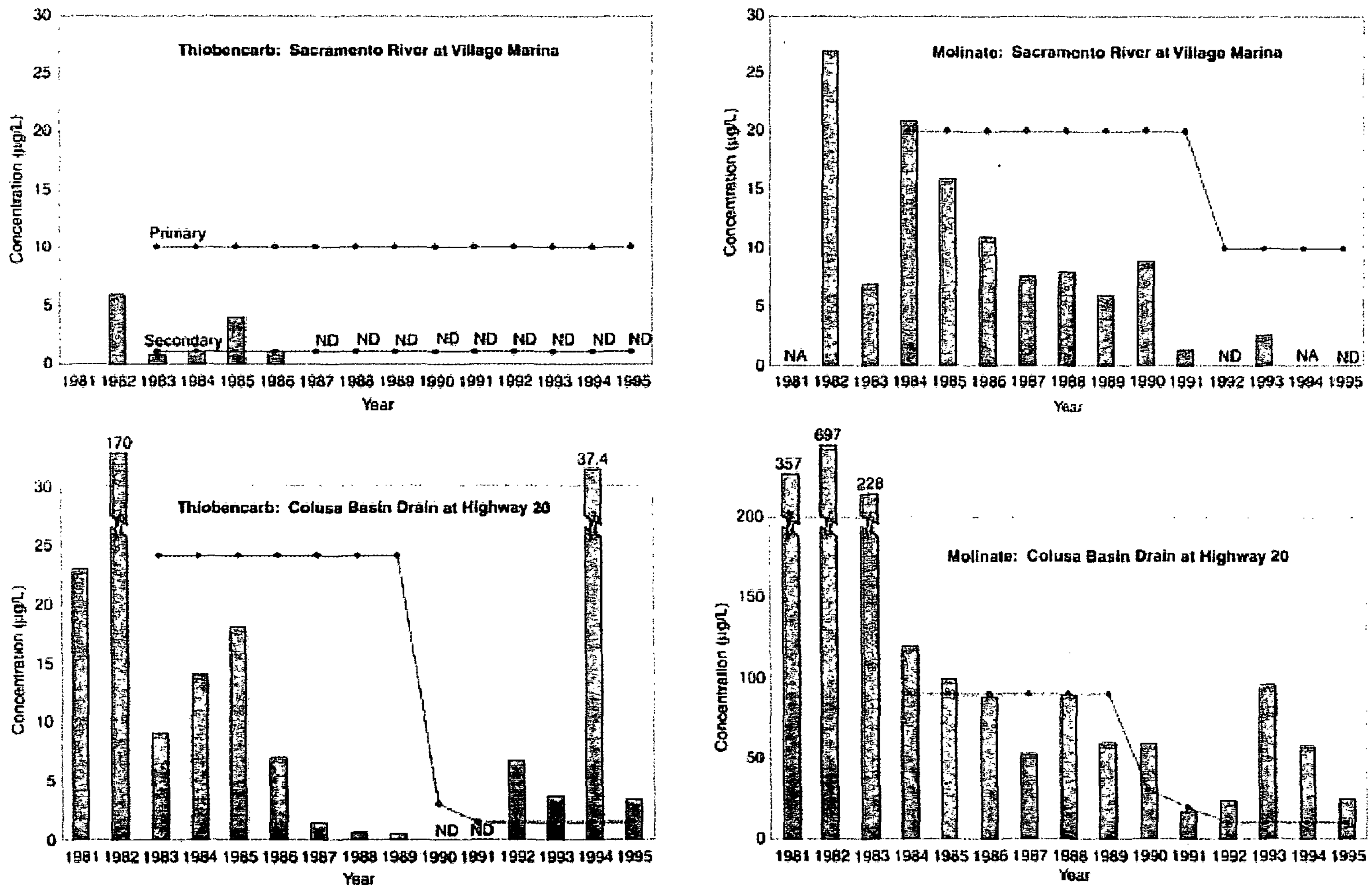


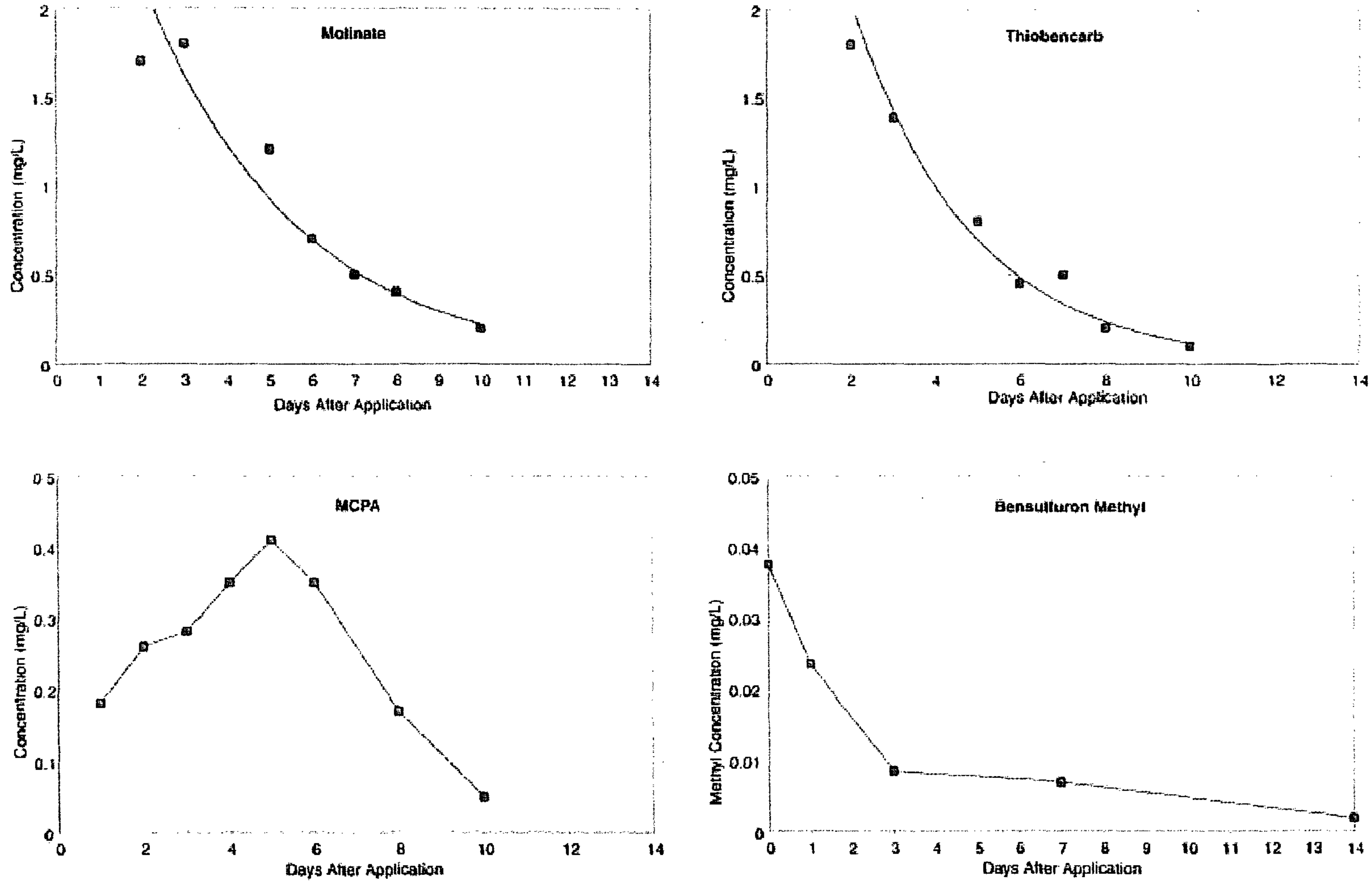
Legend
ND Not Detected
NA Data Not Available
Peak Concentration
Allowable Maximums (pre-1990) and Performance Goals (1990-1995)

Source: DPR, 1995. Information on Rice Pesticides. Submitted to the Water Quality Control Board. December 28.

1971_02

FIGURE 3-1
TRENDS FOR SACRAMENTO RIVER AND COLUSA DRAIN HERBICIDE STANDARDS AND PEAK LEVELS
THE CALIFORNIA RICE PROMOTION BOARD

CH2MHILL

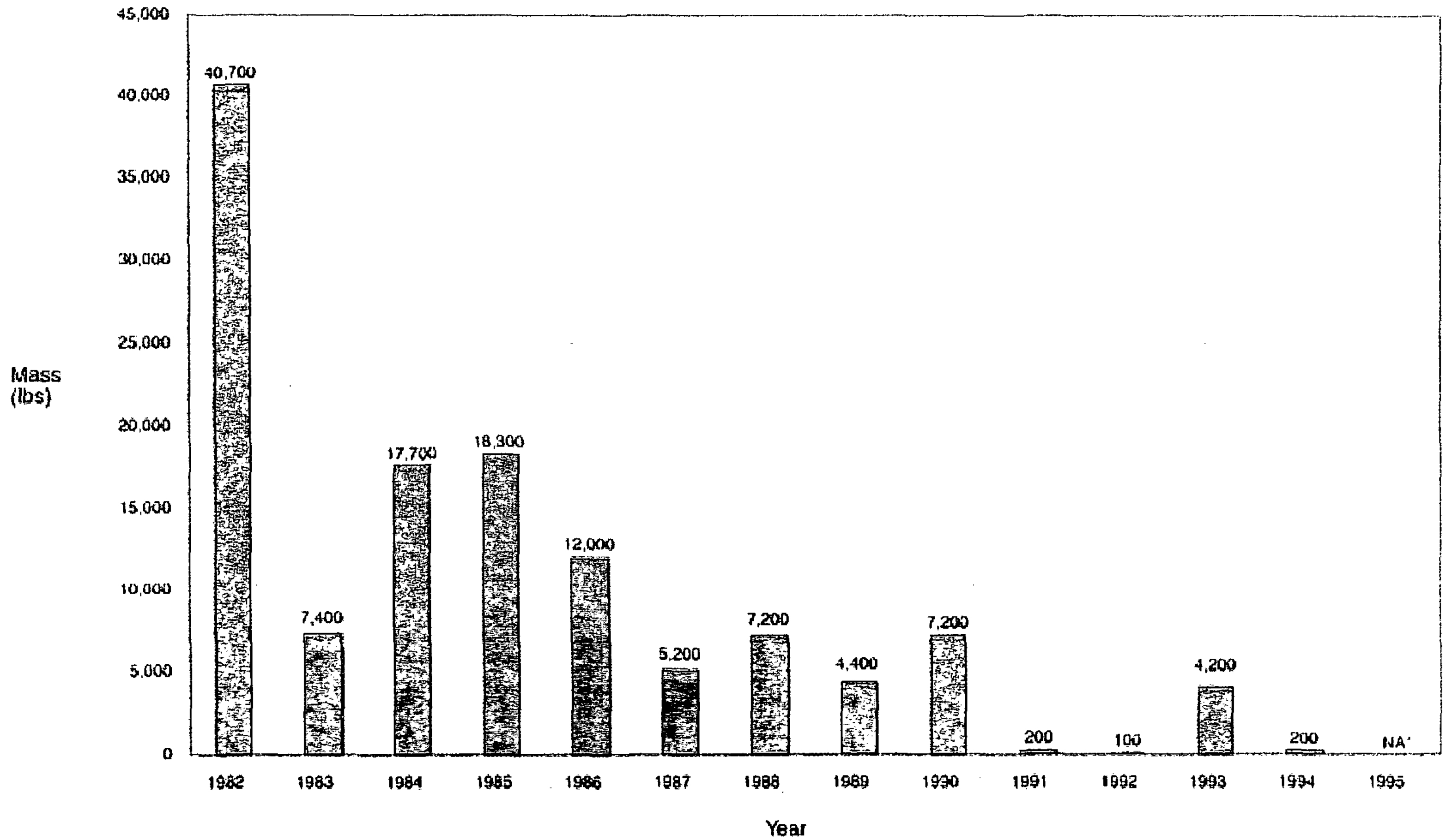


Source: U. C. Cooperative Extension, 1991. *Reducing Pesticide Levels from Rice Field Drain Waters of the Sacramento Valley, 1990 Progress Report.*

1971_61

FIGURE 3-2
RATES OF HERBICIDE BREAKDOWN IN RICE PADDY WATER
CALIFORNIA RICE PROMOTION BOARD

CH2MHILL



*NA Data Not Available

Source: DPR, 1995. Information on Rice Pesticides. Submitted to the Water Quality Control Board. December 28.

FIGURE 3-3
ESTIMATED MASS TRANSPORT OF MOLINATE AND THIOBENCARB IN THE SACRAMENTO RIVER
THE CALIFORNIA RICE PROMOTION BOARD

CH2M HILL

1871_03

ITEM: 11

SUBJECT: Consideration of Water Body Designations to Comply with Provisions of the Water Quality Control Plan for Inland Surface Waters of California (ISWP)

DISCUSSION: The State Water Resources Control Board (State Water Board) adopted the Water Quality Control Plan for Inland Surface Waters of California (ISWP) on 11 April 1991. The Plan includes narrative, toxicity, and numerical water quality objectives for the protection of freshwater aquatic life and for protection of human health.

The numerical water quality objectives in the Plan are intended to apply to all waters in the State. However, the State Water Board recognized that some surface waters are not natural streams, and for these waters, some of the numerical objectives may not be appropriate. The Plan allows the Regional Board to establish special categories of waters for which site specific objectives or performance goals* can be established in lieu of the numerical water quality objectives in the ISWP. These special categories are waters that are dominated by reclaimed water discharges or by agricultural nonpoint source flows.

The Board, at its March 1992 meeting, adopted a listing of the water bodies dominated by reclaimed water discharges. The Plan also directs the Regional Board to designate by 12 October 1992 whether a water body would fall within one of two other special categories. These special categories are natural water bodies dominated by agricultural drainage [Category (b)] or water bodies constructed primarily for the purpose of conveying or holding agricultural drainage [Category (c)].

The attached Resolution and Staff Report are intended to fulfill these 12 October 1992 Plan requirements. They recommend waters for designations in these two special categories, but because of the complexity of the agricultural supply and drainage system in the Region, several subdivisions of these categories are used to facilitate understanding. In addition, the staff report includes information on objectives that are not appropriate for the water bodies and a priority listing for water quality problems.

RECOMMENDATION: Adopt the Resolution as proposed.

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* Performance goals are concentrations of water quality constituents established for receiving waters that a discharger must make best efforts to meet in discharging waste to waters of the State.

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

RESOLUTION NO.

IDENTIFYING CATEGORY (b) AND (c) WATER BODIES AND CONSTITUENTS PURSUANT TO THE INLAND SURFACE WATERS PLAN

WHEREAS, the State Water Resources Control Board (hereafter State Water Board) adopted the Inland Surface Waters Plan (ISWP) on 11 April 1991; and

WHEREAS, the ISWP requires the Regional Water Quality Control Board (hereafter Board) to list and rank the Category (b) and (c) water bodies within its region; and

WHEREAS, the ISWP further requires the Board to identify the Tables 1 and 2 objectives which are inappropriate for the listed water bodies based on available data; and

WHEREAS, the list of Category (b) and (c) waters must be submitted to the State Water Board by 12 October 1992; and

WHEREAS, the attached lists comprise all of the known Category (b) and Category (c) waters in the Central Valley Region; and

WHEREAS, the Board, at a public meeting, heard and considered all comments pertaining to these lists. Therefore, be it

RESOLVED, that the attached Category (b) and Category (c) water body lists using the subcategories outlined in Appendix A be submitted to the State Water Board in fulfillment of the requirements of the Inland Surface Waters Plan.

I, WILLIAM H. CROOKS, Executive Officer, do hereby certify the foregoing is a full, true, and correct copy of a Resolution adopted by the California Regional Water Quality Control Board, Central Valley Region, on 25 September 1992.

WILLIAM H. CROOKS, Executive Officer

Attachment

STAFF REPORT

> *This report would not have been possible without the help of the 340 water, drainage and reclamation agencies who responded to our request for information.*

I. INTRODUCTION

The State Water Resources Control Board (State Water Board) adopted Resolution No. WQ 91-93, approving the Water Quality Control Plan for Inland Surface Waters of California or Inland Surface Waters Plan (ISWP) on 11 April 1991. By 12 October 1992, the ISWP requires, in part, that the Regional Board identify and rank in priority order those natural water bodies that, as of 11 April 1991, are dominated by agricultural drainage and constructed water bodies, used for conveying or holding agricultural drainage. The ISWP further requires the Regional Board to identify the ISWP water quality objectives that are inappropriate for the listed water bodies. The purpose of this staff report is to provide the necessary information to fulfill the 12 October 1992 ISWP requirements.

II. SUMMARY OF THE ISWP

Section 303(c)(2)(B) of the Federal Clean Water Act (CWA) required all states to adopt water quality objectives for the 129 Priority Pollutants that the U.S. Environmental Protection Agency (EPA) has published criteria under Section 304(a) of the CWA. If the State failed to do this, EPA would promulgate these criteria as objectives. The Porter-Cologne Act (California Water Code Section 13170) authorizes the State Water Board to adopt Water Quality Control Plans (Basin Plan) that include the objectives required by the CWA. The State Water Board used this authority in order to continue their role as the agency implementing the CWA in California.

As required of all water quality control plans, the Plan includes designation of beneficial uses, water quality objectives and an implementation program. The ISWP does not include any new beneficial uses but rather incorporates, by reference, beneficial uses in existing Basin Plans and other statewide plans. The ISWP includes five new narrative water quality objectives (Chapter II, Part A, page 3 of Plan), two toxicity objectives (Chapter II, Part B, page 3 of Plan), and numerical water quality objectives for the protection of freshwater aquatic life and for the protection of human health [Chapter II, Part C, pages 4 and 5 of ISWP (Table 1 and 2)]. The Implementation Program of the ISWP (Chapter III, pages 10-25) outlines specific actions for:

(a) point and nonpoint sources (including stormwater)
(b) waters which support threatened/endangered species, and
(c) waters which are predominately composed of reclaimed water or agricultural drainage.

The water quality objectives in the ISWP apply in all surface waters within the State. All agricultural supply canals and drains, whether constructed or flowing in natural channels, are considered surface waters or waters of the State and must conform with the ISWP (State Attorney General's Opinion

No. 65-259 [48 Ops. Cal. Atty. Gen. 30]). The State Water Board recognized, however, that many of the agricultural facilities are not natural waters and that the objectives listed in Table 1 and 2 of the ISWP may not be appropriate. The ISWP establishes special categories of water bodies which are described as follows for categories (b) and (c):

(b) *Natural water bodies, or segments thereof, that, as of the date of adoption of the ISWP are dominated by agricultural drainage; and*

(c) *Water bodies, or segments thereof, that, as of the date of adoption of the ISWP, have been constructed for the primary purpose of conveying or holding agricultural drainage and were not natural water bodies which supported aquatic habitat beneficial uses. Such drains may include drains constructed in normally dry washes and low-lying areas.*

The ISWP allows, in these special category water bodies, establishment of site-specific objectives* or performances goals** in lieu of the Table 1 and 2 objectives in the ISWP.

The plan is to have site-specific objectives* or performance goals** in place within a six-year period. The schedule for the two types of categories are as follows:

Water Body Category	What Applies Upon Adoption	What Applies Within 6 Years or Less
(b) Water Bodies Dominated by Agricultural Drainage	- All Narrative Water Quality Objectives - All Toxicity Objectives - Numerical Objectives Apply as Performance Goals for Purposes of Regulating Agricultural Drainage Discharges & Other NonPoint Sources	- All Numerical Objectives in the Plan or Alternate Site-Specific Objectives Established by the C V Reg Board
c) Constructed Agricultural Drains	- All Narrative Water Quality Objectives - All Toxicity Objectives - The Numerical Objectives Apply as Performance Goals for Purposes of Regulating Agricultural Drainage Discharges & Other NonPoint Sources	- Initial Performance Goals apply or Alternate Site-Specific Performance Goals Established by the Central Valley Regional Board

* A site-specific objective is identical to a water quality objective but has been developed for special local conditions using a site-specific data base rather than the national data base upon which EPA water quality criteria are developed.

** Performance goals, as defined in the Plan, "are concentrations of water quality constituents established for receiving waters that a discharger must make best efforts to meet in discharging waste to waters of the State. For nonpoint source dischargers, these best efforts must be made pursuant to the Nonpoint Source Management Plan. Performance goals will serve as a measure of success in improving water quality."

III. ISWP REQUIREMENTS TO BE COMPLETED BY 12 OCTOBER 1992

The ISWP contains a range of actions that must be completed by the Regional Board by 12 October 1992.

For Category (b) water bodies, by 12 October 1992, the Regional Board must:

- Identify Category (b) water bodies (develop a list).
- Establish a priority list of these waters, consistent with the State Water Board's Clean Water Strategy** (CWS), to identify where early Regional Board action is necessary.
- Identify which numerical objectives defined in Tables 1 and 2 of the ISWP are inappropriate for Category (b) water bodies based on available data.
- Submit the information to State Water Board for consideration and approval.

** The aim of the California Clean Water Strategy (CWS) is to direct State and Regional Board efforts to those water bodies where they will have the greatest impact. To establish CWS priorities, each water body is characterized in terms of relative resource value and severity of impairment of threat. Proposed actions on these water bodies are screened with regard to feasibility.

By 11 April 1993, the State Water Board will act to approve or disapprove the list of Category (b) water bodies and constituents for site-specific objectives (statewide objectives apply in cases of disapproval). Regional Board staff will then proceed to develop the site-specific objectives for Regional Board adoption by 11 April 1997. Until numerical objectives are adopted for Category (b) water bodies, the ISWP Table 1 and 2 objectives apply as performance goals.

For Category (c) water bodies, by 12 October 1992, the Regional Board must:

- Identify Category (c) water bodies (develop a list).
- Establish a priority list of these waters, consistent with the State Water Board's CWS, to identify where early Regional Board action is necessary.
- Submit the information to State Water Board for consideration and approval.

By 11 April 1993, the State Water Board will act to approve or disapprove the list of Category (c) water bodies (statewide objectives apply in cases of disapproval). Tables 1 and 2 objectives in the ISWP will be applied as performance goals to Category (c) waters. For Category (c) water bodies, site-specific performance goals may be developed as needed. The State Water Board shall approve or disapprove the site-specific performance goals.

Natural and constructed water bodies associated with agricultural irrigation not listed as either category (b) or (c) water bodies will have statewide water quality objectives from the ISWP applied to them as if they are natural streams.

IV. REGIONAL BOARD ACTIONS TO COMPLY WITH ISWP

The Regional Board is responsible to prepare the 12 October 1992 report to the State Water Board, but in practicality, the Regional Board can only act as a coordinator. As noted in the Plan, all of the work, described in the previous section, must be conducted with the strong assistance of the water and drainage entities. These agencies have the expertise and information to determine which category a water body should be in.

To compile the information needed to complete the report to the State Water Board, staff contacted by mail over 700 water agencies to request their aid in identifying category (b) and (c) water bodies. Unfortunately most of the agencies were not even aware of the existence of the ISWP; therefore, staff held over 60 area meetings to explain the ISWP and how it impacts agricultural operations. Staff have received reports from over 340 Water, Irrigation, Reclamation, Levee and Drainage Districts which cover over 90 percent of the Region's irrigated area. These reports vary greatly in depth depending upon the information that was available and the agency's understanding of the ISWP.

This wide variability has caused staff a great deal of trouble in trying to bring the information together in one report. This effort was also complicated by the diverse nature of irrigation and drainage system in the Region. Often irrigation canals and drains are used interchangeably as greater and greater portions of the drainage water is recycled through the canal systems.

Because of the diverse topography and nature of irrigation practices in the Central Valley, staff elected to evaluate the information by defined drainage basin. The Region was initially divided between foothills and the valley floor. The valley floor was then divided into four distinct areas with boundaries similar to those of Basin Plans 5A, 5B, 5C and 5D. The four valley floor zones were further subdivided into drainage basins, as shown in Figure 1. These drainage basins represent areas of similar hydrology and common discharge locations and will be used to define future monitoring efforts. The information from the district reports was used to categorize water bodies within each drainage basin.

a. Designation of Water Body Categories

Table 1 lists the category (b) and (c) water bodies. Category (b) are natural channels whose flow and quality are dominated by irrigation activities. The category (c) list is composed of two components. The first is natural dry channels which have been extensively reconstructed and realigned as irrigation/drainage facilities. The second is other constructed facilities named in water agency submittals but too numerous to list in Table 1. The length of the affected reach of each water body is listed.

b. **Priority Listing of Water Bodies**

The prioritization for all listed category (b) and (c) water bodies is shown in Table 1. This prioritization is based on staff judgments, as little water quality data was available.

c. **Inappropriate Water Quality Objectives**

Table 1 shows the water quality concerns for each of the category (b) water bodies. These concerns point to groups of water quality objectives that may be inappropriate, but there was little or no available data for most of the ISWP objectives.

V. DISCUSSION

As specified in the ISWP, staff relied heavily on the information provided by local water agencies. Over 340 informational reports were reviewed, but time and budget constraints have limited the amount of verification possible. The current designations represent the best judgment of staff along with input from local water agencies. Modifications may be necessary before the final approval by the State Water Board.

The ISWP directed the Regional Board to classify water bodies as either natural bodies dominated by agricultural *drainage* or constructed to transport agricultural *drainage*. The district reports showed, however, that three other types of agriculturally dominated water bodies provide beneficial uses which would not exist without the flows resulting from irrigated agriculture. These three types are natural waterways used to transport agricultural *supply* water, constructed facilities used to transport agricultural *supply* water, and dry washes that have been reconstructed and realigned to be an integral component of the *supply or drainage* system.

Because of this complex system, Regional Board staff reviewed the reports and placed the water bodies in one of the following subcategories based on information supplied by the districts:

Natural Water Body

Category (b) Water Bodies:

(b1) - Natural water bodies dominated by agricultural drainage water.

(b2) - Natural water bodies dominated by agricultural supply water.

Constructed Facility

Category (c) Water Bodies:

(c1) - Constructed facilities designed to carry agricultural flows or drainage.

(c2) - Constructed facilities designed to carry irrigation water and may, at times, carry recycled return flows.

(c3) - Natural dry washes that have been altered and now carry agricultural supply water or return flows during time periods.

The criteria for each subcategory are described in Appendix A along with an illustration of a decision-making flow chart. The process outlined in Appendix A was used to categorize all water bodies within each drainage basin. A description of each drainage basin and the agriculturally dominated natural water bodies is presented in Appendix B. **(Appendix B will be mailed under a separate cover)**. Appendix B also presents a summary of all constructed agricultural facilities as provided by the cooperating agencies.

Most of the major natural water bodies in the Central Valley are not dominated by agricultural activities although, in many cases, they do provide either agricultural supply water or receive extensive amounts of agricultural drainage flows. One major water body, the San Joaquin River, is agriculturally dominated. With the construction of Friant Dam and the Friant-Kern Canal, most natural flows downstream of Highway 99 ceased. A 22.8-mile reach of the River is used to convey imported supply of water (Mendota Pool to Sack Dam), but the majority of the River (a 109.7-mile reach from Sack Dam to the Stanislaus River confluence) is dominated by agricultural return flows, drainage water, and ground water seepage.

Also noted in Table 1 are major constructed facilities which have greatly altered the flow of water throughout the Central Valley. These water supply and flood control facilities in many cases either completely eliminated the natural flow to or caused complete realignment of former natural streams. These facilities include the:

Natomas-Cross Canal
Tehema-Colusa Canal
Glenn-Colusa Canal
Colusa Basin Drain
Madera Canal
Yolo Bypass
Sutter Bypass
Knights Landing Ridge Cut
Sacramento Ship Channel
California Aqueduct
Folsom-South Canal
Delta Mendota Canal
Friant-Kern Canal
Tisdale Bypass
Cross Valley Canal

The evaporation basins used for tile drainage are not included in the list of (b) or (c) water bodies. The ISWP in its introduction, clearly states that it "*does not apply to waste treatment systems, including treatment ponds, evaporation ponds, or lagoons designed to meet the requirements of the federal Clean Water Act*" (emphasis added). The ponds are designed to contain the waste without discharge to waters of the United States. This is the same position that State Water Board staff took when responding to issues raised by E.P.A. In their report of 26 September 1991 to Walt Pettit and State Water Board members, the State Water Board staff recommended not to change this portion of the plan.

The second direction to the direction to the Board under the ISWP is to "*establish a priority list of the listed category (b) and (c) water bodies to identify where early Regional Board action is necessary.*" Using the State Water Board's Clean Water Strategy, almost all the listed water bodies would be in the lowest priority state wide. An additional prioritization was conducted, however, to rank these water bodies based upon their potential to have water quality problems present or create similar problems downstream. To make this second assessment consistent with the Clean Water Strategy, the following five factors were used:

1. Magnitude of existing beneficial uses

2. Water Body size (length)

3. Flow (perennial vs. intermittent and volume)

4. Degree of beneficial use impairment

5. Degree of threat to downstream water quality

The prioritization for all listed category (b) and (c) water bodies is shown in Table 1. This prioritization is based upon staff judgment as little water quality data is available.

The third direction to the Board under the ISWP is to "*identify which numerical objectives defined in Table 1 and 2 of the ISWP are inappropriate for the category (b) water bodies based on available data*". For most agricultural drains, canals and natural water bodies dominated by these flows, there is little or no data available on most of the ISWP numerical objectives. Table 1 shows the water quality concerns for each of the category (b) water bodies. These designations point to groups of water quality objectives that may be inappropriate, but more thorough monitoring needs to be conducted before a site-specific objective workplan can be prepared. The designation of water quality concerns was based upon the following observations:

- The water bodies showing elevated selenium concentrations are located principally in the west side of the San Joaquin Valley.

- Elevated boron and total dissolve solids concentrations are common in many water bodies dominated by agricultural drainage and in natural and constructed facilities that carry ground water or recycled agricultural drainage water.

- Monitoring shows that water quality objectives for metals (As, Cd, Cr, Cu, Pb, Ni, ag and Zn) are violated when total recoverable analytical techniques are used for analysis. These elevated levels are commonly due to the natural levels of metals on sediment. This sediment is commonly found in water bodies dominated by agricultural drainage. This sediment also has attached pesticides residues, such as DDT, DDE, toxaphene, chlordane, endosulfan, and other persistent pesticides.

- Concentrations of pesticides can be found in all water bodies that are dominated by agricultural drainage and at times in agricultural supply canals as a result of recycling of drainage water, pumped ground water or maintenance operations that are conducted on constructed canals and drains.

- Maintenance operations in constructed canals and drains may cause water quality objective violations including violation of the toxicity objectives. These maintenance operations, such as use of copper sulfate or other chemicals are critical to maintaining the integrity of the facility's use.

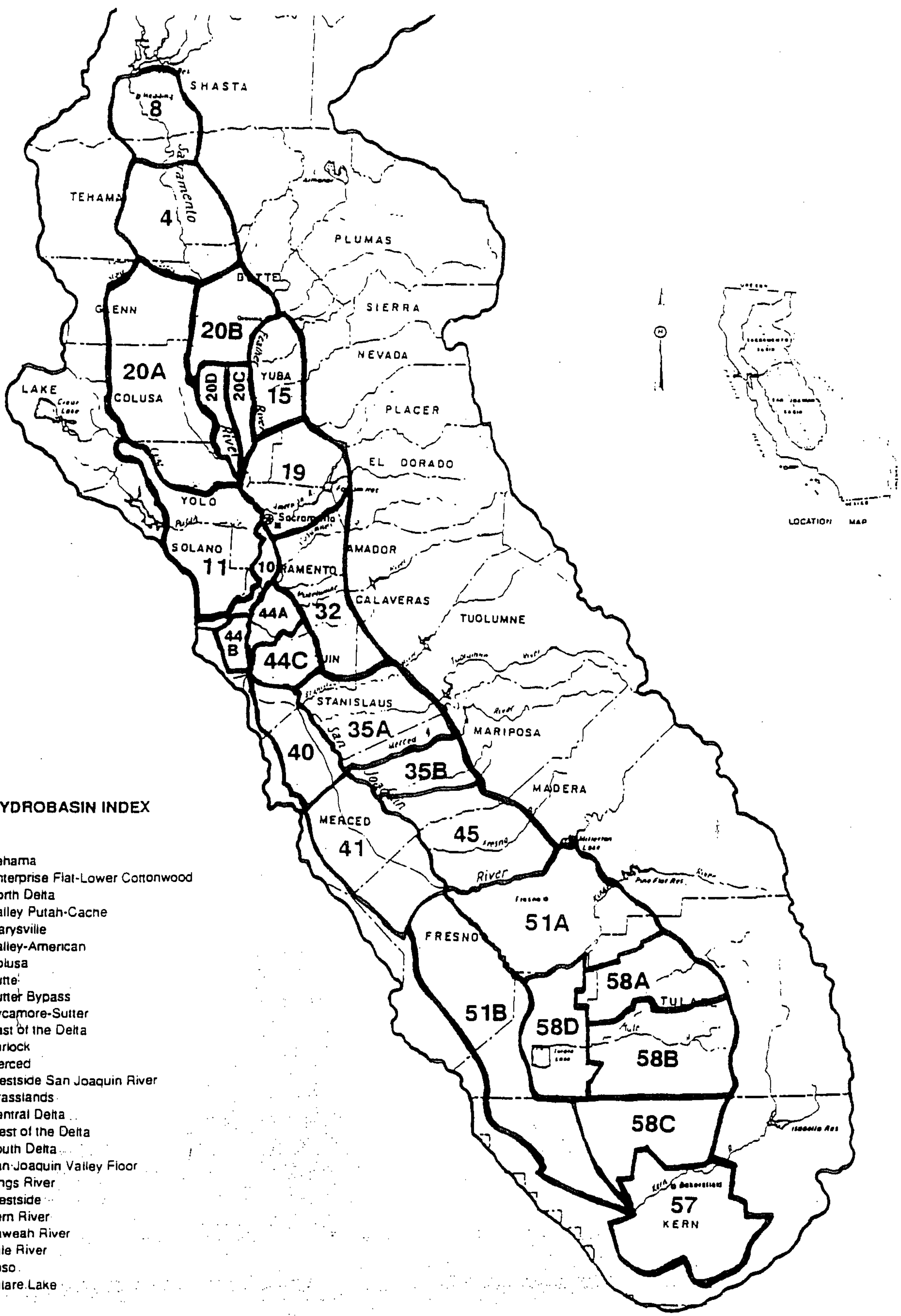
- Many of the category (b) and (c) water bodies are subject to inflows from urban areas.

VI. RECOMMENDATION

Staff recommendation is to adopt Table 1 and all the agency submittals by reference. This approach recognizes the requirement to submit the list but also recognizes the complexity of defining these water bodies. The Resolution for adoption also recognizes the need to include all types of agriculturally dominated water bodies by directing staff to submit the listing to the State Water Board using the 5 subcategories outlined in the Appendix A of the Staff Report. This approach will allow ourselves and State Water Board staff to make modifications to the category designations as they are needed. In addition, the adoption should be done with a clear public understanding that these designations are not intended to impact existing beneficial use designations; rather, these designations are to provide a logical process for developing and implementing water quality objectives consistent with the Federal Clean Water Act.

Figure 1.

Location of Drainage Basins within the Central Valley, California for the Inland Surface Waters Plan



HYDROBASIN INDEX

4	Tehama
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44B	West of the Delta
44C	South Delta
45	San Joaquin Valley Floor
51A	Kings River
51B	Westside
57	Kern River
58A	Kaweah River
58B	Tule River
58C	Poso
58D	Tulare Lake

Table 1. Summary of Category (b) and (c) Water Bodies Within the Central Valley of California

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*
CATEGORY (b) WATER BODIES			
SACRAMENTO RIVER BASIN			
DRAINAGE BASIN 20A			
Unnamed Tributaries to Walker Creek	7	5	3,4
Walker Creek	15	3	3,4
Sheep Corral/White Cabin Creek	5.5	5	3,4
Wilson Creek (Upstream of Road 35, Glenn County)	4	5	3,4
Freshwater Creek	4	5	3,4
Salt Creek (North)	2.5	5	3,4
Cortina Creek	4	5	3,4
Hopkins Slough (Within boundaries of Colusa NWR)	1.5	3	3,4
Hunters Creek (Within boundaries of Sacramento NWR)	1.7	3	3,4
North Fork of Logan Creek (Within boundaries of Sacramento NWR)	6	3	3,4
Logan Creek (Within boundaries of Sacramento NWR)	9	3	3,4
Funks Creek	6	5	3,4
Buckeye Creek	12	5	3,4
Lurline Creek (Tehema Colusa Canal to Glenn-Colusa Canal)	3	5	3,4
DRAINAGE BASIN 20B			
Butte Creek	44	1	3,4
Hamlin Slough	18.5	3	3,4
Butte Slough	6	2	3,4
Butte Sink	10	2	3,4
Angel Slough	21	5	3,4
Campbell Slough	8	5	3,4
Howard Slough	6	5	3,4
Little Butte Creek	6	5	3,4
DRAINAGE BASIN 20C			
Butte Slough	9.4	2	3,4
Willow Slough	1	5	3,4
Nelson Slough	1.3	5	3,4
Sacramento Slough (Downstream of Karnak)	1.5	3	3,4
Gilsizer Slough (Downstream of O'Banion Road)	6	5	3,4
DRAINAGE BASIN 15			
Grasshopper Slough (Diversion to Grass Valley Road)	1	5	3,4,6
Messick Lake	1	5	3,4
Reeds Creek	7.6	5	3,4
Dry Creek (South)	6	5	3,4,6
Clark Slough (Upstream of Plumas Lake Canal)	3	5	3,4,6
Hutchinson Creek	5.1	5	3,4

Table 1. Summary of Category (b) and (c) Water Bodies Within the Central Valley of California

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*
CATEGORY (b) WATER BODIES CONTINUED			
DRAINAGE BASIN 15 Continued:			
Best Slough (HWY 65 to Forty Mile Road)	3	5	3,4
No Name Creek	5.5	5	3,4
Tennessee Creek	5.3	5	3,4
Prairie Creek	6.8	5	3,4
Dry Creek (North)	11.6	2	3,4
Wilson Creek	3.7	5	3,4
North Honcut Creek	3.3	3	3,4
South Honcut Creek	15.3	3	3,4
Jack Slough (Upstream of Trainer Hills)	5.2	2	3,4
DRAINAGE BASIN 19			
Yankee Slough	9.9	3	3,4
Coon Creek (Upstream of the East Side Canal)	9.4	5	3,4,6
Bunkham Slough (Upstream of Pleasant Grove Road)	9.4	5	3,4
Markham Ravine (Upstream of Pleasant Grove Road)	6.8	5	3,4
Auburn Ravine (Upstream of Pleasant Grove Road)	4.4	5	3,4,6
King Slough (Upstream of Western Pacific Railroad)	5	5	3,4
Pleasant Grove Creek	4.5	4	3,4
Ping Slough (Upstream of Cornelius Avenue)	5	4	3,4
DRAINAGE BASIN 11			
Cache Creek	26	2	2,3,4
Goodnow Slough	12	5	2,3,4,6
Almondale Slough	4	5	2,3,4
South Fork of Willow Slough	21	5	2,3,4
Cottonwood Slough	8	5	2,3,4
North Fork of Willow Slough	3	5	2,3,4
Willow Slough	17	5	2,3,4
Union Slough	28	5	2,3,4,6
Moody Slough	16	5	2,3,4
Cache Slough (Upstream of Haas Slough)	3	2	2,3,4
Dry Slough	17.5	5	2,3,4
Putah Creek	16	3	2,3,4
Haas Slough	3	2	2,3,4,6
Old Alamo Creek	3	5	2,3,4
Gordon Slough (Lower West Adams)	6	5	2,3,4
Lamb Valley Slough	2	5	2,3,4
Shag Slough	2.5	3	2,3,4
Duck Slough	1.5	3	2,3,4

Table 1. Summary of Category (b) and (c) Water Bodies Within the Central Valley of California

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*
CATEGORY (b) WATER BODIES CONTINUED			
SAN JOAQUIN RIVER BASIN			
DRAINAGE BASIN 40			
Orestimba Creek	5	3	1,2,3,4,5
Old San Joaquin River Channel at Laird Slough	5.3	4	2,3,4
Del Puerto Creek	5.5	4	2,3,4,5
Tom Payne Slough	13	5	3,4
Mountain House Creek	3.5	5	2,3,4
San Joaquin River (Merced River to Stanislaus River)	34.8	1	1,2,3,4
DRAINAGE BASIN 41			
Los Banos Creek	24	5	2,3,4,6
San Luis Creek	8	5	2,3,4
Garzas Creek	4	5	2,3,4,6
Salt Slough	10	1	1,2,3,4
Mud Slough (south)	3.1	4	2,3,4
Mud Slough (north)	5.1	1	1,2,3,4
San Joaquin River (Mendota Pool to Merced River)	86.7	1	1,2,3,4
DRAINAGE BASIN 35A			
Lone Tree Creek	29	3	3,4
French Camp Slough	6.5	3	3,4
Walthall Slough	5	5	3,4
Littlejohns Creek (Goodwin Dam to Farmington Fld Cntrl Basin)	15	5	3,4
Dry Creek (Crabtree Road to Wellsford Road)	17	4	3,4
Lesnini Creek	3	5	3,4
Simmons Creek	5	5	3,4
DRAINAGE BASIN 35B			
Bear Creek	39	2	3,4
Mariposa Creek	11	5	3,4
Duck Slough	11	5	3,4
Cottonwood Creek	2.5	5	3,4
South Slough	3.5	5	3,4
Black Rascal Creek	16.5	5	3,4
Deadman Creek (Downstream of El Nido Canal)	5.5	5	3,4
Canal Creek	19.5	5	3,4
Edendale Creek	3.2	5	3,4
Parkinson Creek	3	5	3,4
Hartley Slough	2.5	5	3,4
Fahrens Creek	5	5	3,4
Lake Yosemite	N/A	5	3,4

Table 1. Summary of Category (b) and (c) Water Bodies Within the Central Valley of California

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*
CATEGORY (b) WATER BODIES CONTINUED			
DRAINAGE BASIN 35B Continued:			
Miles Creek	7	5	3,4
Owens Creek	26	5	3,4
Dutchman Creek	13	5	3,4
Chowchilla River	12	5	3,4
DRAINAGE BASIN 45			
Root Creek	1	5	3,4,6
Lone Willow Slough	18	5	3,4
Schmidt Creek	2	5	3,4,6
Fresno River	6	5	3,4
Berenda Creek	9	5	3,4
Dry Creek	7	5	3,4
Cottonwood Creek	20	5	3,4
Berenda Slough	1.7	5	3,4
Ash Slough	5	5	3,4
SACRAMENTO-SAN JOAQUIN DELTA			
DRAINAGE BASIN 10			
Mayberry Slough	4.7	5	3,4
DRAINAGE BASIN 44B			
Frisk Creek	3.8	5	3,4
Brushy Creek	2.4	5	2,3,4
Marsh Creek	9	5	2,3,4
DRAINAGE BASIN 44C			
Old River	6	1	2,3,4
Paradise Cut	7.6	3	2,3,4
DRAINAGE BASIN 32			
Pixley Slough	9.7	5	3,4
Bear Creek	13.6	5	3,4
Mosher Creek	19.3	5	3,4
Mormon Slough	13.4	5	3,4
Laguna-Hadelville Creek	10.8	5	3,4
Consumnes River	10.5	1	3,4
Deer Creek	15	5	3,4

Table 1. Summary of Category (b) and (c) Water Bodies Within the Central Valley of California

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*
CATEGORY (b) WATER BODIES CONTINUED			
TULARE LAKE BASIN			
Kings River (Downstream of Peoples Weir)	71.6	1	3,4
Wahtoke Creek	14.9	5	3,4
Navelencia Creek	2.4	5	3,4
Sand Creek	2.2	5	3,4
Traver Creek	10.1	5	3,4
Kaweah River	11.3	4	3,4
St. Johns River	14.1	4	3,4
Elk Bayou	9.9	5	3,4
Outside Creek	6.2	5	3,4
Deep Creek	12	5	3,4
Elbow Creek	16.3	5	3,4
Cottonwood Creek	5.4	5	3,4
Cross Creek	11.7	4	3,4
Byrd Slough	8.3	5	3,4
Cameron Slough	5.3	5	3,4
Clarks Fork	5	4	3,4
Cole Slough	8.8	5	3,4
Dutch John Cut	2.5	5	3,4
Fresno Slough	20	5	2,3,4
Lower North Fork Kings River	5.3	1	3,4
Lower South Fork Kings River	8.7	1	2,3,4
Old Fresno Slough	1.8	4	3,4
Poso Creek	6.5	3	3,4
Buena Vista Lake	N/A	5	3,4
Surprise Creek	2.4	5	3,4
Wooten Creek	2.4	5	3,4
Negro Creek	1.3	5	3,4
Long Creek	1.8	5	3,4
FOOTHILLS			
Jackson Creek	7	5	
Dry Creek (Amador County)	2	5	3,4
Wolf Creek	12	5	
Coon Creek	12	5	6
Auburn Ravine	6	5	6

* Water Quality Concerns:

1 = selenium and molybdenum
2 = boron and total dissolved solids
3 = Metals
4 = pesticides
5 = DDT, Endosulfan, etc.
6 = urban, dairy wastes, WWTP

Table 1. Summary of Category (b) and (c) Water Bodies Within the Central Valley of California

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*
CATEGORY (c) WATER BODIES			
MAJOR CONSTRUCTED FACILITIES WITHIN THE CENTRAL VALLEY			
Natomas Cross Canal	5	3	
Tehama-Colusa Canal	111	2	
Glenn-Colusa Canal	66	2	
Colusa Basin Drain	75	1	
Knights Landing Ridge Cut	6	3	
Yolo Bypass	16.5	1	
Tisdale Bypass	4.5	3	
Sutter Bypass	32	1	
California Aquaduct (Central Valley)	300+	1	
Corning Canal	21	2	
Toe Drain	23	1	
Folsom-South Canal	26.8	2	
Delta Mendota Canal	116+	1	
Madera Canal	36	3	
Friant-Kern Canal	152	2	
Eastside Bypass (plus the Eastside Canal)	45	2	
Cross Valley Canal	20	3	
San Luis Drain	84.8	1	

All constructed canals and drains and their tributaries as designated in reports submitted by the following agencies are incorporated into this table by reference.

USBR
DWR
Friant-Kern Water Users Association
San Luis-Delta Mendot Water Users Authority
Tehama Colusa Water Users Association

SACRAMENTO RIVER BASIN

DRAINAGE BASIN 4

All constructed canals and drains and their tributaries as designated in reports submitted by the following agencies are incorporated into this table by reference.

Poberta Water District
Corning Water District

Table 1. Summary of Category (b) and (c) Water Bodies Within the Central Valley of California

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*
CATEGORY (c) WATER BODIES CONTINUED			
DRAINAGE BASIN 20A			
Orland -Artois Unnamed "A"	9.5	5	
Orland - Artois Unnamed "B"	13	5	
Lateral "A"	13	5	
East Branch of Walker Creek	5	5	
Shepherd Slough	10	5	
Bounde Creek	13	5	
Hopkins Slough	9	5	
Willow Creek	13	5	
North Fork Logan Creek	2.5	5	
Logan Creek	2.5	5	
Hunters Creek	7	5	
Funks Creek (Downstream of Glenn-Colusa Canal)	4	5	
Stone Corral Creek	12	5	
Lurline Creek (Downstream of Glenn-Colusa Canal)	3	5	
Freshwater Creek (Glenn-Colusa Canal to Salt Creek)	6	5	
Salt Creek (North) [Glenn-Colusa Canal to Colusa Trough]	6.5	5	
Spring Creek	3	5	
Cortina Creek	5.5	5	
Wilkins Slough	8	5	
Sycamore Slough	16	5	
Hayes Hollow Creek	3.1	5	
French Creek	6.8	5	
South Fork of Willow Creek (Downstream of Tehema-Colusa Canal)	17	5	
Glenn Valley-Manor Slough	13	5	
Wilson Creek (Road 35 to Willow Creek)	7	5	

All constructed canals and drains and their tributaries as designated in reports submitted by the following agencies are incorporated into this table by reference.

Colusa Basin Drainage District
Glenn-Colusa Irrigation District
Orland-Artois Water District
Provident Irrigation District
Princeton-Cordova-Glenn Irrigation District
Glide Water District
Kanawha Water District
Holthouse Water District
Westside Water District
Maxwell Irrigation District
Cortina Water District

Table 1. Summary of Category (b) and (c) Water Bodies Within the Central Valley of California

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*

CATEGORY (c) WATER BODIES CONTINUED

DRAINAGE BASIN 20A Continued:

Colusa Water District
Dunnigan Water District
Knights Landing Ridge Drainage District
Reclamation District 2047
Reclamation District 479
Reclamation District 108
Reclamation District 787

DRAINAGE BASIN 20B

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*
Durham Slough	7	5	
Little Dry Creek	15	5	
Drumheller Slough	11	5	

All constructed canals and drains and their tributaries as designated in reports submitted by the following agencies are incorporated into this table by reference.

Western Canal Water District
Butte County Drainage District #2
Drainage District 200
Richvale Irrigation District
Butte Water District
Reclamation District 833
Biggs-West Gridley Water District
Reclamation District 1004
Butte Sink Waterfowl Association

DRAINAGE BASIN 20C

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*
Morrison Slough	11	5	
Snake River	30	5	
Live Oak Slough	23	5	
Gilsizer Slough (Yuba City of O'Banion Road)	11	5	
Poodle Creek	5	5	
Sutter Bypass (East and West Borrow Pit Channels)	60	1	

All constructed canals and drains and their tributaries as designated in reports submitted by the following agencies are incorporated into this table by reference.

Biggs-West Gridley Water District
Butte Water District
Sutter Extension Water District

Table 1. Summary of Category (b) and (c) Water Bodies Within the Central Valley of California

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*

CATEGORY (c) WATER BODIES CONTINUED

DRAIANGE BASIN 20C Continued:

Reclamation District 777
Reclamation District 2056
Reclamation District 2054
Drainage District No. 1
Tierra Buena Drainage District
Sutter County Water Agency
Feather Water District
Tudor Mutual Irrigation Company
Hamatani Ranch
Garden Highway Mutual Water Company
Sutter Butte Mutual Water Company
Sutter National Wildlife Refuge
Goose Club Farms (Sutter Bypass Properties)
Department of Water Resources, State of California

DRAINAGE BASIN 20D

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*
Long Lake	2	5	
Sacramento Slough (Within RD 1500)	2.5	5	
Tisdale Bypass	4.4	4	

All constructed canals and drains and their tributaries as designated in reports submitted by the following agencies are incorporated into this table by reference.

Meridian Farm Water Company
Sutter Buttes Mutual Water Company
Reclamation District No. 1660
Reclamation District No. 70
Tisdale Irrigation Company
Butte Slough Irrigation Company
Sutter Mutual Water Company
Pelger Mutual Water Company
Sutter Mutual Water Company
Reclamation District 1500

DRAINAGE BASIN 15

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*
Plumas Lake Drain	2	5	
Algodon Slough Drain	4.1	5	
Baxter Slough	2.9	5	
Kimball Creek	2.5	5	

Table 1. Summary of Category (b) and (c) Water Bodies Within the Central Valley of California

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*

CATEGORY (c) WATER BODIES CONTINUED

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*
DRAINAGE BASIN 15 Continued:			
Simmerly Slough	3.4	5	
Jack Slough (Downstream of Trainer Hills)	6	2	
Clark Slough (Downstream of Plumas Lake Canal)	4.4	4	
Best Slough (Downstream of Forty Mile Road)	2.2	5	
Grasshopper Slough (Downstream of Grass Valley Road)	2	5	

All constructed canals and drains and their tributaries as designated in reports submitted by the following agencies are incorporated into this table by reference.

Oroville-Wyandotte Irrigation District
Yuba County Water Agency
Brophy Water District
South Yuba Water District
Browns Valley Irrigation District
Cordura Irrigation Company
Hallwood Irrigation Company
Ramirez Water District
City of Wheatland
Wheatland Irrigation District
Reclamation District 784
Plumas Mutual Irrigation District
Camp Far West Irrigation District
Dana & Dana, Inc.

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*
DRAINAGE BASIN 19			
Curry Creek (Within RD 1000)	1.2	5	
Ping Slough (Downstream of Cornelius Ave.)	4	5	
Coon Creek (Downstream of the East Side Canal)	2.5	5	
Bunkham Slough (Downstream of Pleasant Grove Rd.)	1.1	5	
Markham Ravine (Downstream of Pleasant Grove Rd.)	1.6	5	
Auburn Ravine (Downstream of Pleasant Grove Rd.)	2.1	5	
King Slough (Downstream of the Western Pacific Railroad)	0.9	5	

All constructed canals and drains and their tributaries as designated in reports submitted by the following agencies are incorporated into this table by reference.

South Sutter Water District
Natomas Central Mutual Water Company
Reclamation District 1000
Reclamation District 1001

Table 1. Summary of Category (b) and (c) Water Bodies Within the Central Valley of California

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*

CATEGORY (c) WATER BODIES CONTINUED

DRAINAGE BASIN 19 Continued:

Neveda Irrigation District
Placer County Water Agency

DRAINAGE BASIN 11

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*
Walnut Canal	6.2	5	
South Fork of Putah Creek	10	5	
Willow Slough Bypass	7	5	
Sweeney Creek	4	5	
Gibson Canyon Creek	5.5	5	
Ulatis Creek	5.5	5	
Ulatis Channel	13	4	

All constructed canals and drains and their tributaries as designated in reports submitted by the following agencies are incorporated into this table by reference.

Cowell Ranch
Reclamation District 2093
Reclamation District 2060
Reclamation District 730
Reclamation District 2104
Reclamation District 1600
Reclamation District 537
Reclamation District 2068
Reclamation District 2098
Reclamation District 2035
Reclamation District 827
Reclamation District 785
Reclamation District 2084
Dixon Resource Conservation District
Maine Prairie Water District
Solano Irrigation District
Solano County Water Agency
Yolo County Flood Control and Water Conservation District

SAN JOAQUIN RIVER BASIN

DRAINAGE BASIN 40

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*
Corral Hollow Creek (Downstream of the Delta Mendota Canal	2.5	5	

Table 1. Summary of Category (b) and (c) Water Bodies Within the Central Valley of California

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*

CATEGORY (c) WATER BODIES CONTINUED

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*
DRAINAGE BASIN 40 Continued:			
Ingram Creek (Downstream of Interstate 5)	6.5	5	
Hospital Creek (Downstream of Interstate 5)	8	5	
Salado Creek (Downstream of the Delta Mendota Canal)	6	5	

All constructed canals and drains and their tributaries as designated in reports submitted by the following agencies are incorporated into this table by reference.

West Stanislaus Irrigation District
Kasson Reclamation District #2085
New Jerusalem Drainage District
Banta-Carbona Irrigation District
Patterson Water District
Newman Drainage District
Hospital Water District
Naglee Burk Irrigation District
Paradise Mutual Water Company
Pescadero Reclamation District 2058
El Solyo Water District
Kern Cañon Water District
Salado Water District
Sunflower Water District
Orestimba Water District
Oak Flat Water District
Foothill Water District
Davis Water District
Central California Irrigation District
Reclamation District 1602
Reclamation District 2099
Reclamation District 2101
Reclamation District 2102
Westside Irrigation District
Byron-Bethany Irrigation District

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*
DRAINAGE BASIN 41			
Santa Rita Slough	7	5	

Table 1. Summary of Category (b) and (c) Water Bodies Within the Central Valley of California

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*

CATEGORY (c) WATER BODIES CONTINUED

DRAINAGE BASIN 41 Continued:

All constructed canals and drains and their tributaries as designated in reports submitted by the following agencies are incorporated into this table by reference.

Central California Irrigation District
Mustang Water District
Quinto Water District
Romero Water District
Centinella Water District
Mercy Springs Water District
Eagle Field Water District
Pacheco Water District
Oro Loma Water District
San Luis Water District
Broadview Water District
Panoche Water and Drainage District
Firebaugh Canal Water District
Grassland Water District
San Luis Canal Company
Poso Canal Company
Charleston Drainage District
Gustine Drainage District
Widren Water District
Dos Palos Drainage District

DRAINAGE BASIN 35A

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*
Littlejohns Creek (Downstream of Farmington Fld Cntrl Basin)	17	5	

All constructed canals and drains and their tributaries as designated in reports submitted by the following agencies are incorporated into this table by reference.

Modesto Irrigation District
Turlock Irrigation District
McMullin Reclamation District #2075
Oakdale Irrigation District
South San Joaquin Irrigation District
Reclamation District 17

Table 1. Summary of Category (b) and (c) Water Bodies Within the Central Valley of California

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*

CATEGORY (c) WATER BODIES CONTINUED

DRAINAGE BASIN 35B

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*
Mariposa Slough	6.3		5
Miles Creek (Downstream of Puglizevich Dam)	5.6		5
North Slough	1		5
Deadman Creek (upstream of the El Nido Canal)	11		5
Turner Slough	3		5
Deep Slough	1.4		5
Sand Slough	7		5
Chamberlain Slough	3.2		5

All constructed canals and drains and their tributaries as designated in reports submitted by the following agencies are incorporated into this table by reference.

Merced Irrigation District
Turner Island Water District
Stevenson Water District
Merquin County Water District
El Nido Irrigation District
LeGrand-Athlone Water District
La Branza Water District
Lone Tree Mutual Water Company

DRAINAGE BASIN 45

All constructed canals and drains and their tributaries as designated in reports submitted by the following agencies are incorporated into this table by reference.

Madera Irrigation District
Gravely Ford Water District
Columbia Canal Company
Chowchilla Water District

SACRAMENTO-SAN JOAQUIN DELTA

DRAINAGE BASIN 10

All constructed canals and drains and their tributaries as designated in reports submitted by the following agencies are incorporated into this table by reference.

North San Joaquin Water Conservation District
Reclamation District 765 (Glide District)
Reclamation District 999

Table 1. Summary of Category (b) and (c) Water Bodies Within the Central Valley of California

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*

CATEGORY (c) WATER BODIES CONTINUED

DRAINAGE BASIN 10 Continued:

Reclamation District 307 (Lisbon District)
Reclamation District 501 (Ryer Island)
Reclamation District 551 (Pierson)
Reclamation District 3 (Grand Island)
Reclamation District 554 (Walnut Grove)
Reclamation District 2110 (McCormack-William Tract)
Reclamation District 556 (Upper Andrus Island)
Reclamation District 2086 (Canal Ranch Tract)
Reclamation District 2111 (Dead Horse Island)
Reclamation District 813 (Erheardt Club)
Reclamation District 348 (New Hope Tract)
Reclamation District 563 (Tyler Island)
Reclamation District 38 (Staten Island)
Reclamation District 341 (Sherman Island)

DRAINAGE BASIN 44A

All constructed canals and drains and their tributaries as designated in reports submitted by the following agencies are incorporated into this table by reference.

Central Delta Water Agency
Reclamation District 2033 (Brack Tract)
Reclamation District 548 (Terminous Tract)
Reclamation District 756 (Bouldin Island)
Reclamation District 2026 (Webb Tract)
Reclamation District 2059 (Bradford Island)
Reclamation District 2044 (King Island
Reclamation District 2029 (Empire Tract)
Reclamation District 2023 (Venice Island)
Reclamation District 2114 (Rio Blanco Island)
Reclamation District 2042 (Bishop Tract)
Reclamation District 2027 (Mandeville Island)
Reclamation District 2041 (Medford Island)
Reclamation District 2030 (McDonald Tract)
Reclamation District 2037 (Rindge Tract)
Reclamation District 2115 (Shima Tract)
Reclamation District 799 (Hotchkiss Tract)
Reclamation District 2025 (Holland Tract)
Reclamation District 2090 (Quimby Island)

Table 1. Summary of Category (b) and (c) Water Bodies Within the Central Valley of California

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*

CATEGORY (c) WATER BODIES CONTINUED

DRAINAGE BASIN 44A Continued:

Reclamation District 2028 (Bacon Island)
Reclamation District 2119 (Wright-Elmwood Tract)
Reclamation District 2036 (Palm Tract)
Reclamation District 2024 (Orwood Tract)
Reclamation District 800 (Byron Tract)
Reclamation District 2117 (Coney Island)
Reclamation District 2040 (Victoria Island)
Reclamation District 2072 (Woodward Island)
Reclamation District 2039 (Upper Jones Tract)
Reclamation District 2038 (Lower Jones Tract)
Reclamation District 684 (Lower Roberts Island)
Reclamation District 2113 (Fay Island)
Reclamation District 2118 (Little Mandeville Island)
Shin Kee Tract
Bethel Island Municipal Improvement District
Drexler-Honker Lake Tract
Franks Tract State Park

DRAINAGE BASIN 44C

All constructed canals and drains and their tributaries as designated in reports submitted by the following agencies are incorporated into this table by reference.

Reclamation District 2 (Union Island West)
Reclamation District 1 (Union Island East)
Reclamation District 773 (Private Landowners)
Reclamation District 2062 (Stewart Tract)
Reclamation District 2089 (Stark Tract)
Reclamation District 544 (Upper Roberts Island)
Reclamation District 524 (Middle Roberts Island)

DRAINAGE BASIN 32

All constructed canals and drains and their tributaries as designated in reports submitted by the following agencies are incorporated into this table by reference.

Omuchumne-Hartnell Water District
Galt Irrigation District
North San Joaquin Water Conservation District
Woodbridge Irrigation District
Stockton East Water District

Table 1. Summary of Category (b) and (c) Water Bodies Within the Central Valley of California

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*

CATEGORY (c) WATER BODIES CONTINUED

DRAINAGE BASIN 32 Continued:

Reclamation District 2074 (Sargent-Barnhart Tract)
Reclamation District 1614 (Smith Tract)
San Joaquin Flood Control and Water Conservation District

DRAINAGE BASIN 44B

All constructed canals and drains and their tributaries as designated in reports submitted by the following agencies are incorporated into this table by reference.

East Contra Costa Irrigation District
Byron - Bethany Irrigation District

TULARE LAKE BASIN

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*
China Slough	7.3	5	
Phillips Ditch	1.6	5	
Carmelita Ditch	3.1	5	
Rice Ditch	1.1	5	
Short Ditch #1	1	5	
McLaughlin Ditch	1.7	5	
Farm Ditch #1	1.8	5	
Farm Ditch #3	1.5	5	
Jacobi Ditch	0.3	5	
Fink Ditch	1	5	
Turner Ditch	1.6	5	
Hanke Ditch	2.9	5	
Byrd Ditch	1.1	5	
Jack Ditch	1.4	5	
Cameron Ditch	0.7	5	
Tule River (Below Friant-Kern Canal)	41	5	
Porter Slough	11.5	5	
Old Fresno Slough	8.2	5	
Harris Slough Ditch	1.8	5	
Bates Slough	4.3	5	
Lewis Creek	3.3	5	
Inside Creek	5.2	5	
Mill Creek	26.7	5	
Cameron Creek	8.4	5	
Tule River (above Friant-Kern Canal)	9	5	
White River	12	5	
Deer Creek	24	5	

Table 1. Summary of Category (b) and (c) Water Bodies Within the Central Valley of California

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*

CATEGORY (c) WATER BODIES CONTINUED

TULARE LAKE BASIN Continued:

All constructed canals and drains and their tributaries as designated in reports submitted by the following agencies are incorporated into this table by reference.

Alpaugh Irrigation District
Alta Irrigation District
Angiola Water District
Arvin-Edison Water Storage District
Berenda Mesa Water District
Buena Vista Water Storage District
Cawelo Water District
City of Bakersfield
Consolidated Irrigation District
Corcoran Irrigation District
Crescent Canal Company
Delano-Earlimart Irrigation District
Devil's Den Water District
Dudley Ridge Water District
Empire West Side Irrigation District
Exeter Irrigation District
Friant Kern Water Users Authority
Fresno Irrigation District
Henry Miller Water District
Ivanhoe Irrigation District
James Irrigation District
Kaweah & St. Johns River Association
KCWA Improvement District #4
Kern Delta Water District
Kern River Levee District
Kern-Tulare Water District
Kings County Water District
Kings River Water District
Laguna Irrigation District
Lakeside Irrigation District
Last Chance Water Ditch Company
Lemoore Canal & Irrigation Company
Lewis Creek Water District
Lindmore Irrigation District
Lindsay-Strathmore Irrigation District
Lost Hills Water District

Table 1. Summary of Category (b) and (c) Water Bodies Within the Central Valley of California

Watershed/Drainage Basin	Mileage	Priority	Water Quality Concerns*

CATEGORY (c) WATER BODIES CONTINUED

TULARE LAKE BASIN Continued:

North Kern Water Storage District
Peoples Ditch Company
Rag Gulch Water District
Reclamation District No. 1601
Riverdale Irrigation District
Rosedale-Rio Bravo Water Storage District
Saucelito Irrigation District
Semitropic Water Storage District
Shafter-Wasco Irrigation District
Southern San Joaquin Municipal Utilities District
Stinson Canal & Irrigation Company
Stone Corral Irrigation District
Terra Bella Irrigation District
Tranquillity Irrigation District
Tulare Lake Drainage District
Tule River Association
Westlands Water District
Wheeler Ridge-Maricopa Water Storage District
Zalda Reclamation District 801

FOOTHILLS

All constructed canals and drains and their tributaries as designated in reports submitted by the following agencies are incorporated into this table by reference.

Tuolumne Regional Water District
Tuolumne Public Utility District
Northridge Water District
Citrus Heights Irrigation District
Squaw Valley Co. Water District
Tehachapi-Cummings Co. Water District
Fall River Conservation District
Nevada Irrigation District
Amador County Water Resources
Jackson Valley Irrigation District
Omochumne-Hartnell Water District
El Dorado Irrigation District
Mill Race Group
Placer County Water Agency
West Lake Resources Conservation District
Sierra County Department of Planning
Yuba County Water District
Plumas County
Plumas County Private Rancher
Indian-American Valleys RCD
Calaveras County Water District
Big Valley Irrigation District
Pit RCD Resource Conservation District
South Fork Irrigation District

APPENDIX A

Category (b1): Natural water bodies dominated by agricultural drainage water. Criteria set down in the ISWP.

Category (b2): Natural water bodies dominated by agricultural supply water. Almost every stream, creek and river within the Central Valley is dominated by water that will be used for agricultural supply. It is not our intent to list all these waterways. The only water bodies we have included carry all of the following criteria:

a) Agricultural supply water dominated the flow and water quality of the water body.

b) The agricultural supply water is not the same natural flow that would have been in the water body.

c) The flow is released into the natural channel and subject to significant changes in volume.

d) The natural channel would not have had significant flow or aquatic life beneficial uses in the absence of the agricultural supply flows.

e) The agricultural supply flows are subject to releases and diversions and are not necessarily continuous throughout the irrigation season or year.

Category (c1): Water bodies that are constructed (drains) for the primary purpose of conveying or holding agricultural return flows or drainage and were not natural water bodies which supported aquatic life beneficial uses. Does not include on-farm facilities, such as furrows, beds, checks, ditches and sumps.

Category (c2): Water bodies that are constructed (canals or channels) to carry irrigation supply water and may, at times, carry blended or recycled agricultural drainage or return flows as supply water.

Category (c3): Natural dry water bodies that have been altered and now only carry agricultural return flows or agricultural supply water. These water bodies may only be dominated by these flows for defined periods each year and the (c3) designation would only apply during this time interval. Water bodies designated under this category must meet all of the following criteria.

a) In the absence of agricultural return flows or irrigation supply water, the water body is ephemeral and only carries flow during heavy rainfall events or very wet periods.

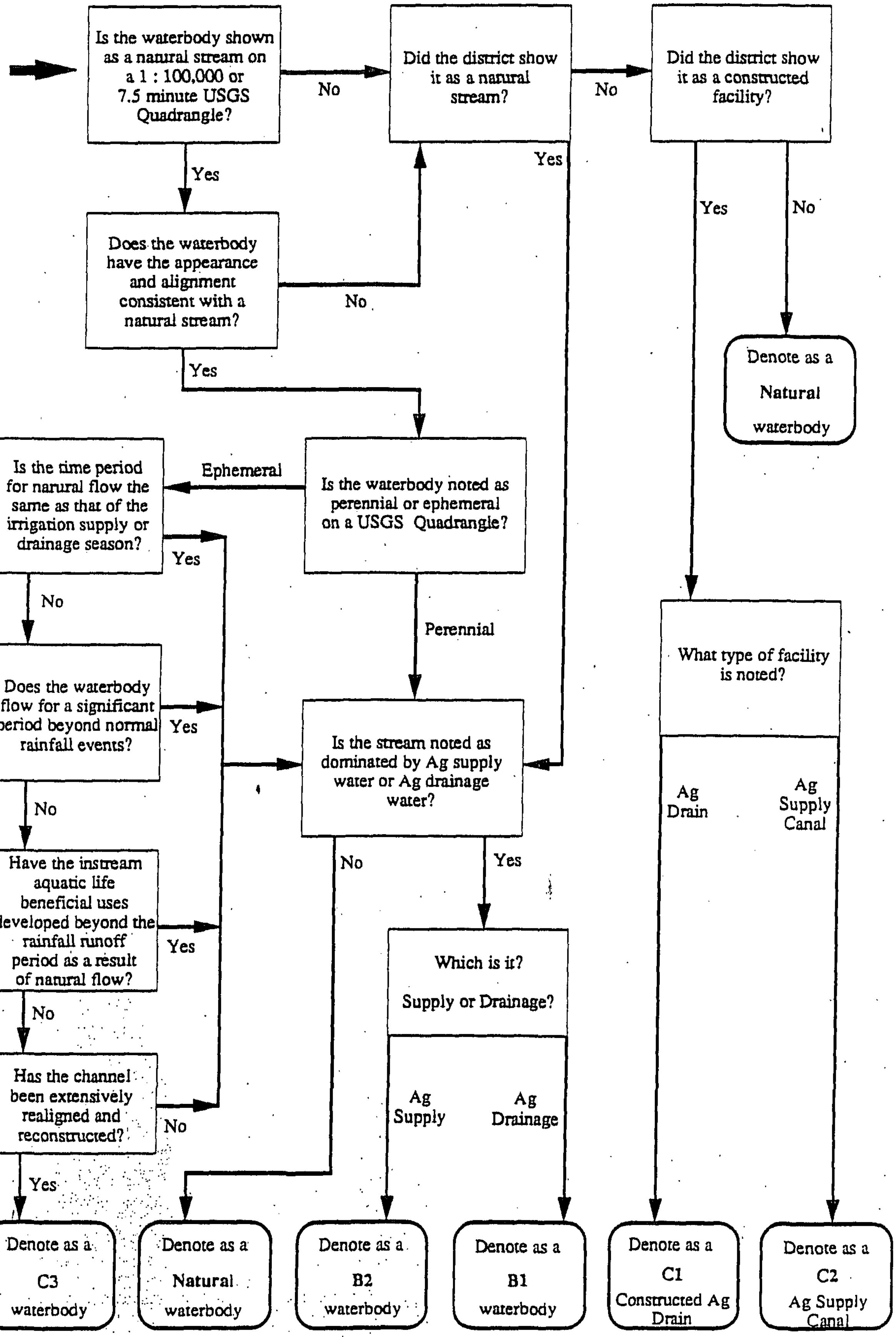
b) In the absence of agricultural return flows or irrigation supply water, in-stream aquatic life beneficial uses would not be present.

c) Shows evidence of extensive in-stream channel modifications including reconstruction and realignment.

d) Riparian habitat has developed as a result of the presence of agricultural return flows or agricultural supply water.

Figure A-1

Flowchart for Categorization of Water Bodies According to the Guidelines of the California Inland Surface Waters Plan



APPENDIX B

(To be mailed separately)

sec

Agenda Item #11

SUBJECT: Consideration of Water Body Designations to Comply with Provisions of the Water Quality Control Plan for Inland Surface Waters of California (ISWP)

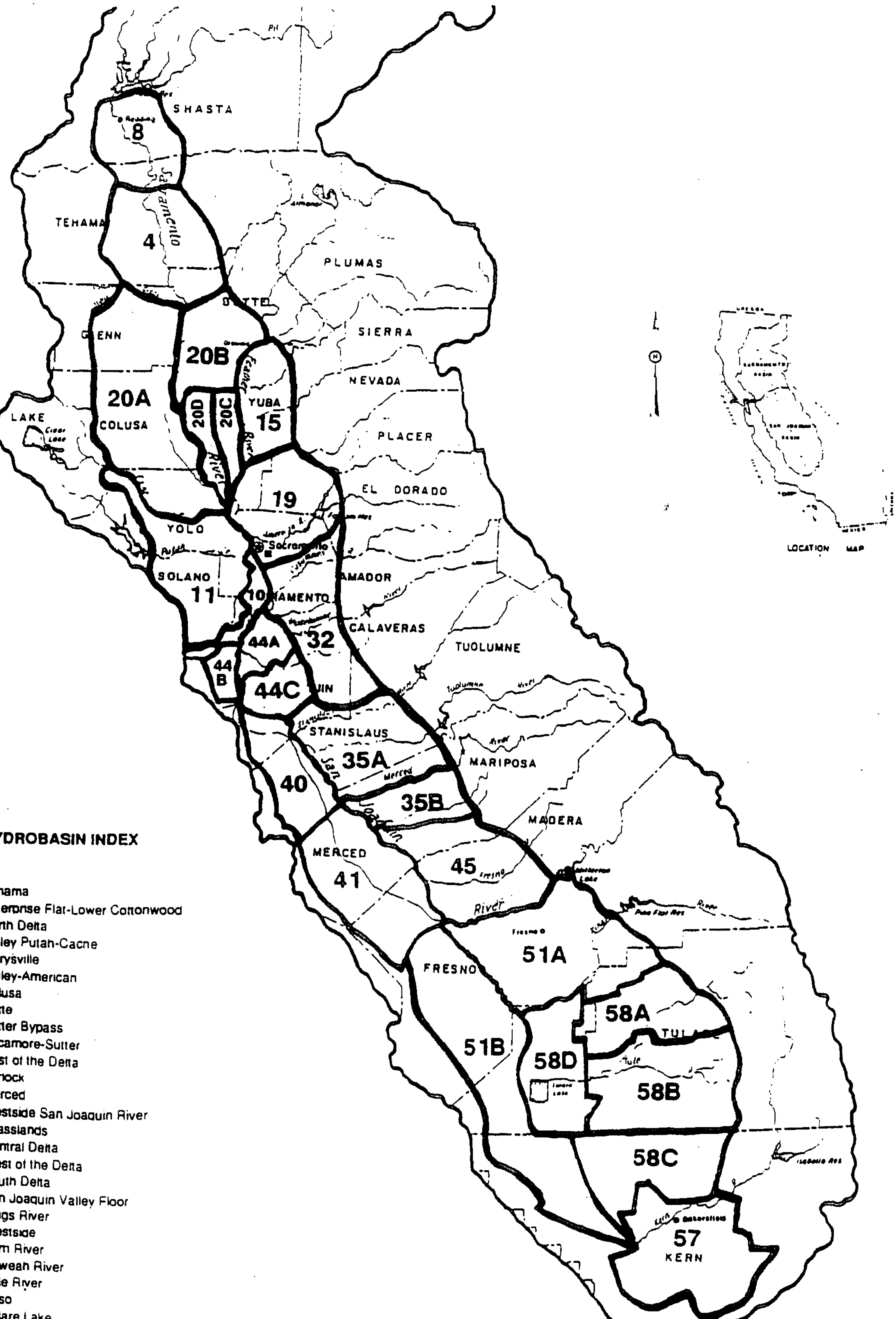
Appendix B

HYDROBASINS WITHIN THE
CENTRAL VALLEY, CALIFORNIA

4	Tehama
8	Enterprise Flat-Lower Cottonwood
10	North Delta
11	Valley Putah-Cache
15	Marysville
19	Valley-American
20A	Colusa
20B	Butte
20C	Sutter Bypass
20D	Sycamore-Sutter
32	East of the Delta
35A	Turlock
35B	Merced
40	Westside San Joaquin River
41	Grasslands
44A	Central Delta
44B	West of the Delta
44C	South Delta
45	San Joaquin Valley Floor
51A	Kings River
51B	Westside
57	Kern River
58A	Kaweah River
58B	Tule River
58C	Poso
58D	Tulare Lake

Figure 1.

Location of Drainage Basins within the Central Valley, California for the Inland Surface Waters Plan.



HYDROBASIN INDEX

4 Tehama
8 Enterprise Flat-Lower Cottonwood
10 North Delta
11 Valley Putah-Cache
15 Marysville
19 Valley-American
20A Colusa
20B Butte
20C Sutter Bypass
20D Sycamore-Sutter
32 East of the Delta
35A Turlock
35B Merced
40 Westside San Joaquin River
41 Grasslands
44A Central Delta
44B West of the Delta
44C South Delta
45 San Joaquin Valley Floor
51A Kings River
51B Westside
57 Kern River
58A Kaweah River
58B Tule River
58C Poso
58D Tulare Lake

SUMMARY OF CHANNELS DOMINATED BY AGRICULTURAL ACTIVITIES

DRAINAGE AREA	# AGENCY REPORTS	CATEGORY (b) # WATER BODIES	CATEGORY (b) LENGTH (MILES)	CATEGORY (c) # WATER BODIES	CATEGORY (c) LENGTH (MILES)
SACRAMENTO					
Drainage Basin 4	2	0	0	1	21
Drainage Basin 11	19	18	190	395	832
Drainage Basin 15	14	15	83	130	387
Drainage Basin 19	4	8	54	267	530
Drainage Basin 20A	18	14	75	1152	1738
Drainage Basin 20B	9	8	120	213	516
Drainage Basin 20C	17	5	19	262	517
Drainage Basin 20D	10	0	0	65	621
Subtotal:	93	68	541	2485	5160
SAN JOAQUIN					
Drainage Basin 35A	6	7	81	441	1707
Drainage Basin 35B	8	17	180	513	905
Drainage Basin 40	25	6	67	107	280
Drainage Basin 41	20	7	141	380	1174
Drainage Basin 45	4	9	70	274	624
Subtotal:	63	46	538	1715	4689
DELTA					
Drainage Basin 10	17	1	5	230	585
Drainage Basin 32	8	7	92	59	123
Drainage Basin 44A	36	0	0	252	560
Drainage Basin 44B	2	3	15	23	56
Drainage Basin 44C	7	2	14	225	225
Subtotal:	70	13	126	789	1548
TULARE LAKE	109	28	268	1068	6460
FOOTHILLS	24	5	39	234	661
Area Subtotal:	359	160	1512	6291	18519
MAJOR WATERWAYS	5	0	0	28	1293
TOTAL:	**364**	**160**	**1512**	**6319**	**19812**

SUMMARY OF CHANNELS DOMINATED BY AGRICULTURAL ACTIVITIES

DRAINAGE AREA	CATEGORY (b1)		CATEGORY (b2)		CATEGORY (c1)		CATEGORY (c2)		CATEGORY (c3)	
	# WATER BODIES	LENGTH (MILES)	# WATER BODIES	LENGTH (MILES)	# WATER BODIES	LENGTH (MILES)	# WATER BODIES	LENGTH (MILES)	# WATER BODIES	LENGTH (MILES)
SACRAMENTO										
Drainage Basin 4	0	0	0	0	0	0	1	21	0	0
Drainage Basin 11	15	131	11	67	212	438	176	342	7	51
Drainage Basin 15	5	19	12	82	52	69	69	288	9	30
Drainage Basin 19	7	49	1	5	100	210	160	307	7	13
Drainage Basin 20A	15	69	0	0	633	773	494	756	25	208
Drainage Basin 20B	8	84	3	49	101	219	109	264	3	33
Drainage Basin 20C	5	19	0	0	195	203	61	173	6	140
Drainage Basin 20D	0	0	0	0	9	248	53	364	3	9
Subtotal:	55	371	27	203	1302	2160	1123	2516	60	484
SAN JOAQUIN										
Drainage Basin 35A	6	74	2	7	203	613	237	1077	1	17
Drainage Basin 35B	6	50	12	135	55	78	450	788	8	39
Drainage Basin 40	6	39	1	72	40	62	63	196	4	23
Drainage Basin 41	7	74	2	16	198	499	181	668	1	7
Drainage Basin 45	3	5	7	60	14	45	260	579	0	0
Subtotal:	28	241	24	290	510	1296	1191	3307	14	86
DELTA										
Drainage Basin 10	0	0	1	5	169	481	61	103	0	0
Drainage Basin 32	2	15	6	77	7	19	52	104	0	0
Drainage Basin 44A	0	0	0	0	188	263	64	297	0	0
Drainage Basin 44B	2	6	1	9	7	19	16	38	0	0
Drainage Basin 44C	0	0	2	14	137	126	88	99	0	0
Subtotal:	4	21	10	105	508	908	281	641	0	0
TULARE LAKE	8	29	10	144	43	1792	998	4484	27	184
FOOTHILLS	4	32	1	7	8	47	226	614	0	0
Area Subtotal:	87	633	61	598	2371	6203	3819	11562	101	753
MAJOR WATERWAYS	0	0	0	0	8	269	20	1025	0	0
TOTAL:	**87**	**633**	**61**	**598**	**2379**	**6472**	**3839**	**12587**	**101**	**753**

* Some water bodies may be included in more than one category at different times of the year due to recycling.

As of September 1992

The footnotes listed below are used throughout the following tables

FOOTNOTES

WATER QUALITY CONCERNS:

1 = excess sediment in tailwater
2 = elevated TDS concentrations
3 = elevated boron concentrations
4 = elevated selenium concentrations
5 = elevated molybdenum concentrations
6 = pesticides
7 = fertilizers
8 = sewage
9 = dairy waste
10 = urban storm runoff
11 = elevated arsenic concentrations
12 = elevated chromium concentrations
13 = elevated mercury concentrations
14 = treated waste water

WATER TYPE:

WT = wetland discharge
WW = waste water treatment plant effluent
Tail = agricultural tail water
Tile = agricultural tile water
U = urban storm runoff
NF = natural flood flows
OP = operational spill
GW = ground water
SW = surface water
DW = dairy waste

CONSTRUCTION:

E = earthlined
C = concrete lined
P = pipeline

THE DELTA BASINS

The Delta area has been divided into five basins. They are Drainage Basin No. 10, 32, 44A, 44B and 44C. The tidal characteristics of the Delta area are dominant in the North Delta (Basin 10), Central Delta (Basin 44A) and South Delta (Basin 44C) Basins. The areas west of the Delta (Basin 44B) draw water for irrigation mostly from the Delta. The basin east of the Delta (Basin 32) contains water districts which drain from the eastside of the valley into the Delta basins.

The Delta Basins that are influenced by tidal action have unique characteristics. These basins contain highly organic soils and are typically islands surrounded by channels of water. These waters are fed primarily by the Sacramento and San Joaquin Rivers. Water in the Delta meanders through sloughs, cuts, canals and channels. The direction of these flows depends on inflow volumes, tides, export pumping, diversions and other factors. Because of these characteristics, the water bodies do not easily fit the descriptions in the Inland Surface Waters Plan.

An argument can be made for a separate classification system for these Delta Basins. Few water bodies in these Basins are agricultural supply or drainage dominated. Many of the channels in the Delta have been constructed and dredged partially for agriculture but none would fall into category (b) designation. These major water bodies have not been classified as category (b) because of tidal influences and difficulties fitting them into the classification scheme.

Since many of the Delta islands are lower than surrounding lands, water supply methods differ from other irrigated lands in the Central Valley. Rather than a network of canals which supply water to a number of growers, irrigation is typically accomplished by the siphoning of the surrounding water by individual farms. More than 1,800 siphons divert water for crop and livestock production (State Lands Commission, 1991 and DWR 1987). Drainage is almost entirely surface (tail) water with little subsurface (tile) water.

Reclamation districts, found throughout the Delta, are responsible for the system of levees which protect the islands. These districts provided much of the data on drainage. Irrigation supply is the responsibility of individual farms. Therefore, information on water supply canals and irrigation systems may be lacking.

REFERENCES:

State Lands Commission, 1991. *Delta-Estuary California Inland Coast, A Public Trust.* 208 pp.
Department of Water Resources, 1987. *Sacramento-San Joaquin Delta Atlas.* 71 pp.

DRAINAGE BASIN 20B

Drainage Basin 20B lies within the valley floor portion of the Sacramento River Basin that is east of the Sacramento River and south of Big Chico Creek. Land within the Basin lies north of the Sutter Buttes and ultimately drains into Butte Slough. Natural streams in the area either originate in the Sierra Foothills or are former flood channels for the Sacramento River. Historically, all the streams were ephemeral and only carried natural runoff or flood flows for two to four months of the year. The foothill streams drained from the northeast to the southwest while the flood channels drained northwest to southeast. As the channels reached the low-lying areas along the eastside of the Sacramento River, they branched into numerous sloughs and meandering waterways creating extensive wetland habitat. All flows converged in the southwest corner at Butte Slough.

Today the majority of the land within the low-lying areas of this basin is in rice production with the local sloughs and channels extensively reconstructed and continually maintained to enhance production. The surrounding lands along the northern and eastern edge of the basin are a combination of orchards, pastures, and rangeland. A narrow strip along the eastside of the Sacramento River is also planted in orchards.

Nine agencies representing approximately 235,000 acres in this basin, provided information on water bodies within their boundaries. These agencies, which have authority over facilities within their boundaries, included:

- Western Canal Water District
- Butte County Drainage District #2
- Drainage District 200
- Richvale Irrigation District
- Butte Water District
- Reclamation District 833
- Biggs-West Gridley Water District
- Reclamation District 1004
- Butte Sink Waterfowl Association

Based on information provided by the districts, ten natural streams within Drainage Basin 20B, as well as the Butte Sink, were found to be agriculturally dominated for at least a portion of each year.

These streams include:

- Butte Creek
- Hamlin Slough
- Angel Slough
- Campbell Slough
- Howard Slough
- Little Butte Creek
- Butte Slough
- Durham Slough
- Little Dry Creek
- Drumheller Slough
- Butte Sink

DRAINAGE BASIN 20

The Butte Sink is considered a natural water body although it is composed of a series of interconnected waterways forming wetland habitat rather than a single channel.

The agriculturally-dominated reaches of these water bodies are listed in Tables 20B-B1, 20B-B2, and 20B-C3 and described in more detail below. In addition, constructed agricultural drains and supply canals are listed in Tables 20B-C1 and 20B-C2, respectively.

CATEGORY B1 WATER BODIES

BUTTE CREEK: The main channel in Drainage Basin 20B, Butte Creek originates in the Sierra Foothills east of Chico and upon reaching the valley floor travels southwest 45 miles until discharging into Butte Slough. Along its length, Butte Creek carries natural runoff, agricultural supply and return flow, and supplies for and runoff from wetland habitat. For 14 miles, from 2.5 miles north of the Colusa County line to its discharge, the creek does receive agricultural return flows. These return flows dominate the downstream reach from August until mid-September. During mid-September, freshwater releases are diverted into the channel for flooding wetland habitat. At the Highline Lateral and again at the Western Canal, the upper 28-mile section of the agriculturally-dominated reach, the creek is dammed during the irrigation season to allow recycling. Enough flow is released at each dam to accommodate riparian and appropriative uses downstream.

HAMLIN SLOUGH: Essentially an overflow channel for Butte Creek, Hamlin Slough originates near Highway 99, southeast of Chico, and continues 12 miles downstream until discharging to Butte Creek. Flow in the slough is dominated by agricultural supply water during the irrigation season though it does receive agricultural return flows along its lower 6.5-mile reach. A dam has been constructed at Rancho Esquon to allow recycling during the irrigation season in that portion of the slough's watershed (the upper 5.5 miles of the agriculturally dominated portion of the slough).

BUTTE SLOUGH: An eight mile slough which begins at the junction of Butte Creek and the Sutter Bypass, Butte Slough carries excess flows from the basin to a discharge point at the Sacramento River. The slough serves as this diversion whenever flows in Butte Creek exceed 350 cfs which, since 1985, has only occurred during winter storm events and during April and May rice field releases. For the remainder of the year, the slough is a backwater reach which receives flows from Butte Creek and is, therefore, dominated by agricultural return flows during the irrigation season.

DRAINAGE BASIN 20

BUTTE SINK: Although the Butte Sink is managed for waterfowl, it should be noted that a multi-agency agreement was reached in 1922 which requires a set amount of tailwater to be released from upstream drainage districts for the floodup of wetland habitat. The releases are to begin in August and continue until contracted freshwater releases begin in mid-September. Between August and mid-September, all waterways within the Butte Sink are dominated by agricultural return flows.

The following former flood channels were cut off from any natural flows when the Sacramento River was leveed. With the exception of one flood channel, Angel Slough, the only water found in these channels is due to water diversions for agricultural supply or tail water return flows. Angel Slough can now receive annual flood flows due to the construction of a diversion channel to enhance wetland habitat restoration as is discussed below.

ANGEL SLOUGH: Originally a 21-mile flood channel for the Sacramento River, Angel Slough was cut off from natural flows when the river was leveed. Recently, the Army Corps of Engineers designed a low level diversion point which allows some winter flows from the river to enter the channel. The diversion was constructed as part of a joint project with the Department of Fish and Game and the Nature Conservancy to restore wetland habitat in the Llano Seco portion of the Basin (the northwest corner). The channel now receives flood flows during winter storm events but continues to be dominated by agricultural return flows during the irrigation season; April through September. During the irrigation season, flows within the upper six miles of Angel Slough are recycled through the Llano Seco Unit. The remaining 15 miles receives agricultural return flows until discharge into Drumheller Slough.

CAMPBELL SLOUGH: Campbell Slough originates three miles east of Glenn and travels eight miles until discharging into Howard Slough. Flows are dominated by agricultural supply water during the majority of the irrigation season. Return flows dominate when the rice fields are drained from August through September.

HOWARD SLOUGH: A six mile channel, Howard Slough originate near Aquas Frias and discharges into Butte Creek. The slough is dominated by agricultural return flows during the irrigation season.

LITTLE BUTTE CREEK: Little Butte Creek originates at the base of the Llano Seco Unit wetlands and travels for six miles before discharging to Butte Creek. Although Little Butte Creek may receive overflow from the wetland area in the winter and spring, it is dominated by agricultural return flows during the irrigation season.

DRAINAGE BASIN 20

CATEGORY B2 WATER BODIES

BUTTE CREEK: For the majority of the irrigation season, April through September, Butte Creek is dominated by supply flows from its intersection with the Southern Pacific Railroad near Esquon to its discharge into Butte Slough, approximately 29 miles. For 14 miles, from 2.5 miles north of the Colusa County line to its discharge, the creek does receive agricultural return flows. During mid-September, freshwater releases are diverted into the channel for flooding wetland habitat. At the Highline Lateral and again at the Western Canal, the upper 28-mile section of the agriculturally-dominated reach, the creek is dammed during the irrigation season to allow recycling. Enough flow is released at each dam to accommodate riparian and appropriative uses downstream.

HAMLIN SLOUGH: Essentially an overflow channel for Butte Creek, Hamlin Slough originates near Highway 99, southeast of Chico, and continues 12 miles downstream until discharging to Butte Creek. Flow in the slough is dominated by agricultural supply water during the irrigation season though it does receive agricultural return flows along its lower 6.5-mile reach. A dam has been constructed at Rancho Esquon to allow recycling during the irrigation season in that portion of the slough's watershed (the upper 5.5 miles of the agriculturally dominated portion of the slough).

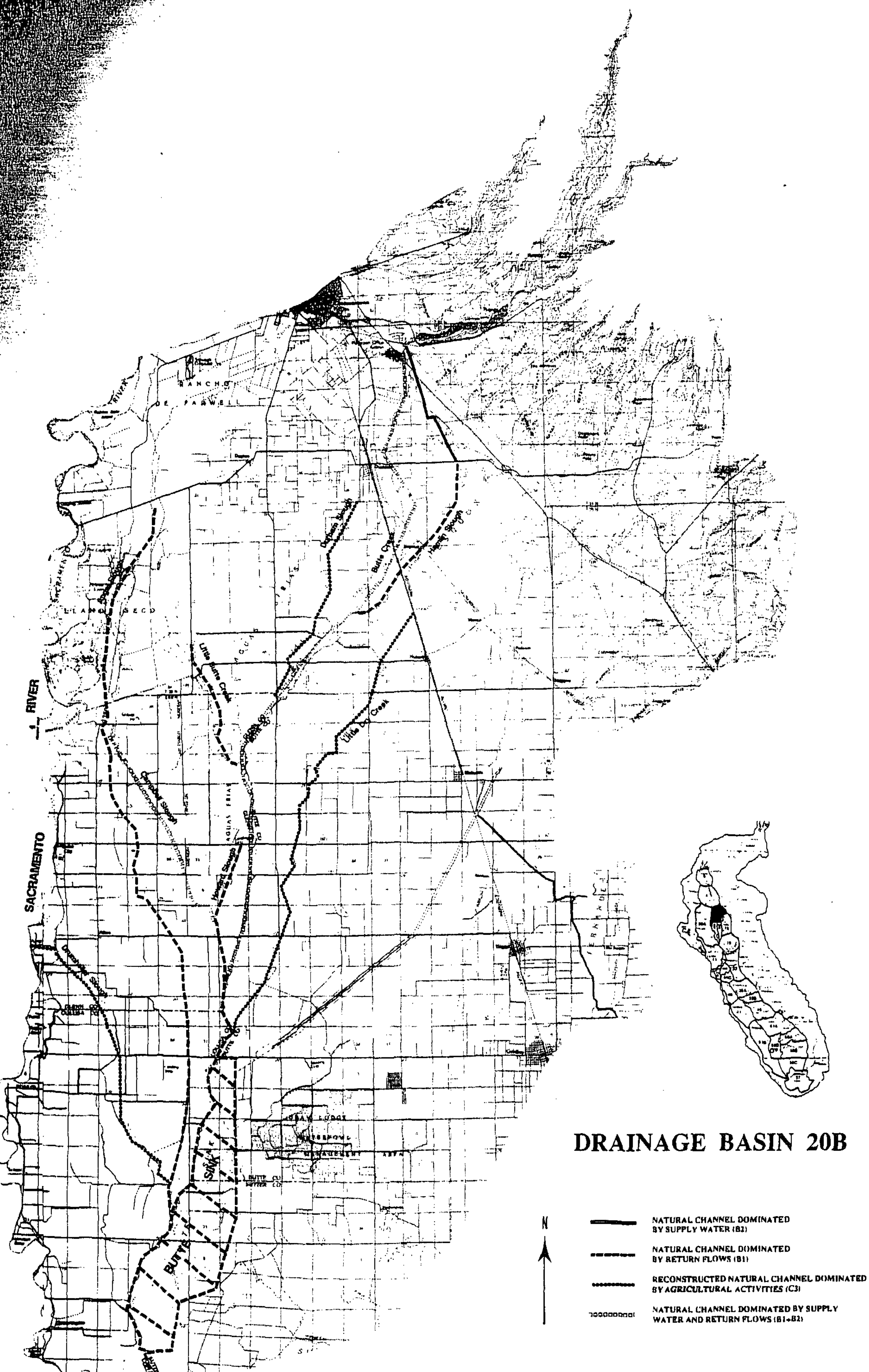
CAMPBELL SLOUGH: Campbell Slough originates three miles east of Glenn and travels eight miles until discharging into Howard Slough. Flows are dominated by agricultural supply water during the majority of the irrigation season. Return flows dominate when the rice fields are drained from August through September.

CATEGORY C3 WATER BODIES

LITTLE DRY CREEK: Extensively reconstructed downstream of the Western Canal, Little Dry Creek is an ephemeral stream that originates near the base of the Sierra Foothills. The upper reaches of the creek meander through rangeland and contain flows only during storm events. The final 15 miles, from the Western Canal to the creek's discharge into Butte Creek, Little Dry Creek has been realigned to receive agricultural return flows. From April through September, the creek is dominated by these return flows.

DURHAM SLOUGH: Originally part of an overflow channel for Butte Creek, Durham Slough has been extensively reconstructed for agricultural conveyance and no longer receives natural runoff. The slough originates south of the town of Durham and travels seven miles until discharging into Butte Creek. During the irrigation season, the slough carries both irrigation supply, as well as agricultural return flows.

DRUMHELLER SLOUGH: A former flood channel for the Sacramento River, Drumheller Slough no longer receives natural runoff and has been realigned to serve as an agricultural supply channel. The slough originates at a pumping station on the Sacramento River two miles north of the Glenn-Colusa County line and travels eleven miles until its discharge into Butte Creek. During the irrigation season, the slough acts primarily as a supply channel but it does receive agricultural return flows as it travels downstream.



DRAINAGE BASIN 20B

TABLE 20B - B1

NATURAL CHANNELS WITHIN DRAINAGE BASIN 20B
DOMINATED BY AGRICULTURAL DRAINAGE FLOWS

Name	Length (miles)	Acres Drained	Water Type	Flow Period	Water Quality Concerns
Butte Creek*	15		Tail	Aug - Sep	6
Hamlin Slough*	12		Tail	Apr - Sep	6
Butte Sink	10		Tail	Aug - Sep	6
Angel Slough	21		Tail	Apr - Sep	6
Campbell Slough*	8		Tail	Aug - Sep	6
Howard Slough	6		Tail	Apr - Sep	6
Little Butte Creek	6		Tail, WT	Apr - Sep	6
Butte Slough	6		Tail	Apr - Sep	6

*Dominated by both tail and supply water.

TABLE 20B - B2

NATURAL CHANNELS WITHIN DRAINAGE BASIN 20B
DOMINATED BY AGRICULTURAL SUPPLY WATER

Name	Length (miles)	Water Type	Flow Period	Water Quality Concerns
Butte Creek*	29	SW, WT, Tail	Apr - Sep	6
Hamlin Slough*	12	Butte Creek	Apr - Sep	6
Campbell Slough*	8	SW	Apr - Aug	6

*Dominated by both tail and supply water.

TABLE 20B - C1

CONSTRUCTED AGRICULTURAL DRAINS WITHIN DRAINAGE BASIN 20B

Name	Type of Construction	Length (miles)	Acres Drained	Water Type	Flow Period	Water Quality Concerns
RD 833 - Lateral A	E	14		Tail	Mar - Oct	6
RD 833 - Lateral A6	E	3.5		Tail	Mar - Oct	6
RD 833 - Main Canal	E	12		U, WW, Tail, LO	Mar - Oct	6
RD 833 - Lateral E	E	9.5		Tail, U, WW	Mar - Oct	6
Watts Lateral	E	1.9		NF, Tail	Jan - Dec	6
A	E	2.6		NF, Tail	Sep - Mar	6
B	E	1.1		NF, Tail	Sep - Mar	6
C	E	1.6		NF, Tail	Sep - Mar	6
D	E	1.7		NF, Tail	Sep - Mar	6
E1	E	1.8		NF, Tail	Sep - Mar	6
E2	E	1.75		NF, Tail	Sep - Mar	6
F1	E	3.4		NF, Tail	Sep - Mar	6
F2	E	1.2		NF, Tail	Sep - Mar	6
G	E	0.7		NF, Tail	Sep - Mar	6
H	E	1.3		NF, Tail	Sep - Mar	6
J	E	4.4		NF, Tail	Sep - Mar	6
K1	E	4.3		NF, Tail	Sep - Mar	6
K2	E	0.5		NF, Tail	Sep - Mar	6
K3	E	1.2		NF, Tail	Sep - Mar	6
L	E	1		NF, Tail	Sep - Mar	6
M	E	1.7		NF, Tail	Sep - Mar	6
N1	E	0.5		NF, Tail	Sep - Mar	6
N2	E	0.8		NF, Tail	Sep - Mar	6
O	E	1.8		NF, Tail	Sep - Mar	6
P	E	0.6		NF, Tail	Sep - Mar	6
Q1	E	2.2		NF, Tail	Sep - Mar	6
Q2	E	0.5		NF, Tail	Sep - Mar	6
Q3	E	0.7		NF, Tail	Sep - Mar	6
Q4	E	1		NF, Tail	Sep - Mar	6
DD 200 - Main Ditch A	E	4	3203	Tail, NF	Dec - Sep	6
DD 200 - Lateral A1	E	0.25		Tail, NF	Dec - Sep	6
DD 200 - Lateral A2	E	1.25		Tail, NF	Dec - Sep	6
DD 200 - Lateral A2b	E	1		Tail, NF	Dec - Sep	6
DD 200 - Lateral A3	E	1.5		Tail, NF	Dec - Sep	6
DD 200 - Lateral A4	E	1		Tail, NF	Dec - Sep	6
DD 200 - Lateral A4a	E	1.25		Tail, NF	Dec - Sep	6
DD 200 - Lateral A5	E	0.25		Tail, NF	Dec - Sep	6
DD 200 - Lateral A6	E	1.5		Tail, NF	Dec - Sep	6
DD 200 - Lateral A7	E	1.25		Tail, NF	Dec - Sep	6
DD 200 - Main Ditch B	E	6.5	3155	Tail, NF	Dec - Sep	6
DD 200 - Lateral B1	E	1.5		Tail, NF	Dec - Sep	6
DD 200 - Lateral B2	E	1.5		Tail, NF	Dec - Sep	6
DD 200 - Lateral B3	E	0.25		Tail, NF	Dec - Sep	6
DD 200 - Lateral B3a	E	0.5		Tail, NF	Dec - Sep	6
DD 200 - Lateral B3b	E	0.5		Tail, NF	Dec - Sep	6
DD 200 - Lateral B4	E	0.25		Tail, NF	Dec - Sep	6
DD 200 - Lateral B5	E	0.25		Tail, NF	Dec - Sep	6
DD 200 - Lateral B6	E	0.25		Tail, NF	Dec - Sep	6
DD 200 - Lateral B7	E	0.25		Tail, NF	Dec - Sep	6
DD 200 - Lateral B8	E	2		Tail, NF	Dec - Sep	6
DD 200 - Lateral B9	E	1.5		Tail, NF	Dec - Sep	6
DD 200 - Lateral B9a	E	0.5		Tail, NF	Dec - Sep	6
DD 200 - Lateral B9b	E	0.5		Tail, NF	Dec - Sep	6
March	E	2		Tail, Supply	Apr - Jan	6
Bradford	E	4		Tail, Supply	Apr - Jan	6
BL Sper A	E	0.5		Tail, Supply	Apr - Jan	6
BL Sper B	E	1		Tail, Supply	Apr - Sep	6
BL Sper C	E	1		Tail, Supply	Apr - Jan	6
BL Sper D	E	0.5		Tail, Supply	Apr - Jan	6
Watts	E	4.3		Tail, Supply	Apr - Jan	6
Maxwell	E	3		Tail, Supply	Apr - Jan	6
ML Sper A	E	1.5		Tail, Supply	Apr - Jan	6
ML Sper B	E	1.5		Tail, Supply	Apr - Jan	6
Cherokee	E	3		Tail, Supply	Apr - Jan	6
Crocker	E	5		Tail, Supply	Apr - Jan	6
Dunaho	E	3		Tail, Supply	Apr - Jan	6
Theback	E	1.5		Tail, Supply	Apr - Sep	6
Mayni's	E	1		Tail, Supply	Apr - Sep	6

Table 20B-C1 continued:

Name	Type of Construction	Length (miles)	Acres Drained	Water Type	Flow Period	Water Quality Concerns
Browning	E	1		Tail, Supply	Apr - Jan	6
BWG - 2054 Drain	E	5		Tail, Supply	Mar - Oct	6
BWG - Drain #832	E	3		Tail, Supply	Mar - Oct	6
BWG - Lateral C	E	5		Tail, Supply	Mar - Oct	6
BWG - Lateral E1	E	6		Tail, Supply	Mar - Oct	6
BWG - Lateral E5	E	1		Tail, Supply	Mar - Oct	6
BWG - Lateral H	E	6		Tail, Supply	Mar - Oct	6
BGW - Lateral A-6	E	2		Tail, Supply	Mar - Oct	6
Cherokee Canal	E	2		Tail, Supply	Apr - Jan	6
D-1	E	11.3		Tail	Mar - Nov	6
D-2	E	1.3		Tail	Mar - Nov	6
D-3	E	1.4		Tail	Mar - Nov	6
D-4	E	1.7		Tail	Mar - Nov	6
D-5	E	0.9		Tail	Mar - Nov	6
D-6	E	0.8		Tail	Mar - Nov	6
D-7	E	0.8		Tail	Mar - Nov	6
D-8	E	1.5		Tail	Mar - Nov	6
D-9	E	0.6		Tail	Mar - Nov	6
D-10	E	2		Tail	Mar - Nov	6
D-11	E	3.3		Tail	Mar - Nov	6
D-12	E	0.93		Tail	Mar - Nov	6
D-13	E	1.8		Tail	Mar - Nov	6
D-14	E	0.9		Tail	Mar - Nov	6
D-15	E	1.1		Tail	Mar - Nov	6
D-18	E	3.6		Tail	Mar - Nov	6
D-19	E	1.2		Tail	Mar - Nov	6
D-20	E	2		Tail	Mar - Nov	6
D-21	E	1.9		Tail	Mar - Nov	6
D-22	E	1.7		Tail	Mar - Nov	6
D-23	E	2.6		Tail	Mar - Nov	6
D-24	E	1.1		Tail	Mar - Nov	6
D-25	E	0.8		Tail	Mar - Nov	6
D-26	E	1.3		Tail	Mar - Nov	6

LO = Lake Oroville

TABLE 20B - C2

CONSTRUCTED AGRICULTURAL IRRIGATION SUPPLY CANALS
WITHIN DRAINAGE BASIN 20B

Name	Type of Construction	Length (miles)	Water Type	Flow Period	Water Quality Concerns
Sutter Butte Main Canal	E	6.5	LO	Mar - Oct	6
Biggs Ditch Lateral	E	3	LO	Mar - Oct	6
Biggs Colony Lateral	E	2	LO	Mar - Oct	6
Sheppard Ditch	E	0.25	LO	Mar - Oct	6
BWD Lateral 3	E	1.5	LO	Mar - Oct	6
BWD Lateral 4	E	5	LO	Mar - Oct	6
Biggs Extension	E		FR	Mar - Oct	6
Belding Lateral	E	6	FR	Mar - Oct	6
Ashley Lateral	E	10	FR	Mar - Oct	6
Ditch No. 19	E		FR	Mar - Oct	6
Green Lateral	E	2.5	FR	Mar - Oct	6
Traynor Lateral	E	5	FR	Mar - Oct	6
Spence Lateral	E	2	FR	Mar - Oct	6
Gerst Lateral	E	3.5	FR	Mar - Oct	6
Evans Lateral	E	1	FR	Mar - Oct	6
Ditzler Lateral	E	2	FR	Mar - Oct	6
Baynon Lateral	E	1.5	FR	Mar - Oct	6
Farris Lateral	E	1	FR	Mar - Oct	6
Fleming Lateral	E	1.5	FR	Mar - Oct	6
N#8	E	1.25	FR	Mar - Oct	6
Lateral 8	E	2	FR	Mar - Oct	6
S#8	E	1	FR	Mar - Oct	6
Schwind Lateral	E	2	FR	Mar - Oct	6
Richvale	E	3	FR	Apr - Jan	6
High Lift	E	5	FR	Apr - Jan	6
March *	E	2	FR	Apr - Jan	6
Pratt	E	3.5	FR	Apr - Jan	6
Pump Ditch	E	1	FR	Apr - Jan	6
Lowlift	E	3	FR	Apr - Jan	6
LL Sper A	E	0.75	FR	Apr - Sep	6
LL Sper B	E	1	FR	Apr - Sep	6
LL Sper C	E	0.5	FR	Apr - Sep	6
Bradford *	E	4	FR	Apr - Jan	6
BL Sper A *	E	0.5	FR	Apr - Jan	6
BL Sper B *	E	1	FR	Apr - Sep	6
BL Sper C *	E	1	FR	Apr - Jan	6
BL Sper D *	E	0.5	FR	Apr - Jan	6
Biggs Ext.	E	4	FR	Apr - Jan	6
High Gravity	E	2.5	FR	Apr - Jan	6
Low Gravity	E	2	FR	Apr - Jan	6
Evans	E	1.2	FR	Apr - Sep	6
McQueen	E	0.5	FR	Apr - Sep	6
Baker	E	1	FR	Apr - Sep	6
McKee	E	0.75	FR	Apr - Sep	6
Watts *	E	4.3	FR	Apr - Jan	6
Maxwell *	E	3	FR	Apr - Jan	6
ML Sper A *	E	1.5	FR	Apr - Jan	6
ML Sper B *	E	1.5	FR	Apr - Jan	6
Stine	E	2	FR	Apr - Jan	6
Government	E	1.5	FR	Apr - Jan	6
Burns Gov.	E	3	FR	Apr - Jan	6
Cherokee *	E	3	FR	Apr - Jan	6
Crocker *	E	5	FR	Apr - Jan	6
Dunaho *	E	3	FR	Apr - Jan	6
Theback *	E	1.5	FR	Apr - Sep	6
Mayni's *	E	1	FR	Apr - Sep	6
Browning *	E	1	FR	Apr - Jan	6
WC Main Canal	E	14.8	FR	Apr - Jan	6
374 Lateral **	E	0.4	FR	Apr - Jan	6
462 Lateral **	E	1.6	FR	Apr - Jan	6
522 Lateral **	E	0.8	FR	Apr - Jan	6
574 Lateral **	E	1.7	FR	Apr - Jan	6
575 Lateral **	E	1	FR	Apr - Jan	6
599 R Lateral **	E	1.7	FR	Apr - Jan	6
660 Lateral **	E	0.7	FR	Apr - Jan	6
690 Lateral **	E	1.7	FR	Apr - Jan	6
701 Lateral **	E	1.6	FR	Apr - Jan	6

Table 20B-C2 continued:

Name	Type of Construction	Length (miles)	Water Type	Flow Period	Water Quality Concerns
735 Lateral **	E	2.2	FR	Apr - Jan	6
743 Lateral **	E	2.4	FR	Apr - Jan	6
806 Lateral **	E	3	FR	Apr - Jan	6
924 Lateral	E	7.8	FR	Apr - Jan	6
Highline Lateral	E	3	FR	Apr - Jan	6
Pratt Lateral	E	1	FR	Apr - Jan	6
Pratt Lateral **	E	3.8	FR	Apr - Jan	6
1052 Lateral **	E	1	FR	Apr - Jan	6
1131 Lateral **	E	1	FR	Apr - Jan	6
1184 Lateral **	E	2	FR	Apr - Jan	6
1190 Lateral **	E	1	FR	Apr - Jan	6
1500 Lateral	E	5.4	FR	Apr - Jan	6
Ward Lateral	E	6.2	FR	Apr - Jan	6
Ward 120 Lateral	E	3	FR	Apr - Jan	6
WC Main south of Reservoir	E	7	FR	Apr - Jan	6
1625 Lateral	E	5	FR	Apr - Jan	6
Cherokee Canal*	E	18	FR, Tail	Apr - Jan	6
S-2	E	1.2	Sac River	Mar - Nov	6
S-3	E	1.1	Sac River, GW	Mar - Nov	6
S-4	E	2.8	Sac River, GW	Mar - Nov	6
S-5	E	1	Sac River, GW	Mar - Nov	6
S-6	E	1.3	Sac River, GW	Mar - Nov	6
S-7	E	1.3	Sac River, GW	Mar - Nov	6
S-8	E	1.5	Sac River, GW	Mar - Nov	6
S-9	E	1.5	Sac River, GW	Mar - Nov	6
S-10	E	0.8	Sac River, GW	Mar - Nov	6
S-12	E	1.8	Sac River, GW	Mar - Nov	6
S-13	E	1.5	Sac River, GW	Mar - Nov	6
S-14	E	0.9	Sac River, GW	Mar - Nov	6
S-15	E	2	Sac River, GW	Mar - Nov	6
S-16A	E	1	Sac River, GW	Mar - Nov	6
SD-17	E	2.1	Sac River, GW,Tail	Mar - Nov	6
S-18	E	2	Sac River, GW	Mar - Nov	6
S-19	E	1	Sac River, GW	Mar - Nov	6
S-20	E	1.1	Sac River	Mar - Nov	6
S-21	E	2	Sac River	Mar - Nov	6
S-22	E	1.7	Sac River	Mar - Nov	6
S-23	E	0.6	Sac River	Mar - Nov	6
S-24	E	3	Sac River	Mar - Nov	6
S-25	E	0.5	Sac River	Mar - Nov	6
S-26	E	0.9	Sac River	Mar - Nov	6

LO = Lake Oroville
FR = Feather River
* Canals which contain both supply and agtail water
** Grower Owned

TABLE 20B - C3

RECONSTRUCTED NATURAL CHANNELS WITHIN DRAINAGE BASIN 20B
DOMINATED BY AGRICULTURAL DRAINAGE FLOWS OR AGRICULTURAL SUPPLY FLOWS

Name	Type of Construction	Length (miles)	Water Type	Flow Period	Water Quality Concerns
Durham Slough	E	7	Tail	Apr - Sep	6
Drumheller Slough	E	11	Sac River, Tail	Apr - Sep	6
Little Dry Creek	E	15	Tail	Apr - Sep	6

Occurrence and Transport of Diazinon in the Sacramento River and its Tributaries During Three Winter Storms, January-February 2000

By Peter D. Dileanis, *and* Joseph L. Domagalski
U.S. GEOLOGICAL SURVEY

Kevin P. Bennett
CALIFORNIA STATE DEPARTMENT OF PESTICIDE REGULATION

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 00-______

Prepared in Cooperation with the

CALIFORNIA STATE DEPARTMENT OF PESTICIDE REGULATION

SACRAMENTO RIVER WATERSHED PROGRAM

Sacramento, California
2000

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Table 1. Monitoring site names, locations, and availability of streamflow data.

Site Number	Site Name	Latitude *deg-min-sec*	Longitude *deg-min-sec*	Description	Flow data available
1	*Sacramento River at Alamar*	38-40-30	121-37-36	71 miles upstream of the mouth of the Sacramento River, just upstream of Hwy 5 bridge. Samples collected from pier on left bank.	yes
2	Colusa Basin Drain at Rd. 99E nr Knights Landing	38-48-45	121-46-23	2 miles nw of the town of Knights Landing. Samples collected from bridge over Colusa Basin Drain. (USGS site number 11390890)	no
3	Feather River at Nicolaus	38-54-02	121-35-01	Samples collected from a boat in the reach between the Hwy 99 bridge and a point 0.8 miles upstream.	Yes
4	DWR Pumping Plant #1	38-55-60	121-38-01	DWR pumping plant about 20 miles northwest of Sacramento along the Sutter Bypass. Samples collected from the bank of north channel. Channel is branch of Gilsizer Slough	yes
5	Bear River near Berry Road	38-56-22	121-34-32	Samples collected 1000 feet upstream of Bear River mouth by boat. A single sample at extreme high flow was collected from the levee bank about 2 miles upstream of the mouth.	yes
6a	DWR Pumping Plant #2, north channel	39-01-33	121-43-30	DWR pumping plant about 25 miles northwest of Sacramento along the Sutter Bypass. Samples collected from pedestrian bridge just upstream of weir. Channel drains area north of Gilsizer Slough.	yes
6b	DWR Pumping Plant #2, south channel	39-01-33	121-43-30	Samples collected from single-lane bridge just before the pumping plant. Channel is branch of Gilsizer Slough.	yes
7	Gilsizer Slough at Bogue Road	39-05-54	121-38-16	Just south of Yuba City, 1/4 mile west Highway 99. Samples collected from bridge.	no
8	Feather River at Yuba City	39-08-37	121-36-26	West bank of river beneath Highway 20 bridge. Alternate site is boat ramp about 3/4 mile south of primary site. Samples collected from right bank	no
9	Yuba River at Marysville	39-08-31	121-34-30	Just east of Marysville at Simpson Lane. Samples collected from left bank.	yes
10	Wadsworth Canal at South Butte Road	39-09-11	121-44-00	Approximately 6 miles west of Yuba City and north of Highway 20 at South Butte Rd. Samples collected from bridge.	no
11	Jack Slough at Doc Adams Rd	39-09-43	121-35-43	Just north of Marysville. Samples collected from bank	no
12	Butte Slough at Lower Pass Road	39-11-16	121-54-28	South east of the Sutter Buttes. Samples collected from bridge.	yes
13	Sacramento River at Colusa	39-12-52	121-59-58	In the town of Colusa. Samples collected from bridge. (USGS site number 11389500)	yes
14	Butte Creek at Gridley Road	39-21-43	121-53-30	Approximately 10.5 miles west of Gridley on Gridley Rd. Samples collected from bridge.	no
15	Cherokee Canal at Gridley Road	39-21-44	121-52-03	Approximately 9 miles west of Gridley on Gridley Rd. Samples collected from bridge.	yes
16	Main Canal at Gridley Road	39-21-44	121-49-23	Approximately 7 miles west of Gridley on Gridley Rd. Samples collected from bridge.	no
17	Sacramento River at Sacramento	38-34-30	121-30-20	Tower Bridge on Capitol Ave. in downtown Sacramento. (USGS site number 383430121302001)	yes

FOREWORD

[by Robert M. Hirsch, Chief Hydrologist]

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Conversion Factors

Multiply	by	to get
cubic foot per second (cfs)	28.317	liters per second (L/s)
inch (in.)	2.54	centimeter (cm)
mile (mi)	1.6093	kilometers (km)
nanosgram per liter (mg/L)	0.001	micrograms per liter (ug/L)
pound	0.4546	kilograms (kg)
kilograms (kg)	2.20462	pounds

Water-Quality Information

Pesticide concentrations in water samples are given in nanograms per liter (ng/L). One thousand nanograms per liter is equivalent to 1 microgram per liter (µg /L) or 0.001 milligram per liter (mg/L). Nanograms per liter is equivalent to "parts per trillion."

Abbreviations and Symbols

µg	microgram
a.i.	active ingredient
cfs	cubic feet per second
DPR	California State Department of Pesticide Regulation
kg	kilogram
L	liter
mg	milligram
mL	milliliter
ng	nanogram
NAWQA	National Water-Quality Assessment

NWQL	National Water Quality Laboratory
ppt	parts per trillion
SRWP	Sacramento River Watershed Program
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

Acknowledgments

Monitoring water-quality over a large study area in the relatively brief time period of a winter storm required the efforts of a large field team laboring long hours in wet and cold weather. Field personnel included Kevin Kelley, Andy Fecko, Jesse Ybarra, and Sainey Ceesay from DPR; Michelle McGraw from the RQWC; Steve Gallanthine and Frank Moseanko with the USGS; and our colleagues from the University of California at Davis: Tom Kimball, Melvin Whitlock, and Bryan Stafford.

Occurrence and Transport of Diazinon in the Sacramento River and its Tributaries During Three Winter Storms, January-February 2000

organophosphorus - see pg. 13 introduct.

Abstract

The organophosphate insecticide diazinon is applied as an orchard dormant spray in the Sacramento Valley during the winter months when the area receives a majority of its annual rainfall. Dormant spray pesticides thus have the potential to wash off targeted areas of application and migrate with storm runoff water to streams in the Sacramento River Basin. Previous monitoring studies have shown that rain and associated runoff from winter storms plays an important role in the transport of diazinon from its point of application to the Sacramento River and its tributaries.

Diazinon concentrations in the Sacramento River and its tributaries were monitored on 5 consecutive days during each of 3 winter storms that swept through the Sacramento Valley soon after diazinon had been applied to orchards in the watershed. Water samples were collected at 17 sites chosen to represent the effects of upstream land use on a variety of scales; from small tributaries and drains representing local agricultural and urban land use in watershed subbasins to main-stem river sites representing regional effects. The majority of samples were analyzed by ELISA (enzyme-linked immunosorbent assay) with GC/ECD/TSD used to confirm ELISA ? results on 30 percent of the samples. A significant and consistent bias was observed in the ELISA analyses. Concentration values from ELISA analyses were consistently higher than

concentration values for duplicate samples analyzed by other well-proved methods. The observed bias in the ELISA diazinon concentrations does not allow direct comparison to regulatory standards, and load calculations using the ELISA analyses would be similarly biased. Because the bias was consistent, however, the ELISA data is useful in site-to-site comparisons used to rank the relative levels and contributions of diazinon from individual subbasins in the watershed. At two of the sites where pesticide concentrations were expected to be low (Sacramento River at Sacramento and Feather River nr Nicolaus), all analyses were done using GC/MS because of that method's lower detection limits. Data from these sites were used to estimate diazinon loads transported to the lower Sacramento River and loads contributed by the Feather River, during the monitoring period.

Concentrations of diazinon in 138 samples analyzed by GC methods ranged from below detection to 2890 ng/L with a median of 44 ng/L. 30 percent of the samples had concentrations greater than 80 ng/L, the value being considered by the state of California as its Criterion Maximum Concentration for the protection of aquatic habitat. Concentrations were highest in small tributaries and canals draining subbasins with predominantly agricultural land use and in a channel draining the Yuba City urban district.

Load estimates using concentrations derived from GC/MS analyses indicate that about 30 percent of the diazinon in the lower Sacramento River is introduced from the Feather River Basin. Loads estimated using ELISA analyses show a similar, but slightly higher fraction of the total load coming from that basin. The source of over half the total load measured at Sacramento

River at Alamar appears to have originated in the portion of the drainage basin upstream of the city of Colusa.

About 12,493 Kg of diazinon were reported applied to agricultural land in Sacramento Valley just before and during the monitoring period. About 0.5 percent of the applied insecticide (60 Kg) appeared to be transported to the lower Sacramento River during the period of monitoring. A similar percent of applied diazinon was estimated to have entered the Feather River from upstream sources.

Diazinon use in the study area during the year 1999/2000 dormant-spray season was unusually low, less than half the average of the previous 4 years. Concentrations and loads in a more average use season may be greater than the levels observed in this study. Although diazinon was the most frequently detected pesticide and the pesticide detected at the highest concentrations, 10 other pesticides were detected in the course of the study. These included the insecticides methidathion and chlorpyrifos, and the herbicides simazine, molinate and thiobencarb.

Key words: pesticide; diazinon; ELISA; water quality; non-point source pollution; dormant spray; Sacramento River; Feather River; California

Introduction

The occurrence of pesticides in surface water is controlled by the quantity and timing of pesticide use, transport mechanisms, the pesticide's chemical properties, and environmental conditions. In parts of the Sacramento River Basin these factors contribute to the frequent detection of the organophosphorus insecticide diazinon during the winter months of the year.

Diazinon, and the insecticides chlorpyrifos, or methidathion are applied to nut and stone fruit trees during the winter dormant season to control peach twig borer, San Jose scale, and mite pests. The dormant season, which generally runs from December through March, is considered the best time to achieve control of these pests because the efficacy of pesticide applications is greatest when trees have lost their leaves and better pesticide coverage is possible (Zalom and others, 1995). Diazinon is also used in home, garden, and commercial applications in urban areas of the watershed.

Reference?

The dormant-spray season coincides with the winter months when the area receives a majority of its annual rainfall. Previous monitoring studies have shown that rain and associated runoff from winter storms plays an important role in the transport of diazinon from its point of application to the Sacramento River and its tributaries. Diazinon has also been detected in air samples and in rain collected during the dormant spray season indicating that atmospheric transport may play a role in the offsite movement of diazinon. – Reference?

Chemical properties that are important in the transport of a pesticide are those which effect its persistence in the environment and those which characterize its movement from one environmental matrix to another, such as movement from soil to water or movement from water to air (Larson and others, 1997).

Persistence is a function of the rate of degradation in the environmental conditions the compound is likely to encounter. Degradation may result from chemical transformation processes such as hydrolysis (reactions with water), photochemical reactions, and biological transformation processes such as microbial metabolism of organic pesticides. One measure of environmental persistence is the field dissipation half-life, an empirical determination that incorporates the many individual transformations and variables of the degradation process. Reported values for diazinon range from 3 to 54 days with the range of 3 to 13 days considered the most representative of actual field conditions (USDA Pesticide Properties Database). As a rule of thumb, the time needed for about 90 percent of the chemical residue to dissipate is 4 times the field dissipation rate.

Properties that affect a pesticide's ability to move from one environmental matrix to another or to remain partitioned in particular matrix are water solubility, sorption coefficient, and Henry's law constant (Smith and others, 1987; Larson and others, 1997; Majewski and Capel, 1995). Solubility in water is a measure of how readily a compound will dissolve and go into solution. Once in solution, a chemical is free to be transported along with any water that moves offsite. The solubility of diazinon in water is been reported to be between 38 and 68.8 mg/L (Howard, 1991; USDA Pesticide Properties Database). These values indicate that solubility is probably not limiting the movement of diazinon into aqueous solution for transport in moving water.

The tendency for a pesticide to bind to soil or sediment particles is often characterized by its soil adsorption coefficient expressed on an organic carbon basis (K_{oc}). Pesticides with high K_{oc} values will tend to remain in the soil or attach to soil particles that have become entrained in flowing water, restricting or slowing their movement downstream. Pesticides with low K_{oc} values tend to bind less tightly to soil particles and are therefore more likely to be leached from the soil and transported by moving water. The K_{oc} values for diazinon in a variety of soil types is reported as 1007 to 1842 (USDA Pesticide Properties Database) indicating that diazinon has a low to moderate tendency to remain bound to soil and sediment.

The tendency of a pesticide to remain in aqueous solution or to volatilize into the atmosphere is indicated by Henry's law constant, which is related to a pesticide's concentration in air over its concentration in water at equilibrium. Values reported for diazinon range from 0.049 to 0.072 Pa-m^3/mole (Suntio and others, 1988; Novartis, 2000; USDA Pesticide Properties Database; Howard, 1991). Compounds with values less than about 1.2 Pa-m^3/mole are considered to be of low volatility. The Henry's law constants generally accepted for diazinon indicate that once the pesticide is in solution it will tend to remain in solution rather than volatilize to the atmosphere (Howard, 1991; Lyman and others, 1990).

The chemical characteristics described above indicate that diazinon applied to soil, plants, or pavement will tend to move into the liquid water phase in a wet environment and will tend to remain in that phase. Water may therefore provide an efficient transport mechanism for the offsite movement of the pesticide. Because the frequency of storms during the dormant spray season generally falls within the range of diazinon's persistence in the environment, it is reasonable to expect that winter storm water runoff may facilitate the movement of diazinon from its point of application to streams in the Sacramento River Basin.

Data from previous studies and ongoing monitoring programs show that diazinon has been frequently detected in the Sacramento River Basin during the dormant-spray season and has been measured at higher concentrations than any other detected pesticide. Toxicity associated with the presence of diazinon and other pesticides has also been measured using standard toxicity tests with the aquatic invertebrate *Ceriodaphnia dubia*.

The documented occurrence of diazinon and the occurrence of toxicity has lead the State of California's Environmental Protection Agency, through its Central Valley Regional Water Quality Control Board (Regional Board) to add the Sacramento and Feather Rivers to the 1998 Clean Water Act 303d list of impaired water bodies. Inclusion on the 303d list requires that impairment be addressed by the U.S. Environmental Protection Agency's TMDL (Total Maximum Daily Load) program administered by the Regional Board. There is additional interest concerning potential effects of diazinon transported from the Sacramento and San Joaquin River Basins downstream to the San Francisco Bay/ Estuary.

In 1998, members of the Sacramento River Watershed Project (SRWP) identified organophosphate (OP) pesticides as a priority issue in the Sacramento River watershed. The

SRWP is an inclusive organization made up of people (stakeholders) with an interest in water quality issues in the Sacramento River Basin. The goal of the SRWP is to formulate and implement a technically valid, cost effective, and protective strategy for a watershed-based water-quality management program. The stakeholders are a diverse group of citizens representing government agencies, agricultural organizations, and environmental groups among others.

The stakeholders agreed that the presence of these pesticides in the watershed, at certain levels, appear to cause aquatic toxicity and recommended that an OP pesticide management plan be developed under the aegis of the SRWP to reduce or eliminate that toxicity. The California Department of Pesticide Regulation (DPR) and the Regional Board prepared a detailed scope of work for the development of an OP pesticide management plan for the Sacramento River upstream of the Delta and the Feather River. This work plan was reviewed by the Toxics Subcommittee of the SRWP and submitted to the Sacramento Regional County Sanitation District on June 28, 1999. The Sacramento Regional County Sanitation District, Regional Board, and DPR provide funding for the development of the management plan. Although a number of monitoring studies have been done in the past or are currently operating, several tasks listed in the management plan call for the development and implementation of additional monitoring studies to fill in gaps in the knowledge base that will be needed to develop an effective OP pesticide management plan.

Purpose and Scope

The first of the monitoring studies to support the development of the management plan and TMDL program was done by the Department of Pesticide Regulation and the U.S. Geological Survey (USGS) during the 1999/2000 dormant-spray season. The goal of the monitoring study was to better characterize the occurrence of diazinon in Sacramento valley streams and determine the sources of the pesticide detected in the Sacramento and Feather Rivers.

Between January 30 and February 25, 2000 diazinon concentrations were monitored on 5 consecutive days during each of 3 winter storms that swept through the Sacramento Valley soon after dormant-spray applications had begun. Water samples were collected at 17 sites chosen to represent the effects of upstream land use on a variety of scales; from small tributaries and drains representing local land use to main-stem river sites representing regional effects. The majority of samples were analyzed by ELISA (enzyme-linked immunosorbent assay) with GC/ECD/TSD used to confirm ELISA results on about 26 percent of the samples. Samples from two of the sites which were expected to have very low concentrations of pesticides, were analyzed by GC/MS because of that method's lower detection limits.

This report describes the pesticide concentrations present in water samples collected during the monitoring period and the quantity (load) of diazinon transported to the Sacramento River from selected subbasins within the watershed. Concentrations and loads are evaluated with regard to the quantity and timing of pesticide applications upstream of the monitoring sites.

Previous Studies

Previous studies of the Sacramento River by the U.S. Geological Survey (USGS), the California Department of Pesticide Regulation (DPR), and the Central Valley Regional Water Quality Control Board (CVRWQCB) have shown that diazinon is detected more frequently during the dormant-spray season than at other times of the year and that the highest observed concentrations are associated with winter storm runoff during the dormant-spray season (MacCoy and others, 1995; Ganapathy, 1997; Holmes and otheres, 2000).

During the winters of 1998-99 and the two previous winters, DPR conducted pesticide and toxicity monitoring at sites along the Sutter Bypass and the Sacramento River (Nordmark, 1999 and 1998; Nordmark and others, 1998). Results from the three seasons were similar in that diazinon was the primary insecticide detected with most detections occurring in conjunction with rainfall. Other pesticides, including those in other chemical classes such as carbamate and pyrethroid insecticides and triazine herbicides, have been detected in the watershed but have not been correlated with observed toxicity. In a study by the California State Regional Water Quality Control Board (RWQCB), acute toxicity to *Ceriodaphnia dubia* in conjunction with high diazinon and methidathion concentrations was found at Gilsizer Slough, which drains agricultural and urban areas west of the Feather River and enters the Sutter Bypass (Foe and Sheipline, 1993).

The study that is of the greatest interest is the RWQCB report, "Sources and Concentrations of Diazinon in the Sacramento Watershed During the 1994 Orchard Dormant Spray Season"

(Holmes and others, 2000). Since it was a diazinon loading study, it greatly aided the selection of monitoring sites for the 1999/2000 dormant season monitoring program.

Many past and current monitoring efforts in the Sacramento and Feather River watersheds document the occurrence of diazinon in the aquatic system and diazinon-associated toxicity. These studies are listed in Appendix 1 along with brief study summaries.

Description of the Sacramento River Watershed and Environmental Setting

The Sacramento River (fig. 1) is about 370 miles long and drains more than 27,000 square miles of land from its upper reaches near the California-Organ border to its mouth 50 miles northeast of the city of San Francisco (Karl, 1979). On average, over 22 million acre-feet of water flow from its watershed each year (Webster and others, 2000) making the Sacramento the largest river in California. Water flowing through the Sacramento River Basin supplies a multitude of beneficial uses including the irrigation of extensive agricultural lands, a domestic water supply for ~~one of~~ the most populated states in the union, instream use for aquatic habitat, and recreational opportunities. The basin is therefore a vital resource for the state's economy, the well being of its citizens and the health of its natural environment. The Sacramento River's largest natural tributary is the Feather River, which originates in the Sierra Nevada and drains much of the eastern area of the Sacramento River Basin. Many smaller tributaries originate in the coastal mountains, and the Sierra Nevada. Wintertime flow in the basin is affected by reservoir releases, storm runoff, and diversions to by-pass channels used for flood control.

Fig1. Study area with location of the monitoring sites

The middle and lower reaches of the Sacramento River flow through the Sacramento Valley, which forms the northern part of California's prominent Central Valley. It is geographically continuous with the San Joaquin Valley to its south, but is defined by its distinct drainage basin. Beginning near the town of Red Bluff at its northern terminus, the valley stretches about 150 miles to the southeast were it merges into the broad expanse of the Sacramento-San Joaquin River Delta south of the Sacramento metropolitan area. The valley is 30 to 45 miles wide in the southern to central parts, but narrows to about 5 miles near Red Bluff. Its elevation decreases almost imperceptibly from 300 feet at its northern end to near sea level in the delta. The generally flat valley floor occupies about 5,000 square miles and is interrupted only by the abrupt profile of the Sutter Buttes, remnants of a volcano that pushed up through the valley floor during the last ice age 1.5 to 2.5 million years ago (Olmstead and Davis, 1961;Wood and Kienle, 1990).

The major land uses in the Sacramento River Basin are forestry, agriculture, urban, and mining. Agriculture is the dominant land use on the valley floor followed by urban development. The availability of water for irrigation during the normally dry summer months allows a wide variety of crops to be grown including rice, row crops, vineyards, and orchards (fig.2). Land once occupied by flood basins on either side of the Sacramento River is affected by shallow ground water and silty, poorly draining soils. Much of that area is planted in rice. Row crops and orchards requiring well-drained land are grown on soil derived from alluvial fans and the coarser soils associated with stream channels and elevated natural deposits that built up around the larger rivers and streams. About 2,300 square miles in the basin are devoted to agricultural use. Stone fruit and almond orchards occupy about 290 square miles, mostly in the northern and central parts of the valley (California Dept. of Water Resources, 1989, 1990,1993, 1994).

Fig 2. Land use in the Sacramento Valley

Most precipitation in the basin falls between the months of November through March, with the wettest month on average being January (see fig. 3). Mean annual rainfall on the valley floor tends to increase with latitude and elevation ranging from 15 inches in the Sacramento-San Joaquin Delta to 22 inches at Red Bluff (Rantz, 1969). In the high mountainous areas of the Sierra Nevada, precipitation averages 80 to 90 inches each year, primarily from heavy snowfall during the winter months.

Fig 3. Average monthly Precipitation, and monthly precipitation Dec 1999-March2000

Diazinon use in the study area

In the state of California, the location and quantity of agricultural and commercial pesticide applications must be reported to DPR. Data from DPR's Pesticide Use Database show that from late 1995 through the spring of 1999 between 74,700 and 96,000 pounds active ingredient (lbs. a.i.) were applied each year during the dormant spray season in the 10 counties that occupy the Sacramento Valley (fig.4). The average quantity of diazinon applied during that period was 82,000 pounds. The greatest use occurred in January and February. January was the month of highest use with 56 to 66 percent of the total seasonal application occurring in that one month (statistics derived from the California Department of Pesticide Regulation's Pesticide Use Database, 1999).

Fig 4. Diazinon use in the Sacramento Valley, California, during annual dormant spray seasons since 1995/96.

Study design and Methods

Selection of sampling sites

17 monitoring sites were chosen to evaluate the occurrence and transport of diazinon during the 1999/2000 dormant-spray season. Descriptions of individual sites are listed in Table 1 and their location shown on the map of the study area, figure 1. Site selection was based on the need for data from specific areas of the watershed, availability of stream flow data, accessibility during inclement weather, and the safety of field crews collecting samples. Consideration was also given to sites currently or historically monitored for pesticides or toxicity by other programs.

Table 1. Monitoring site names and locations.

Most sites were located on tributaries and drains where diazinon detections were expected because of upstream pesticide use. Many of the sites (site numbers 3-11, 15, and 16) were located in the Feather River and Butte Creek watersheds because of a lack of previous water-quality data from that area and the large acreage of almond, and stone-fruit orchards in these watersheds. Site 7, Gilsizer Slough at Bogue Rd., located downstream of Yuba City was chosen to represent possible urban sources of pesticides. Land use in the watershed upstream of site 7 was predominantly residential/commercial. Although there were a few acres of walnut orchards immediately upstream of the site, diazinon is not normally applied to this crop as a dormant spray and no applications are recorded in the DPR Pesticide Use Database during the monitoring period. Site 9, Yuba River at Marysville, was located near the mouth of the Yuba River. Although there is very little agricultural activity or urban development upstream of Site 9, the Yuba River is the largest tributary to the Feather River and contributes a significant proportion of its total stream flow.

A single site (site 2) was chosen to represent pesticide sources in the Colusa Basin Drain (CBD) located on the west site of the Sacramento Valley. The CBD flows into the Sacramento River near Knights Landing during periods of low flow in the Sacramento River, but winter runoff from the CBD is often diverted into the Yolo Bypass and enters the Sacramento River near its mouth 85 miles downstream. Previous studies indicated that the Colusa Basin Drain was probably not a significant source of diazinon to the Sacramento River.

Three sites (13,1, and 17) were located on the Sacramento River to evaluate pesticide contamination in the main-stem river environment and diazinon inputs to the Bay-Delta estuary. Site 13, Sacramento River at Colusa, was the furthest upstream and chosen to represent all potential sources from the northern portions of the watershed. Site 1, Sacramento River at Alamar, included additional sources from the Feather River, Butte Creek, and Natomas Cross Canal watersheds. Additional inputs from agricultural land downstream of Alamar and the northern parts of the Sacramento Metropolitan area are combined in the flows sampled at site 17, the site located furthest downstream in the study area.

Monitoring began during the first rainstorm that produced runoff after widespread application of dormant sprays had begun. Because dormant sprays are applied over a period of weeks or sometimes months, samples were collected during two additional rainstorms to better characterize pesticide transport during a large portion of the application period. Sampling for each storm event began just before or at the beginning of rainfall and continued for 5 consecutive days. Each five-day period allowed most of the storm related runoff, as defined by storm hydrographs, to be sampled yet avoided unsafe working conditions that could develop when field crews become tired and exhausted after a long and intensive sampling effort.

Individual sites were sampled at one of 3 sampling frequencies. Sites 1, 3, 4, 5, 8, 11, 12, 13, and 17 were sampled once each day throughout each storm event. Sites located on small watersheds with rapid flow response to runoff and historically high diazinon use were sampled more frequently. Sites 6a, 6b, 7, 10, 14, and 16 were assigned to this intensive sampling category and sampled multiple times each day of the sampling event to better define peak concentrations and loads. Sites 2, 9, and 15 were monitored to confirm the results of previous studies that determined they are not significant sources of pesticides. Samples at these 3 sites were collected daily during the first two days of each storm event, but less frequently thereafter.

Table 2. Sampling frequency at monitoring sites.

Sample collection methods

Water samples representative of the stream at the time of sampling were collected at most sites from bridges using a US series D-77 sampler. Depth integrated samples at a single point in the center of each channel was collected in a 3 liter PTFE (polytetrafluoroethylene) bottle mounted in the sampler. PTFE collection bottles were used to minimize contamination or loss of pesticide due to sorption to container walls. After vigorous mixing, subsamples were then poured into baked amber 1-L glass bottles fitted with PTFE lined caps. At site 3 and 5 (Feather River near Nicolaus and Bear River) water was collected from a boat at 7 to 10 points along the channel cross section. The total volume of water collected for each sample exceeded the capacity of a single 3 L bottle so water collected at each point in the cross section was poured into a PTFE lined stainless steel churn splitter (a device for mixing and sub-sampling composite samples, Capel and Larson, 1996) and the glass sample bottles filled from the splitter.

Because of extreme weather and high flows, sample collection protocol at the Bear River site was altered for 3 days during the second sampling event. On February 13 a grab sample was collected from the riverbank after an attempt to access the site by boat was unsuccessful. On February 14 and 15 very high flows and large amounts of debris moving down the channel required the field crew to minimize time spent collecting a sample from the boat. On those 2 days a grab sample was ~~collected by~~ submersing the churn splitter at a single point at the center of the channel before hastily retreating downstream to the relatively benign waters of the Feather River.

I applaud the literary license.

At sites 1, 8, and 11, grab samples were collected directly into the glass sample bottles from piers or the stream bank. Bottles were held at the end of a telescoping rod and submerged to a depth of one meter while filling. At site 17, a grab sample was collected from a bridge at a point near the center of the channel in a glass sample bottle strapped to a weighted cage suspended from a line. An autosampler (Isco®model 6700) was used to collect water at site 6a. The water intake (PTFE tubing with a stainless steel screen) for the autosampler was located midway in width and depth of the rectangular concrete channel at this site. Before each sample was collected, the intake tubing was purged of residual water and the sample then pumped directly into an individual glass bottle mounted in the autosampler.

Immediately after collection, sample bottles were placed in wet ice or in a refrigerated storage unit until delivery to a laboratory. Samples for the USGS lab were shipped on ice by overnight freight the day of collection. Samples for the local labs were delivered immediately after each 5-day sampling event. Between samples, PTFE collection bottles were rinsed in deionized water. The collection bottles and the churn splitter used at sites 3 and 5 were field washed with a non-phosphate detergent before rinsing with deionized water that had received additional treatment to remove organic material. At site 6a, the autosampler bottles were collected several times each day, capped and stored on ice.

Laboratory analytical methods

The majority of samples were analyzed using an enzyme-linked immunosorbent assay (ELISA) specific for diazinon. Gas chromatography (GC) methods were used to confirm ELISA results on 30 percent of the samples.

ELISA analyses were done on 412 environmental water samples collected at all sites except Sacramento River at Sacramento (site 17). The analyses were performed by the California Department of Food and Agriculture Center for Analytical Chemistry. The reporting limit for detection of diazinon using ELISA was set at 30 ng/L.

Filtered?

The California Department of Fish and Game Water Pollution Control Laboratory used gas chromatography coupled with an electron capture detector and thermionic specific detector (GC/ECD/TSD) to determine the concentration of diazinon and methidation in 107 environmental samples. For this method, the reporting limit for diazinon concentration was 20 ng/L.

Whole

31 samples from site 3 (Feather River near Nicolaus) and site 17 (Sacramento River at Sacramento) were analyzed by the U.S. geological Survey's National Water Quality Laboratory in Lakewood, Colorado using gas chromatography and mass spectrometry (GC/MS) operated in the SIM mode for selective identification and quantification of 41 pesticides and pesticide metabolites. Water samples were filtered through glass fiber filters with a 0.7 µm effective pore diameter and organic compounds isolated by C-18 solid-phase extraction prior to analysis by

GCMS (Zaugg and others, 1995). The reporting limit for diazinon concentration using this method was 2 ng/L.

Stage and Stream discharge measurement at sampling sites

The source of stream stage and discharge data for each sampling site is shown in table 2. Six of the sampling sites (1,9,12,13, 15, and 17) were located in close proximity to established USGS or DPR gaging stations, which provided continuous stream discharge data during the monitoring period. Data from USGS sites (sites 1, 9, 13, and 17) was reviewed and approved for release and is available on the web at http://water.usgs.gov/nwis. Data from DPR sites (12 and 15) is preliminary and available on the web at http://cdec.water.ca.gov/. Sites 4, 6a, and 6b were located just upstream of DPR pumping plants No.s 1 and 2 which pump water into the Sutter Bypass when the water level in the levied bypass is above the elevation of the surrounding land. Water levels were high in the bypass during the entire monitoring period so flows in the channels leading to the pumping plants were due only to operation of the pumps. Pumping records provided discharge data for sites 4 and 6b as well as partial records for discharge at site 6a. Discharge at site 6a was controlled by 2 of the 6 turbine pumps at Pump Plant No.2 as well as a broad crested weir separating the North Channel from Gilsizer Slough just downstream of the sampling site. To estimate the portion of the discharge flowing over the weir, a continuous stage recorder was installed at the site and a stage-discharge relationship (rating) developed for the weir based on theoretical computations. After a survey was made of the site, the rating was calculated using the critical-depth computation model WSPRO (Water Surface Profile

Computations) and equations based on dimensional analysis and empirically derived constants (Hulsing, 1967). Stage data and rating were then used to compute a continuous record of streamflow over the weir (Kennedy, 1983). Total discharge was calculated by combining the estimated flow over the weir with flow derived from pumping records. A single instantaneous measurement made during the sampling period using current meter methods (Rantz and others, 1982) was within 12 percent of the estimated discharge.

This is not a familiar term to me.

Continuous discharge at sites 3 and 5 was estimated by routing discharge recorded at upstream gaging stations to the sampling site and using instantaneous discharge measurements made at the sampling site to adjust the hydrograph for ungaged inputs to the rivers. Because flow in the Feather and Bear Rivers were much greater than ungaged tributaries, stage relations at a series of downstream stage recorders could be used to measure flood wave travel time to the sampling sites (Linsley and others, 1958). For site 5, discharge recorded at Bear River near Wheatland, was ~~routed~~ assumed equal to the mouth of the Bear River 13 miles downstream. Local inputs between the gage near Wheatland and the sample site included Yankee Slough, Algodon Slough, and Dry Creek.

Discharge at site 3, Feather River near Nicolaus, was estimated by ~~routing~~ summing measured flow from the gage at Feather River near Gridley (40 miles upstream), Yuba River near Marysville (42miles upstream), and the estimated flow from the mouth of the Bear River (2 miles upstream). Ungaged flow to the Feather included Honcutt Creek and Jack Slough. Stage gages used in the analysis included Feather River at Yuba City, Feather River at Live Oak, and Feather River at Boyd's Landing. Instantaneous measurements of discharge were made on all sampling days except February 13. An Acoustic Doppler Current Profiler (ADCP) mounted on the sampling

Ungaged flows from small tributaries representing "__%" of the watershed were not included.

boat was used was used to determine water depth and velocity. Differential GPS or the bottom tracking function of the ADCP was used to determine horizontal position and cross-section widths. Discharge was calculated using the software program Transect™ version 4.0 from RD Instruments, Inc., the maker of the ADCP. The ADCP measures the Doppler frequency shift of reflected sound waves (propagated by the instrument at a frequency of 600 KHz) to determine the speed and direction of moving water. The technology allowed the field crew to make measurements in difficult high flow conditions that would have prevented more traditional current meter measurements.

Only stage (water surface elevation) data was available for sites 7, 8, 10, 11, 14, and 16. Stage gages at sites 8, 10, and 14 are operated by DWR as part of their flood control network. Stage recording equipment was installed at sites 7, 11, and 16 for the duration of the monitoring study. Backwater conditions at high flows preclude measuring stream discharge using simple stage-discharge relationships at all these sites with the exception of site 8. Site 8 would require periodic discharge measurements to be made at the site to allow a discharge record to be computed. Neither flow or stage data was available for site 2 at the Colusa Basin Drain.

Load calculation methods

Diazinon loads are the quantity of diazinon (mass) flowing past a sampling site over a period of time. Concentrations are dependent on both the mass of material and its dilution at the point of sampling. Load calculations effectively remove the effect of dilution and allow direct comparison of the quantity of diazinon transported downstream from different sites.

Instantaneous loads at the time of sampling were calculated by multiplying the measured concentration by the discharge at the time of sample collection and a unit conversion term. For example:

Concentration (ng/L) x Discharge (cfs) x 0.002447 = Load (g/day)

For sites where discharge data was available at every hour or 15-minute interval throughout each storm event, loads were calculated for each time interval using estimates of concentration derived from a linear extrapolation between known concentrations. For sites 1, 3, 5, 13, and 17, where one sample was collected each day, concentrations were extrapolated over a period of about 24 hours duration. At sites on smaller streams and canals where concentrations and flows may change rapidly, multiple samples were collected each day and concentrations were extrapolated over a number of hours depending on sampling frequency.

Total loads during each 5-day storm event were estimated by summing the hourly or 15-minute loads for the entire period. All load values are presented in units of grams/day or Kg/day.

Quality Assurance and Quality Control

The reliability of field and laboratory methods used in this study was assessed using a variety of blanks, spiked samples, and analysis of split samples by separate laboratories using different methods of analyses.

Possible contamination of environmental samples during the entire process from sample collection to laboratory analysis was evaluated by analyzing blanks made from deionized water that had passed through all sample collection equipment and collection bottles before being poured into sample bottles and stored alongside environmental samples. 12 such blanks were made at random times throughout the monitoring period and analyzed by ELISA. No diazinon was detected in any of these blank samples.

Another 50 blanks were prepared by pouring deionized water directly into sample bottles at the same time that environmental samples were being processed in the field. These blanks were used to evaluate possible contamination from all sources except sampling equipment and collection bottles. Diazinon concentrations in all of these randomly distributed samples were below detection levels of the ELISA analysis. Blanks accompanied 15 percent of all environmental samples submitted for analysis. Data from blank analyses do not indicate a problem with sample contamination resulting from site to site carryover or other possible sources.

The bias and variability of laboratory analyses were evaluated using spiked samples. Blind spikes were made by adding a known quantity of diazinon to split replicates of environmental

Matrix spikes

samples before submitting them for analysis along with regular samples. These samples were not identified as spikes to the analyst and thus were treated in the same manner as regular environmental samples. Diazinon concentrations were 100 or 500 ng/L in 14 blind spikes analyzed by ELISA. Percent recovery of diazinon ranged from 111 to 161 percent with an average of 130 percent. In 4 blind spikes analyzed by GC/ECD/TSD, diazinon concentrations were set at 100, 500, or 1000 ng/L. Recovery ranged from 53 to 102 percent with an average of 87 percent. Deviations from 100 percent recovery represent bias and variability of laboratory methods as well as matrix effects caused by the interference of organic materials other than the analyte that may be present in the environmental water samples.

Reagent spikes are used in the laboratory to monitor the system performance of the analytical process. They are analyzed in between small sets of environmental samples to determine that analytical instruments are in calibration and functioning correctly. Nineteen reagent spikes were analyzed by the CDFG lab using GC/ECD/TSD during their analysis of environmental samples for this project. These spikes were made by adding diazinon to American River water to concentrations of 100, 200, or 500 ng/L. Diazinon recoveries from these spikes averaged 85 percent with a standard deviation of 11percent. 54 reagent spikes were analyzed by GC/MS along with samples sent to the USGS lab. These spikes were made by adding diazinon to laboratory reagent water. Recoveries averaged 98 percent with a standard deviation of 18.

A single replicate analysis of an environmental sample was submitted for analysis by ELISA. Diazinon concentration was 542 ng/L in the environmental sample and 502 ng/L in the replicate.

These values are within the range of acceptable variation (control limits) determined by the laboratory.

Split replicates of 117 environmental samples were analyzed by both ELISA and GC methods. There was a significant and consistent bias observed between the two methods of analyses. Concentration values from ELISA analyses were consistently higher than values from both GC/ECD/TSD and GC/MS analyses. The coefficient of determination (r^2) value for a linear regression of the entire data set of paired values was 0.98 indicating a good correlation and a consistent bias between the two analyses. The difference between concentrations measured by ELISA and GC, averaged 85 (median 83) percent above GC analysis values over the entire range of observed concentrations. At concentrations of 80 ng/L or less, the relative difference between the ELISA and GC analysis tended to be slightly lower averaging about 60 percent. The regression trend line in figure 5 illustrates the positive bias of the ELISA values. An unbiased analysis would plot close to the 1:1 line on the graph.

Avg. Bias in the blanks was 50%

The large bias observed during this study was not apparent in an extensive method performance evaluation completed prior to the study (Sullivan and Goh, 2000) although there was some positive bias between ELISA tests and confirmatory GC analyses on runoff water samples. Sullivan and Goh suspected that the bias they observed in runoff water might be due to cross-reaction with diazoxon, or an unknown metabolite in the water matrix. Diazoxon, however, has not been detected in surface water in the study area (Domagalski, 1996), or in municipal wastewater treatment plant effluent with detectable diazinon concentrations (USEPA, 1999).

Bias was also not evident in a 1994 study of dormant spray season diazinon sources in which water samples collected in the same general study area were analyzed by both ELISA and GC/MS analysis (Holmes and others, 2000).

There is no clear explanation of the observed bias between the two analytical methods used in this study. Although recovery rates for GC analyses tended to be less than 100 percent, the recovery rate alone does not account for the large discrepancy between ELISA and GC analyses. The higher than expected concentrations provided by the ELISA analysis may be due to factors such as interference caused by the physical presence of particulate matter in the unfiltered samples that were used in the analysis, or chemical cross-reactions with compounds other than the targeted pesticide in the water samples.

Although there were only 7 samples analyzed by both GC/ECD/TSD and GC/MS, concentrations between the 2 methods were in close agreement in all but one sample. The average difference was 11 percent. Because ELISA methods for diazinon are relatively new and GC methods have been widely used and proven over the years and because of the confidence provided by the confirming analysis of spiked samples, GC analyses will be considered the more accurate method when interpreting data for this report.

→ Conclusions should be based on DQO's for % recovery & whether DQOs were met?

Fig 5. Plot of diazinon concentration by ELISA vs. GC/ECD/TSD

Hydrologic conditions during the study period

Although the total rainfall for the 1999/2000 dormant spray season was very near average, precipitation during individual months departed from the normal seasonal pattern (figure 3). Most of December and January were unusually dry. Dormant sprays may damage trees if humidity in the orchards is low, so the dry weather hindered pesticide application in the early part of the season. Winter storms began to move into the Valley in late January, bringing that months rainfall totals to near normal. February was unusually wet. The city of Marysville, which is centrally located in the study area, receives an average of 3.15 inches of rain in February. The area was inundated with 10 inches of rain in February 2000.

Flows in the smaller tributaries generally reflect local storm runoff during the winter months after irrigation decreases in the fall. Flows in the Sacramento, Feather, Yuba, and Bear Rivers are largely controlled by reservoirs above the Valley floor. Large volumes of water were released from these rivers in February in response to storm runoff in the upper watersheds. Hydrographs at sites located on the Sacramento, Feather, and Bear Rivers tend to be dominated by these reservoir releases, which are determined by downstream flood and reservoir management concerns and thus may not always correspond well to actual storm runoff patterns and flow volumes.

Pesticide use during the winter of 1999-2000

Records from pesticide applicators sent to DPR documenting applications made from December 1999 to March 2000 (written communication and digital data, DPR) indicate that diazinon use in the Sacramento Valley during the 1999/2000 dormant spray season was significantly lower than in previous years (Figure 4). The pesticide use data for the 1999/2000 dormant spray season used in this report is preliminary and subject to revision after full review by DPR. While processing the data we have attempted to eliminate large and obvious errors. Although final values may change, they are not expected to change significantly for the purposes of this report.

The current records document 33,800 lbs. a.i. of diazinon applied in the basin by registered applicators, an amount 41 percent less than the average application of the previous 4 dormant spray seasons. Much of the decrease was due to a reduction of use in almond orchards, where applications were only about 19 percent of the amount applied the previous winter (table 3). Diazinon use in prune orchards was also significantly lower at 59% of the previous years level. The decrease in use may be due in part to recent low market prices for these commodities. During periods of depressed market prices, pesticide use may not be cost effective since the increased production resulting from the use of pesticides may not offset the cost of the applications.

Table 3. Pesticide applications by crop type.

The majority of diazinon use occurred from late January through February. Bar charts in figure 6 shows the daily application amounts during the dormant spray season for selected subbasins in the Sacramento River watershed. Between December 1 and the first significant rain storm of the season on January 24, only 5,900 lbs a.i. had been applied to the drainage basin above site 17 (Sacramento R at Sacramento). After the January 24 storm, conditions for dormant spraying improved and diazinon applications increased. Between Jan 25 and the end of the monitoring period on February 25, 23,607 lbs a.i. had been applied. At the tail end of the dormant spray season, between the end of the monitoring period and March 31, 3,000 additional lbs a.i. of diazinon were applied.

In order to determine diazinon use within individual subbasins, pesticide use data was incorporated into a GIS coverage (ARC-INFO) of the study area and the data segregated into those subbasins with known boundaries. Figure 6a shows the general timing of applications throughout the dormant spray season since this site (number 6, Sacramento River at Sacramento) includes application data from the entire study area.

Pesticide applications upstream of these monitoring sites during 4 time periods related to the monitored storm events are summarized in table 4. Period 1 includes all applications made between January 1 and the end of the first monitoring period on February 3. Although there was some agricultural use of diazinon in December, the amount was relatively small and sufficient time had elapsed between those early applications and the first monitored storm at the end of January for significant degradation and loss of applied diazinon. Period 2, and 3 include applications made after the previous monitored storm through the end of the second and third monitored storms. Period 4 covers the time between the third monitored storm and the end of the dormant spray season.

Maps shown in figure 6 show the areal distribution of registered diazinon applications within the selected subbasins from December through March. Application quantities are plotted on the maps at the section level of the Public Lands Survey System.

Table 4. Pesticide use for selected subbasins during 4 time periods in the 1999/2000 dormant spray season.

Figure 6. Temporal and special distribution of diazinon applications in selected subbasins of the Sacramento Valley, CA.

Concentrations of diazinon observed during storm events

Diazinon concentrations measured in the study are plotted along with stream discharge or stage if no discharge was available in figure 14. Sites 2 and 9 are not included. Neither discharge nor stage was available for site 2 (Colusa Basin Drain) and site 9 (Yuba River) had no detectable pesticides in any of the samples.

Fig 14. Plots of diazinon concentration and stream discharge (or stage) over the monitoring period.

Because of the positive bias observed in the ELISA analyses relative to GC methods in this study, the ELISA data may over estimate actual concentrations measured in the environment. Because the bias is consistent, the data is useful in judging the relative differences between samples collected at different times during a storm event and the relative difference between sites.

With few exceptions the highest concentrations were observed during the first large storm of the dormant spray season even though the first storm was not the largest in terms of total rainfall. This "first flush" washed off pesticides that had accumulated since the beginning of the dormant spray season. The period before and during the first storm was also the period when the largest quantity of diazinon was applied (Table 4). Another factor influencing the high concentrations observed in the first storm were the relatively low flows in the Sacramento, Feather, and Bear Rivers. Because upstream reservoir releases were low during the first storm, there was less dilution of agricultural and urban runoff than in later storms when reservoir releases increased dramatically. The 2 greatest exceptions to this trend were at site 4 (DPR Pump Plant 1) and site 16 (Main Canal). Because the boundaries of the subbasins upstream of these sites have not been defined, it is unclear whether the low concentrations observed during the first storm are due to low applications or are characteristics of the basins that resulted in restricted transport from sources to monitoring sites during the initial storm.

Boxplots of data aggregated by storm (figure 15) show that overall the concentrations during the first and second storm were not greatly different from one another. Median concentrations in samples analyzed by ELISA were 174, 159, and 55 ng/L for storms 1, 2, and 3. Median concentrations of samples analyzed by GC methods were 57, 44, and 22 for storms 1, 2, and 3.

50 ng/L

Sites receiving mostly agricultural or urban drain water had the highest concentrations of diazinon. The State of California is ~~considering~~ establishing acute and chronic criteria for the protection of aquatic habitat at 80 and 40 ng/L. All samples collected at agricultural sites 6b, 10, 11, and 16 as well as site 7, which drains the Yuba City urban watershed, were above 80 ng/L (GC analyses). Out of a total of 138 samples analyzed by GC methods 55 percent were over 40 ng/L and 30 percent were greater than 80 ng/L.

Not appropriate comparison, since 40 ng is a 4-day avg.

The median concentration of diazinon in the 16 samples analyzed by GC/MS at site 17 (Sacramento River at Sacramento) was 27 ng/L with a range of 12 to 67 ng/L. The USGS Toxic

Contaminants Hydrology Program did extensive monitoring at site 17 from 1991 through 1994 (MacCoy and others, 1995). Samples for that study were collected once or twice daily during periods of high flow. During the 3 dormant spray seasons (December through March) in that time period median concentrations were 23, 37, and 39 ng/L with maximum concentrations of 155, 393, and 253 ng/L.

The median concentration of diazinon in samples collected at site 3 (Feather River near Nicolaus) and analyzed by GC was 36 ng/L with a maximum of 130 ng/L. In 1994 a dormant spray monitoring study directed by the SWQCB included a site adjacent to site 3. Eleven samples from that site were analyzed by GC/MS. The median concentration was 180 ng/l with a maximum concentration of 782 ng/L. These comparisons suggests that diazinon concentrations observed during the 1999/2000 dormant spray season were lower than previous years, perhaps due to the relatively low diazinon use.

Fig 15. Boxplots of diazinon concentration by storm event.

Fig 15. Boxplots of diazinon concentration by site.

Measured and estimated loads at monitoring sites

Storm period loads using ELISA analyses were calculated for sites 1, 3, 4, 5, 6a, 6b, 13, and 15 (figure 17, table 5). Because these loads were derived from samples analyzed by ELISA, they are presented here only for site-to-site and storm-to-storm comparison. At sites 3 (Feather River near Nicolaus) and 17 (Sacramento River at Sacramento) a sufficient number of samples were analyzed by GC/MS to estimate loads based on those analyses. These loads are estimates of the actual mass transport of diazinon passing through the rivers at those two sites (table 6).

Table 5. Storm loads calculated using data from ELISA analyses.

Figure 17. Storm loads calculated using data from ELISA analyses.

Table 6. Storm loads calculated using data from GC/MS analyses.

Total loads in the Sacramento River at the mouth of the Feather River during the 3 monitored storms were estimated to be about 80,000 grams using ELISA data. The value was derived by summing the estimated loads entering that reach from sites 13, 3, 4, 6a, 6b, and 12. The watershed upstream of site 13 (Sacramento River at Colusa) appears to contribute about 1/2 of the total diazinon load to the Sacramento River at the Feather River. About 1/4 of the total storm load appeared to come from the Feather River. Butte Slough contributed about 1/6 and the 2 DPR pumping plants on the Sutter Bypass added about 1/16 of the total mass of diazinon. A large portion of the water flowing through Butte Slough during the second and third storm events (86 percent of the volume) was Sacramento River water that had been diverted to the slough by way of the Moulton and Colusa weirs located upstream of the city of Colusa (site 13). An unknown portion of the loads from the slough during those periods may have originated in the upper reaches of the Sacramento River.

The estimated storm loads at site 1 (Sac R at Alamar) are consistently lower than the sum of estimated loads upstream by 25,16, and 25 percent for events 1, 2, and 3. Although some flows were diverted from the Sacramento River to the Yolo Bypass 10 miles upstream of Alamar, the diversions during the first and second storm events do not appear to be enough to account for all the difference. Provisional stream flow records indicate that only about 5 percent of the flow was diverted during the first 2 events. Diversions increased substantially during the third event to about one half the flow at Alamar. Another source of error that could lead to underestimation of loads at Alamar is related to the timing of sample collections. As a pulse of material entrained in flowing water moves down channel, it tends to attenuate and elongate because of differences in water velocity throughout the channel. In the case of storm runoff, steam flow also tends to lag due to the effect of channel storage as water levels rise and fall. The mass of diazinon that passed by upstream sites in each 5-day sampling period may have taken more than 5 days to pass through the lower sites. The convention of assigning a concentration of 1/2 the detection limit to samples below the detection limit when computing loads, may also have contributed to underestimating loads, particularly in the last sampling event when diazinon concentrations in many samples from the Sacramento River were below the relatively high detection limits of the ELISA analysis.

Estimates of actual storm loads using data from GC/MS analyses are available for 2 sites. 16,000 grams of diazinon were transported down the Feather River at site 3 and 60,000 grams moved down the Sacramento River at site 17. The later represents the contribution from all sources upstream of the city of Sacramento minus an unknown portion of the upstream loads diverted to the Yolo Bypass.

Relation of loads to pesticide use

In general diazinon loads increased with use in the watershed. Figure 18 shows the relation between use and total storm loads in the 4 subbasins in which both pesticide use and loads were known. The loads shown are the sum of the 3 monitored storm events based on ELISA analyses.

Figure 18. Diazinon load in relation to use in 4 subbasins.

Estimates of the fraction of applied diazinon transported to the Feather and Sacramento Rivers were made by dividing storm loads calculated using GC/MS data at sites 3 and 17 by the mass of diazinon applied upstream in the period before and during the monitored storm events (table 4). Diazinon transported to the Feather River (site 3) during the 3 storm events ranged between 0.3 and 1 percent of the applied pesticide with a total for the monitoring period of 0.5 percent. Diazinon transported to the Sacramento River at Sacramento (site 17) ranged from 0.2 to 1 percent in individual storms with a total for the monitoring period of 0.5 percent. Because some of the load was diverted to the Yolo Bypass upstream of Sacramento, the fraction may be slightly higher than this estimate suggests.

These values are similar to estimates of 0.5 to 1.7 percent of applied diazinon transported to the Sacramento River based on data collected in 1993 in the study reported by Kuivila and Foe, 1995, but are higher than estimates made for rivers in the San Joaquin Valley by Kratzer, 1997. Kratzer estimated that about 0.05 percent of the total applied diazinon was transported to the San Joaquin River during 2 storms monitored in 1994. The values derived for the Sacramento Valley, however, are consistent with estimates from other parts of the United States. Diazinon fluxes to 7 rivers in the Mississippi River Basin during 1991 were estimated to be between 0.08 and 20 percent with a median value of 0.13 percent (Larson and others, 1995). The high values in some rivers may have resulted from significant urban use that was not accounted for in pesticide use records of agricultural applications.

Summary

A portion of the diazinon applications made to orchards and urban areas during the winter months in the Sacramento Valley of California is transported to streams and agricultural drains in storm runoff.. Diazinon concentrations in the Sacramento and Feather Rivers exceed proposed criteria for short periods of time close to peak storm flows. Concentrations ranged from below detection to 2890 ng/L with a median of 44 ng/L. 30 percent of the samples had concentrations greater than 80 ng/L, the value being considered by the state of California as its Criterion Maximum Concentration for the protection of aquatic habitat. Concentrations were highest in small tributaries and canals draining subbasins with predominantly agricultural land use and in a channel draining Yuba City.

Load estimates indicate that about 30 percent of the diazinon in the lower Sacramento River is introduced from the Feather River Basin. The source of over half the total load measured above the city of Sacramento appears to have originated in the portion of the drainage basin upstream of the city of Colusa.

About 12,493 Kg of diazinon were reported applied to agricultural land in the Sacramento Valley just before and during the monitoring period. About 0.5 percent of the applied insecticide (60 Kg) appeared to be transported to the lower Sacramento River during the period of monitoring. A similar percent of applied diazinon was estimated to have entered the Feather River from upstream sources.

Diazinon use in the study area during the year 1999/2000 dormant-spray season was unusually low, less than half the average of the previous 4 years. Peak concentrations observed during the study were lower than those recorded in previous monitoring. Concentrations and loads in years with more average use may be greater than the levels observed in this study.

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Tables

Table 2. Sampling frequency and source of streamflow data.
[NA, not available; –, no sample taken]

Site Number	Site Name	Sampling Frequency for Each Storm Event		Source of Flow Data
		Diazinon by ELISA	Pesticide Scan by GC/ECD/TSD or GC/MS	
1	Sacramento River at Alamar	1 sample/day x 5 days	1 sample/day x 4 days	USGS gaging station: Sacramento River at Verona, CA
2	Colusa Basin Drain at Rd. 99E nr Knights Landing	1 sample/day x 2 days	–	NA
3	Feather River at Nicolaus	1 sample/day x 5days	1 sample/day x 5 days	Estimated using daily Instantaneous measurements and routed flow from upstream gages[1]
4	DWR Pumping Plant #1	1 sample/day x 5 days	1 sample/day x 4 days	DWR pumping records
5	Bear River near Berry Road	1 sample/day x 5 days	1 sample/day x 2 days	Estimated using daily Instantaneous measurements and routed flow from upstream gage[2]
6a	DWR Pumping Plant #2, north channel	3-6 samples/day x 5 days	1 sample/day x 1 day	DWR pumping records and project stream gage
6b	DWR Pumping Plant #2, south channel	3-6 samples/day x 5 days	1 sample/day x 2 days	DWR pumping records
7	Gilsizer Slough at Bogue Road	3-6 samples/day x 5 days	1 sample/day x 1day	NA
8	Feather River at Yuba City	1 sample/day x 5 days	1 sample/day x 3days	NA
9	Yuba River at Marysville	1 sample/day x 2 days	1 sample/day x 1day	USGS gaging station:Yuba River near Marysville
10	Wadsworth Canal at South Butte Road	1-7 sample/day x 5 days	1-2 samples/day x 1-3days	NA
11	Jack Slough at Doc Adams Rd	1 sample/day x 5 days	1 sample/day x 3days	NA
12	Butte Slough at Lower Pass Road	1 sample/day x 5 days	1 sample/day x 3days	DWR gaging station: Butte Slough near Meridian
13	Sacramento River at Colusa	1 sample/day x 5 days	1 sample/day x 3days	USGS gaging station: Sacramento River at Colusa
14	Butte Creek at Gridley Road	1-6 sample/day x 5 days	1 sample/day x 2days	NA
15	Cherokee Canal at Gridley Road	1 sample/day x 2 days	1 sample/day x 1day	DWR gageing station: Cherokee Canal near Richvale
16	Main Canal at Gridley Road	1-6 sample/day x 5 days	1 sample/day x 1day	NA
17	Sacramento River at Sacramento	–	1 sample/day x 5-7 days	DWR gageing station: Sacramento River at I Street

[1]Feather River near Gridely (DWR), Yuba River near Marysville (USGS) and, estimated flow from Bear River near Berry Rd.
[2]Bear River near Wheatland (USGS)

Table 3. Diazinon applications reported for selected crops and other uses in the Sacramento Valley, California in pounds active ingredient.

Crop	1998/99 Dormant Spray season	1999/2000 Dormant Spray season	Percent of previous year
Almond	29816	5543	19%
Peach	7273	6374	88%
Prune	28958	17187	59%
Apple	363	212	58%
Walnut	251	0	–
Cherry	0	383	–
Structural	0	370	–
Other uses	438	427	97%
Total	67099	30496	45%

Table 4. Diazinon use in selected subbasins during 4 time periods in the 1999/2000 dormant spray season.

			Period 1 (1/1/00-2/3/00)		Period 2 (2/4/00-2/15/00)		Period 3 (2/16/00-2/25/00)		Period 4 (2/26/00-3/31/00)	
Basin, subbasin or site name	Site No.	Basin Area	Pounds Applied	Application area (sq. miles)	Pounds Applied	Application area (sq. miles)	Pounds Applied	Application area (sq. miles)	Pounds Applied	Application area (sq. miles)
Sacramneto River at Colusa	13	12,255	4,991	23	505	4	267	6	876	12
Sacramento River at Alamar/Verona	1	21,463	17,152	123	5,806	36	4,668	30	2,988	14
Sacramento River at Sacramento	17	23,698	17,152	123	5,806	36	4,668	30	2,988	14
Feather River at Nicolaus	3	5,883	3,566	24	2,306	11	670	2	85	2
Feather River at Yuba	8	3,928	2,205	14	1,320	6	670	2	85	2
Jack Slough	11	72	1,023	7	448	3	0	0	40	1
Bear River	5	575	876	5	119	1	0	0	0	0
Butte Creek	14	590	956	9	0	0	0	0	607	1
Colusa Basin Drain	2	1,635	1,086	12	172	1	433	6	1,125	3
Total			49,008		16,483		11,377		8,792	

Table 5. Diazinon storm loads calculated using data from samples analyzed by ELISA.

[All values in grams.]

Site	Event 1	Event 2	Event 3
5 - Bear River nr Berry Rd.	2,049	2,707	1,687
12 - Butte Slough at Lower Pass Rd.	3,435	4,899	<4,438
4 - DPR Pumping Plant 1	147	1,720	381
6a - DPR Pumping Plant 2 North	110	262	71
6b - DPR Pumping Plant 2 South	414	606	324
3 - Feather River at Nicolaus	8,355	7,512	5,601
13 - Sacramento River at Colusa	22,055	13,177	6,046
1 - Sacramento River at Alamar	25,536	23,699	12,601

Table 6. Diazinon use and storm loads caluculated using samples analyzed by GC/MS.

Pesticide use and storm loads

Site	Event 1 (Applications from Jan 1- Feb 3)		
	Pesticide use (Kg)	Event load (Kg)	Percent difference
Feather River nr Nicolaus	1618	5	0.31
Sacramento River at Tower Bridge	7780	17.5	0.22
	Event 2 (Applications from Feb 4 - 15)		
	Pesticide use (Kg)	Event load (Kg)	Percent difference
Feather River nr Nicolaus	1046	8	0.76
Sacramento River at Tower Bridge	2595	27.6	1.06
	Event 3 (applications from Feb 16-25)		
	Pesticide use (Kg)	Event load (Kg)	Percent difference
Feather River nr Nicolaus	304	3	0.99
Sacramento River at Tower Bridge	2117	14.8	0.70
	Total (applications from Jan 1 - Feb 25)		
	Pesticide use (Kg)	Event load (Kg)	Percent difference
Feather River nr Nicolaus	2967	16	0.54
Sacramento River at Tower Bridge	12493	59.9	0.48

Figures

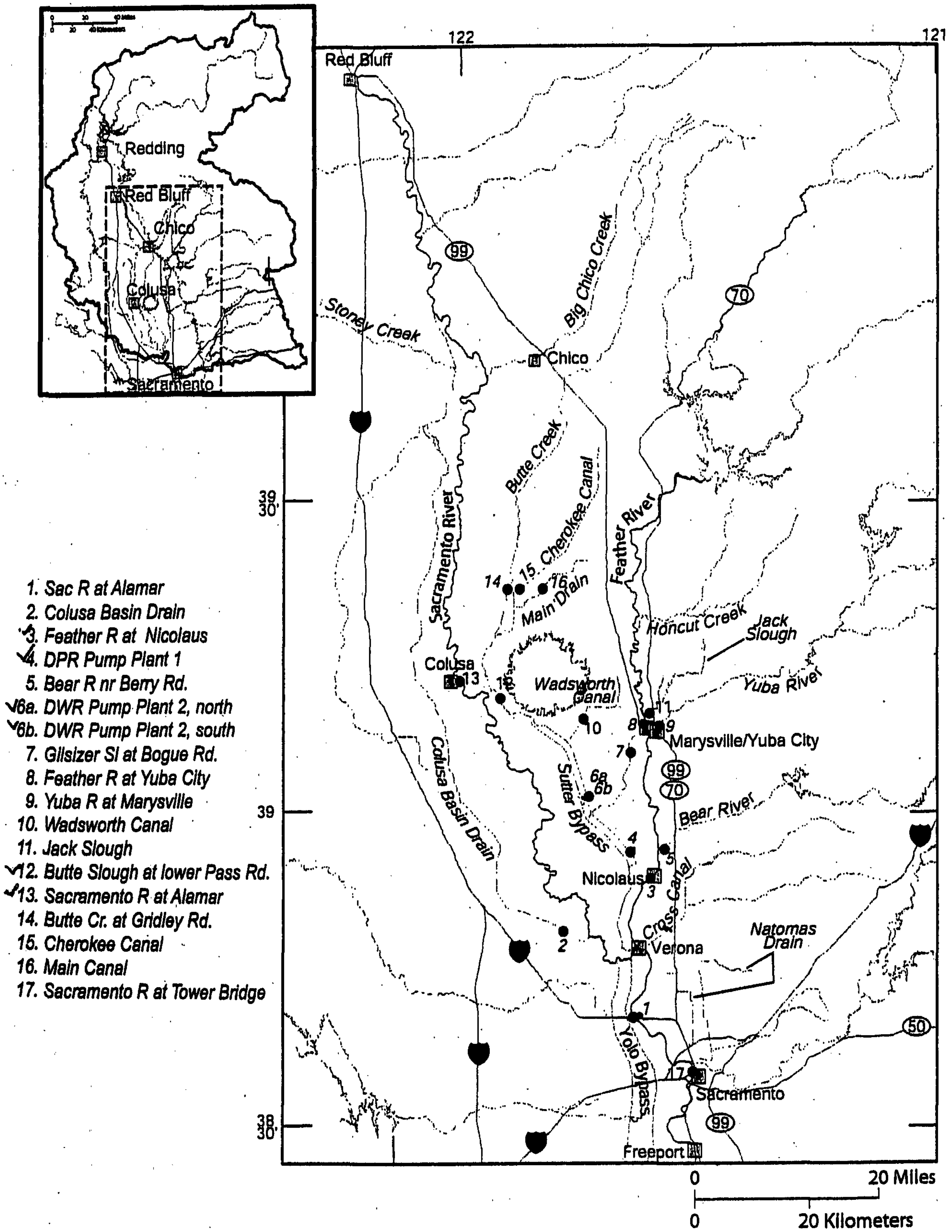


Figure 1. Location of sampling sites in the Sacramento River Basin, California

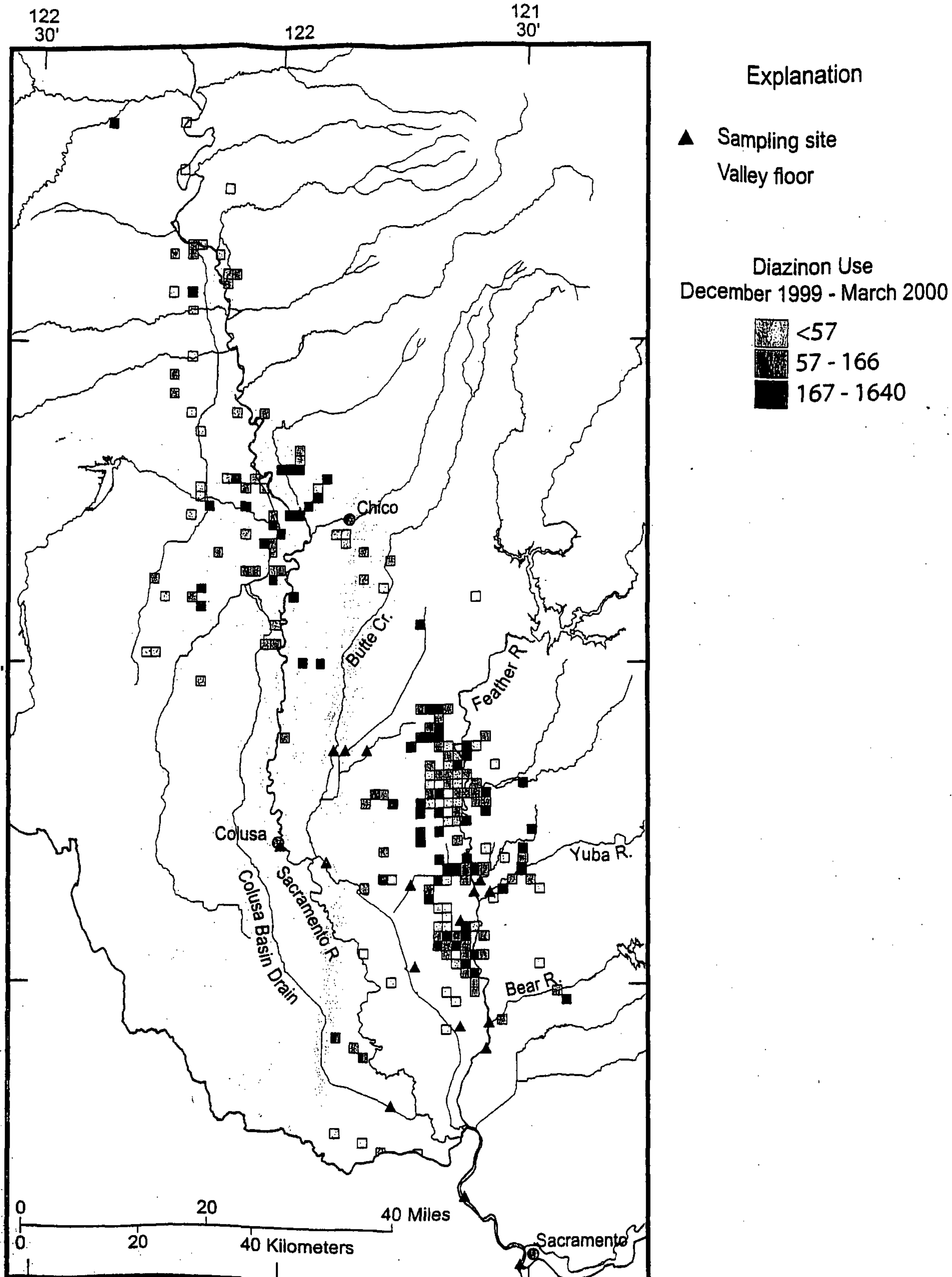


Figure 6. Diazinon use upstream of site 17, Sacramento River at Sacramento. (B). Areal distribution of applications within the subbasin

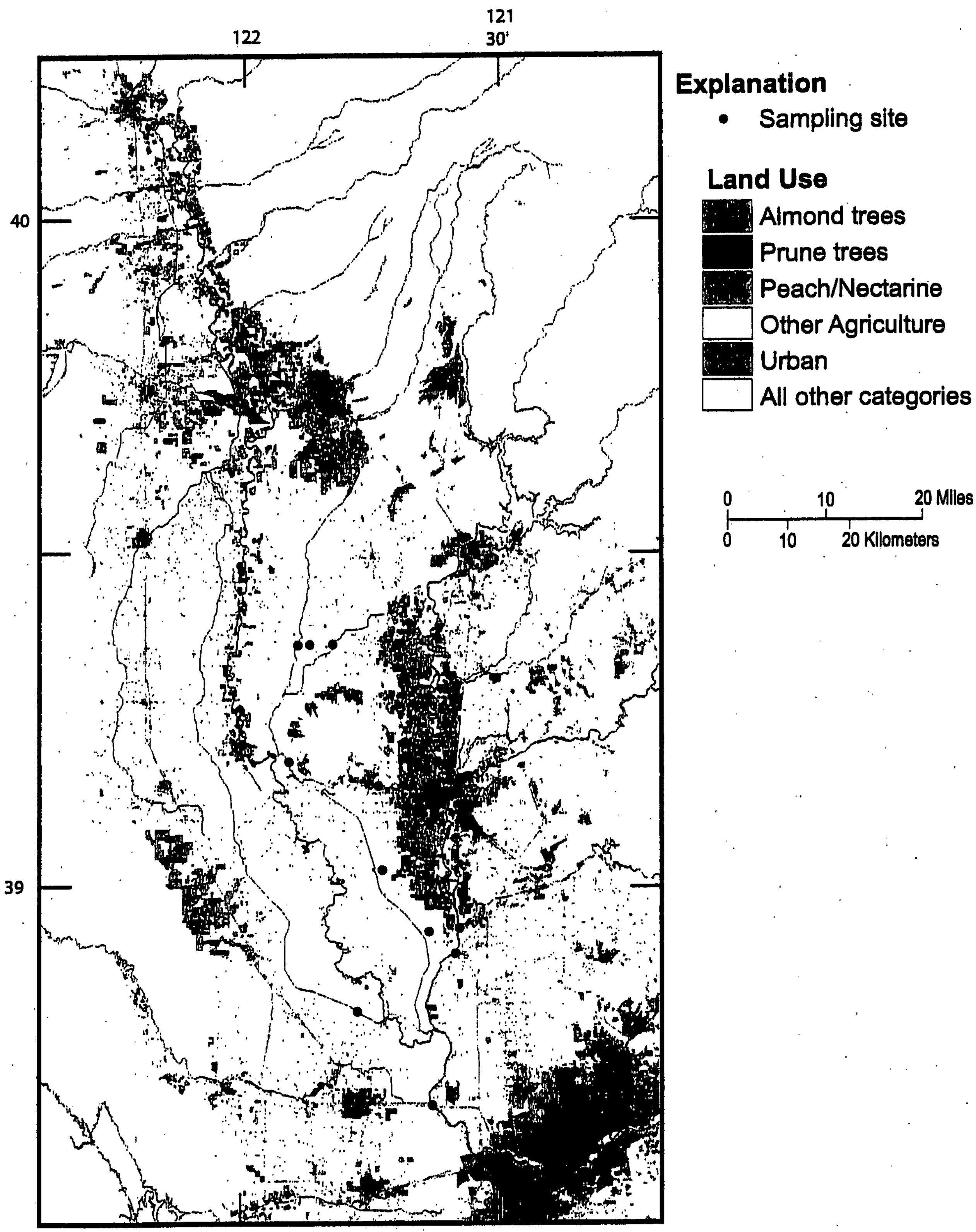


Figure 2. Land use in the Sacramento Valley, California.

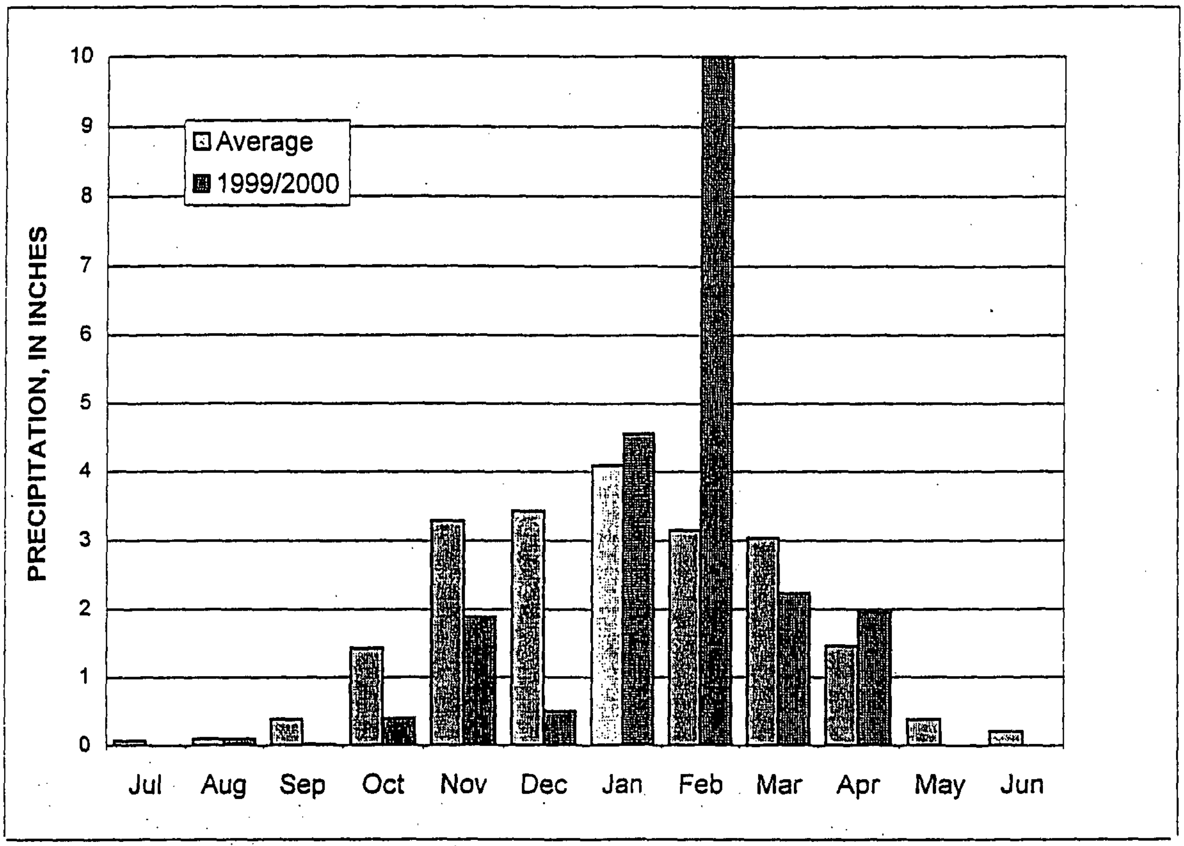


Figure 3. Monthly precipitation recorded at Marysville. California. Average values are based on data collected from 1961 through 1990 (NOAA Annual Summary for California, 1999)

sac_pest-precip.xls

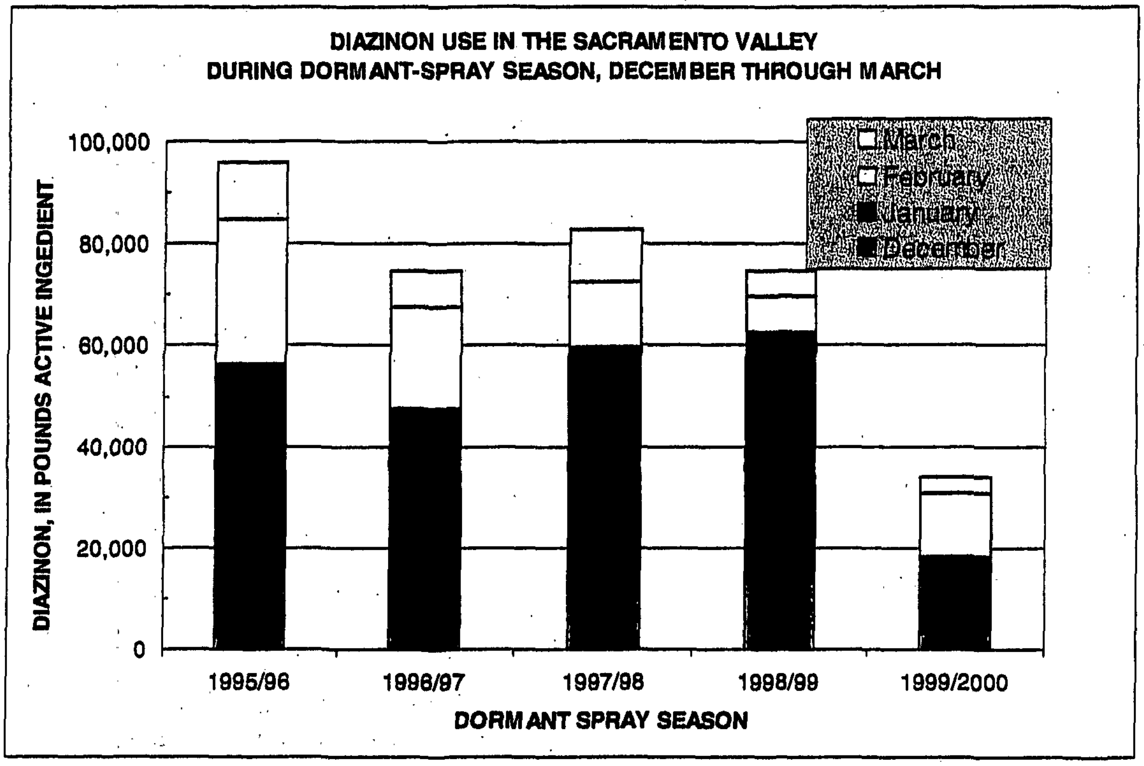


Figure 4. Diazinon use in the Sacramento Valley during dormant spray seasons from 1995 through 2000.

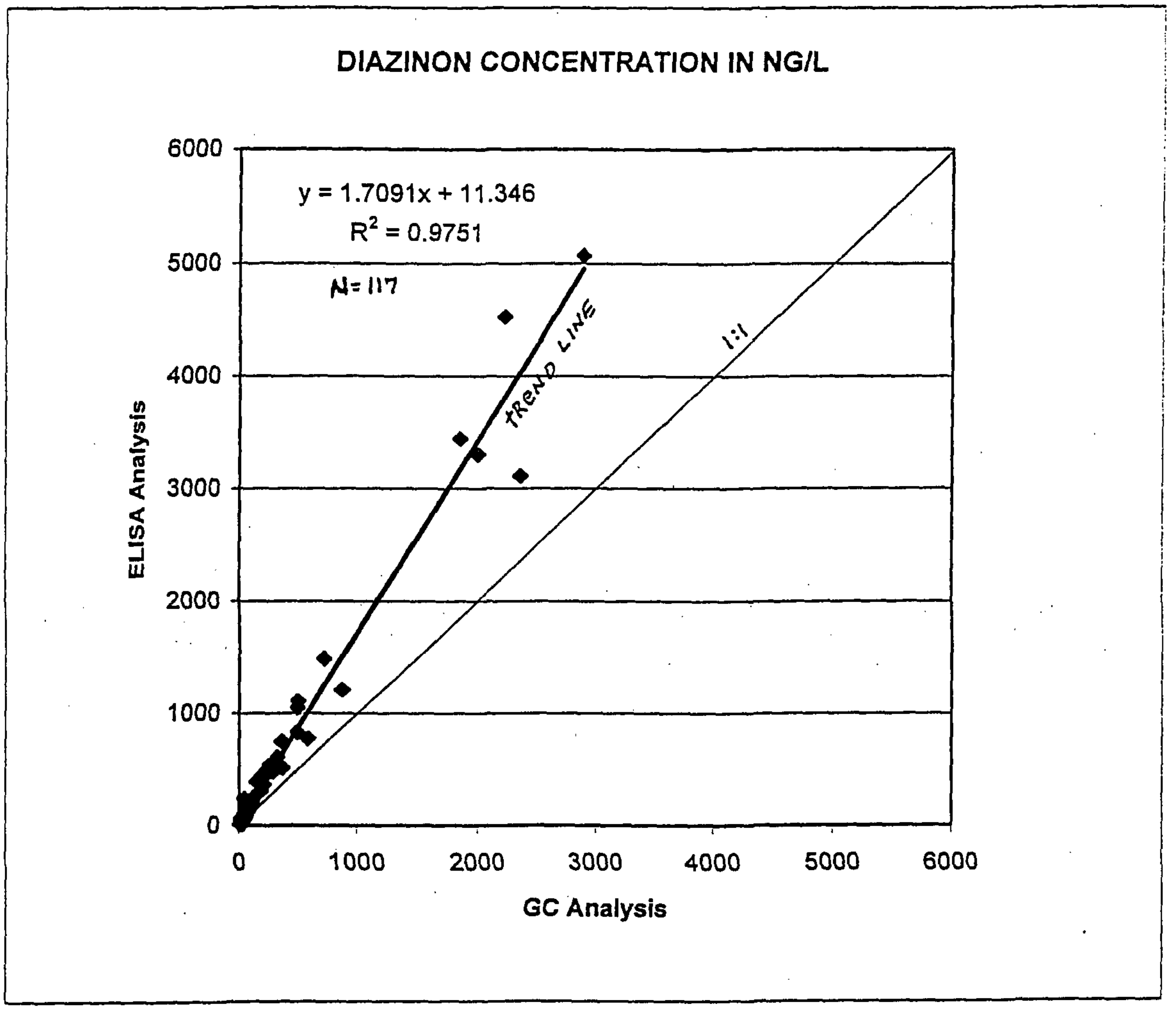


Figure 5. Concentrations of diazinon in split replicate samples analysed by ELISA and GC methods.

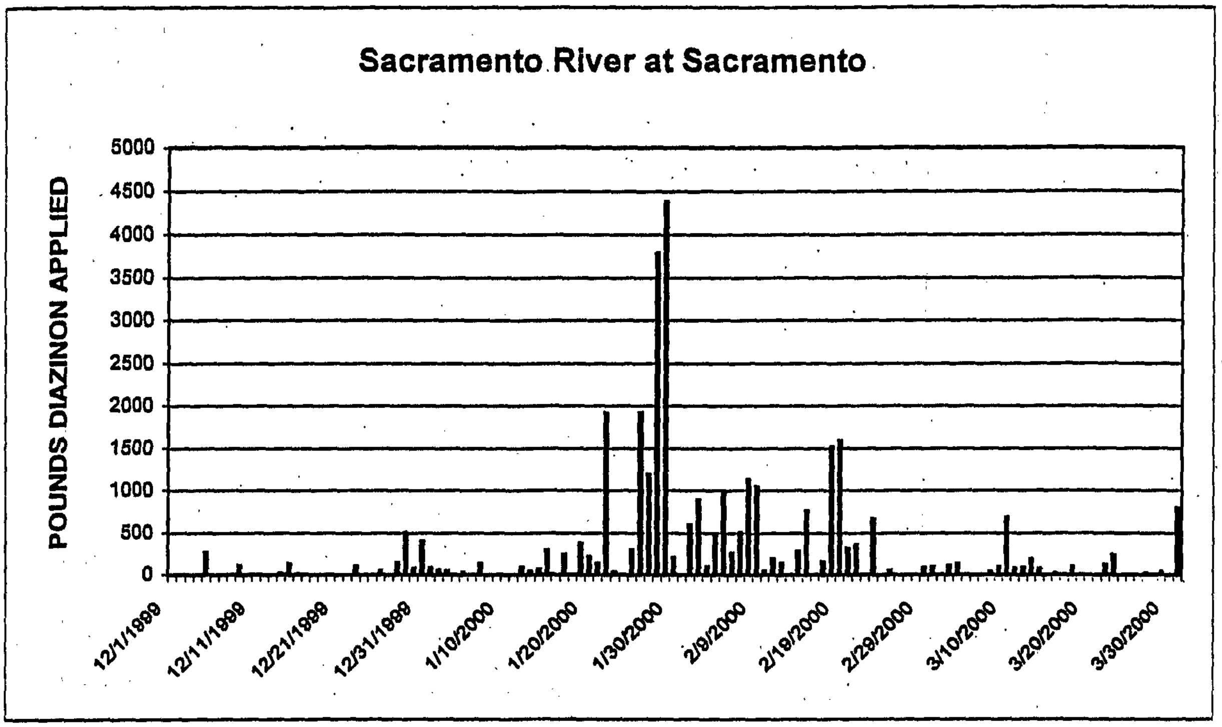


Figure 6. Diazinon use upstream of site 17, Sacramento River at Sacramento.

(A) daily diazinon use in pounds active ingredient.

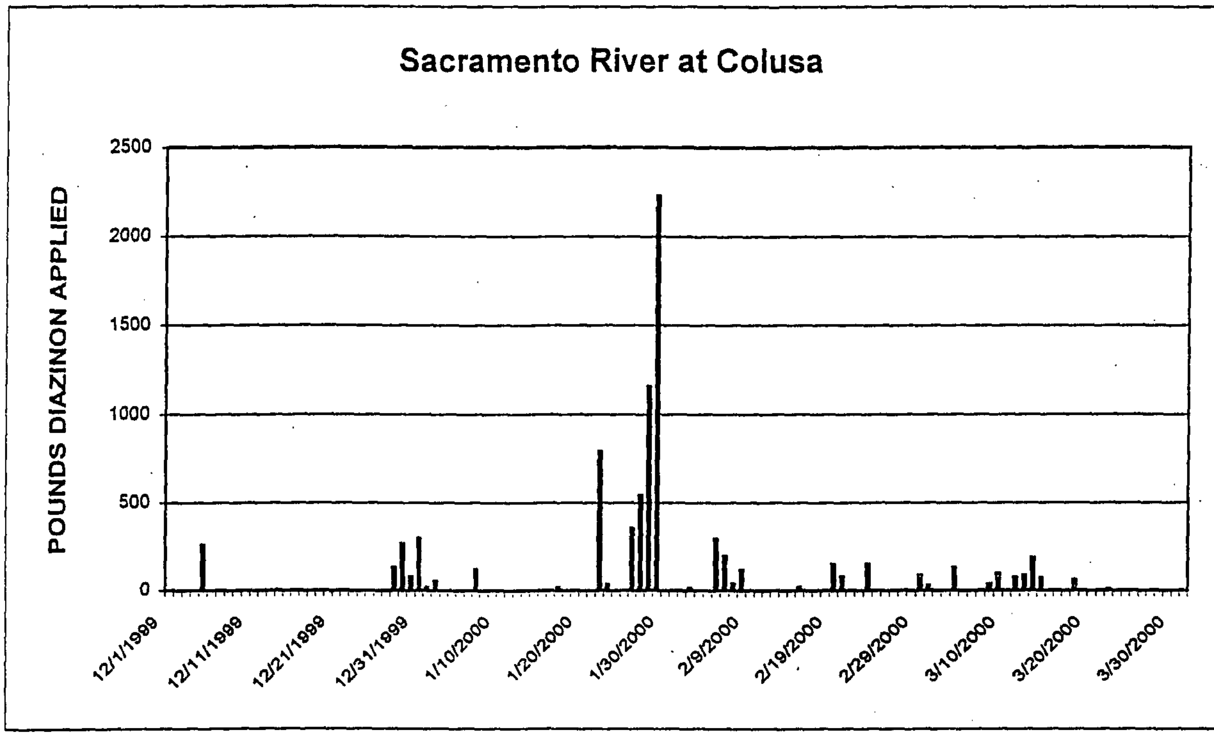


Figure 7. Diazinon use upstream of site 13, Sacramento River at Colusa.

(A) daily diazinon use in pounds active ingredient.

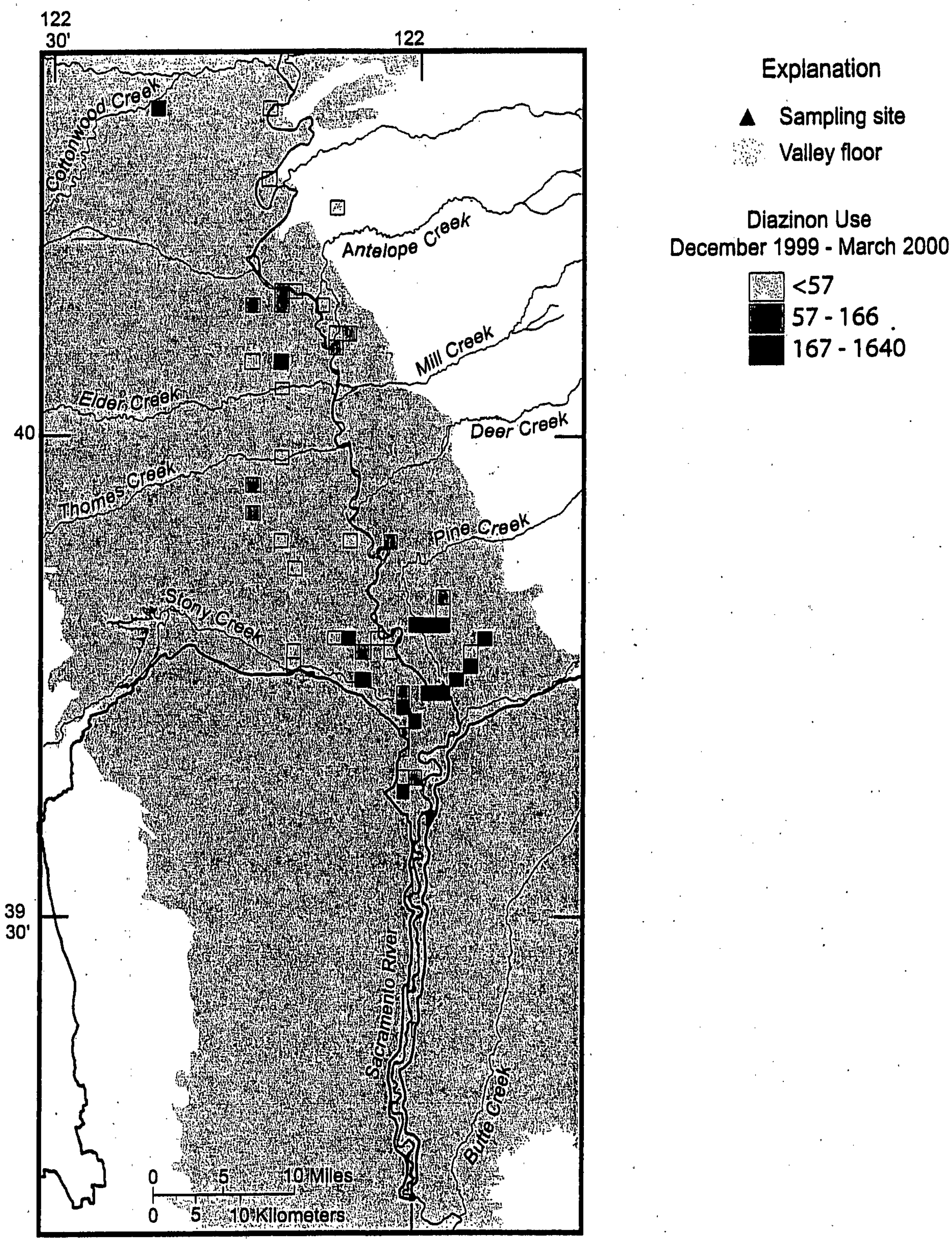
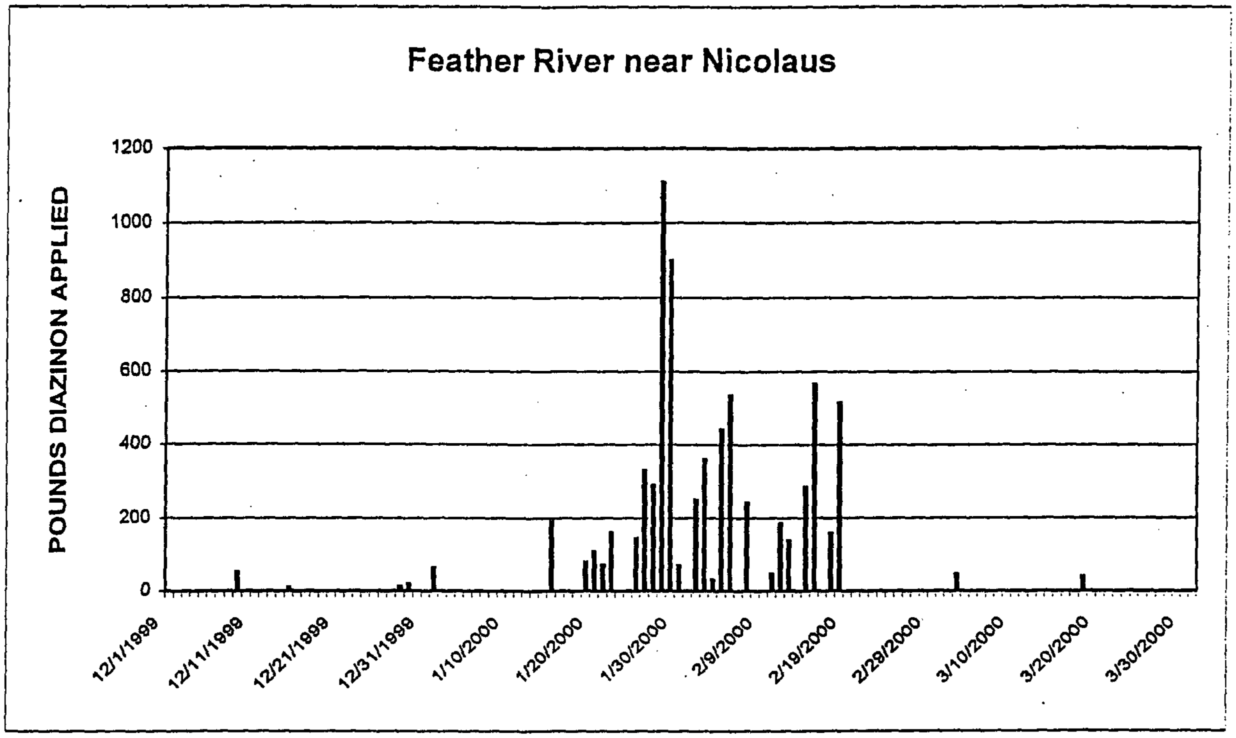


Figure 7. Diazinon use upstream of site 13, Sacramento River at Colusa
(B) Areal distribution of applications within the subbasin



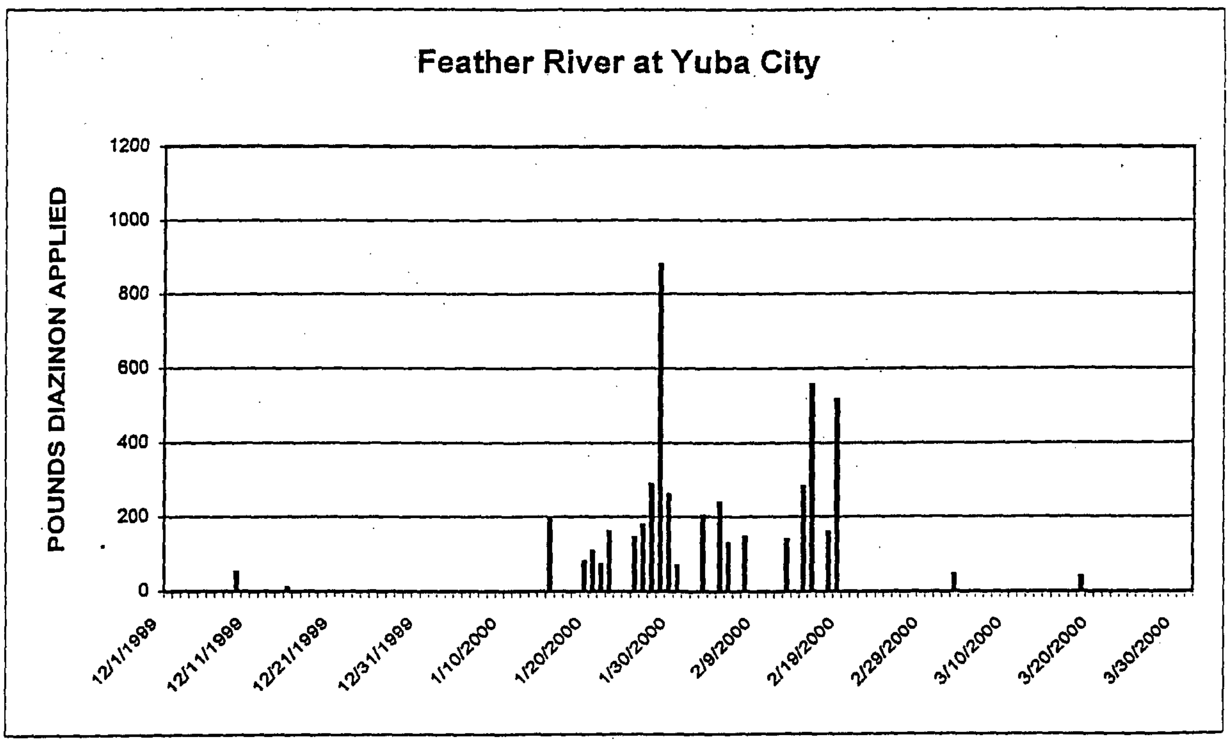


Figure 8. Diazinon use upstream of site 3, Feather River near Nicolaus, . and site 8, Feather River at Yuba City.

(A) daily diazinon use in pounds active ingredient.

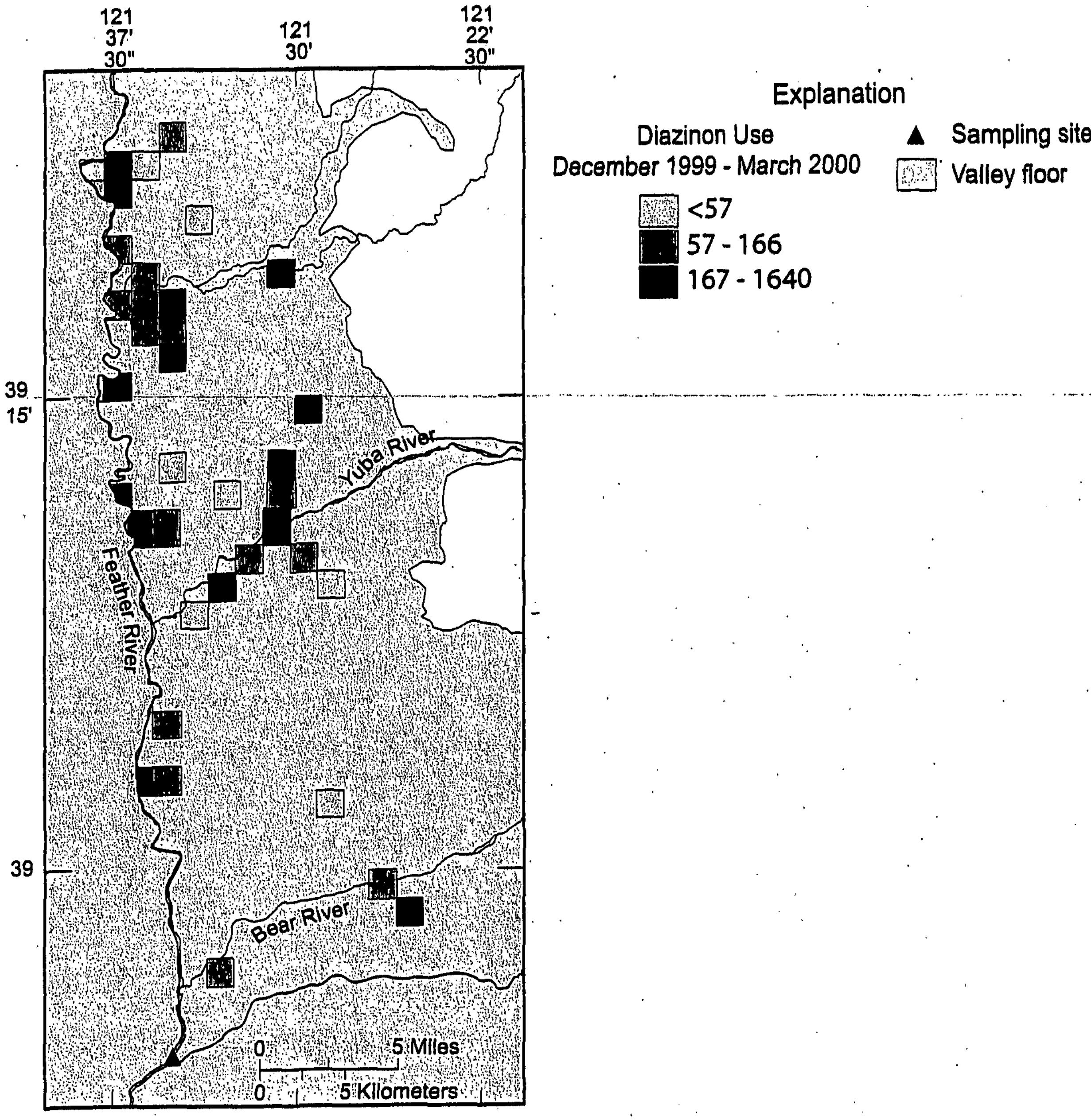


Figure 8. Diazinon use upstream of site 3, FeatherRiver near Nicolaus, and site 8, Feather River at Yuba City.

(B) Areal distribution of applications within the subbasin

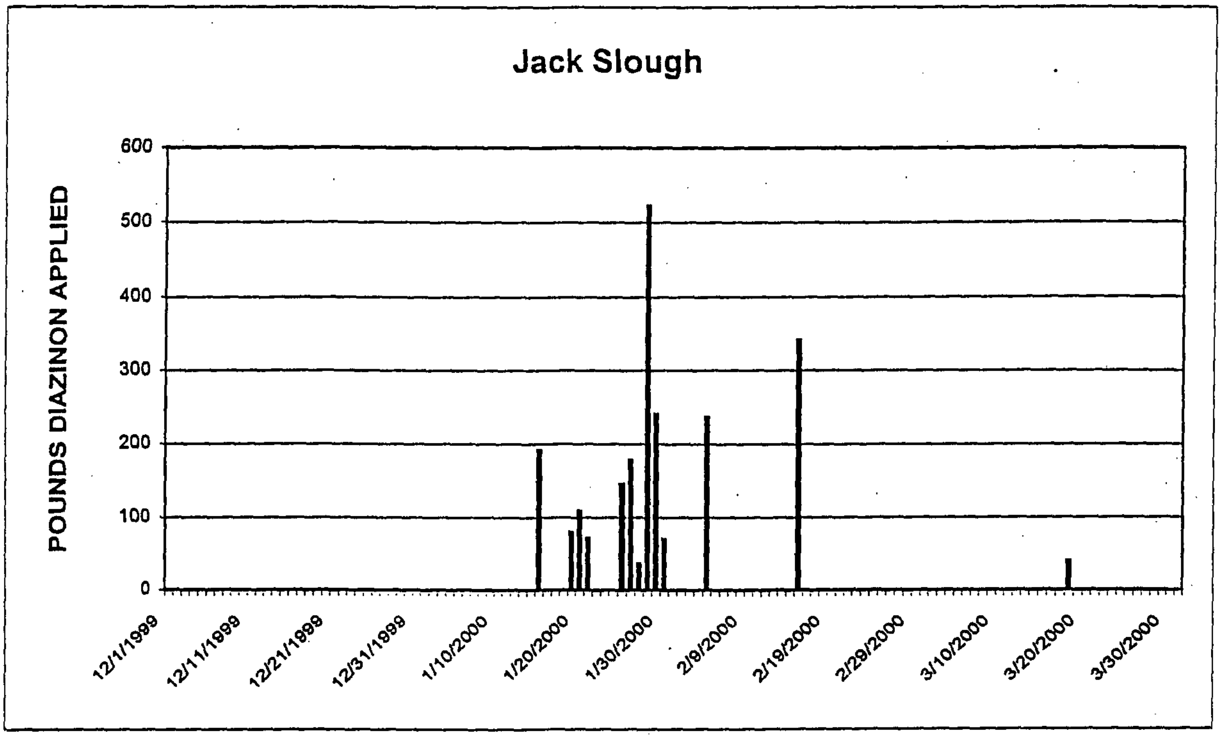


Figure 9. Diazinon use upstream of site 11, Jack Slough at Doc Adams Rd.

(A) daily diazinon use in pounds active ingredient.

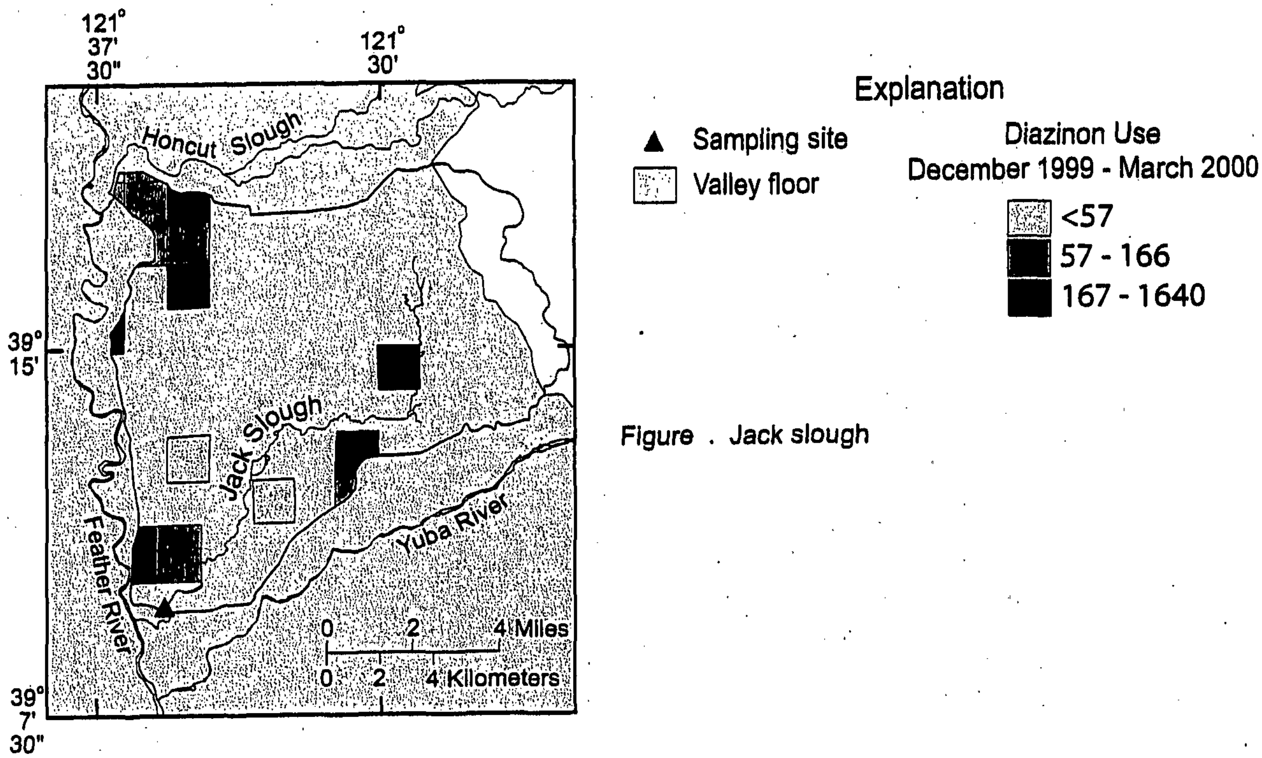


Figure . Jack slough

Figure 9. Diazinon use upstream of site 11, Jack Slough at Doc Adams Rd.

(B) Areal distribution of applications within the subbasin

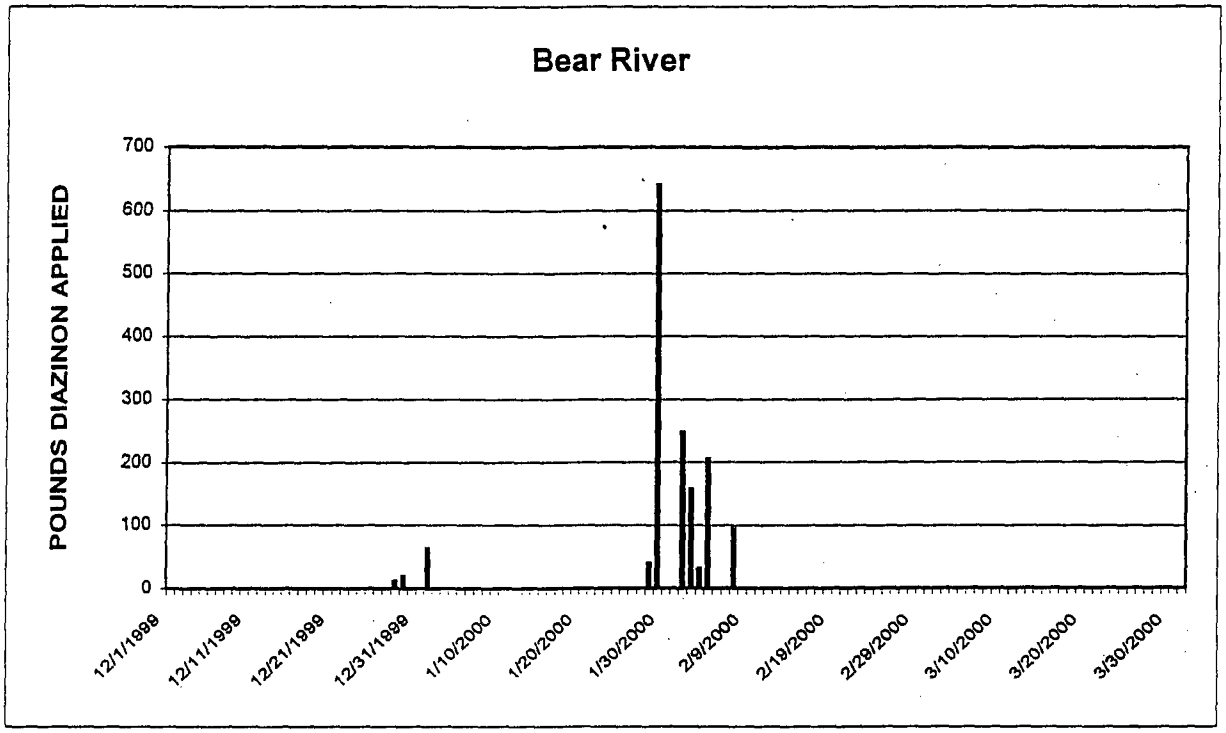


Figure 10. Diazinon use upstream of site 5, Bear River near Berry Rd.

(A) daily diazinon use in pounds active ingredient.

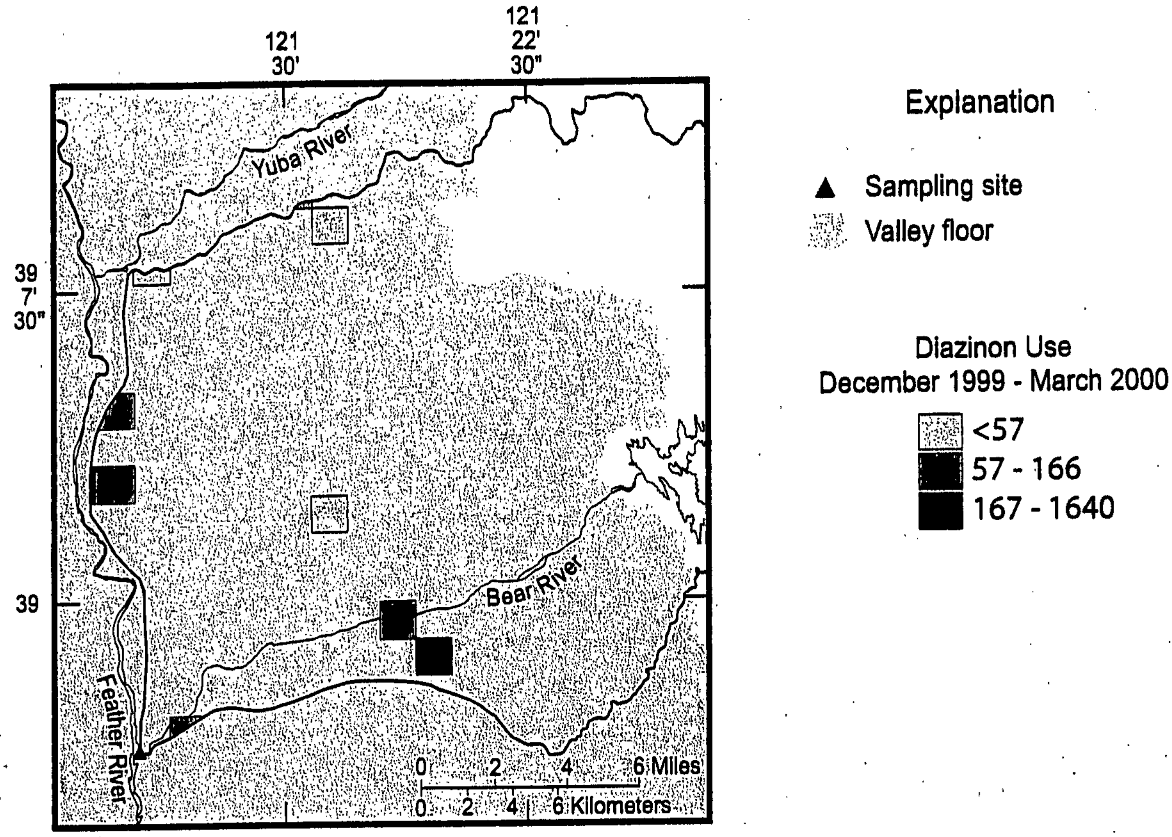


Figure 10. Diazinon use upstream of site 5, Bear River near Berry Rd.

(B) Areal distribution of applications within the subbasin

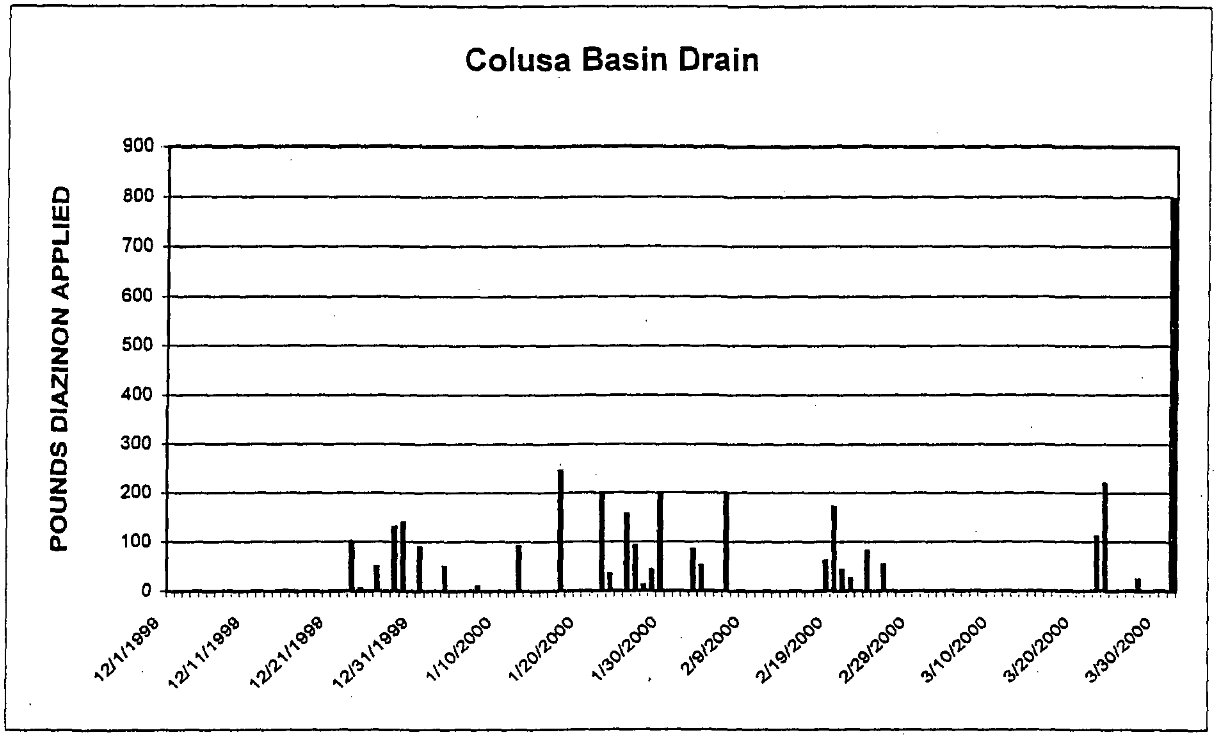


Figure 11. Diazinon use upstream of site 2, Colusa Basin Drain near Knights Landing.

(A) daily diazinon use in pounds active ingredient.

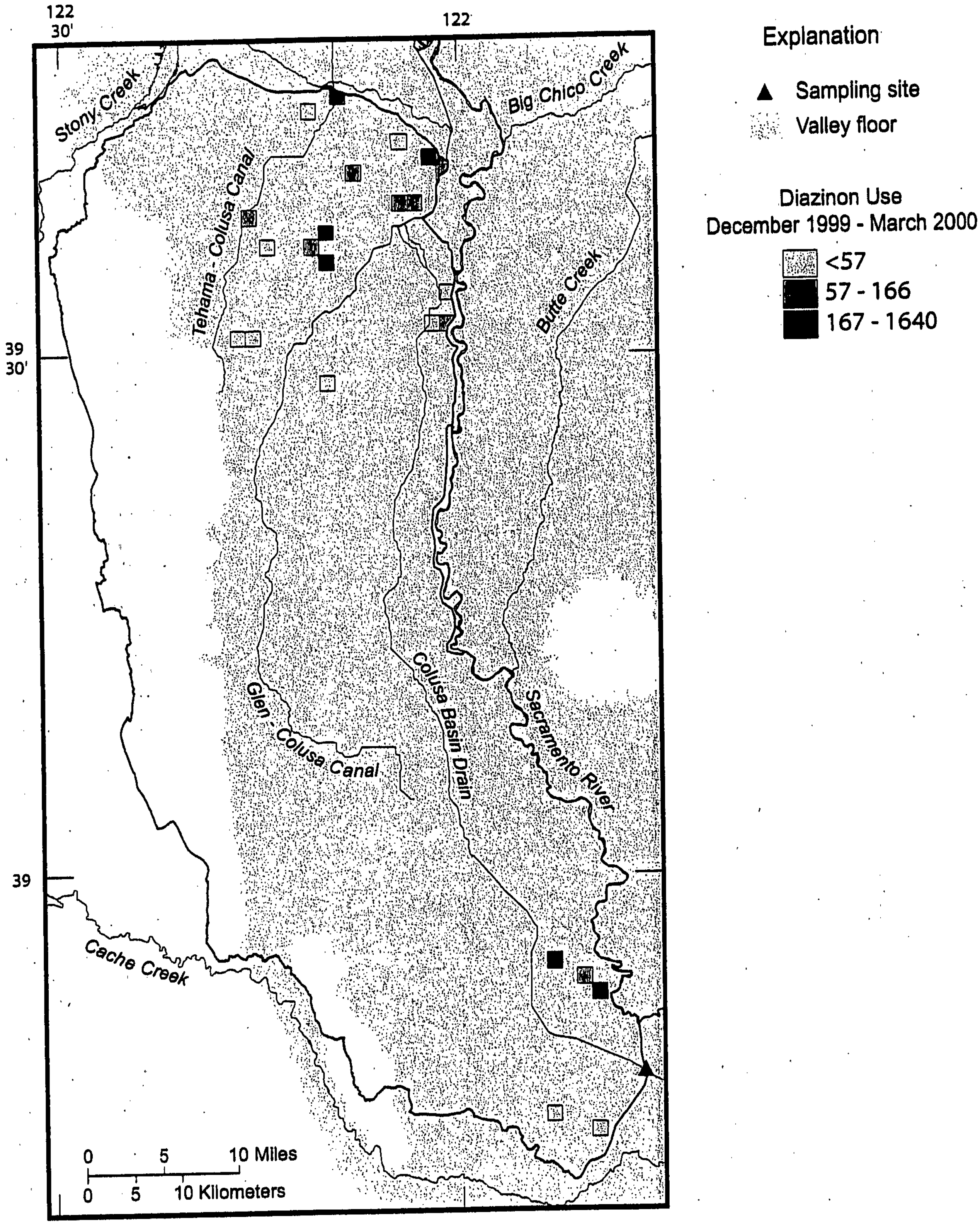


Figure 11. Diazinon use upstream of site 2, Colusa Basin Drain near Knights Landing.

(B) Areal distribution of applications within the subbasin

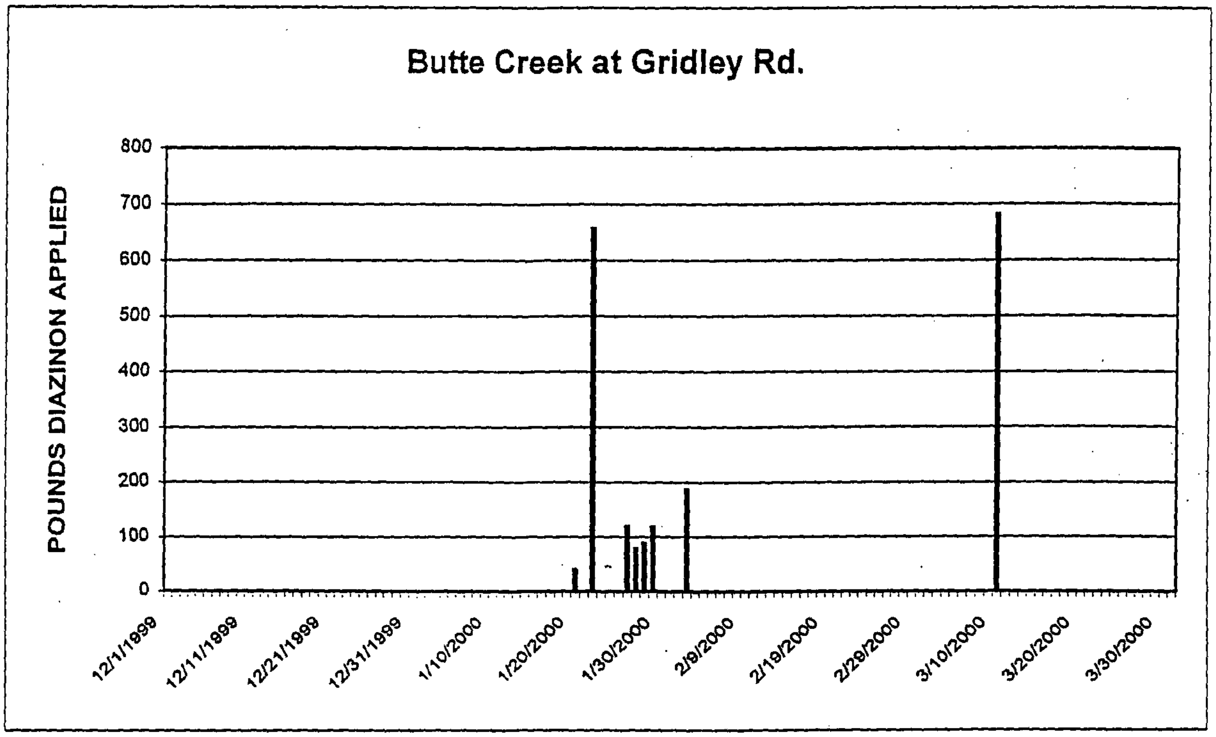


Figure 12. Diazinon use upstream of site 14, Butte Creek at Gridely Rd.

(A) daily diazinon use in pounds active ingredient.

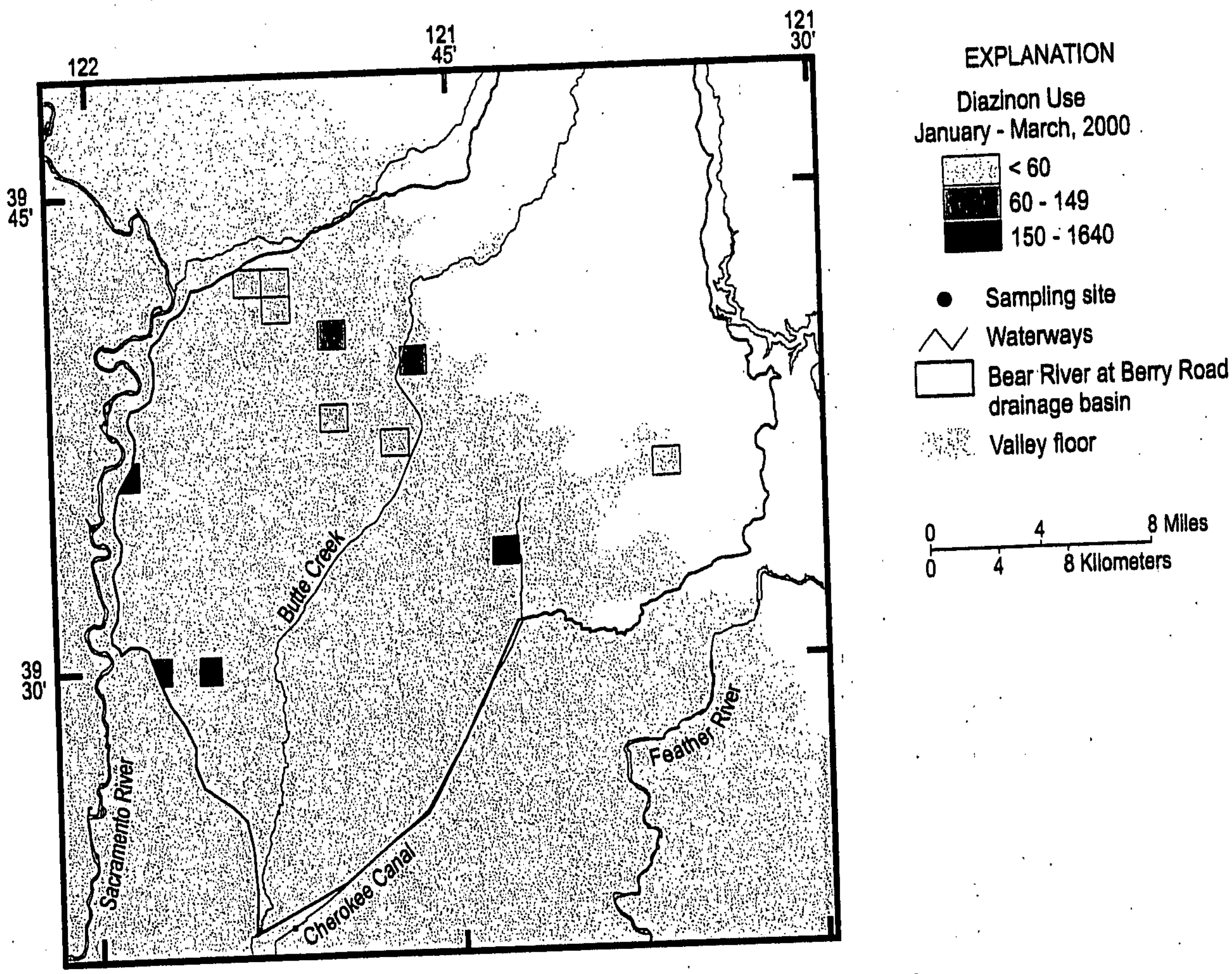


Figure 12. Diazinon use upstream of site 14, Butte Creek at Gridely Rd.

(B) Areal distribution of applications within the subbasin

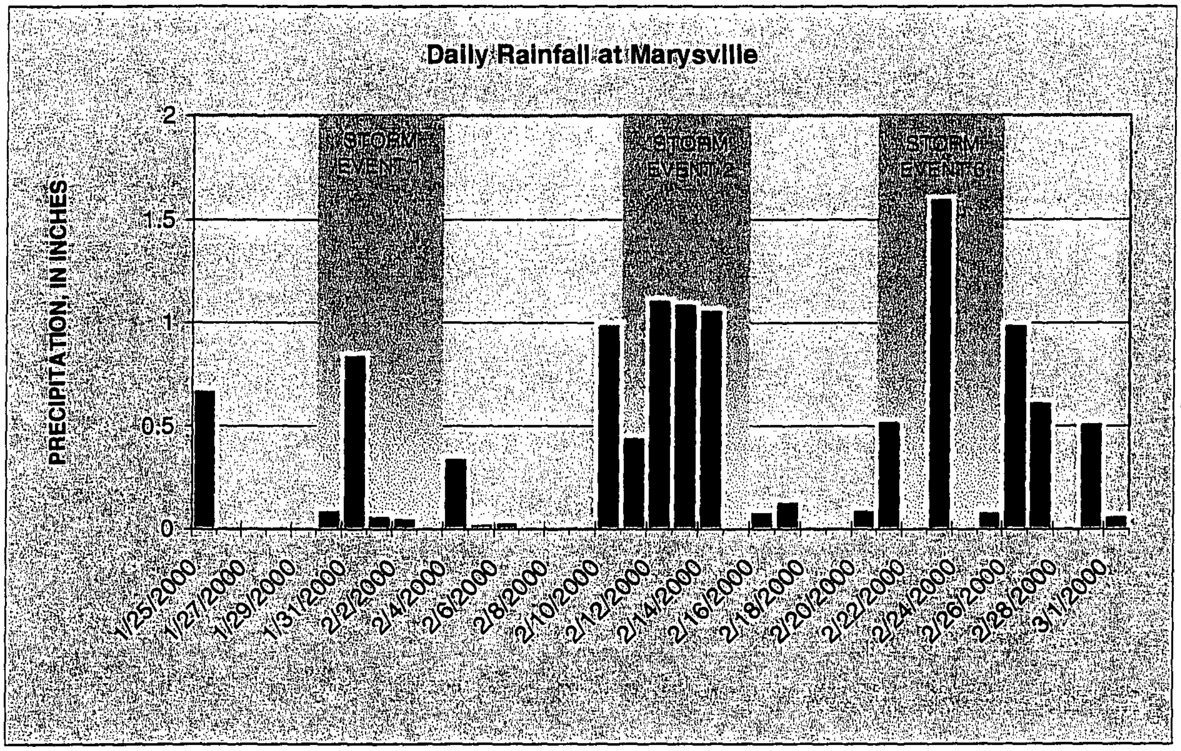


Figure 13. Precipitation at Marysville, CA, during the monitoring period.

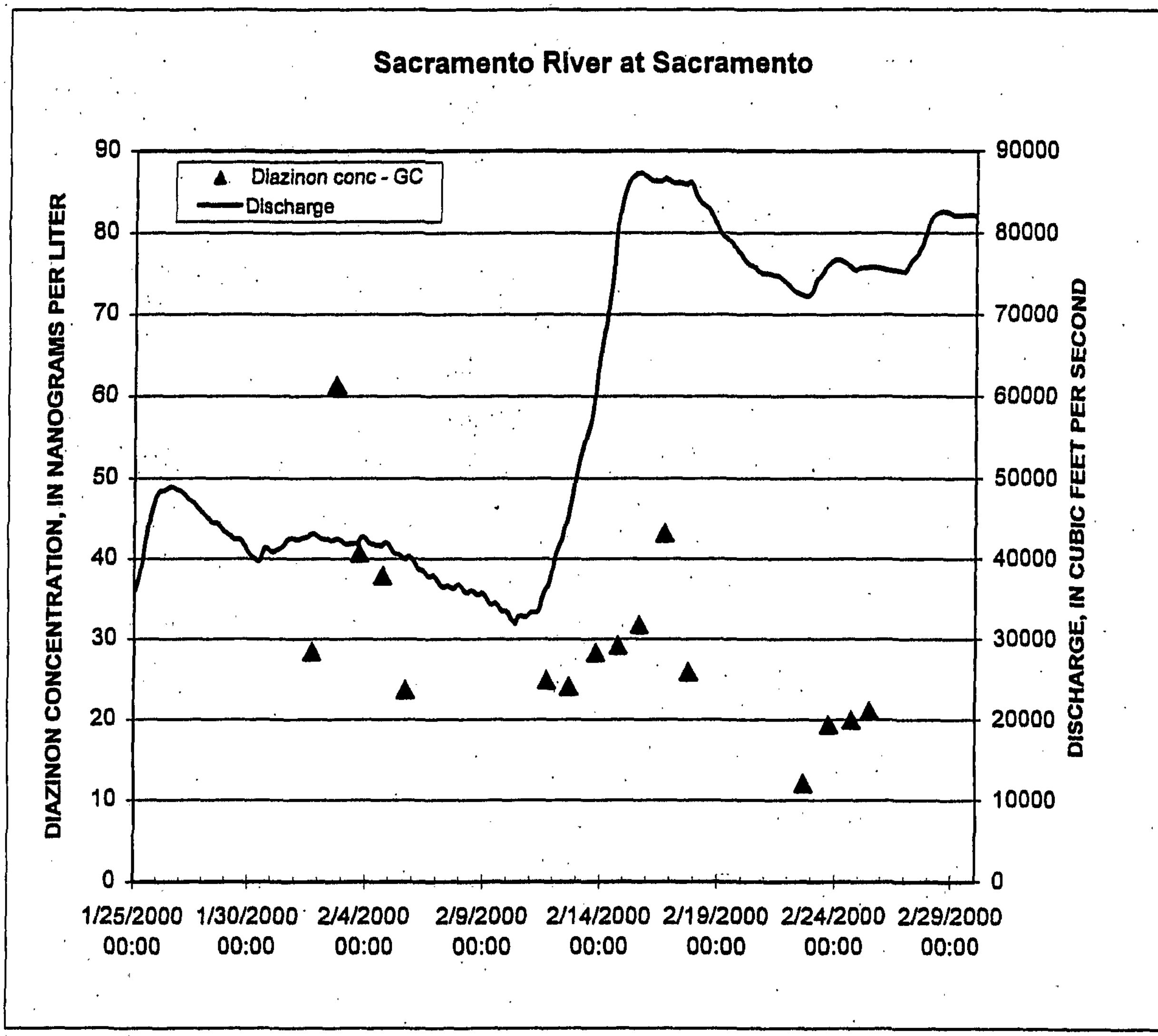


Figure 14a. Diazinon concentration (GC) and discharge at site 17, Sacramento River at Sacramento.

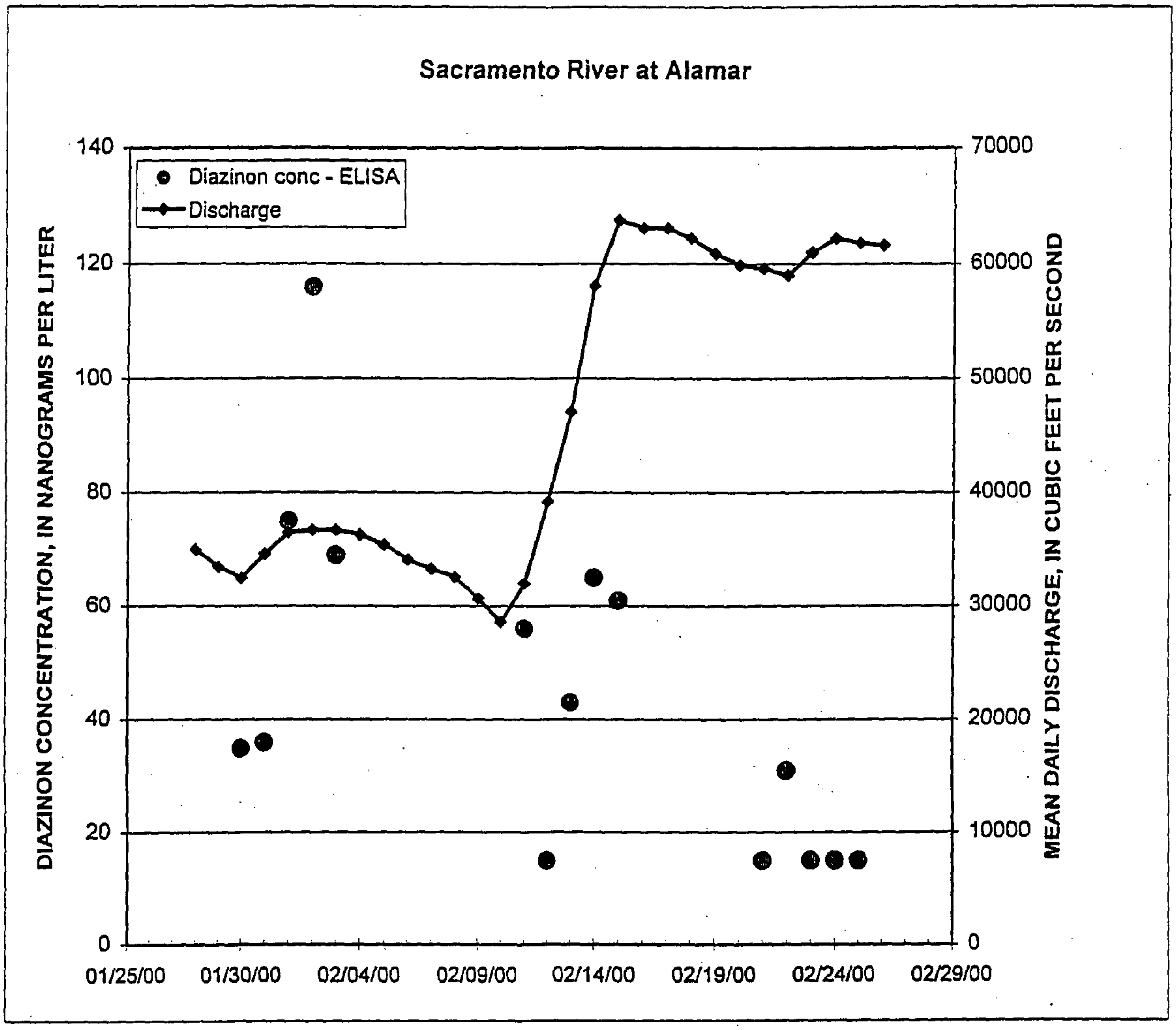


Figure 14b. Diazinon concentration (ELISA) and discharge at site 13, Sacramento River at Alamar.

B

1

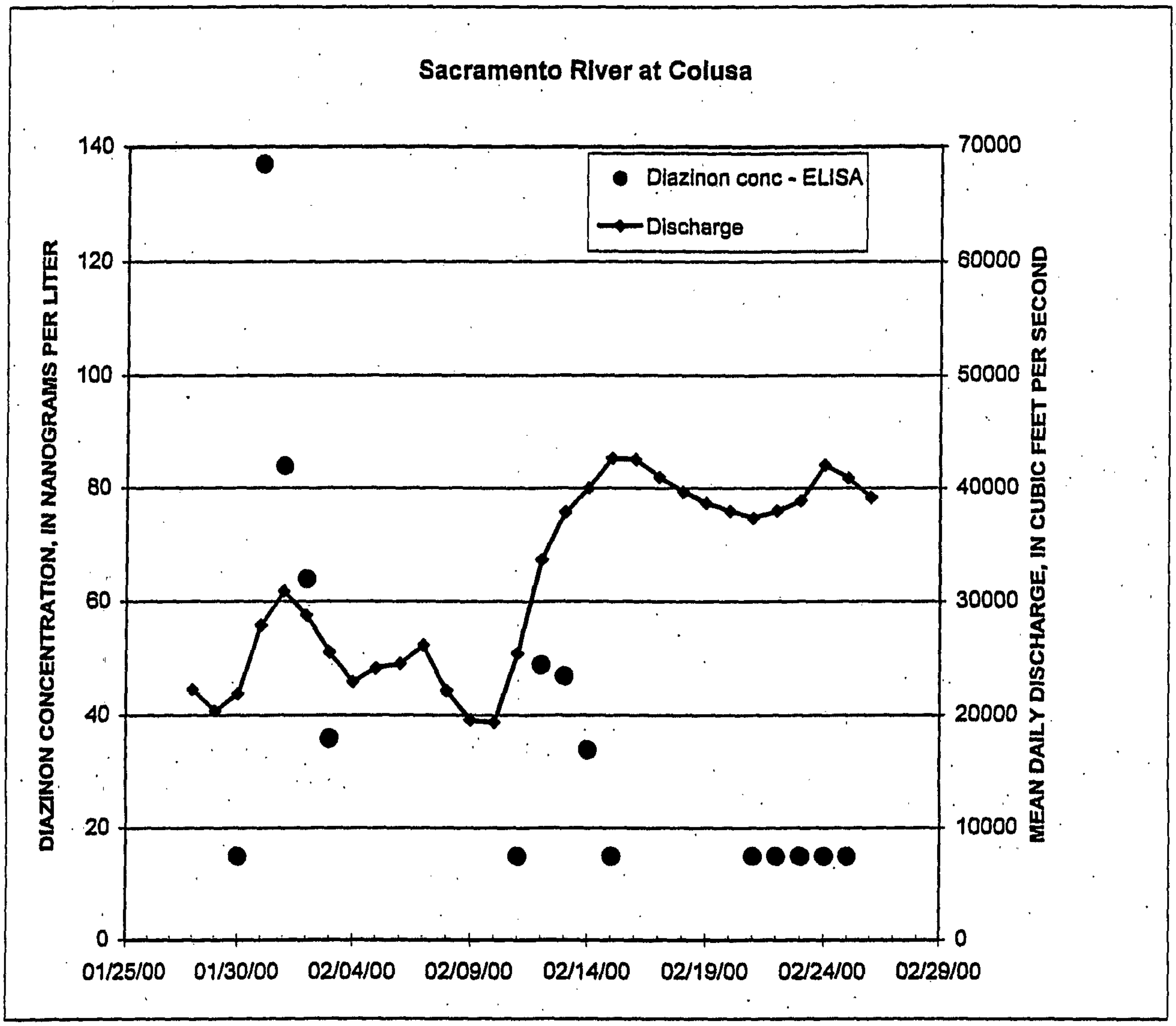


Figure 14c. Diazinon concentration (ELISA) and discharge at site 13, Sacramento River at Colusa.

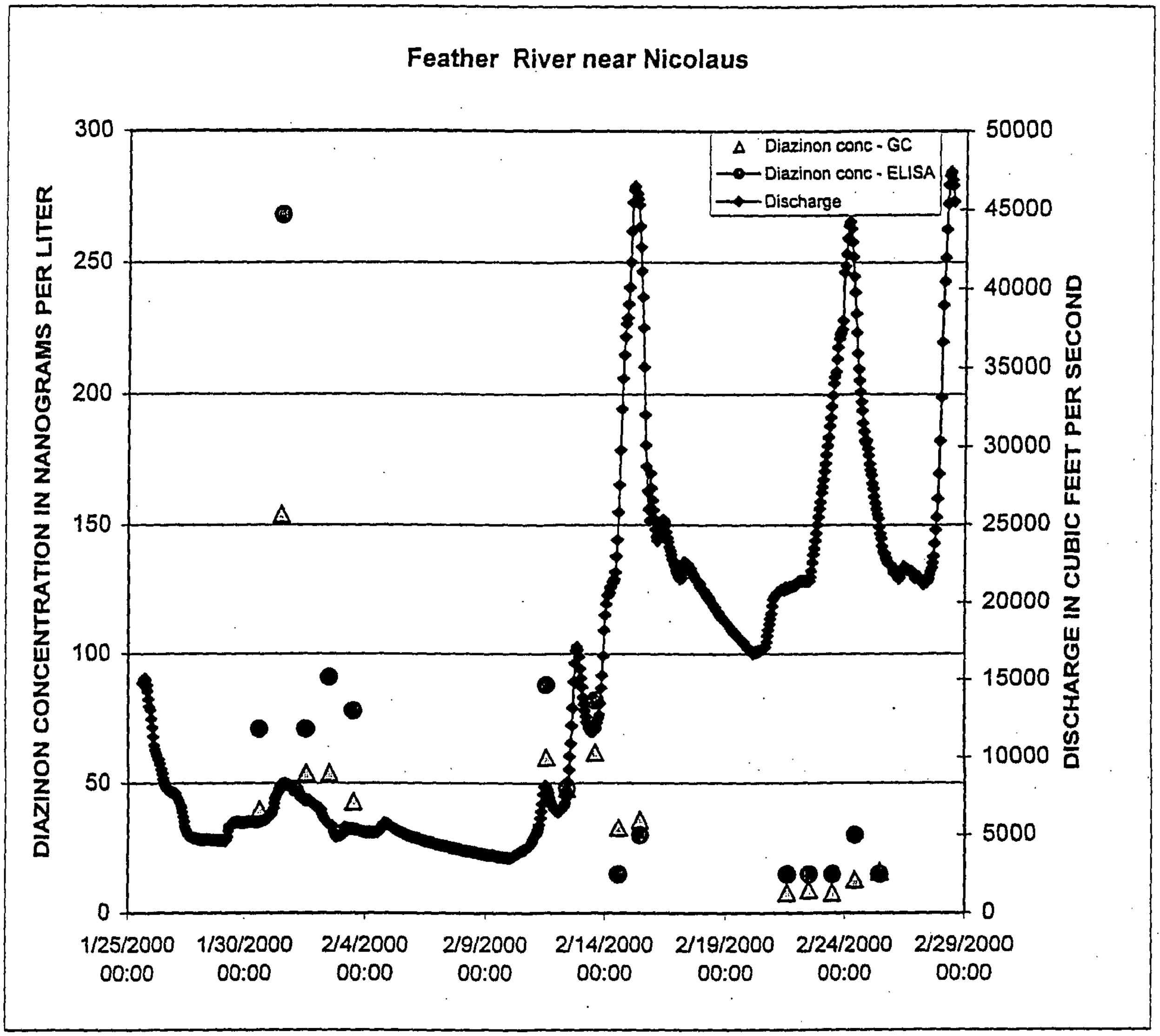


Figure 14d. Diazinon concentration (ELISA and GC) and discharge at site 3, Feather River near Nicolaus.

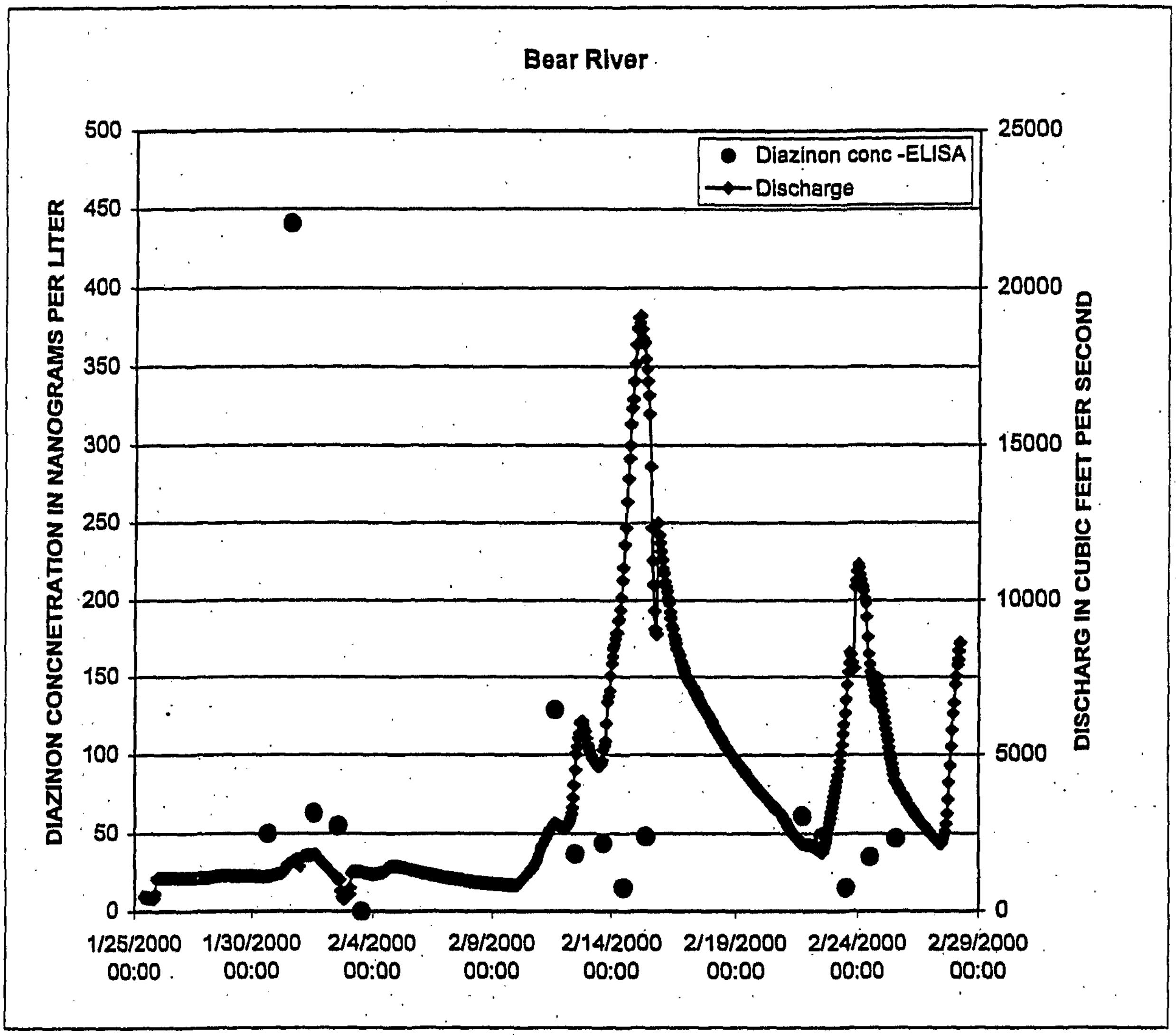


Figure 14e. Diazinon concentration (ELISA) and discharge at site 5, Bear River near Berry Rd.

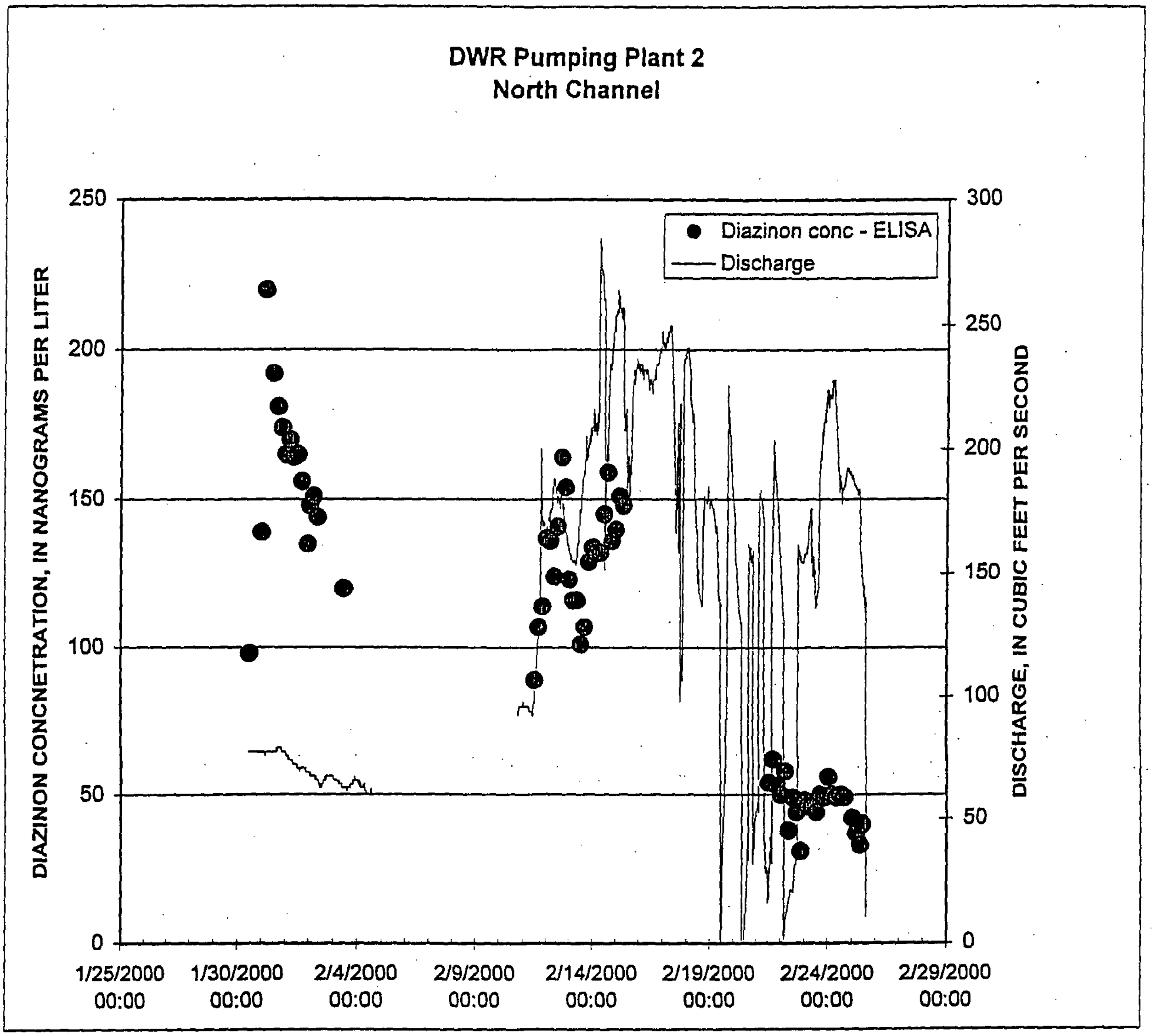


Figure 14f. Diazinon concentration (ELISA) and discharge at site 6a, DPR Pump Plant #2, North Channel.

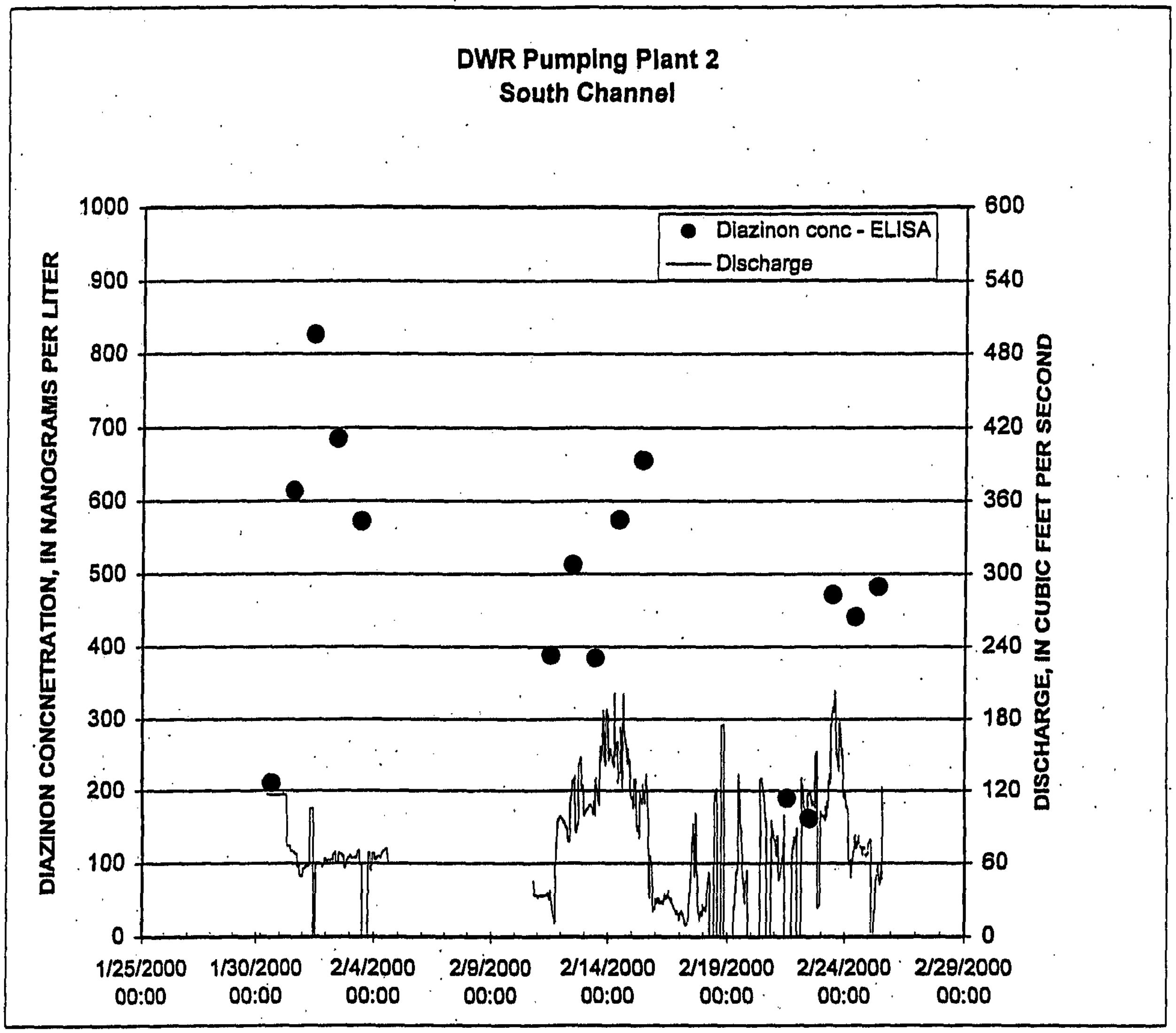


Figure 14g . Diazinon concentration (ELISA) and discharge at site 6b, DPR Pump Plant #2, South Channel.

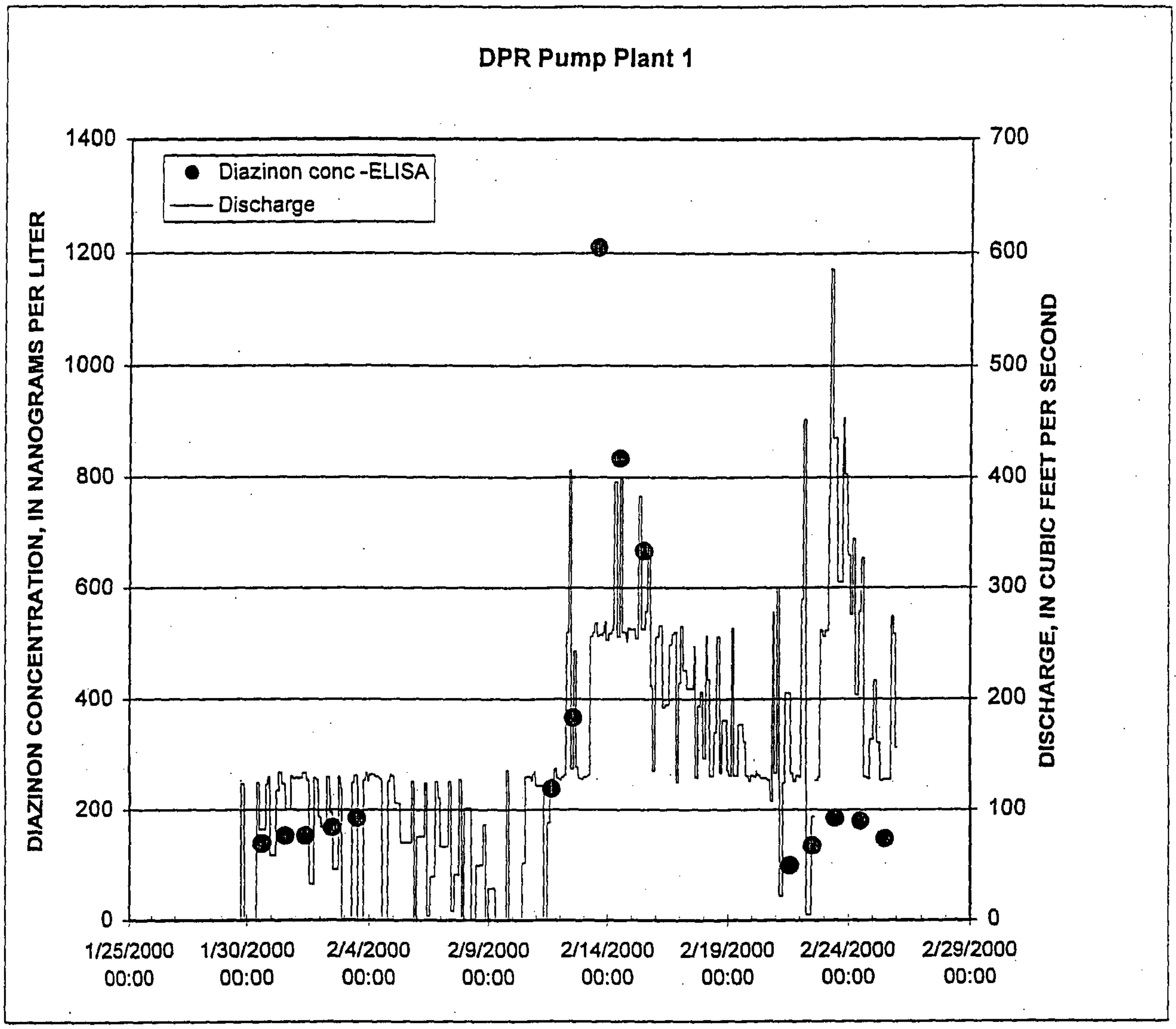


Figure 14h . Diazinon concentration (ELISA) and discharge at site 4, DPR Pump Plant #1.

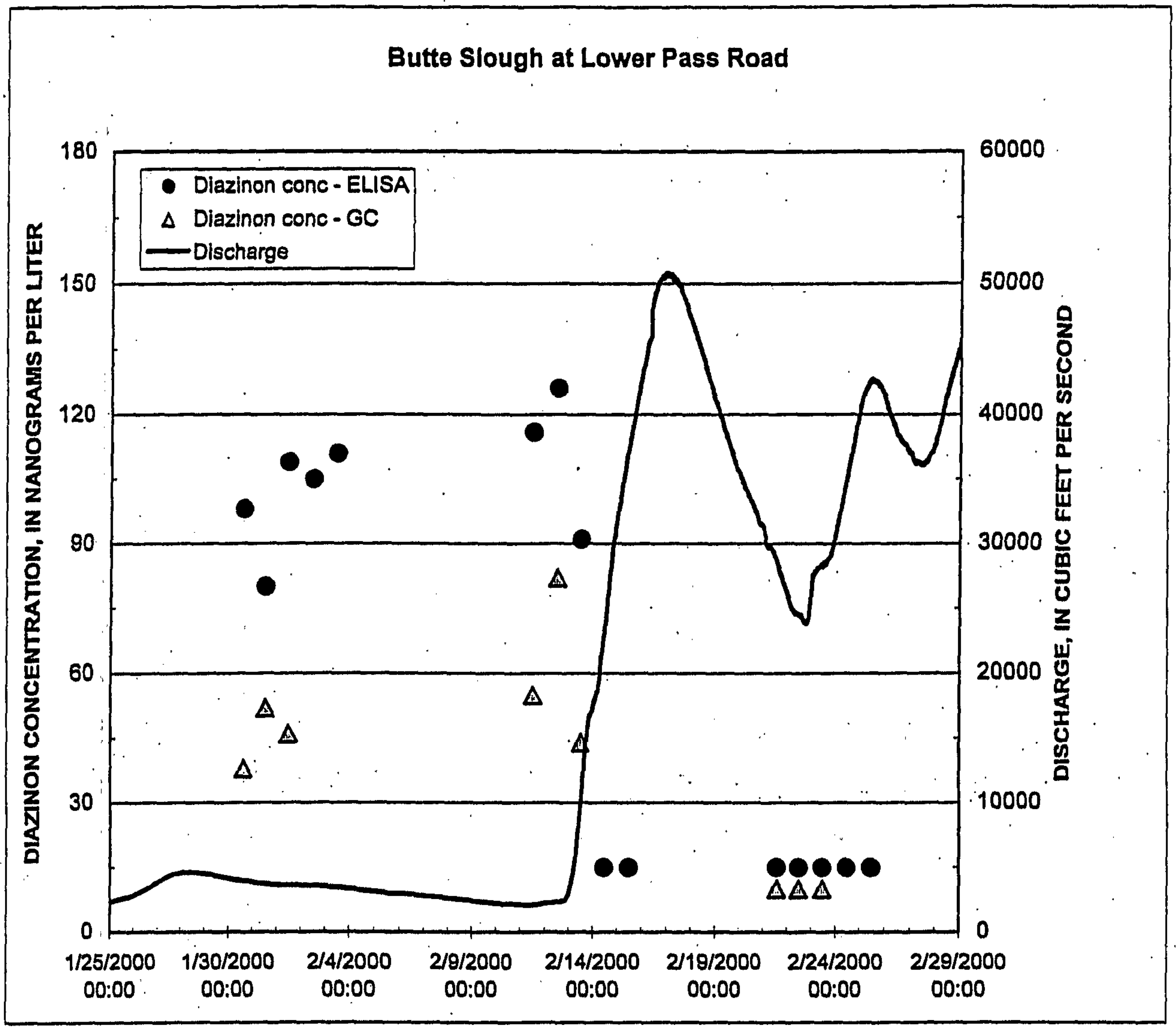


Figure 14I. Diazinon concentration (ELISA and GC) and discharge at site 12, Butte Slough at Lowe Pass Rd.

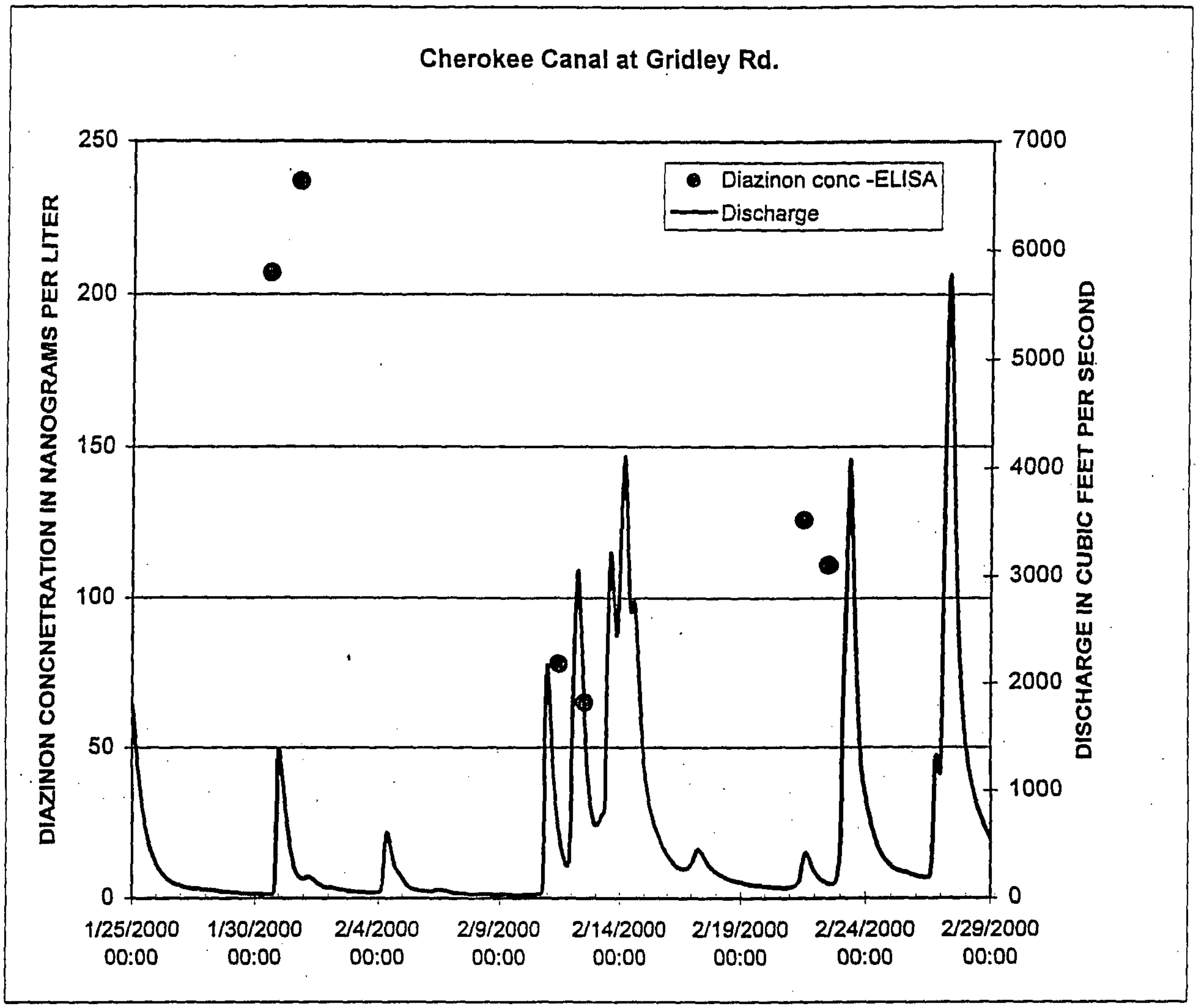


Figure 14j. Diazinon concentration (ELISA) and stage at site 15, Cherokee Canal at Gridley Rd.

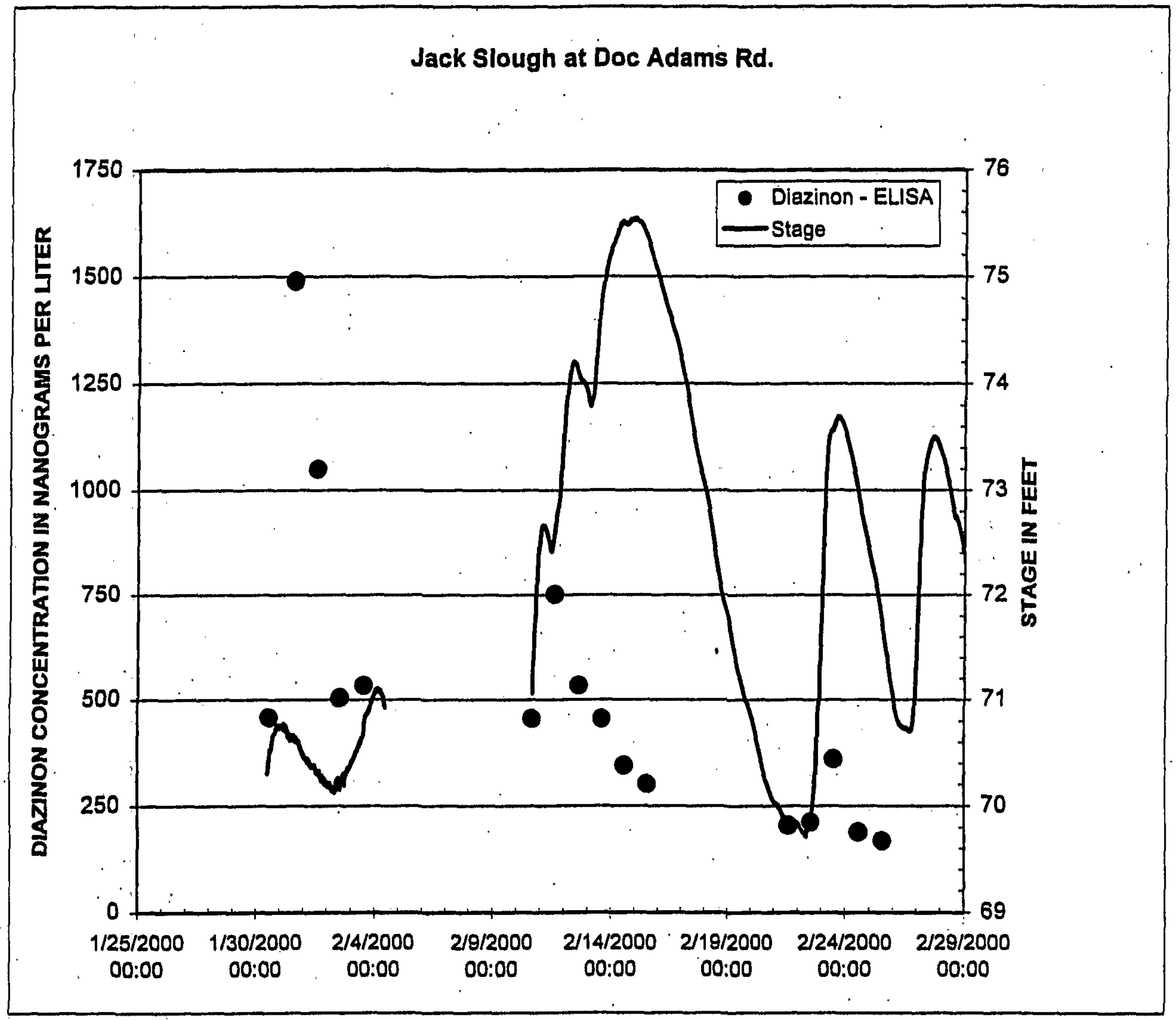


Figure 14k. Diazinon concentration (ELISA) and stage at site 11, Jack Slough at Doc Adams Rd.

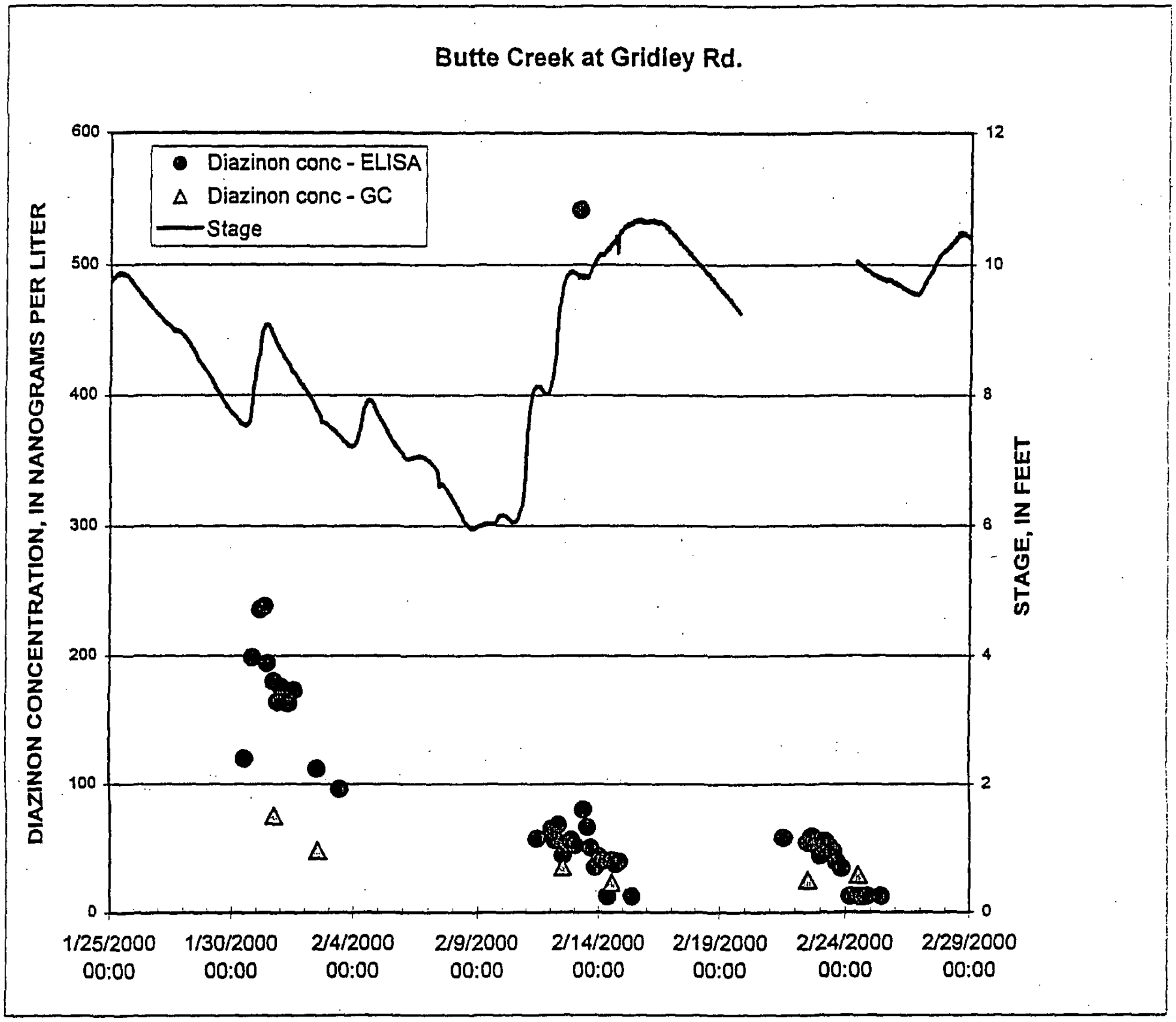


Figure 14l. Diazinon concentration (ELISA and GC) and stage at site 14, Butte Creek at Gridley Rd.

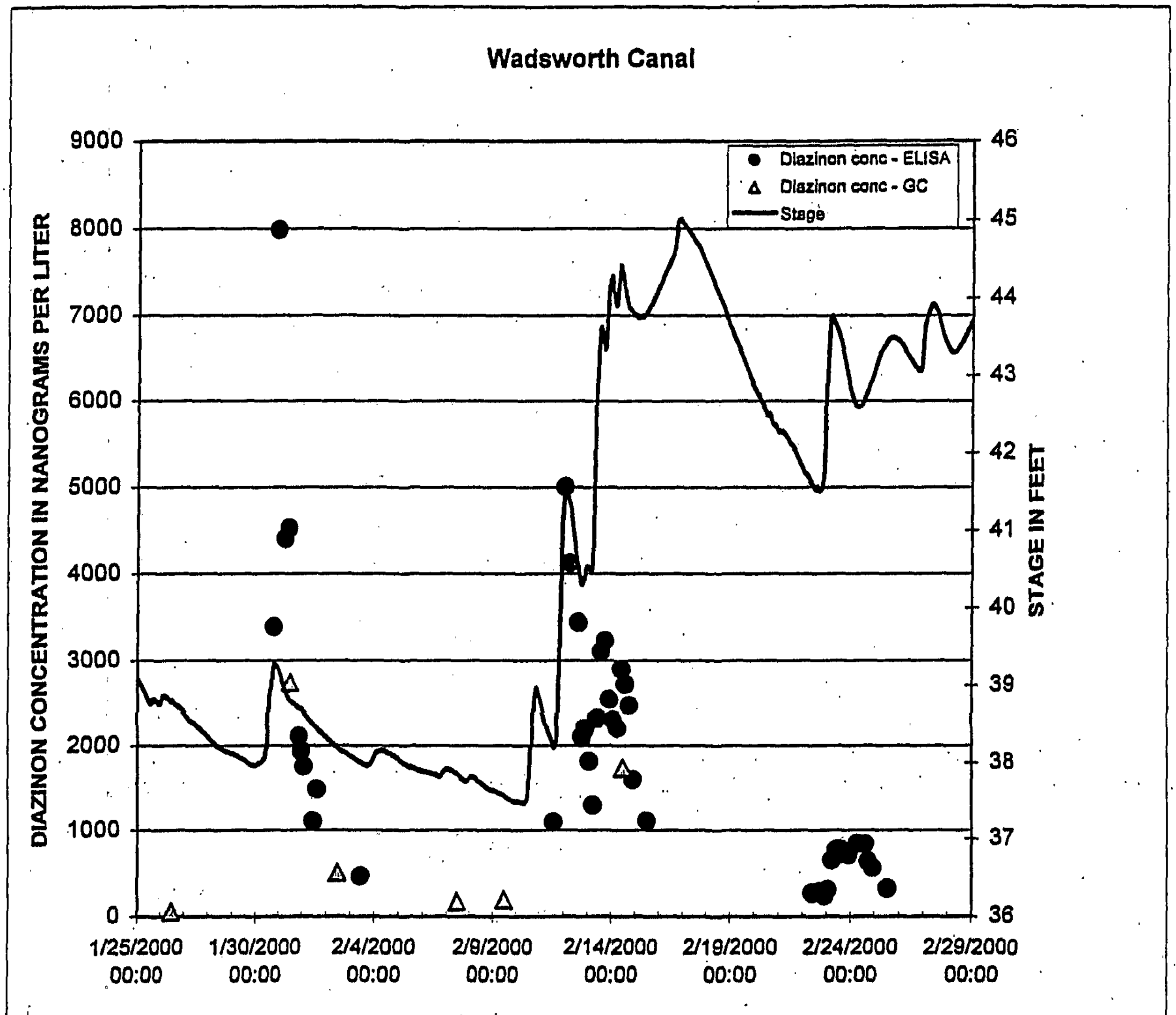


Figure 14m. Diazinon concentration (ELISA and GC) and stage at site 10, Wadsworth Canal at South Butte Rd.

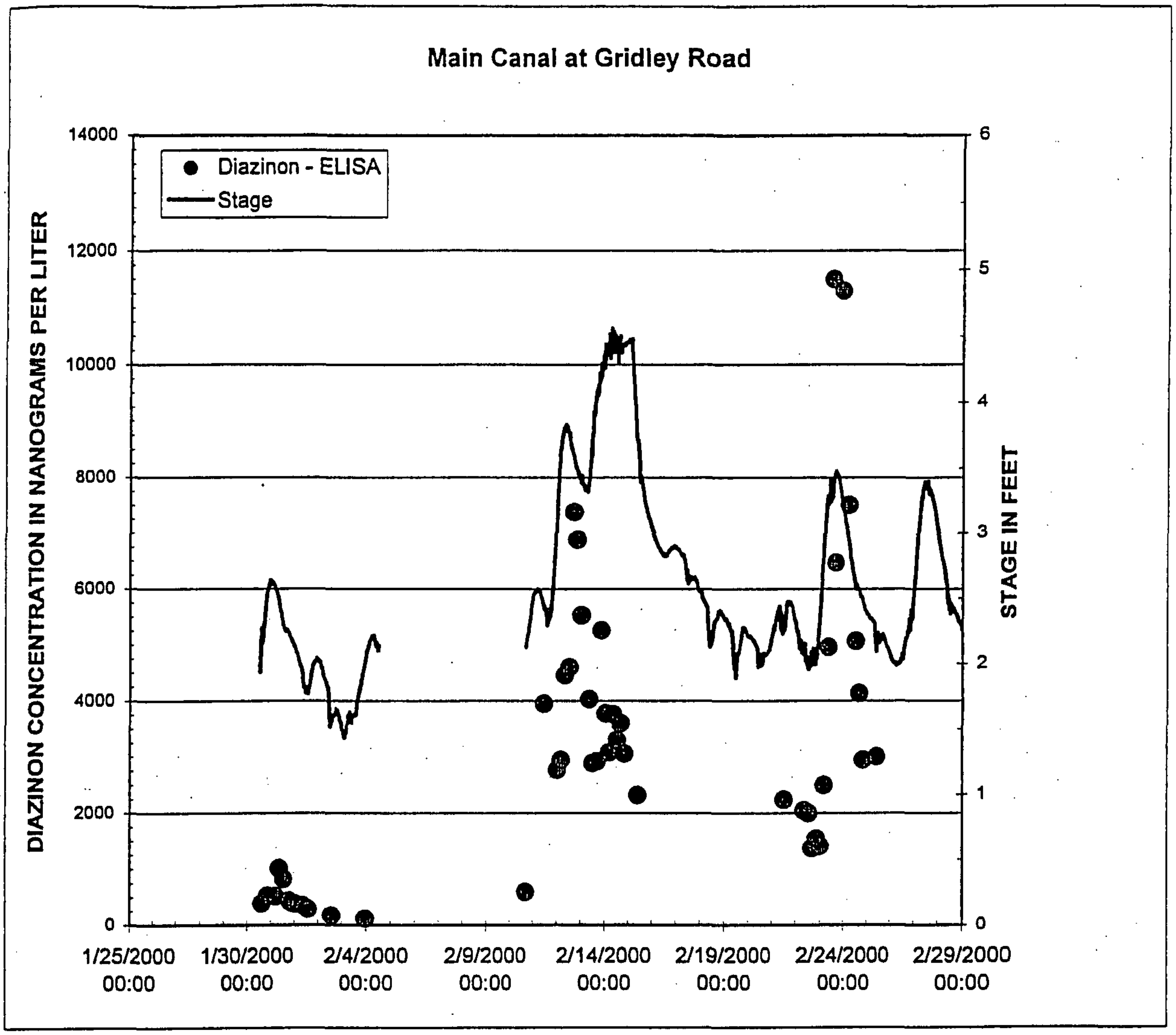


Figure 14n. Diazinon concentration (ELISA)and discharge at site 16, Main Canal at Gridley Rd.

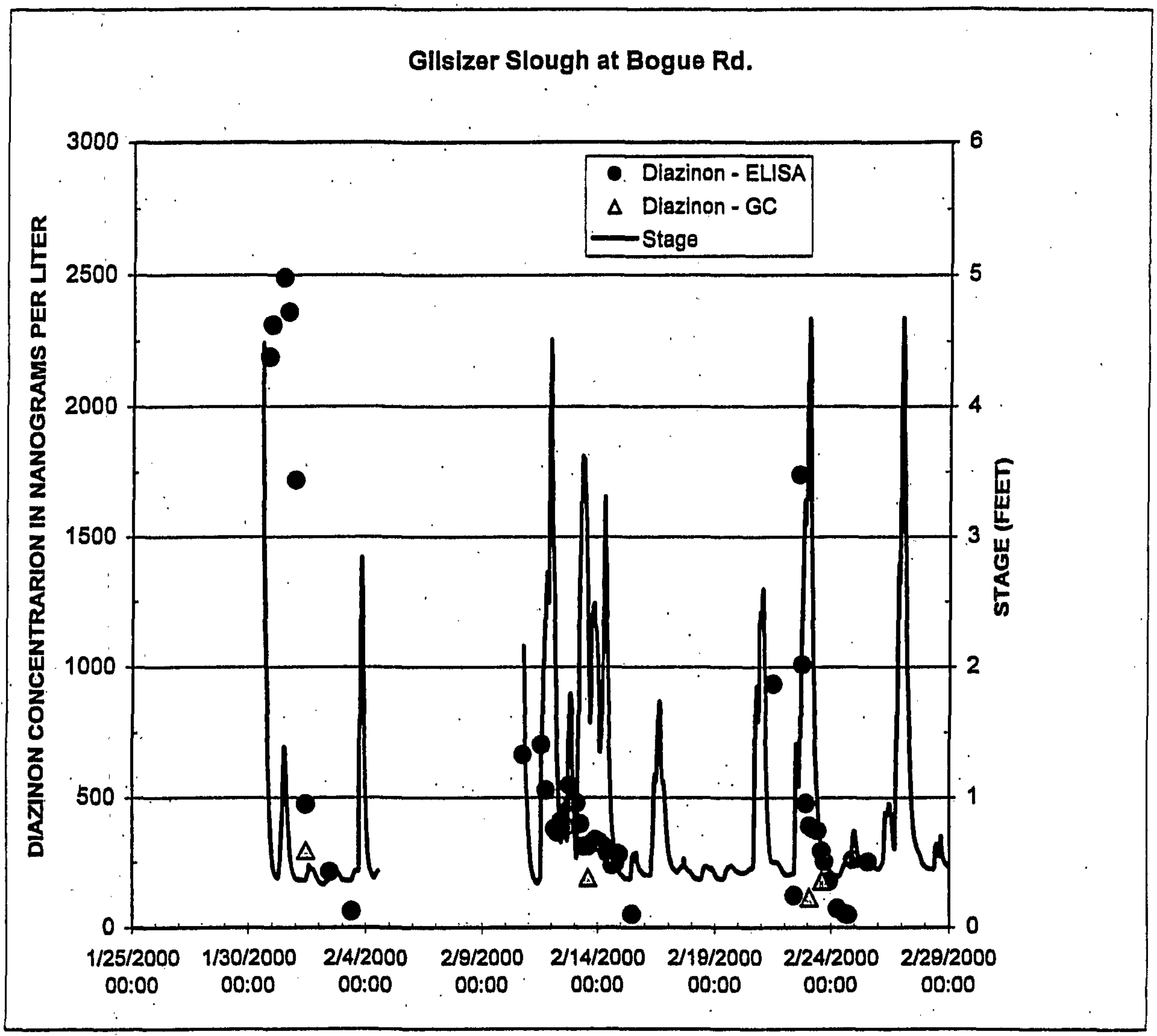


Figure 14o. Diazinon concentration (ELISA and GC) and stage at site 7, Gilsizer Slough at Bogue Rd.

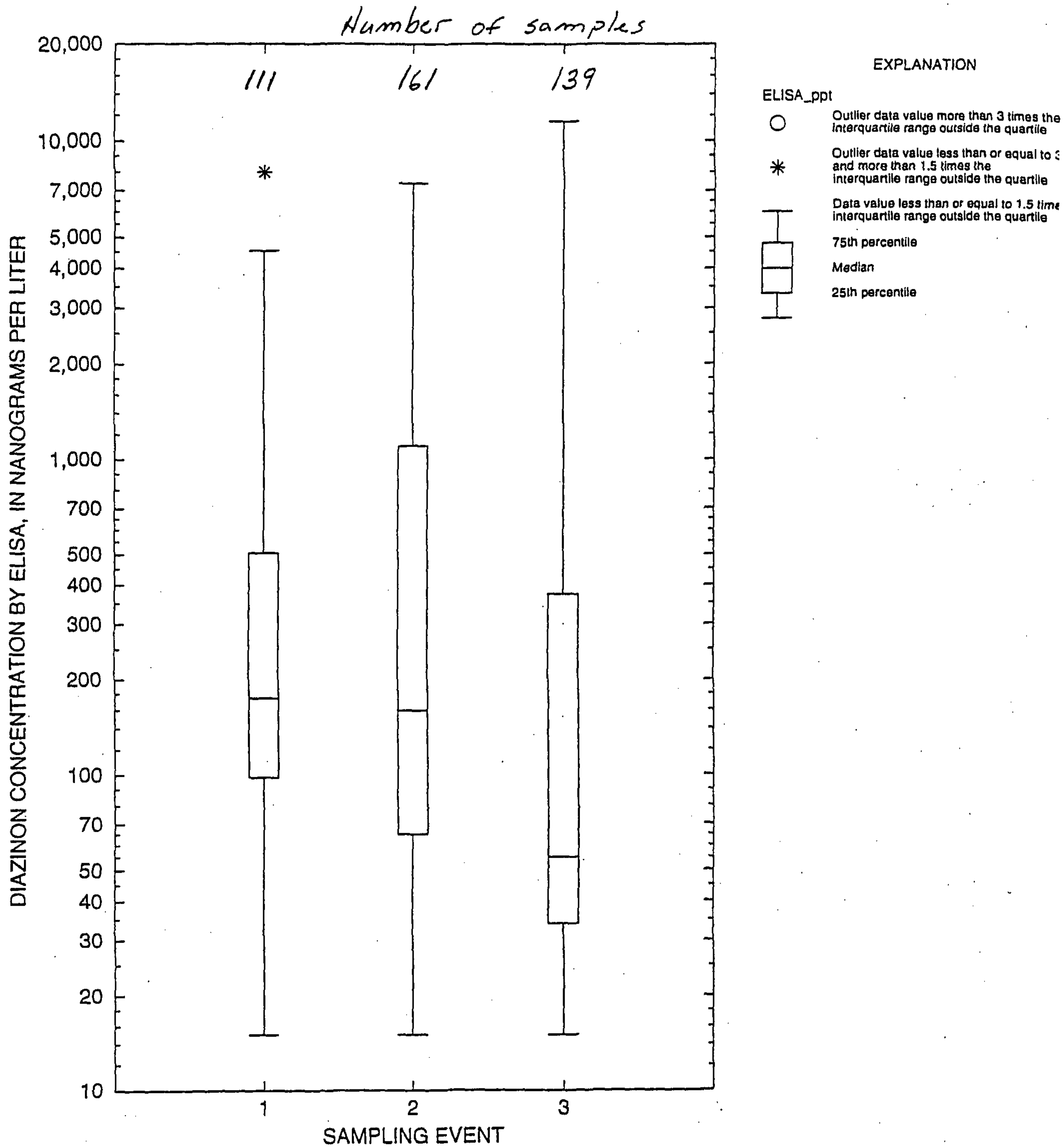


Figure 15a. Boxplots of diazinon concentration determined by ELISA for each sampling event.

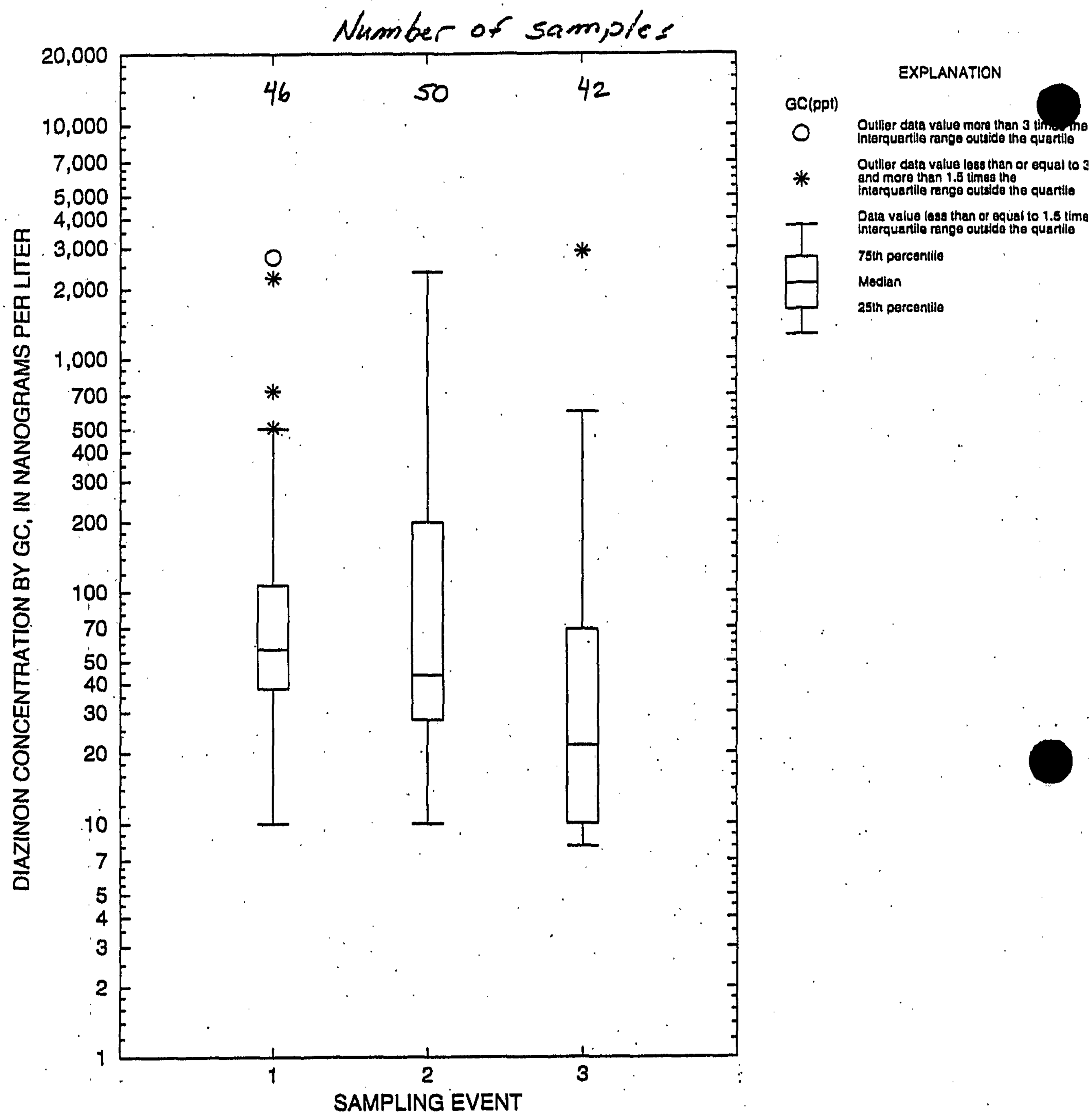


Figure 15b. Boxplots of diazinon concentration determined by GC/ECD/TSD/MS for each sampling event. [n, number of samples]

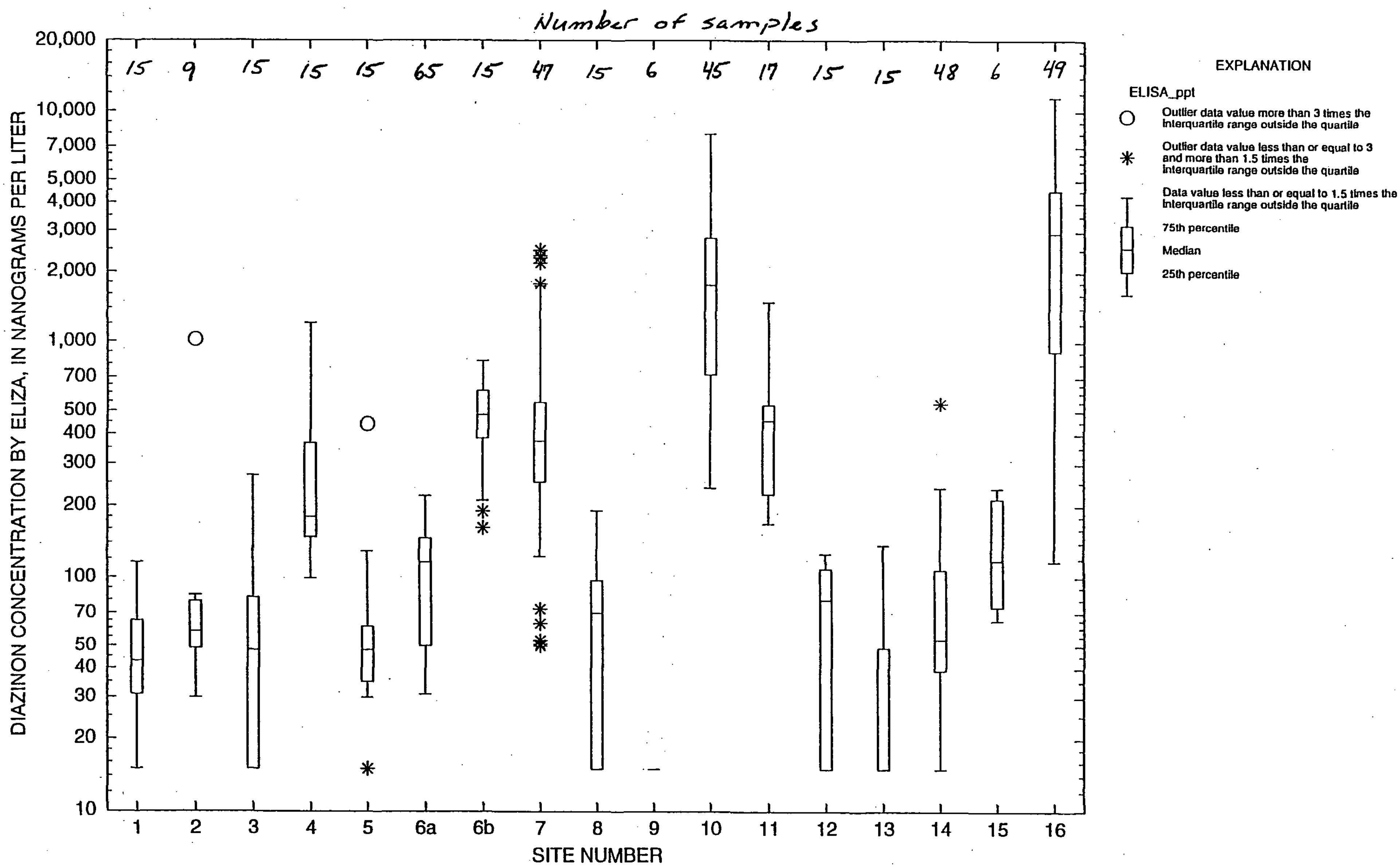


Figure 16a. Boxplots of diazinon concentration determined by ELISA for each sampling site.

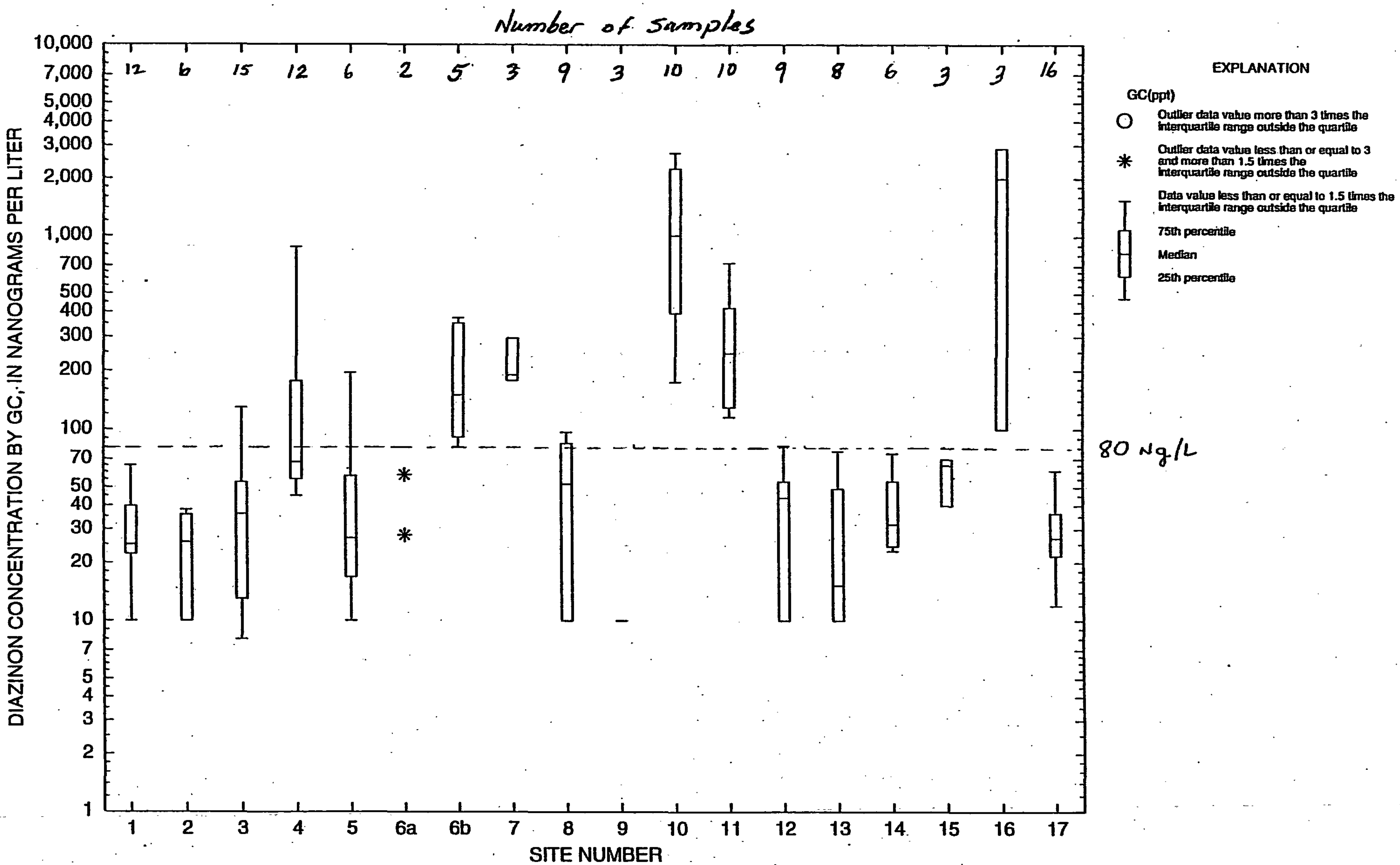


Figure 16b. Boxplots of diazinon concnetration determined by GC/ECD/TSD/MS for each sampling site.
[n, number of samples]

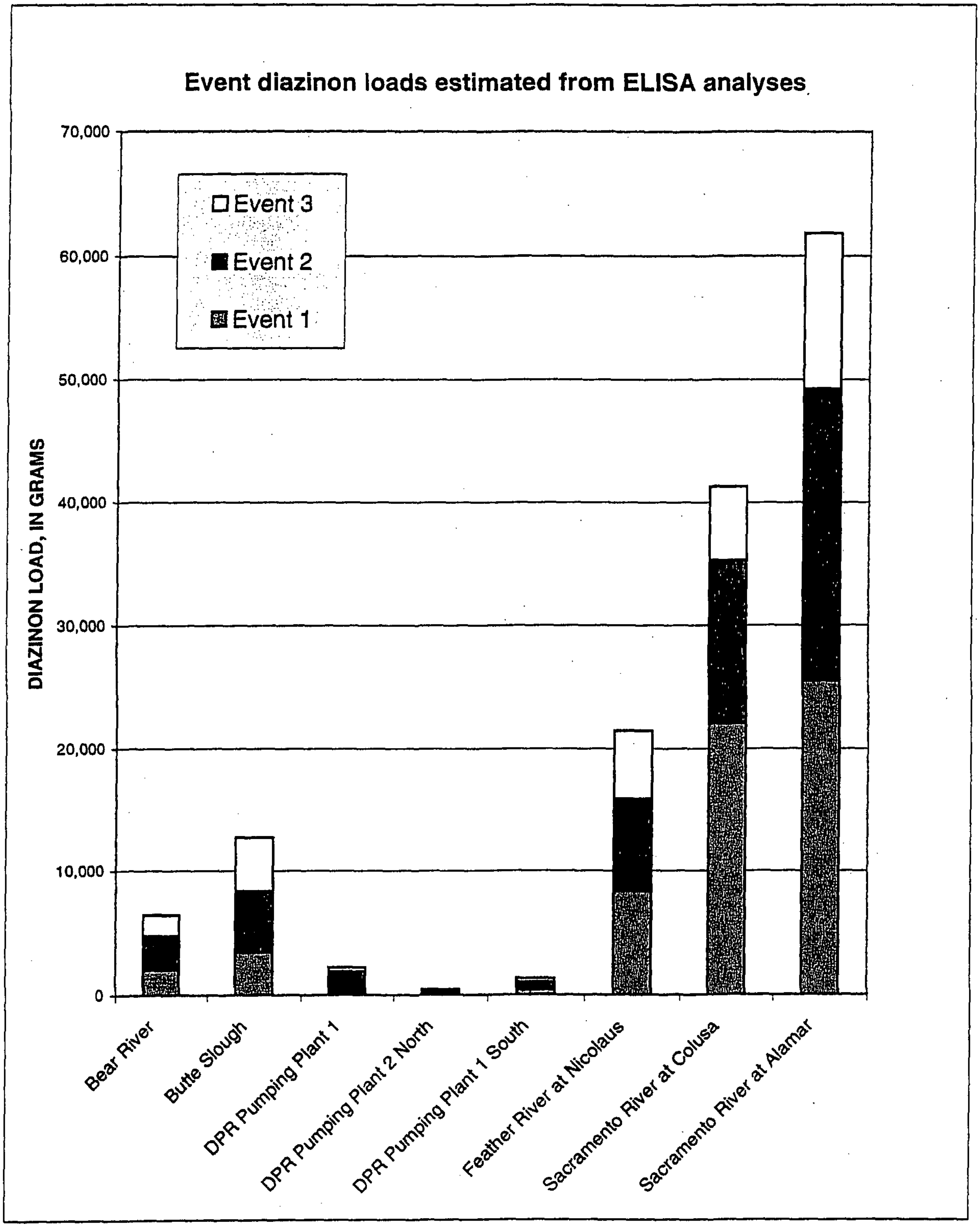


Figure 17. Storm loads calculated using samples analyzed by ELISA.

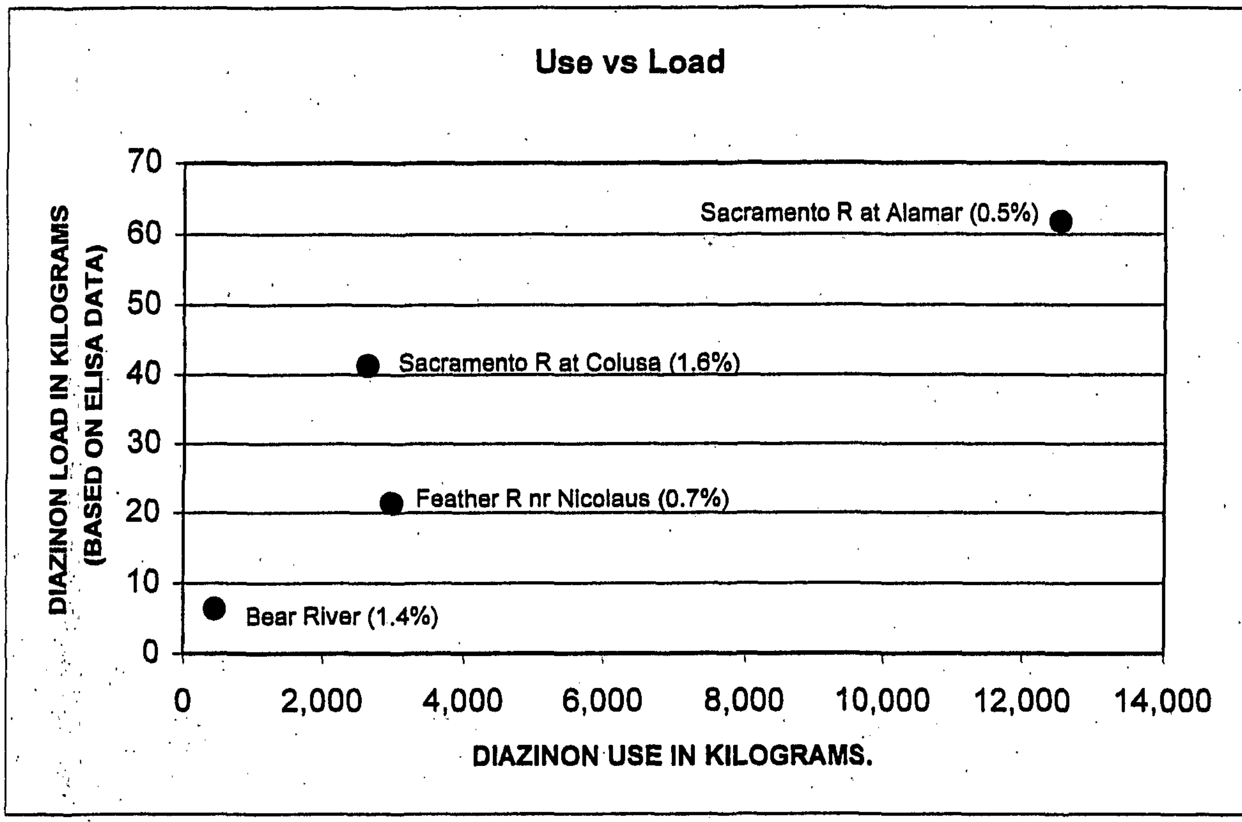


Figure 18. Diazinon load in relation to use in 4 subbasins.
[number in parenthesis is the ratio of load to upstream use as a percentage]

use vs load, 2000.xls

Appendix 1

Current monitoring programs and previous studies

Current Monitoring Programs and Sites

Sacramento River Watershed Program, Toxicity Monitoring

Monitoring Period: August 1996-June 2000(monitoring is continuous though sites are slightly revised from year to year).

Monitoring Program Objective: To characterize the spatial and temporal distribution of toxicity in the Sacramento River Watershed focusing on the main stem river, major tributaries, and several mid-basin tributaries.

Description of Monitoring: EPA 3-Species bioassays w/Phase I TIE's when major toxicity is detected.

Monitoring Frequency: Monthly/bimonthly sampling

Applicable Findings from 1997-98 Monitoring: These findings are presented in the "SRWP Toxicity Monitoring Results: 1997-987" report. Part of the 1997-98 toxicity monitoring focused on *Ceriodaphnia* toxicity in the Sacramento River tributaries. Note some of these sites are not part of the 1999-00 SRWP toxicity monitoring. Due to the focus of the monitoring effort, the distribution of sampling was weighted towards tributaries expected to have high *Ceriodaphnia* toxicity and during the dormant season spray when pesticides toxic to *Ceriodaphnia* were expected to be present.

Four out of five samples collected from the urban creek site, Arcade Creek, exhibited 100% *Ceriodaphnia* mortality. Chemical analyses and TIEs identified diazinon as the primary toxicant.

48% of the samples (20 out of 42) collected during January and February 1998 exhibited *Ceriodaphnia* reproductive impairment. Due to limited funding, no TIEs or chemical analyses were conducted, so the cause of the toxicity is unknown. These results are consistent with those observed in winter 1997 when 67% of the samples collected during January and February exhibited significantly lower reproduction than laboratory control. Acute *Ceriodaphnia* mortality was observed in the sample collected from the Feather River during February 1998. This is consistent with results obtained during previous dormant spray special studies in 1996 and 1997.

No *Ceriodaphnia* impairment was detected in samples collected from the Mill Creek (at mouth), Deer Creek (at HWY. 99) and Butte Creek (1/4 mile downstream of Centerville Rd. junction w/Honey Run Rd.) watersheds. In addition, the samples collected from the Sacramento River downstream of Keswick Reservoir did not exhibit *Ceriodaphnia* impairment.

1999/00 Toxicity Monitoring Sites

1. Pit River above Shasta (bimonthly)
2. McCloud River above Shasta (bimonthly)
3. Sacramento River above Shasta (bimonthly)
4. Spring Creek pumping plant discharge (bimonthly)
5. Sacramento River below Keswick (monthly)
6. Sacramento River at Bend Bridge (monthly)
7. Sacramento River near Hamilton City (monthly)
8. Sacramento River at Colusa (monthly)*NAWQA site
9. Butte Creek (bimonthly)
10. Sacramento Slough (9 times/year)
11. Colusa Basin Drain (9 times/year)
12. Feather River near Nicolaus (monthly)
13. Sacramento River at Veterans Bridge (monthly)
14. Arcade Creek (monthly)
15. American River at Discovery Park (monthly)
16. Sacramento River at Freeport (monthly) *NAWQA site
17. Cache Slough near Ryers Ferry (bimonthly)

Sacramento River Watershed Program Water Chemistry Monitoring

Monitoring Period: OP pesticide monitoring beginning in June 1999-June 2000, monitoring is continuous though sites are slightly revised from year to year.

Program Objective: To identify the causes, effects and extent of constituents of concern that affect the beneficial uses of water and to measure progress and control strategies that are implemented.

Description of Monitoring: Chemical, physical, biological, and toxicological elements. The toxicological monitoring was integrated into the overall water quality monitoring when water quality monitoring was initiated in June 1998.

Monitoring Frequency: OP pesticides monitoring for 1999/00 are monthly.

1999/00 monitoring sites where OP pesticides are monitored:

1. Sacramento River near Hamilton City
2. Sacramento River at Colusa
3. Sacramento Slough
4. Colusa Basin Drain
5. Sacramento River at Veterans Bridge
6. Arcade Creek

7. Sacramento River at Freeport*NAWQA site

Coordinated Monitoring Program—combined effort of the Sacramento Stormwater Program (includes City and County of Sacramento) and Sacramento Regional County Sanitation District

Monitoring Period: Monitoring was initiated in 1992 and is currently ongoing.

Program Objective: To develop high quality data to aid in the development and implementation of water quality policy and regulations in the Sacramento area. Coordinate ongoing surface water monitoring activities in the Sacramento area. Research and implement new water quality-monitoring efforts to address present and future regulatory requirements and to satisfy data needs.

Description of Monitoring: Water samples are analyzed for trace elements (including metals), conventional parameters (temperature, dissolved oxygen, pH, conductivity, hardness, total suspended solids, and totals and dissolved organic carbon). Depth composite water samples are collected by boat.

Monitoring Frequency: Samples were initially collected twice monthly (1992-1994) and have been collected monthly from 1995 to present.

Applicable Findings from 1996-97 Monitoring: Monitoring for diazinon and chlorpyrifos was initiated in 1996. Of 15 events for which these two pesticides were analyzed on the Sacramento River, diazinon was detected two times at concentrations between 10 - 40 ng/l and chlorpyrifos was not detected (it's detection limit was 50 ng/l and less). For the 16 events for which these pesticides were monitored on the American River, diazinon was only detected at Discovery Park for 4 events at concentrations between 10 - 30 ng/l.

CMP Monitoring Sites:

1. Sacramento River at Veteran's Bridge *SRWP monitoring site
2. Sacramento River at Freeport *SRWP monitoring site
3. Sacramento River at River Mile 44 (downstream of SRCSD discharge)
4. American River at Discovery Park *SRWP monitoring site
5. American River at Discovery Park *SRWP monitoring site

Dormant Spray Water Quality Program – Department of Pesticide Regulation

Monitoring Period: Monitoring was initiated in Dec. 1996 and is 5 year study which will continue through March 2001. Monitoring occurs during the dormant spray period, Dec. - March.

Program Objective: To identify the levels of dormant spray residues present in the Sacramento River watershed, and their relationship to the water quality objective for toxicity.

Description of Monitoring: Analyze for physical parameters (pH, NH_3, DO, EC, temperature, alkalinity, and hardness), OP pesticides using GC.FPD, carbamates and herbicides using HPLC. Evaluate acute toxicity to *Ceriodaphnia* in 7-day test for Sacramento River at Alamar Marina/Bryte.

Monitoring Frequency: Pesticide and toxicity monitoring approximately weekly from December through March.

Dormant Spray Program Monitoring Sites:

1. Sutter Bypass at Karnak Pumping Station (just prior to Sacramento Slough) (previous years during lower flows, this site was Sutter Bypass at Kirkville Road)
2. Sacramento River at Alamar Marina (moved from Bryte for the 1997/98 season)
3. Wadsworth Canal (3.5 miles upstream of confluence with Sutter Bypass)

Applicable Findings from 1998/99 Season Monitoring:

Site	Insecticide Results	Toxicity Results
Wadsworth Canal	• Diazinon detected in 17/20 samples from ~~Jan. 4 - Mar. 1 at~~ concentrations ranging from 4 ng/l.	• 8/20 samples were acutely toxic to *C. dubia.* Complete mortality found in 7 samples, 1 sample has reduced survival. Diazinon detected in all samples that had significant mortality but also 9 samples that did not show significant mortality. Diazinon concentration 0f 200 ng/l seemed to be about the toxic threshold limit.
Sutter Bypass	• Diazinon detected in 9/20 samples from Jan. 11 - Feb. 8 at conc. Ranging from 41 ng/l - 110 ng/l, avg. conc. = 80 ng/l. • No other insecticides	• Not available.

	detected.	
Sacramento River @ Alamar	• No insecticides detected in any of the 30 samples collected.	• Except for Jan. 4-8 samples no chronic toxicity tests had less than 80 % survival. No pesticides were detected in this sample.

Sacramento Stormwater Program OP Pesticide Grant Study

Monitoring Period: May 1999 - (hopefully April 2002 if receive full CALFED funding for a 3 year study).

Study Objectives: Determine levels of diazinon and chlorpyrifos (including temporal and spatial trends) within urban runoff, urban creeks, the Sacramento and American Rivers and rainfall.

Description of Monitoring: For all sites ELISA analyses for diazinon and chlorpyrifos w/ 10% of samples analyzed using GC/MS. Some *Ceriodaphnia* bioassay in Arcade Creek. Analyze rainfall at 3 sites for diazinon and chlorpyrifos.

Monitoring Frequency: Monthly diazinon and chlorpyrifos analyses plus 5 storm events per year. Conduct *Ceriodaphnia* bioassays for 3 storm events. Collect rain samples for 5 storm events.

Sacramento Stormwater Program OP Pesticide Study Monitoring Sites:

1-5. Monitoring sites on Arcade Creek (the pilot urban watershed)

6. City of Sacramento's Sump 111 (off Richard's Blvd. Drains industrial/commercial area).

7. City of Sacramento's Sump 104 (drains residential/commercial area off Fruitridge Road)

8. Strong Ranch Slough (drains residential/commercial area around Watt Avenue)

9-10. Additional urban runoff sites not in Arcade Creek watershed.

Past Monitoring Studies and Sites

CVRWQCB Study: "Sources and Concentrations of Diazinon in the Sacramento Watershed during the 1994 Orchard Dormant Spray Season"

Monitoring Period: January 1 - March 4, 1994.

Study Objectives: To (1) monitor diazinon concentrations in the Sacramento River after three rainstorms in January /February 1994 to ascertain whether insecticide pulses were present; (2) if pulses were observed, then determine the geographic sources of the insecticide; and (3) compare the accuracy and precision of ELSA and GC/MS methods to determine the utility of ELSA procedure for analyzing surface water samples.

Description of Monitoring: Diazinon was analyzed by 3 methods: 10 ELSA, 2) GC/MS by USGS lab in Arvada, Colorado, 3) GC/MS by USGS lab in Sacramento, California. Rainfall data was obtained from the Desert Research Center's Atmospheric Science Center for four locations: the cities of Sacramento, Colusa, Marysville, and Red Bluff.

Monitoring Frequency: Monitoring frequencies varied based upon whether a site was a primary or secondary monitoring site. Primary monitoring sites were monitored by daily grab samples following a storm and every 2 - 7 days during non-storm periods. Secondary monitoring sites were monitored 1-3 consecutive days during storms.

Major Study Findings: The primary source of diazinon varied depending upon the storm event. First storm-primary source of diazinon was from the Feather River drainage especially Jack Slough and the Bear River. Second and third storms primary sources of diazinon in the Upper Sacramento River watershed were unclear but seemed to be located between Bend and Vina. Major sources of diazinon to Sacramento slough were the Main Drain, Wadsworth Canal, and DWR pumping stations at Obanion and Sacramento Avenue.

What about accuracy of GC/MS vs. ELISA

Primary Monitoring Sites:

1. Sacramento River @ City of Sacramento, Tower Bridge at Capitol Mall
2. Feather River @ Hwy. 99, Hwy. 99 Bridge
3. Feather River @ Yuba City, West bank below Hwy. 20 Bridge
4. Sacramento Slough @ Karnak Bridge off Ely Road
5. Butte Creek @ Pass Road Bridge
6. Colusa Darin @ Knights Landing, Road 99 E Bridge
7. Sacramento River @ City of Colusa, bridge on River Road at City of Colusa

Secondary Monitoring Sites:

8. Bear River @ Berry Road (tributary to Feather River)

9. Yuba River @ Marysville (tributary to Feather River)
10. Jack Slough @ 14^{th} Street in Marysville (tributary to Feather River)
11. Honcut Creek @ Chandler Road (tributary to Feather River)
12. Sacramento Outfall @ DWR pumping plant on Sacramento Road (tributary to Butte creek)
13. Obanion Outfall @ DWR pumping plant on Obanion Road (tributary to Butte Creek)
14. Wadsworth Canal @ Franklin Road (tributary to Butte Creek).
15. Main Drain to Cherokee Canal @ Colusa Hwy. (tributary to Butte Creek)
16. Sacramento River @ Butte City @ Hwy. 162 Bridge
17. Sacramento River @ Ord Bend @ Ord Bend Road Bridge
18. Sacramento River @ Hamilton @ Hwy. 32 Bridge
19. Sacramento River @ Vina @ South Avenue Bridge
20. Sacramento River @ Tehama @ Aramayo Way Bridge
21. Sacramento River @ Red Bluff @ Balls Ferry Road Bridge
22. Sacramento River @ Bend @ Bend Ferry Road Bridge

USGS National Water Quality Assessment (NAWQA) Program, 3 Year Intensive Monitoring Effort in the Sacramento River Watershed

Monitoring Period: The intensive monitoring was initiated in February 1996 and went through early 1999.

Study Objectives: To assess the condition of surface and ground waters by measuring constituents in water, sediment, and tissue of selected species and species abundance. Since NAWQA is a national monitoring program, compounds and species studied were selected for cross-country comparisons.

Description of Monitoring: The categories of parameters monitored varied depending upon the sites. Monitoring conducted included water quality, sediment, tissue, toxicity, and bioassessment. Water quality monitoring included conventionals,. nutrients, metals, and organics (including extensive pesticide scans and analyses).

Monitoring Frequency: Monitoring frequency varied depending upon the type of monitoring involved, the location, and the constituent. Water quality monitoring typically occurred on a monthly basis.

Major Study Findings: An evaluation of the 3 years worth of data is not yet available.

Sacramento River Watershed NAWQA Water Quality Monitoring Sites where water column pesticide levels were monitored:

1. Sacramento River at Freeport
2. Colusa Basin Drain

3. Arcade Creek, Del Paso Heights

USGS Study: "Pesticides and Pesticide Degradation Products in Stormwater Runoff: Sacramento River basin, California"

Monitoring Period: January 12 - February 4, 1994.

Study Objectives: To determine the principal locations of sources of OP pesticides to the Sacramento River. (Other pesticides were also analyzed in association with other study objectives). This monitoring coincided with the 1994 CVRWQCB monitoring of the same area and USGS's analyses provided matching GC/MS results to the ELISA analyses used in the CVRWQCB study.

Description of Monitoring: Diazinon was analyzed by GC?MS by USGS labs in Arvada, Colorado and Sacramento, California. Flow rate data were obtained for the Sacramento River at Colusa, Verona, and City of Sacramento; the Feather River; Colusa Basin Drain; and Sacramento Slough.

Monitoring Frequency: Monitoring was rainfall-event based and focused on one storm which occurred from January 22-26. Pre-rainfall monitoring occurred on January 12th and event monitoring occurred five times from January 24-29.

Major Study Findings: Diazinon was detected most frequently of the pesticides and in the highest concentrations. Results of monitoring of this particular event indicated that the Feather River contributed the majority of the diazinon loading to the Sacramento River. Toxicity was associated with these diazinon loadings for at least two days following the rainfall event. For this event, the northern and western areas of the Sacramento Valley did not contribute significant diazinon loading but this may be partly attributable to the distribution of rainfall.

Primary Monitoring Sites:

1. Sacramento River @ Colusa
2. Feather River at Yuba City
3. Butte slough
4. Feather River below Yuba City
5. Colusa Basin Drain
6. Sacramento Slough
7. Sacramento River at Sacramento

Additional Sampling Sites (sampled only once):

1. Main Drainage Canal (flows into Butte Creek
2. Honcut Creek
3. Jack Slough
4. Yuba River at Yuba City
5. Wadsworth Canal
6. O'Bannion Drain
7. DWR Drain
8. Bear River

USGS Study: "Dissolved Pesticide Data for the San Joaquin River at Vernalis and the Sacramento River at Sacramento, California, 1991-1994"

Monitoring Period: January 1991 - April 1994.

Study Objectives: "To determine the fate and transport of organic pesticides that enter the San Francisco Bay Estuary". This report, evaluating 3 years of pesticide data, was part of USGS San Francisco Bay Estuary Toxic Contaminants Project.

Description of Monitoring: Pesticides were analyzed by GC/MS.

Monitoring Frequency: Monitoring for diazinon at the Sacramento River site was conducted approximately every two or three days over a 3-year period.

Major Study Findings: The report does not evaluate the data there are the following obvious characteristics regarding OP pesticide concentrations for the Sacramento River monitoring:

- Diazinon was rarely detected outside of the period of the year spanning Jan. 10-Mar. 31.
- Diazinon levels during the Jan. 10 - Mar. 31 period ranged from 10-393 ng/l.
- Chlorpyrifos was not detected during the same time periods that diazinon was detected at levels ranging from 10-212 ng/l.

Monitoring Sites:

1. Sacramento River @ City of Sacramento
2. San Joaquin River @ Vernalis

CVRWQCB Study: "Pesticides In Surface Water from Applications on Orchards and Alfalfa During the Winter and Spring of 1991-92".

Monitoring Period: Early January 1992 - end of April 1992.

Study Objectives: There were two elements of this study, 1) focusing on pesticide use on alfalfa; 2) focusing on dormant spray pesticide use on orchards. The objective of the orchard part of this study was to determine if dormant spray pesticide runoff occurred in general in stone fruit orchards when dormant sprays are applied or just in the San Joaquin River watershed. A secondary objective was to determine how rain impacts pesticide movement in surface water.

Description of Monitoring: *Ceriodaphnia* bioassay analyses, carbamate and OP pesticide analyses using EPA 622 and 632. There was a 3-way split of some samples that were analyzed by the commercial lab (Eureka Labs, used to analyze all the pesticide samples), USGS's Central Lab in Colorado, and DPR's Sacramento lab.

Monitoring Frequency: Weekly monitoring from early January to late April.

Major Study Findings: 25% of the samples collected as part of the Sacramento portion of the orchard dormant spray study were toxic to *Ceriodaphnia*. Acute *Ceriodaphnia* mortality was observed whenever there was low in Clark's Ditch and for over two-thirds of the Gilsizer Slough samples. Much less toxicity was observed in water collected from the Feather and Sacramento Rivers and for the Sacramento River, no toxicity was observed except for one event in which 10% toxicity was measured.

Diazinon, diuron, and methidathion were detected in toxic samples from Clark's Ditch and Gilsizer Slough. These pesticides were present both in the drainages and in the Feather River indicating that pesticides measured in small watercourses contribute to the concentrations in their receiving waters. For about half the toxics samples, methidathion and diazinon concentrations were sufficient to explain toxicity found. For the other samples, the observed pesticide concentrations only explained part of the toxicity measured. Five pesticides were used extensively during the dormant spray season and only two of these (methidathion and diazinon) were routinely detected in this study. The other three pesticides (chlorpyrifos, parathion, and malathion) have been detected in other studies where lower detection limits were used. Therefore, these pesticides may have been present in toxic samples in this study and could have contributed to the observed toxicity but were not detected due to higher detection limits.

Monitoring Sites: (for Sacramento River watershed portion of this study):

1. Sacramento River @ Meridian (200 yards north of the Hwy. 20 Meridian Bridge)
2. Clark's Ditch, tributary to Colusa Basin Drain
3. Gilsizer Slough (south bank of slough at South George Washington Road)
4. Feather River (about 200 yds. Downstream of intersection of Lee Rd. and Garden Hwy.)

DPR and DFG Study: "Four Rivers Study Report" 11/7/96:

Monitoring Period: November 12, 1993 - November 6, 1994.

Study Objective: Implement a year-round pesticide monitoring effort in California Rivers that have the potential to have pesticide residues due to the significant amounts of agricultural runoff that they receive. Determine if these pesticides are occurring at significant concentrations in receiving waters. Identify California Rivers and time periods that require further pesticide monitoring.

Description of Monitoring: Pesticides that were known to be used in the watersheds were analyzed in the receiving waters. Fathead minnow and *Ceriodaphnia dubia* toxicity analyses was conducted. General physical water quality monitoring was conducted. (temperature, DO, pH.)

Monitoring Frequency: Weekly monitoring for pesticides by taking 3-day composite samples to represent each week. Bimonthly fathead minnow and *Ceriodaphnia dubia* toxicity analyses.

Major Study Findings (for Sacramento River): 2 of 52 samples collected over the 1-year period had detectable diazinon concentrations with 100ng/l detected for the 1/25-28/94 composite sample and 70 ng/l detected for the 2/8-11/94 composite sample. These two detections occurred during the dormant spray season and coincide with 2 of the 3 significant rainfall/runoff events that occurred during the dormant spray season. No diazinon was detected in conjunction with the third dormant spray season significant rainfall/runoff event that occurred Feb. 16-19. Evaluating the diazinon applications to the watershed during the dormant spray season (see table 1), by far the greatest amount of diazinon was applied during January with peak application occurring in mid-January. Diazinon applications tapered off significantly in February and March. The diazinon application amounts and the timing of the January 21-25 and February 4-8 storm events help in explaining the diazinon detections that occurred around January 28 and February 11.

Appendix 2

Environmental sample pesticide concentration table

Appendix 2, Table 1. Concentrations of diazinon and methidathion in water samples.

[ng/L, nanogram per liter; R, River; Cr, Creek; Sl., Slough; Br., Bridge; --, no data available]

Site No.	Site name	Storm event number	Date / Time	Diazinon ELISA (ng/L)	Diazinon GC/ECD (ng/L)	Diazinon GC/MS (ng/L)	Methidathion (ng/L)
1	Sacramento R. at Alamar	1	01/30/2000 11:00	35	25	--	--
1	Sacramento R. at Alamar	1	01/31/2000 10:45	36	25	--	--
1	Sacramento R. at Alamar	1	02/01/2000 13:10	75	38	--	--
1	Sacramento R. at Alamar	1	02/02/2000 12:50	116	65	--	--
1	Sacramento R. at Alamar	1	02/03/2000 12:50	69	--	--	--
1	Sacramento R. at Alamar	2	02/11/2000 16:10	56	25	--	--
1	Sacramento R. at Alamar	2	02/12/2000 14:05	43	39	--	--
1	Sacramento R. at Alamar	2	02/13/2000 14:50	43	40	--	--
1	Sacramento R. at Alamar	2	02/14/2000 13:15	65	42	--	--
1	Sacramento R. at Alamar	2	02/15/2000 13:40	61	--	--	--
1	Sacramento R. at Alamar	3	02/21/2000 15:00	<30	23	--	--
1	Sacramento R. at Alamar	3	02/22/2000 13:25	31	<20	--	--
1	Sacramento R. at Alamar	3	02/23/2000 14:00	<30	<20	--	--
1	Sacramento R. at Alamar	3	02/24/2000 12:50	30	22	--	--
1	Sacramento R. at Alamar	3	02/25/2000 12:05	32	--	--	--
2	Colusa Basin Drain	1	01/30/2000 13:15	52	<20	--	--
2	Colusa Basin Drain	1	01/31/2000 12:00	30	20	--	--
2	Colusa Basin Drain	1	02/03/2000 09:25	1,020	--	--	--
2	Colusa Basin Drain	2	02/11/2000 14:05	58	<20	--	--
2	Colusa Basin Drain	2	02/12/2000 09:20	61	33	--	--
2	Colusa Basin Drain	2	02/15/2000 09:30	84	--	--	--
2	Colusa Basin Drain	3	02/21/2000 11:20	52	35	--	--
2	Colusa Basin Drain	3	02/22/2000 10:30	46	38	--	--
2	Colusa Basin Drain	3	02/25/2000 08:55	74	--	--	--
3	Feather R. nr Nicolaus	1	01/30/2000 14:30	71	35	40	--
3	Feather R. nr Nicolaus	1	01/31/2000 12:30	268	105	154	--
3	Feather R. nr Nicolaus	1	02/01/2000 12:50	71	45	54	--
3	Feather R. nr Nicolaus	1	02/02/2000 11:50	91	52	54	--
3	Feather R. nr Nicolaus	1	02/03/2000 11:30	78	--	43	--
3	Feather R. nr Nicolaus	2	02/11/2000 12:40	88	70	60	--
3	Feather R. nr Nicolaus	2	02/12/2000 10:30	48	35	35	--
3	Feather R. nr Nicolaus	2	02/13/2000 14:20	82	55	63	--
3	Feather R. nr Nicolaus	2	02/14/2000 13:00	<30	26	33	--
3	Feather R. nr Nicolaus	2	02/15/2000 10:40	34	--	36	--
3	Feather R. nr Nicolaus	3	02/21/2000 12:40	<30	--	8	--
3	Feather R. nr Nicolaus	3	02/22/2000 10:30	<30	--	9	--
3	Feather R. nr Nicolaus	3	02/23/2000 10:20	<30	--	9	--
3	Feather R. nr Nicolaus	3	02/24/2000 10:10	30	--	13	--
3	Feather R. nr Nicolaus	3	02/25/2000 10:50	<30	20	16	--
4	DWR Pump Plant 1	1	01/30/2000 14:30	139	48	--	--
4	DWR Pump Plant 1	1	01/31/2000 12:55	153	65	--	168
4	DWR Pump Plant 1	1	02/01/2000 09:30	153	55	--	--
4	DWR Pump Plant 1	1	02/02/2000 11:50	168	70	--	--
4	DWR Pump Plant 1	1	02/03/2000 11:50	185	--	--	--
4	DWR Pump Plant 1	2	02/11/2000 15:00	238	45	--	660
4	DWR Pump Plant 1	2	02/12/2000 12:45	366	215	--	389
4	DWR Pump Plant 1	2	02/13/2000 13:40	1,210	878	--	145
4	DWR Pump Plant 1	2	02/14/2000 12:20	834	500	--	402
4	DWR Pump Plant 1	2	02/15/2000 12:30	666	--	--	--
4	DWR Pump Plant 1	3	02/21/2000 13:55	99	55	--	95
4	DWR Pump Plant 1	3	02/22/2000 12:20	135	57	--	58

Appendix 2, Table 1. Concentrations of diazinon and methidathion in water samples.-Cont.

[ng/L, nanogram per liter; R, River; Cr, Creek; Sl., Slough; Br., Bridge; --, no data available]

Site No.	Site name	Storm event number	Date / Time	Diazinon ELISA (ng/L)	Diazinon GC/ECD (ng/L)	Diazinon GC/MS (ng/L)	Methidathion (ng/L)
4	DWR Pump Plant 1	3	02/23/2000 10:30	185	96	--	1,580
4	DWR Pump Plant 1	3	02/24/2000 11:45	180	98	--	504
4	DWR Pump Plant 1	3	02/25/2000 12:00	148	--	--	--
5	Bear River	1	01/30/2000 16:00	50	--	--	--
5	Bear River	1	01/31/2000 13:10	441	195	--	--
5	Bear River	1	02/01/2000 14:20	63	--	--	--
5	Bear River	1	02/02/2000 13:30	55	38	--	--
5	Bear River	1	02/03/2000 12:40	30	--	--	--
5	Bear River	2	02/11/2000 14:30	129	--	--	--
5	Bear River	2	02/12/2000 11:30	37	<20	--	--
5	Bear River	2	02/13/2000 15:30	44	--	--	--
5	Bear River	2	02/14/2000 12:20	<30	26	--	--
5	Bear River	2	02/15/2000 10:10	48	--	--	--
5	Bear River	3	02/21/2000 15:30	61	--	--	--
5	Bear River	3	02/22/2000 12:10	48	28	--	--
5	Bear River	3	02/23/2000 12:00	<30	--	--	--
5	Bear River	3	02/24/2000 12:40	35	20	--	--
5	Bear River	3	02/25/2000 14:30	47	--	--	--
6a	DWR Pump Plant 2, north	1	01/30/2000 12:00	98	--	--	--
6a	DWR Pump Plant 2, north	1	01/30/2000 20:00	139	--	--	--
6a	DWR Pump Plant 2, north	1	01/31/2000 04:00	220	--	--	--
6a	DWR Pump Plant 2, north	1	01/31/2000 12:00	192	--	--	--
6a	DWR Pump Plant 2, north	1	01/31/2000 16:30	181	--	--	--
6a	DWR Pump Plant 2, north	1	01/31/2000 20:30	174	--	--	--
6a	DWR Pump Plant 2, north	1	02/01/2000 00:30	165	--	--	--
6a	DWR Pump Plant 2, north	1	02/01/2000 04:30	170	--	--	--
6a	DWR Pump Plant 2, north	1	02/01/2000 08:30	164	--	--	--
6a	DWR Pump Plant 2, north	1	02/01/2000 12:30	165	--	--	--
6a	DWR Pump Plant 2, north	1	02/01/2000 16:30	156	--	--	--
6a	DWR Pump Plant 2, north	1	02/01/2000 20:30	135	--	--	--
6a	DWR Pump Plant 2, north	1	02/02/2000 00:30	148	--	--	--
6a	DWR Pump Plant 2, north	1	02/02/2000 04:30	151	--	--	--
6a	DWR Pump Plant 2, north	1	02/02/2000 08:30	144	--	--	--
6a	DWR Pump Plant 2, north	1	02/03/2000 10:25	120	58	--	--
6a	DWR Pump Plant 2, north	2	02/11/2000 12:01	89	--	--	--
6a	DWR Pump Plant 2, north	2	02/11/2000 16:01	107	--	--	--
6a	DWR Pump Plant 2, north	2	02/11/2000 20:01	114	--	--	--
6a	DWR Pump Plant 2, north	2	02/12/2000 00:01	137	--	--	--
6a	DWR Pump Plant 2, north	2	02/12/2000 04:01	136	--	--	--
6a	DWR Pump Plant 2, north	2	02/12/2000 08:01	124	--	--	--
6a	DWR Pump Plant 2, north	2	02/12/2000 12:01	141	--	--	--
6a	DWR Pump Plant 2, north	2	02/12/2000 16:01	164	--	--	--
6a	DWR Pump Plant 2, north	2	02/12/2000 20:01	154	--	--	--
6a	DWR Pump Plant 2, north	2	02/13/2000 00:01	123	--	--	--
6a	DWR Pump Plant 2, north	2	02/13/2000 04:01	116	--	--	--
6a	DWR Pump Plant 2, north	2	02/13/2000 08:01	116	--	--	--
6a	DWR Pump Plant 2, north	2	02/13/2000 12:01	101	--	--	--
6a	DWR Pump Plant 2, north	2	02/13/2000 16:01	107	--	--	--
6a	DWR Pump Plant 2, north	2	02/13/2000 20:01	129	--	--	--
6a	DWR Pump Plant 2, north	2	02/14/2000 00:01	134	--	--	--
6a	DWR Pump Plant 2, north	2	02/14/2000 04:01	132	--	--	--

Appendix 2, Table 1. Concentrations of diazinon and methidathion in water samples. – Cont.

[ng/L, nanogram per liter; R, River; Cr, Creek; Sl., Slough; Br., Bridge; --, no data available]

Site No.	Site name	Storm event number	Date / Time	Diazinon ELISA (ng/L)	Diazinon GC/ECD (ng/L)	Diazinon GC/MS (ng/L)	Methidathion (ng/L)
6a	DWR Pump Plant 2, north	2	02/14/2000 08:01	132	--	--	--
6a	DWR Pump Plant 2, north	2	02/14/2000 12:01	145	--	--	--
6a	DWR Pump Plant 2, north	2	02/14/2000 16:01	159	--	--	--
6a	DWR Pump Plant 2, north	2	02/14/2000 20:01	136	--	--	--
6a	DWR Pump Plant 2, north	2	02/15/2000 00:01	140	--	--	--
6a	DWR Pump Plant 2, north	2	02/15/2000 04:01	151	--	--	--
6a	DWR Pump Plant 2, north	2	02/15/2000 08:01	148	--	--	--
6a	DWR Pump Plant 2, north	2	02/15/2000 11:05	116	--	--	--
6a	DWR Pump Plant 2, north	3	02/21/2000 12:30	54	--	--	--
6a	DWR Pump Plant 2, north	3	02/21/2000 16:30	62	--	--	--
6a	DWR Pump Plant 2, north	3	02/21/2000 20:30	53	--	--	--
6a	DWR Pump Plant 2, north	3	02/22/2000 00:30	50	--	--	--
6a	DWR Pump Plant 2, north	3	02/22/2000 04:30	58	--	--	--
6a	DWR Pump Plant 2, north	3	02/22/2000 08:30	38	--	--	--
6a	DWR Pump Plant 2, north	3	02/22/2000 12:30	49	--	--	--
6a	DWR Pump Plant 2, north	3	02/22/2000 16:30	44	--	--	--
6a	DWR Pump Plant 2, north	3	02/22/2000 20:30	31	--	--	--
6a	DWR Pump Plant 2, north	3	02/23/2000 00:30	48	--	--	--
6a	DWR Pump Plant 2, north	3	02/23/2000 04:30	46	--	--	--
6a	DWR Pump Plant 2, north	3	02/23/2000 08:30	46	--	--	--
6a	DWR Pump Plant 2, north	3	02/23/2000 12:30	44	--	--	--
6a	DWR Pump Plant 2, north	3	02/23/2000 16:30	50	--	--	--
6a	DWR Pump Plant 2, north	3	02/23/2000 20:30	49	--	--	--
6a	DWR Pump Plant 2, north	3	02/24/2000 00:30	56	--	--	--
6a	DWR Pump Plant 2, north	3	02/24/2000 04:30	50	--	--	--
6a	DWR Pump Plant 2, north	3	02/24/2000 08:30	49	--	--	--
6a	DWR Pump Plant 2, north	3	02/24/2000 12:30	50	--	--	--
6a	DWR Pump Plant 2, north	3	02/24/2000 16:30	49	--	--	--
6a	DWR Pump Plant 2, north	3	02/25/2000 00:30	42	--	--	--
6a	DWR Pump Plant 2, north	3	02/25/2000 04:30	37	--	--	--
6a	DWR Pump Plant 2, north	3	02/25/2000 08:30	33	--	--	--
6a	DWR Pump Plant 2, north	3	02/25/2000 10:25	40	28	--	--
6b	DWR Pump Plant 2, south	1	01/30/2000 15:30	211	--	--	--
6b	DWR Pump Plant 2, south	1	01/31/2000 13:48	614	330	--	525
6b	DWR Pump Plant 2, south	1	02/01/2000 11:00	827	--	--	--
6b	DWR Pump Plant 2, south	1	02/02/2000 11:00	686	--	--	--
6b	DWR Pump Plant 2, south	1	02/03/2000 10:50	573	--	--	--
6b	DWR Pump Plant 2, south	2	02/11/2000 12:40	389	150	--	--
6b	DWR Pump Plant 2, south	2	02/12/2000 11:15	513	375	--	550
6b	DWR Pump Plant 2, south	2	02/13/2000 10:50	385	--	--	--
6b	DWR Pump Plant 2, south	2	02/14/2000 10:50	575	--	--	--
6b	DWR Pump Plant 2, south	2	02/15/2000 10:35	656	--	--	--
6b	DWR Pump Plant 2, south	3	02/21/2000 12:45	190	103	--	--
6b	DWR Pump Plant 2, south	3	02/22/2000 11:20	162	81	--	--
6b	DWR Pump Plant 2, south	3	02/23/2000 11:10	472	--	--	--
6b	DWR Pump Plant 2, south	3	02/24/2000 10:50	442	--	--	--
6b	DWR Pump Plant 2, south	3	02/25/2000 09:55	483	--	--	--
7	Gisizer Sl. at Bogue Rd.	1	01/30/2000 19:00	2,190	--	--	--
7	Gisizer Sl. at Bogue Rd.	1	01/30/2000 22:10	2,310	--	--	--
7	Gisizer Sl. at Bogue Rd.	1	01/31/2000 06:15	1,780	--	--	--
7	Gisizer Sl. at Bogue Rd.	1	01/31/2000 10:10	2,490	--	--	--

Appendix 2, Table 1. Concentrations of diazinon and methidathion in water samples.- Cont.

[ng/L, nanogram per liter; R, River; Cr, Creek; Sl., Slough; Br., Bridge; --, no data available]

Site No.	Site name	Storm event number	Date / Time	Diazinon ELISA (ng/L)	Diazinon GC/ECD (ng/L)	Diazinon GC/MS (ng/L)	Methidathion (ng/L)
7	Gisizer Sl. at Bogue Rd.	1	01/31/2000 14:55	2,360	--	--	--
7	Gisizer Sl. at Bogue Rd.	1	01/31/2000 22:35	1,720	--	--	--
7	Gisizer Sl. at Bogue Rd.	1	02/01/2000 10:20	476	295	--	62
7	Gisizer Sl. at Bogue Rd.	1	02/02/2000 11:05	213	--	--	--
7	Gisizer Sl. at Bogue Rd.	1	02/03/2000 09:10	63	--	--	--
7	Gisizer Sl. at Bogue Rd.	2	02/11/2000 13:03	704	--	--	--
7	Gisizer Sl. at Bogue Rd.	2	02/11/2000 18:05	529	--	--	--
7	Gisizer Sl. at Bogue Rd.	2	02/12/2000 02:10	380	--	--	--
7	Gisizer Sl. at Bogue Rd.	2	02/12/2000 05:45	367	--	--	--
7	Gisizer Sl. at Bogue Rd.	2	02/12/2000 09:40	412	--	--	--
7	Gisizer Sl. at Bogue Rd.	2	02/12/2000 14:45	388	--	--	--
7	Gisizer Sl. at Bogue Rd.	2	02/12/2000 17:57	547	--	--	--
7	Gisizer Sl. at Bogue Rd.	2	02/12/2000 21:37	482	--	--	--
7	Gisizer Sl. at Bogue Rd.	2	02/13/2000 02:05	480	--	--	--
7	Gisizer Sl. at Bogue Rd.	2	02/13/2000 05:40	400	--	--	--
7	Gisizer Sl. at Bogue Rd.	2	02/13/2000 09:15	312	--	--	--
7	Gisizer Sl. at Bogue Rd.	2	02/13/2000 13:55	313	190	--	--
7	Gisizer Sl. at Bogue Rd.	2	02/13/2000 17:20	324	--	--	--
7	Gisizer Sl. at Bogue Rd.	2	02/13/2000 21:45	338	--	--	--
7	Gisizer Sl. at Bogue Rd.	2	02/14/2000 01:40	329	--	--	--
7	Gisizer Sl. at Bogue Rd.	2	02/14/2000 06:05	314	--	--	--
7	Gisizer Sl. at Bogue Rd.	2	02/14/2000 10:00	287	--	--	--
7	Gisizer Sl. at Bogue Rd.	2	02/14/2000 14:40	238	--	--	--
7	Gisizer Sl. at Bogue Rd.	2	02/14/2000 17:50	243	--	--	--
7	Gisizer Sl. at Bogue Rd.	2	02/14/2000 21:45	283	--	--	--
7	Gisizer Sl. at Bogue Rd.	2	02/15/2000 11:50	51	--	--	--
7	Gisizer Sl. at Bogue Rd.	3	02/21/2000 11:15	937	--	--	--
7	Gisizer Sl. at Bogue Rd.	3	02/22/2000 09:45	123	--	--	--
7	Gisizer Sl. at Bogue Rd.	3	02/22/2000 14:00	1,740	--	--	--
7	Gisizer Sl. at Bogue Rd.	3	02/22/2000 17:30	1,010	--	--	--
7	Gisizer Sl. at Bogue Rd.	3	02/22/2000 21:50	479	--	--	--
7	Gisizer Sl. at Bogue Rd.	3	02/23/2000 01:25	393	--	--	--
7	Gisizer Sl. at Bogue Rd.	3	02/23/2000 05:30	382	--	--	--
7	Gisizer Sl. at Bogue Rd.	3	02/23/2000 09:55	374	--	--	--
7	Gisizer Sl. at Bogue Rd.	3	02/23/2000 14:13	294	178	--	--
7	Gisizer Sl. at Bogue Rd.	3	02/23/2000 17:05	252	--	--	--
7	Gisizer Sl. at Bogue Rd.	3	02/23/2000 21:44	177	--	--	--
7	Gisizer Sl. at Bogue Rd.	3	02/24/2000 06:25	73	--	--	--
7	Gisizer Sl. at Bogue Rd.	3	02/24/2000 14:45	53	--	--	--
7	Gisizer Sl. at Bogue Rd.	3	02/24/2000 17:35	50	--	--	--
7	Gisizer Sl. at Bogue Rd.	3	02/24/2000 21:55	260	--	--	--
7	Gisizer Sl. at Bogue Rd.	3	02/25/2000 13:10	252	--	--	--
7	Gisizer Sl. at Bogue Rd.		02/10/2000 18:00	665	--	--	--
8	Feather R. at Yuba City	1	01/30/2000 11:50	88	48	--	--
8	Feather R. at Yuba City	1	01/31/2000 15:05	177	92	--	--
8	Feather R. at Yuba City	1	02/01/2000 12:30	191	97	--	--
8	Feather R. at Yuba City	1	02/02/2000 13:45	86	--	--	--
8	Feather R. at Yuba City	1	02/03/2000 13:30	97	--	--	--
8	Feather R. at Yuba City	2	02/11/2000 14:00	82	52	--	--
8	Feather R. at Yuba City	2	02/12/2000 13:45	60	52	--	--
8	Feather R. at Yuba City	2	02/13/2000 13:45	122	78	--	--

Appendix 2, Table 1. Concentrations of diazinon and methidathion in water samples. - Cont.

[ng/L, nanogram per liter; R, River; Cr, Creek; Sl., Slough; Br., Bridge; --, no data available]

Site No.	Site name	Storm event number	Date / Time	Diazinon ELISA (ng/L)	Diazinon GC/ECD (ng/L)	Diazinon GC/MS (ng/L)	Methidathion (ng/L)	
8	Feather R. at Yuba City	2	02/14/2000 13:00	65	--	--	--	
8	Feather R. at Yuba City	2	02/15/2000 12:20	70	--	--	--	
8	Feather R. at Yuba City	3	02/21/2000 15:50	<30	<20	--	--	
8	Feather R. at Yuba City	3	02/22/2000 12:50	<30	<20	--	--	
8	Feather R. at Yuba City	3	02/23/2000 12:15	<30	<20	--	--	
8	Feather R. at Yuba City	3	02/24/2000 12:45	34	--	--	--	
8	Feather R. at Yuba City	3	02/25/2000 12:30	<30	--	--	--	
9	Yuba R. at Marysville	1	01/30/2000 17:40	<30	<20	--	--	
9	Yuba R. at Marysville	1	01/31/2000 14:10	<30	--	--	--	
9	Yuba R. at Marysville	2	02/11/2000 14:30	<30	<20	--	--	
9	Yuba R. at Marysville	2	02/12/2000 13:50	<30	--	--	--	
9	Yuba R. at Marysville	3	02/21/2000 15:00	<30	<20	--	--	
9	Yuba R. at Marysville	3	02/22/2000 14:30	<30	--	--	--	
10	Wadsworth Canal	1	01/30/2000 18:15	3,390	--	--	--	
10	Wadsworth Canal	1	01/30/2000 21:45	7,990	--	--	--	
10	Wadsworth Canal	1	01/31/2000 05:40	4,410	--	--	--	
10	Wadsworth Canal	1	01/31/2000 09:40	4,530	2,230	--	805	3,335
10	Wadsworth Canal	1	01/31/2000 11:18		2,740	--	--	
10	Wadsworth Canal	1	01/31/2000 20:33	2,110	--	--	--	
10	Wadsworth Canal	1	01/31/2000 23:00	1,940	--	--	--	
10	Wadsworth Canal	1	02/01/2000 01:35	1,760	--	--	--	
10	Wadsworth Canal	1	02/01/2000 10:25	1,110	506	--	331	75
10	Wadsworth Canal	1	02/01/2000 15:00	1,490	--	--	--	
10	Wadsworth Canal	1	02/02/2000 10:40		504	--	--	
10	Wadsworth Canal	1	02/03/2000 10:00	465	--	--	--	
10	Wadsworth Canal	2	02/07/2000 10:30		175	--	--	
10	Wadsworth Canal	2	02/09/2000 10:49		193	--	--	
10	Wadsworth Canal	2	02/11/2000 13:35	1,100	--	--	--	
10	Wadsworth Canal	2	02/12/2000 01:45	5,010	--	--	--	
10	Wadsworth Canal	2	02/12/2000 05:20	4,130	--	--	--	
10	Wadsworth Canal	2	02/12/2000 09:10	2,940	--	--	--	
10	Wadsworth Canal	2	02/12/2000 14:20	3,440	1,850	--	235	2695
10	Wadsworth Canal	2	02/12/2000 17:40	2,100	--	--	--	
10	Wadsworth Canal	2	02/12/2000 21:10	2,190	--	--	--	
10	Wadsworth Canal	2	02/13/2000 01:30	1,820	--	--	--	
10	Wadsworth Canal	2	02/13/2000 05:21	1,390	--	--	--	
10	Wadsworth Canal	2	02/13/2000 09:35	2,320	--	--	--	
10	Wadsworth Canal	2	02/13/2000 13:30	3,110	2,355	--	105	2733
10	Wadsworth Canal	2	02/13/2000 16:55	3,230	--	--	--	
10	Wadsworth Canal	2	02/13/2000 21:25	2,540	--	--	--	
10	Wadsworth Canal	2	02/14/2000 02:06	2,300	--	--	--	
10	Wadsworth Canal	2	02/14/2000 05:35	2,210	--	--	--	
10	Wadsworth Canal	2	02/14/2000 09:40	2,900	--	--	--	
10	Wadsworth Canal	2	02/14/2000 11:11	NA	1,736	--	--	
10	Wadsworth Canal	2	02/14/2000 13:50	2,720	--	--	--	
10	Wadsworth Canal	2	02/14/2000 17:20	2,470	--	--	--	
10	Wadsworth Canal	2	02/14/2000 21:25	1,600	--	--	--	
10	Wadsworth Canal	2	02/15/2000 11:25	1,110	--	--	--	
10	Wadsworth Canal	3	02/22/2000 09:18	266	--	--	--	
10	Wadsworth Canal	3	02/22/2000 14:50	290	--	--	--	
10	Wadsworth Canal	3	02/22/2000 17:00	282	--	--	--	

Appendix 2, Table 1. Concentrations of diazinon and methidathion in water samples.

[ng/L, nanogram per liter; R, River; Cr, Creek; Sl., Slough; Br., Bridge; --, no data available]

Site No.	Site name	Storm event number	Date / Time	Diazinon ELISA (ng/L)	Diazinon GC/ECD (ng/L)	Diazinon GC/MS (ng/L)	Methidathion (ng/L)
10	Wadsworth Canal	3	02/22/2000 21:25	238	--	--	--
10	Wadsworth Canal	3	02/23/2000 01:03	307	--	--	--
10	Wadsworth Canal	3	02/23/2000 05:05	654	--	--	--
10	Wadsworth Canal	3	02/23/2000 09:20	772	--	--	--
10	Wadsworth Canal	3	02/23/2000 14:00	778	591	--	80
10	Wadsworth Canal	3	02/23/2000 16:40	729	--	--	--
10	Wadsworth Canal	3	02/23/2000 21:23	715	--	--	--
10	Wadsworth Canal	3	02/24/2000 06:05	847	--	--	--
10	Wadsworth Canal	3	02/24/2000 14:20	839	--	--	--
10	Wadsworth Canal	3	02/24/2000 17:00	641	--	--	--
10	Wadsworth Canal	3	02/24/2000 21:30	565	--	--	--
10	Wadsworth Canal	3	02/25/2000 12:45	323	--	--	--
11	Jack Slough	1	01/30/2000 13:20	459	208	--	--
11	Jack Slough	1	01/31/2000 14:10	1,490	727	--	--
11	Jack Slough	1	02/01/2000 14:00	1,050	499	--	--
11	Jack Slough	1	02/02/2000 12:45	505	--	--	--
11	Jack Slough	1	02/03/2000 12:30	534	--	--	--
11	Jack Slough	2	02/10/2000 16:00	457	--	--	--
11	Jack Slough	2	02/11/2000 14:30	752	365	--	--
11	Jack Slough	2	02/11/2000 15:00		397	--	--
11	Jack Slough	2	02/12/2000 14:30	534	258	--	--
11	Jack Slough	2	02/13/2000 14:45	456	236	--	--
11	Jack Slough	2	02/14/2000 13:40	346	--	--	--
11	Jack Slough	2	02/15/2000 13:00	302	--	--	--
11	Jack Slough	3	02/21/2000 14:30	205	116	--	--
11	Jack Slough	3	02/22/2000 13:30	213	118	--	--
11	Jack Slough	3	02/23/2000 12:50	261	134	--	275
11	Jack Slough	3	02/24/2000 13:15	189	--	--	--
11	Jack Slough	3	02/25/2000 13:00	169	--	--	--
12	Butte Sl. at Lower Pass Rd	1	01/30/2000 15:20	98	38	--	--
12	Butte Sl. at Lower Pass Rd	1	01/31/2000 12:45	80	52	--	--
12	Butte Sl. at Lower Pass Rd	1	02/01/2000 11:30	109	46	--	--
12	Butte Sl. at Lower Pass Rd	1	02/02/2000 11:35	105	--	--	--
12	Butte Sl. at Lower Pass Rd	1	02/03/2000 11:30	111	--	--	--
12	Butte Sl. at Lower Pass Rd	2	02/11/2000 12:00	116	55	--	--
12	Butte Sl. at Lower Pass Rd	2	02/12/2000 12:00	126	82	--	--
12	Butte Sl. at Lower Pass Rd	2	02/13/2000 11:30	91	44	--	--
12	Butte Sl. at Lower Pass Rd	2	02/14/2000 11:15	<30	--	--	--
12	Butte Sl. at Lower Pass Rd	2	02/15/2000 11:10	<30	--	--	--
12	Butte Sl. at Lower Pass Rd	3	02/21/2000 13:40	<30	<20	--	--
12	Butte Sl. at Lower Pass Rd	3	02/22/2000 11:30	<30	<20	--	--
12	Butte Sl. at Lower Pass Rd	3	02/23/2000 11:00	<30	<20	--	--
12	Butte Sl. at Lower Pass Rd	3	02/24/2000 11:15	<30	--	--	--
12	Butte Sl. at Lower Pass Rd	3	02/25/2000 11:15	<30	--	--	--
13	Sacramento R. at Colusa	1	01/30/2000 16:20	<30	<20	--	--
13	Sacramento R. at Colusa	1	01/31/2000 10:45	137	77	--	--
13	Sacramento R. at Colusa	1	02/01/2000 10:00	84	60	--	--
13	Sacramento R. at Colusa	1	02/02/2000 09:45	64	--	--	--
13	Sacramento R. at Colusa	1	02/03/2000 09:50	36	--	--	--
13	Sacramento R. at Colusa	2	02/11/2000 10:30	<30	<20	--	--
13	Sacramento R. at Colusa	2	02/12/2000 11:00	49	23	--	--

Appendix 2, Table 1. Concentrations of diazinon and methidathion in water samples. - Cont.

[ng/L, nanogram per liter; R, River; Cr, Creek; Sl., Slough; Br., Bridge; --, no data available]

Site No.	Site name	Storm event number	Date / Time	Diazinon			Methidathion (ng/L)
				ELISA (ng/L)	GC/ECD (ng/L)	GC/MS (ng/L)	
13	Sacramento R. at Colusa	2	02/13/2000 10:20	47	27	--	--
13	Sacramento R. at Colusa	2	02/14/2000 10:00	34	--	--	--
13	Sacramento R. at Colusa	2	02/15/2000 09:40	<30	--	--	--
13	Sacramento R. at Colusa	3	02/21/2000 12:20	<30	<20	--	--
13	Sacramento R. at Colusa	3	02/22/2000 10:35	<30	<20	--	--
13	Sacramento R. at Colusa	3	02/23/2000 10:15	<30	--	--	--
13	Sacramento R. at Colusa	3	02/24/2000 09:50	<30	--	--	--
13	Sacramento R. at Colusa	3	02/25/2000 10:05	<30	--	--	--
14	Butte Cr. nr Gridley	1	01/30/2000 13:15	120	--	--	--
14	Butte Cr. nr Gridley	1	01/30/2000 20:15	199	--	--	--
14	Butte Cr. nr Gridley	1	01/31/2000 04:20	236	--	--	--
14	Butte Cr. nr Gridley	1	01/31/2000 08:10	238	--	--	--
14	Butte Cr. nr Gridley	1	01/31/2000 12:15	194	--	--	--
14	Butte Cr. nr Gridley	1	01/31/2000 17:40	180	75	--	--
14	Butte Cr. nr Gridley	1	01/31/2000 21:25	164	--	--	--
14	Butte Cr. nr Gridley	1	02/01/2000 00:30	176	--	--	--
14	Butte Cr. nr Gridley	1	02/01/2000 08:30	163	--	--	--
14	Butte Cr. nr Gridley	1	02/01/2000 13:25	173	--	--	--
14	Butte Cr. nr Gridley	1	02/02/2000 13:00	112	48	--	--
14	Butte Cr. nr Gridley	1	02/03/2000 11:03	96	--	--	--
14	Butte Cr. nr Gridley	2	02/11/2000 10:10	57	--	--	--
14	Butte Cr. nr Gridley	2	02/12/2000 00:38	65	--	--	--
14	Butte Cr. nr Gridley	2	02/12/2000 04:20	56	--	--	--
14	Butte Cr. nr Gridley	2	02/12/2000 08:05	68	--	--	--
14	Butte Cr. nr Gridley	2	02/12/2000 12:15	44	35	--	--
14	Butte Cr. nr Gridley	2	02/12/2000 16:35	53	--	--	--
14	Butte Cr. nr Gridley	2	02/12/2000 20:15	56	--	--	--
14	Butte Cr. nr Gridley	2	02/13/2000 00:16	52	--	--	--
14	Butte Cr. nr Gridley	2	02/13/2000 04:10	542	--	--	--
14	Butte Cr. nr Gridley	2	02/13/2000 08:10	80	--	--	--
14	Butte Cr. nr Gridley	2	02/13/2000 12:20	66	--	--	--
14	Butte Cr. nr Gridley	2	02/13/2000 15:50	50	--	--	--
14	Butte Cr. nr Gridley	2	02/13/2000 20:10	35	--	--	--
14	Butte Cr. nr Gridley	2	02/14/2000 00:15	43	--	--	--
14	Butte Cr. nr Gridley	2	02/14/2000 04:22	40	--	--	--
14	Butte Cr. nr Gridley	2	02/14/2000 08:25	<30	--	--	--
14	Butte Cr. nr Gridley	2	02/14/2000 12:25	40	23	--	--
14	Butte Cr. nr Gridley	2	02/14/2000 16:20	37	--	--	--
14	Butte Cr. nr Gridley	2	02/14/2000 20:20	39	--	--	--
14	Butte Cr. nr Gridley	2	02/15/2000 09:20	<30	--	--	--
14	Butte Cr. nr Gridley	3	02/21/2000 12:40	58	--	--	--
14	Butte Cr. nr Gridley	3	02/22/2000 08:10	44	--	--	--
14	Butte Cr. nr Gridley	3	02/22/2000 12:20	54	25	--	--
14	Butte Cr. nr Gridley	3	02/22/2000 16:00	59	--	--	--
14	Butte Cr. nr Gridley	3	02/22/2000 20:20	52	--	--	--
14	Butte Cr. nr Gridley	3	02/23/2000 00:08	44	--	--	--
14	Butte Cr. nr Gridley	3	02/23/2000 04:15	55	--	--	--
14	Butte Cr. nr Gridley	3	02/23/2000 08:10	51	--	--	--
14	Butte Cr. nr Gridley	3	02/23/2000 12:10	47	--	--	--
14	Butte Cr. nr Gridley	3	02/23/2000 15:35	39	--	--	--
14	Butte Cr. nr Gridley	3	02/23/2000 20:21	34	--	--	--

Appendix 2, Table 1. Concentrations of diazinon and methidathion in water samples. – Cont.

[ng/L, nanogram per liter; R, River; Cr, Creek; Sl., Slough; Br., Bridge; --, no data available]

Site No.	Site name	Storm event number	Date / Time	Diazinon ELISA (ng/L)	Diazinon GC/ECD (ng/L)	Diazinon GC/MS (ng/L)	Methidathion (ng/L)
14	Butte Cr. nr Gridley	3	02/24/2000 04:40	<30	--	--	--
14	Butte Cr. nr Gridley	3	02/24/2000 12:20	<30	29	--	--
14	Butte Cr. nr Gridley	3	02/24/2000 16:05	<30	--	--	--
14	Butte Cr. nr Gridley	3	02/24/2000 20:20	<30	--	--	--
14	Butte Cr. nr Gridley	3	02/25/2000 10:05	<30	--	--	--
15	Cherokee Canal	1	01/30/2000 13:45	207	70	--	--
15	Cherokee Canal	1	01/31/2000 18:15	237	--	--	--
15	Cherokee Canal	2	02/11/2000 10:35	78	40	--	--
15	Cherokee Canal	2	02/12/2000 12:35	65	--	--	--
15	Cherokee Canal	3	02/21/2000 13:05	126	65	--	--
15	Cherokee Canal	3	02/22/2000 12:30	111	--	--	--
16	Main Canal	1	01/30/2000 14:45	389	--	--	--
16	Main Canal	1	01/30/2000 20:45	523	--	--	--
16	Main Canal	1	01/31/2000 04:50	520	--	--	--
16	Main Canal	1	01/31/2000 08:33	1,010	--	--	--
16	Main Canal	1	01/31/2000 12:40	823	--	--	--
16	Main Canal	1	01/31/2000 18:40	437	--	--	--
16	Main Canal	1	01/31/2000 21:45	404	--	--	--
16	Main Canal	1	02/01/2000 00:45	385	--	--	--
16	Main Canal	1	02/01/2000 09:10	346	--	--	--
16	Main Canal	1	02/01/2000 14:00	291	--	--	--
16	Main Canal	1	02/02/2000 13:30	172	100	--	--
16	Main Canal	1	02/03/2000 23:23	117	--	--	--
16	Main Canal	2	02/10/2000 16:45	596	--	--	--
16	Main Canal	2	02/11/2000 11:05	3,950	--	--	--
16	Main Canal	2	02/12/2000 00:55	2,770	--	--	--
16	Main Canal	2	02/12/2000 04:35	2,950	--	--	--
16	Main Canal	2	02/12/2000 08:20	4,460	--	--	--
16	Main Canal	2	02/12/2000 12:55	4,600	--	--	--
16	Main Canal	2	02/12/2000 16:50	7,380	--	--	--
16	Main Canal	2	02/12/2000 20:25	6,880	--	--	--
16	Main Canal	2	02/13/2000 00:40	5,530	--	--	--
16	Main Canal	2	02/13/2000 04:30	4,720	--	--	--
16	Main Canal	2	02/13/2000 08:30	4,030	--	--	--
16	Main Canal	2	02/13/2000 12:35	2,890	--	--	--
16	Main Canal	2	02/13/2000 16:10	2,920	--	--	--
16	Main Canal	2	02/13/2000 20:25	5,260	--	--	--
16	Main Canal	2	02/14/2000 00:55	3,780	--	--	--
16	Main Canal	2	02/14/2000 04:45	3,080	--	--	--
16	Main Canal	2	02/14/2000 08:50	3,760	--	--	--
16	Main Canal	2	02/14/2000 13:00	3,300	1,999	--	60
16	Main Canal	2	02/14/2000 16:30	3,600	--	--	--
16	Main Canal	2	02/14/2000 20:35	3,060	--	--	--
16	Main Canal	2	02/15/2000 09:50	2,320	--	--	--
16	Main Canal	3	02/21/2000 13:20	2,240	--	--	--
16	Main Canal	3	02/22/2000 08:25	2,050	--	--	--
16	Main Canal	3	02/22/2000 12:45	2,000	--	--	--
16	Main Canal	3	02/22/2000 16:15	1,370	--	--	--
16	Main Canal	3	02/22/2000 20:40	1,540	--	--	--
16	Main Canal	3	02/23/2000 00:20	1,410	--	--	--
16	Main Canal	3	02/23/2000 04:20	2,500	--	--	--

Appendix 2, Table 1. Concentrations of diazinon and methidathion in water samples. - Cont.

[ng/L, nanogram per liter; R, River; Cr, Creek; Sl., Slough; Br., Bridge; --, no data available]

Site No.	Site name	Storm event number	Date / Time	Diazinon ELISA (ng/L)	Diazinon GC/ECD (ng/L)	Diazinon GC/MS (ng/L)	Methidathion (ng/L)
16	Main Canal	3	02/23/2000 08:35	4,960	--	--	--
16	Main Canal	3	02/23/2000 12:35	11,500	--	--	--
16	Main Canal	3	02/23/2000 15:55	6,470	--	--	--
16	Main Canal	3	02/23/2000 20:30	11,300	--	--	--
16	Main Canal	3	02/24/2000 05:15	7,510	--	--	--
16	Main Canal	3	02/24/2000 12:40	5,070	2,890	--	--
16	Main Canal	3	02/24/2000 16:20	4,130	--	--	--
16	Main Canal	3	02/24/2000 20:30	2,950	--	--	--
16	Main Canal	3	02/25/2000 10:25	3,010	--	--	--
17	Sacramento R. at Sacramento	1	02/01/2000 17:00	--	--	29	--
17	Sacramento R. at Sacramento	1	02/02/2000 17:10	--	--	61	--
17	Sacramento R. at Sacramento	1	02/03/2000 17:00	--	--	41	--
17	Sacramento R. at Sacramento	1	02/04/2000 17:00	--	--	38	--
17	Sacramento R. at Sacramento	1	02/05/2000 17:00	--	--	24	--
17	Sacramento R. at Sacramento	2	02/11/2000 17:15	--	--	25	--
17	Sacramento R. at Sacramento	2	02/12/2000 16:00	--	--	24	--
17	Sacramento R. at Sacramento	2	02/13/2000 19:00	--	--	28	--
17	Sacramento R. at Sacramento	2	02/14/2000 17:30	--	--	29	--
17	Sacramento R. at Sacramento	2	02/15/2000 15:30	--	--	32	--
17	Sacramento R. at Sacramento	2	02/16/2000 17:30	--	--	43	--
17	Sacramento R. at Sacramento	2	02/17/2000 20:00	--	--	26	--
17	Sacramento R. at Sacramento	3	02/22/2000 15:45	--	--	12	--
17	Sacramento R. at Sacramento	3	02/23/2000 17:35	--	--	19	--
17	Sacramento R. at Sacramento	3	02/24/2000 16:35	--	--	20	--
17	Sacramento R. at Sacramento	3	02/25/2000 11:50	--	--	21	--

Appendix 2, Table 2. Pesticide concentrations in samples analyized by the U.S. Geological Survey National Water-Quality Laboratory using GC/MS.

Site name	Date	Time	2,6-Diethylaniline (µg/L) 82660	Acetochlor (µg/L) 49260	Alachlor (µg/L) 46342	Alpha-BHC (µg/L) 34253	Atrazine (µg/L) 39632	Benfluralin (µg/L) 82673	Butylate (µg/L) 04028
Feather R nr Nicolaus	02/03/00	1130	<0.003	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002
Feather R nr Nicolaus	02/01/00	1250	<0.003	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002
Feather R nr Nicolaus	02/02/00	1150	<0.003	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002
Feather R nr Nicolaus	01/31/00	1230	<0.003	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002
Feather R nr Nicolaus	01/30/00	1430	<0.003	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002
Feather R nr Nicolaus	02/15/00	1040	<0.003	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002
Feather R nr Nicolaus	02/14/00	1300	<0.003	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002
Feather R nr Nicolaus	02/11/00	1240	<0.003	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002
Feather R nr Nicolaus	02/13/00	1420	<0.003	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002
Feather R nr Nicolaus	02/21/00	1240	<0.003	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002
Feather R nr Nicolaus	02/22/00	1030	<0.003	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002
Feather R nr Nicolaus	02/23/00	1020	<0.003	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002
Feather R nr Nicolaus	02/24/00	1010	<0.003	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002
Feather R nr Nicolaus	02/25/00	1050	<0.003	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002
Sacramento R at Tower Bridge	02/01/00	1700	<0.003	<0.002	<0.002	<0.002	E0.003	<0.002	<0.002
Sacramento R at Tower Bridge	02/02/00	1710	<0.003	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002
Sacramento R at Tower Bridge	02/03/00	1700	<0.003	<0.002	<0.002	<0.002	0.004	<0.002	<0.002
Sacramento R at Tower Bridge	02/04/00	1700	<0.003	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002
Sacramento R at Tower Bridge	02/05/00	1700	<0.003	<0.002	<0.002	<0.002	E0.003	<0.002	<0.002
Sacramento R at Tower Bridge	02/11/00	1715	<0.003	<0.002	<0.002	<0.002	0.005	<0.002	<0.002
Sacramento R at Tower Bridge	02/12/00	1600	<0.003	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002
Sacramento R at Tower Bridge	02/13/00	1900	<0.003	<0.002	<0.002	<0.002	E0.003	<0.002	<0.002
Sacramento R at Tower Bridge	02/14/00	1730	<0.003	<0.002	<0.002	<0.002	0.004	<0.002	<0.002
Sacramento R at Tower Bridge	02/15/00	1530	<0.003	<0.002	<0.002	<0.002	0.005	<0.002	<0.002
Sacramento R at Tower Bridge	02/16/00	1730	<0.003	<0.002	<0.002	<0.002	0.005	<0.002	<0.002
Sacramento R at Tower Bridge	02/17/00	1757	<0.003	<0.002	<0.002	<0.002	0.005	<0.002	<0.002
Sacramento R at Tower Bridge	02/22/00	1545	<0.003	<0.002	<0.002	<0.002	E0.003	<0.002	<0.002
Sacramento R at Tower Bridge	02/23/00	1735	<0.003	<0.002	<0.002	<0.002	E0.003	<0.002	<0.002
Sacramento R at Tower Bridge	02/24/00	1635	<0.003	<0.002	<0.002	<0.002	<0.001	<0.002	<0.002
Sacramento R at Tower Bridge	02/25/00	1150	<0.003	<0.002	<0.002	<0.002	E0.003	<0.002	<0.002

Appendix 2, Table 2. – *Continued*

Site name	Date	Time	Carbaryl (µg/L) 82680	Carbofuran (µg/L) 82674	Chlorpyrifos (µg/L) 38933	Cyanazine (µg/L) 04041	DCPA (µg/L) 82682	Desethyl Atrazine (µg/L) 04040	Diazinon Surrogate (percent) 91063	Diazinon (µg/L) 39572
Feather R nr Nicolaus	02/03/00	1130	E0.0048	E0.0226	<0.004	<0.004	<0.002	<0.002	98	0.043
Feather R nr Nicolaus	02/01/00	1250	<0.003	<0.010	<0.004	<0.004	<0.002	<0.002	107	0.054
Feather R nr Nicolaus	02/02/00	1150	<0.003	<0.010	<0.004	<0.004	<0.002	<0.002	110	0.054
Feather R nr Nicolaus	01/31/00	1230	<0.003	<0.010	<0.004	<0.004	<0.002	<0.002	103	0.154
Feather R nr Nicolaus	01/30/00	1430	<0.003	<0.010	<0.004	<0.004	<0.002	<0.002	104	0.040
Feather R nr Nicolaus	02/15/00	1040	<0.003	<0.003	<0.004	<0.004	<0.002	<0.002	106	0.036
Feather R nr Nicolaus	02/14/00	1300	<0.003	E0.004	E0.004	<0.004	<0.002	<0.002	104	0.033
Feather R nr Nicolaus	02/11/00	1240	E0.010	<0.015	E0.004	<0.004	E0.002	<0.002	106	0.060
Feather R nr Nicolaus	02/13/00	1420	<0.003	E0.007	0.006	<0.004	<0.002	<0.002	109	0.063
Feather R nr Nicolaus	02/21/00	1240	<0.003	E0.003	<0.004	<0.004	<0.002	<0.002	90.8	0.008
Feather R nr Nicolaus	02/22/00	1030	<0.003	E0.004	<0.004	<0.004	<0.002	<0.002	89.5	0.009
Feather R nr Nicolaus	02/23/00	1020	<0.003	E0.003	<0.004	<0.004	<0.002	<0.002	92.4	0.009
Feather R nr Nicolaus	02/24/00	1010	<0.003	<0.003	<0.004	<0.004	<0.002	<0.002	102	0.013
Feather R nr Nicolaus	02/25/00	1050	<0.003	<0.003	<0.004	<0.004	E0.001	<0.002	101	0.016
Sacramento R at Tower Bridge	02/01/00	1700	<0.003	<0.013	<0.004	<0.004	<0.002	<0.002	109	0.029
Sacramento R at Tower Bridge	02/02/00	1710	E0.005	E0.011	0.004	<0.004	<0.002	<0.002	104	0.061
Sacramento R at Tower Bridge	02/03/00	1700	E0.004	E0.011	E0.003	<0.004	<0.002	<0.002	99	0.041
Sacramento R at Tower Bridge	02/04/00	1700	E0.005	E0.011	<0.004	<0.004	<0.002	<0.002	101	0.038
Sacramento R at Tower Bridge	02/05/00	1700	<0.003	E0.008	<0.004	<0.004	E0.002	<0.002	101	0.024
Sacramento R at Tower Bridge	02/11/00	1715	E0.007	E0.010	<0.004	<0.004	E0.002	<0.002	97.1	0.025
Sacramento R at Tower Bridge	02/12/00	1600	E0.005	<0.010	<0.004	<0.004	<0.002	<0.002	91.8	0.024
Sacramento R at Tower Bridge	02/13/00	1900	E0.005	<0.003	E0.003	<0.004	E0.001	<0.002	90.5	0.028
Sacramento R at Tower Bridge	02/14/00	1730	E0.006	<0.003	0.005	<0.004	E0.002	<0.002	90.1	0.029
Sacramento R at Tower Bridge	02/15/00	1530	E0.005	E0.006	<0.004	<0.004	<0.002	<0.002	87.4	0.032
Sacramento R at Tower Bridge	02/16/00	1730	E0.008	<0.008	0.004	<0.004	E0.002	<0.002	108	0.043
Sacramento R at Tower Bridge	02/17/00	1757	<0.003	<0.003	E0.003	<0.004	E0.002	<0.002	106	0.026
Sacramento R at Tower Bridge	02/22/00	1545	<0.003	E0.004	<0.004	<0.004	<0.002	<0.002	90.7	0.012
Sacramento R at Tower Bridge	02/23/00	1735	E0.005	E0.006	<0.004	<0.004	E0.002	<0.002	92	0.019
Sacramento R at Tower Bridge	02/24/00	1635	<0.003	E0.007	<0.004	<0.004	<0.002	<0.002	103	0.020
Sacramento R at Tower Bridge	02/25/00	1150	E0.004	E0.007	<0.004	<0.004	<0.002	<0.002	105	0.021

Appendix 2, Table 2. -- *Continued*

Site name	Date	Time	Dieldrin (µg/L) 39381	Disulfoton (µg/L) 82677	EPTC (µg/L) 82668	Ethalfluralin (µg/L) 82663	Ethoprop (µg/L) 82672	Fonofos (µg/L) 04095	Alpha D6 HCH (percent) 91065	Lindane (µg/L) 39341
Feather R nr Nicolaus	02/03/00	1130	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	106	<0.004
Feather R nr Nicolaus	02/01/00	1250	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	90.6	<0.004
Feather R nr Nicolaus	02/02/00	1150	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	95.8	<0.004
Feather R nr Nicolaus	01/31/00	1230	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	88.3	<0.004
Feather R nr Nicolaus	01/30/00	1430	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	91.2	<0.004
Feather R nr Nicolaus	02/15/00	1040	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	100	<0.004
Feather R nr Nicolaus	02/14/00	1300	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	99.1	<0.004
Feather R nr Nicolaus	02/11/00	1240	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	94.6	<0.004
Feather R nr Nicolaus	02/13/00	1420	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	104	<0.004
Feather R nr Nicolaus	02/21/00	1240	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	74.4	<0.004
Feather R nr Nicolaus	02/22/00	1030	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	78.8	<0.004
Feather R nr Nicolaus	02/23/00	1020	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	73.3	<0.004
Feather R nr Nicolaus	02/24/00	1010	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	81.8	<0.004
Feather R nr Nicolaus	02/25/00	1050	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	97.3	<0.004
Sacramento R at Tower Bridge	02/01/00	1700	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	95.4	<0.004
Sacramento R at Tower Bridge	02/02/00	1710	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	107	<0.004
Sacramento R at Tower Bridge	02/03/00	1700	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	109	<0.004
Sacramento R at Tower Bridge	02/04/00	1700	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	110	<0.004
Sacramento R at Tower Bridge	02/05/00	1700	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	98.1	<0.004
Sacramento R at Tower Bridge	02/11/00	1715	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	102	<0.004
Sacramento R at Tower Bridge	02/12/00	1600	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	92.3	<0.004
Sacramento R at Tower Bridge	02/13/00	1900	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	91.8	<0.004
Sacramento R at Tower Bridge	02/14/00	1730	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	92.5	<0.004
Sacramento R at Tower Bridge	02/15/00	1530	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	90.4	<0.004
Sacramento R at Tower Bridge	02/16/00	1730	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	99	<0.004
Sacramento R at Tower Bridge	02/17/00	1757	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	97.2	<0.004
Sacramento R at Tower Bridge	02/22/00	1545	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	74.4	<0.004
Sacramento R at Tower Bridge	02/23/00	1735	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	71.8	<0.004
Sacramento R at Tower Bridge	02/24/00	1635	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	102	<0.004
Sacramento R at Tower Bridge	02/25/00	1150	<0.001	<0.017	<0.002	<0.004	<0.003	<0.003	102	<0.004

Appendix 2, Table 2. -- *Continued*

Site name	Date	Time	Linuron (µg/L) 82666	Malathion (µg/L) 39532	Methyl Azinphos (µg/L) 82686	Methyl Parathion (µg/L) 82667	Metolachlor (µg/L) 39415	Metribuzin (µg/L) 82630	Molinate (µg/L) 82671	Napropamide (µg/L) 82684
Feather R nr Nicolaus	02/03/00	1130	<0.002	<0.005	<0.001	<0.006	0.005	<0.004	0.021	<0.003
Feather R nr Nicolaus	02/01/00	1250	<0.002	<0.005	<0.001	<0.006	<0.002	<0.004	0.030	<0.003
Feather R nr Nicolaus	02/02/00	1150	<0.002	<0.005	<0.001	<0.006	<0.002	<0.004	0.025	<0.003
Feather R nr Nicolaus	01/31/00	1230	<0.002	<0.005	<0.001	<0.006	<0.002	<0.004	0.026	<0.003
Feather R nr Nicolaus	01/30/00	1430	<0.002	<0.005	<0.001	<0.006	<0.002	<0.004	0.025	<0.003
Feather R nr Nicolaus	02/15/00	1040	<0.002	<0.005	<0.001	<0.006	0.006	<0.004	0.009	<0.003
Feather R nr Nicolaus	02/14/00	1300	<0.002	<0.005	<0.001	<0.006	<0.002	<0.004	0.007	<0.003
Feather R nr Nicolaus	02/11/00	1240	<0.002	E0.004	<0.001	<0.006	0.004	<0.004	0.023	<0.003
Feather R nr Nicolaus	02/13/00	1420	<0.002	<0.005	<0.04	<0.006	<0.006	<0.004	0.009	<0.003
Feather R nr Nicolaus	02/21/00	1240	<0.002	<0.005	<0.001	<0.006	<0.002	<0.004	<0.010	<0.003
Feather R nr Nicolaus	02/22/00	1030	<0.002	<0.005	<0.001	<0.006	<0.002	<0.004	<0.010	<0.003
Feather R nr Nicolaus	02/23/00	1020	<0.002	<0.005	<0.001	<0.006	<0.002	<0.004	<0.004	<0.003
Feather R nr Nicolaus	02/24/00	1010	<0.002	<0.005	<0.001	<0.006	<0.002	<0.004	0.008	<0.003
Feather R nr Nicolaus	02/25/00	1050	<0.002	<0.005	<0.001	<0.006	<0.002	<0.004	0.008	<0.003
Sacramento R at Tower Bridge	02/01/00	1700	<0.002	<0.005	<0.001	<0.006	0.005	<0.004	0.012	<0.003
Sacramento R at Tower Bridge	02/02/00	1710	<0.002	<0.005	<0.001	<0.006	0.007	<0.004	0.010	<0.003
Sacramento R at Tower Bridge	02/03/00	1700	<0.002	<0.005	<0.001	<0.006	0.006	<0.004	0.010	<0.003
Sacramento R at Tower Bridge	02/04/00	1700	<0.002	<0.005	<0.001	<0.006	0.007	<0.004	0.009	<0.003
Sacramento R at Tower Bridge	02/05/00	1700	<0.002	<0.005	<0.001	<0.006	E0.004	<0.004	0.011	<0.003
Sacramento R at Tower Bridge	02/11/00	1715	<0.002	<0.005	<0.001	<0.006	0.007	<0.004	0.009	<0.003
Sacramento R at Tower Bridge	02/12/00	1600	<0.002	<0.005	<0.001	<0.006	0.006	<0.004	0.011	<0.003
Sacramento R at Tower Bridge	02/13/00	1900	<0.002	<0.005	<0.001	<0.006	0.006	<0.004	0.007	<0.003
Sacramento R at Tower Bridge	02/14/00	1730	<0.002	<0.005	<0.001	<0.006	0.006	<0.004	0.006	<0.003
Sacramento R at Tower Bridge	02/15/00	1530	<0.002	<0.005	<0.001	<0.006	0.005	<0.004	0.009	<0.003
Sacramento R at Tower Bridge	02/16/00	1730	<0.002	<0.005	<0.001	<0.006	0.011	<0.004	0.009	<0.003
Sacramento R at Tower Bridge	02/17/00	1757	<0.002	<0.005	<0.001	<0.006	0.005	<0.004	0.008	<0.003
Sacramento R at Tower Bridge	02/22/00	1545	<0.002	<0.005	<0.001	<0.006	0.004	E0.0030	0.007	<0.003
Sacramento R at Tower Bridge	02/23/00	1735	<0.002	E0.004	<0.001	<0.006	0.008	<0.004	0.011	<0.003
Sacramento R at Tower Bridge	02/24/00	1635	<0.002	<0.005	<0.001	<0.006	0.005	<0.004	0.010	<0.003
Sacramento R at Tower Bridge	02/25/00	1150	<0.002	<0.005	<0.001	<0.006	0.006	<0.004	0.009	<0.003

Appendix 2, Table 2. -- *Continued*

Site name	Date	Time	p,p'-DDE (µg/L) 34653	Parathion (µg/L) 39542	Pebulate (µg/L) 82669	Pendimethalin (µg/L) 82683	Permethrin (µg/L) 82687	Phorate (µg/L) 82664	Prometon (µg/L) 04037	Pronamide (µg/L) 82676
Feather R nr Nicolaus	02/03/00	1130	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003
Feather R nr Nicolaus	02/01/00	1250	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003
Feather R nr Nicolaus	02/02/00	1150	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003
Feather R nr Nicolaus	01/31/00	1230	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003
Feather R nr Nicolaus	01/30/00	1430	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003
Feather R nr Nicolaus	02/15/00	1040	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003
Feather R nr Nicolaus	02/14/00	1300	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003
Feather R nr Nicolaus	02/11/00	1240	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003
Feather R nr Nicolaus	02/13/00	1420	<0.006	<0.004	<0.004	0.008	<0.005	<0.002	<0.018	<0.003
Feather R nr Nicolaus	02/21/00	1240	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003
Feather R nr Nicolaus	02/22/00	1030	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003
Feather R nr Nicolaus	02/23/00	1020	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003
Feather R nr Nicolaus	02/24/00	1010	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003
Feather R nr Nicolaus	02/25/00	1050	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003
Sacramento R at Tower Bridge	02/01/00	1700	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003
Sacramento R at Tower Bridge	02/02/00	1710	<0.006	<0.004	<0.004	<0.008	<0.005	<0.002	<0.018	<0.003
Sacramento R at Tower Bridge	02/03/00	1700	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003
Sacramento R at Tower Bridge	02/04/00	1700	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003
Sacramento R at Tower Bridge	02/05/00	1700	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003
Sacramento R at Tower Bridge	02/11/00	1715	<0.006	<0.004	<0.004	0.009	<0.005	<0.002	<0.018	<0.003
Sacramento R at Tower Bridge	02/12/00	1600	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003
Sacramento R at Tower Bridge	02/13/00	1900	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003
Sacramento R at Tower Bridge	02/14/00	1730	<0.006	<0.004	<0.004	0.011	<0.005	<0.002	E0.005	<0.003
Sacramento R at Tower Bridge	02/15/00	1530	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	E0.004	<0.003
Sacramento R at Tower Bridge	02/16/00	1730	E0.0014	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003
Sacramento R at Tower Bridge	02/17/00	1757	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	E0.002	<0.003
Sacramento R at Tower Bridge	02/22/00	1545	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003
Sacramento R at Tower Bridge	02/23/00	1735	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003
Sacramento R at Tower Bridge	02/24/00	1635	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	E0.005	<0.003
Sacramento R at Tower Bridge	02/25/00	1150	<0.006	<0.004	<0.004	<0.004	<0.005	<0.002	<0.018	<0.003

Appendix 2, Table 2. -- *Continued*

Site name	Date	Time	Propachlor (µg/L) 04024	Propanil (µg/L) 82679	Propargite (µg/L) 82685	Simazine (µg/L) 04035	Tebuthiuron (µg/L) 82670	Terbacil (µg/L) 82665	Terbufos (µg/L) 82675	Thiobencarb (µg/L) 82681
Feather R nr Nicolaus	02/03/00	1130	<0.007	<0.004	<0.013	0.033	<0.010	<0.007	<0.013	0.009
Feather R nr Nicolaus	02/01/00	1250	<0.007	<0.004	<0.013	0.026	<0.010	<0.007	<0.013	0.011
Feather R nr Nicolaus	02/02/00	1150	<0.007	<0.004	<0.013	0.031	<0.010	<0.007	<0.013	0.010
Feather R nr Nicolaus	01/31/00	1230	<0.007	<0.004	<0.013	0.060	<0.010	<0.007	<0.013	0.011
Feather R nr Nicolaus	01/30/00	1430	<0.007	<0.004	<0.013	0.012	<0.010	<0.007	<0.013	0.009
Feather R nr Nicolaus	02/15/00	1040	<0.007	<0.004	<0.013	0.034	<0.010	<0.007	<0.013	0.007
Feather R nr Nicolaus	02/14/00	1300	<0.007	<0.004	<0.013	0.031	<0.010	<0.007	<0.013	0.006
Feather R nr Nicolaus	02/11/00	1240	<0.007	<0.004	<0.013	0.062	<0.010	<0.007	<0.013	0.009
Feather R nr Nicolaus	02/13/00	1420	<0.007	<0.004	<0.013	0.051	<0.010	<0.007	<0.013	0.007
Feather R nr Nicolaus	02/21/00	1240	<0.007	<0.004	<0.013	0.006	<0.010	<0.007	<0.013	<0.002
Feather R nr Nicolaus	02/22/00	1030	<0.007	<0.004	<0.013	0.006	<0.010	<0.007	<0.013	E0.003
Feather R nr Nicolaus	02/23/00	1020	<0.007	E0.004	<0.013	0.015	<0.010	<0.007	<0.013	E0.003
Feather R nr Nicolaus	02/24/00	1010	<0.007	<0.004	<0.013	0.017	<0.010	<0.007	<0.013	E0.004
Feather R nr Nicolaus	02/25/00	1050	<0.007	<0.004	<0.013	0.011	<0.010	<0.007	<0.013	E0.004
Sacramento R at Tower Bridge	02/01/00	1700	<0.007	<0.004	<0.013	0.013	<0.010	<0.007	<0.013	0.007
Sacramento R at Tower Bridge	02/02/00	1710	<0.007	<0.004	<0.013	0.023	<0.010	<0.007	<0.013	0.007
Sacramento R at Tower Bridge	02/03/00	1700	<0.007	<0.004	<0.013	0.019	<0.010	<0.007	<0.013	0.007
Sacramento R at Tower Bridge	02/04/00	1700	<0.007	<0.004	<0.013	0.012	<0.010	<0.007	<0.013	0.008
Sacramento R at Tower Bridge	02/05/00	1700	<0.007	<0.004	<0.013	0.014	<0.010	<0.007	<0.013	0.006
Sacramento R at Tower Bridge	02/11/00	1715	<0.007	<0.004	<0.013	0.013	E0.008	<0.007	<0.013	0.005
Sacramento R at Tower Bridge	02/12/00	1600	<0.007	<0.004	<0.013	0.019	0.012	<0.007	<0.013	0.006
Sacramento R at Tower Bridge	02/13/00	1900	<0.007	<0.004	<0.013	0.019	0.014	<0.007	<0.013	0.004
Sacramento R at Tower Bridge	02/14/00	1730	<0.007	<0.004	<0.013	0.023	0.012	<0.007	<0.013	<0.002
Sacramento R at Tower Bridge	02/15/00	1530	<0.007	0.009	<0.013	0.028	E0.0066	<0.007	<0.013	0.007
Sacramento R at Tower Bridge	02/16/00	1730	<0.007	<0.004	<0.013	0.030	<0.010	<0.007	<0.013	0.007
Sacramento R at Tower Bridge	02/17/00	1757	<0.007	<0.004	<0.013	0.040	E0.005	<0.007	<0.013	0.006
Sacramento R at Tower Bridge	02/22/00	1545	<0.007	<0.004	<0.013	0.01	E0.008	<0.007	<0.013	0.005
Sacramento R at Tower Bridge	02/23/00	1735	<0.007	<0.004	<0.013	0.011	E0.010	<0.007	<0.013	0.007
Sacramento R at Tower Bridge	02/24/00	1635	<0.007	<0.004	<0.013	0.024	E0.007	<0.007	<0.013	0.006
Sacramento R at Tower Bridge	02/25/00	1150	<0.007	<0.004	<0.013	0.027	<0.010	<0.007	<0.013	0.006

Appendix 2, Table 2. -- *Continued*

Site name	Date	Time	Triallate (µg/L) 82678	Trifluralin (µg/L) 82661
Feather R nr Nicolaus	02/03/00	1130	<0.001	0.006
Feather R nr Nicolaus	02/01/00	1250	<0.001	<0.002
Feather R nr Nicolaus	02/02/00	1150	<0.001	<0.002
Feather R nr Nicolaus	01/31/00	1230	<0.001	<0.002
Feather R nr Nicolaus	01/30/00	1430	<0.001	<0.002
Feather R nr Nicolaus	02/15/00	1040	<0.001	<0.002
Feather R nr Nicolaus	02/14/00	1300	<0.001	<0.002
Feather R nr Nicolaus	02/11/00	1240	<0.001	<0.002
Feather R nr Nicolaus	02/13/00	1420	<0.001	<0.002
Feather R nr Nicolaus	02/21/00	1240	<0.001	<0.002
Feather R nr Nicolaus	02/22/00	1030	<0.001	<0.002
Feather R nr Nicolaus	02/23/00	1020	<0.001	<0.002
Feather R nr Nicolaus	02/24/00	1010	<0.001	<0.002
Feather R nr Nicolaus	02/25/00	1050	<0.001	<0.002
Sacramento R at Tower Bridge	02/01/00	1700	<0.001	E0.002
Sacramento R at Tower Bridge	02/02/00	1710	<0.001	0.006
Sacramento R at Tower Bridge	02/03/00	1700	<0.001	0.006
Sacramento R at Tower Bridge	02/04/00	1700	<0.001	0.006
Sacramento R at Tower Bridge	02/05/00	1700	<0.001	E0.002
Sacramento R at Tower Bridge	02/11/00	1715	<0.001	0.006
Sacramento R at Tower Bridge	02/12/00	1600	<0.001	E0.001
Sacramento R at Tower Bridge	02/13/00	1900	<0.001	E0.002
Sacramento R at Tower Bridge	02/14/00	1730	<0.001	E0.001
Sacramento R at Tower Bridge	02/15/00	1530	<0.001	E0.001
Sacramento R at Tower Bridge	02/16/00	1730	<0.001	E0.003
Sacramento R at Tower Bridge	02/17/00	1757	<0.001	E0.002
Sacramento R at Tower Bridge	02/22/00	1545	<0.001	E0.002
Sacramento R at Tower Bridge	02/23/00	1735	<0.001	E0.003
Sacramento R at Tower Bridge	02/24/00	1635	<0.001	<0.002
Sacramento R at Tower Bridge	02/25/00	1150	<0.001	<0.002

Appendix 2, Table 3. Field measurements.
[°C, degrees Celsius; mg/L, milligram per liter; uS/cm, microsiemens per centimeter at 25°C; R., River; Cr., Creek; Sl., Slough; --, no data avalable]

Site No.	Site name	Storm event number	Date / Time mm/dd/yyyy hr:min	Temp. (°C)	Diss. Oxygen (mg/l)	Spec. Cond. (uS/cm)	pH
1	Sacramento R. at Alamar	1	01/30/2000 11:00	10.2	10.6	62	9.7
1	Sacramento R. at Alamar	1	01/31/2000 10:45	9.7	10.2	148	7.6
1	Sacramento R. at Alamar	1	02/01/2000 13:10	10.0	12.4	144	7.7
1	Sacramento R. at Alamar	1	02/02/2000 12:50	10.9	9.9	141	7.6
1	Sacramento R. at Alamar	1	02/03/2000 12:50	10.2	10.8	146	7.7
1	Sacramento R. at Alamar	2	02/11/2000 16:10	10.9	9.6	154	7.6
1	Sacramento R. at Alamar	2	02/12/2000 14:05	10.5	10.2	129	7.8
1	Sacramento R. at Alamar	2	02/13/2000 14:50	10.6	10.2	123	7.6
1	Sacramento R. at Alamar	2	02/14/2000 13:15	10.9	10.6	101	7.5
1	Sacramento R. at Alamar	2	02/15/2000 13:40	12.3	10.1	116	7.3
1	Sacramento R. at Alamar	3	02/21/2000 15:00	11.6	9.9	123	7.7
1	Sacramento R. at Alamar	3	02/22/2000 13:25	11.2	9.8	125	7.6
1	Sacramento R. at Alamar	3	02/23/2000 14:00	10.5	9.3	120	7.7
1	Sacramento R. at Alamar	3	02/24/2000 12:50	10.3	9.3	106	7.2
1	Sacramento R. at Alamar	3	02/25/2000 12:05	10.0	9.5	113	7.4
2	Colusa Basin Drain	1	01/30/2000 13:15	10.5	7.9	777	7.6
2	Colusa Basin Drain	1	01/31/2000 12:00	10.0	7.7	784	7.9
2	Colusa Basin Drain	1	02/03/2000 09:25	11.3	7.4	770	7.7
2	Colusa Basin Drain	2	02/11/2000 14:05	12.5	7.3	871	8.7
2	Colusa Basin Drain	2	02/12/2000 09:20	11.8	7.7	851	7.9
2	Colusa Basin Drain	2	02/15/2000 09:30	11.8	7.5	450	7.4
2	Colusa Basin Drain	3	02/21/2000 11:20	13.3	8.0	633	7.6
2	Colusa Basin Drain	3	02/22/2000 10:30	12.8	7.4	690	7.5
2	Colusa Basin Drain	3	02/25/2000 08:55	10.2	7.4	451	7.4
3	Feather R. nr Nicolaus	1	01/30/2000 14:30	10.8	11.9	--	--
3	Feather R. nr Nicolaus	1	01/31/2000 12:30	9.9	11.5	95	--
3	Feather R. nr Nicolaus	1	02/01/2000 12:50	10.8	9.8	95	7.4
3	Feather R. nr Nicolaus	1	02/02/2000 11:50	11.0	9.0	92	7.4
3	Feather R. nr Nicolaus	1	02/03/2000 11:30	10.6	--	98	7.4
3	Feather R. nr Nicolaus	3	02/22/2000 10:30	--	--	73	--
3	Feather R. nr Nicolaus	3	02/23/2000 10:20	--	--	72	--
3	Feather R. nr Nicolaus	3	02/24/2000 10:10	--	--	69	--
4	DWR Pump Plant 1	1	01/30/2000 14:30	10.9	8.5	450	7.9
4	DWR Pump Plant 1	1	01/31/2000 12:55	10.5	7.9	407	7.7
4	DWR Pump Plant 1	1	02/01/2000 09:30	10.5	6.4	574	7.2
4	DWR Pump Plant 1	1	02/02/2000 11:50	11.7	8.0	560	7.7
4	DWR Pump Plant 1	1	02/03/2000 11:50	12.2	--	440	7.4
4	DWR Pump Plant 1	2	02/11/2000 15:00	11.2	6.7	583	7.6
4	DWR Pump Plant 1	2	02/12/2000 12:45	10.3	7.9	506	7.8
4	DWR Pump Plant 1	2	02/13/2000 13:40	11.3	9.3	497	7.7
4	DWR Pump Plant 1	2	02/14/2000 12:20	13.1	8.5	429	7.8
4	DWR Pump Plant 1	2	02/15/2000 12:30	12.7	7.0	481	7.3
4	DWR Pump Plant 1	3	02/21/2000 13:55	14.9	7.9	750	7.8

Appendix 2, Table 3. -- *Continued*.

[°C, degrees Celsius; mg/L, milligram per liter; uS/cm, microsiemens per centimeter at 25°C; R., River; Cr., Creek; Sl., Slough; --, no data avalable]

Site No.	Site name	Storm event number	Date / Time mm/dd/yyyy hr:min	Temp. (°C)	Diss. Oxygen (mg/l)	Spec. Cond. (uS/cm)	pH
4	DWR Pump Plant 1	3	02/22/2000 12:20	12.3	8.1	728	8.7
4	DWR Pump Plant 1	3	02/23/2000 10:30	9.7	8.4	390	7.0
4	DWR Pump Plant 1	3	02/24/2000 11:45	10.4	7.0	490	7.0
4	DWR Pump Plant 1	3	02/25/2000 12:00	11.7	6.4	554	7.5
5	Bear River	1	01/30/2000 16:00	10.3	11.1	--	--
5	Bear River	1	01/31/2000 13:10	10.1	11.0	105	
5	Bear River	1	02/01/2000 14:20	10.9	9.3	98	7.3
5	Bear River	1	02/02/2000 13:30	11.7	8.0	108	7.3
5	Bear River	1	02/03/2000 12:40	10.3	--	100	7.3
5	Bear River	2	02/12/2000 11:30	--	--	73	--
5	Bear River	3	02/22/2000 12:10	--	--	79	--
5	Bear River	3	02/23/2000 12:00	--	--	62	--
5	Bear River	3	02/24/2000 12:40	--	--	63	--
5	Bear River	3	02/25/2000 14:30	--	--	69	--
6a	DWR Pump Plant 2, north	1	02/03/2000 10:25	13.6	5.3	404	7.4
6a	DWR Pump Plant 2, north	2	02/15/2000 11:05	12.1	6.5	258	7.2
6a	DWR Pump Plant 2, north	3	02/25/2000 10:25	11.4	6.3	364	7.1
6b	DWR Pump Plant 2, north	1	01/30/2000 15:30	12.4	5.8	259	7.4
6b	DWR Pump Plant 2, north	1	01/31/2000 13:48	11.2	7.8	4	7.7
6b	DWR Pump Plant 2, north	1	02/01/2000 11:00	11.7	5.8	398	7.2
6b	DWR Pump Plant 2, north	1	02/02/2000 11:00	11.9	4.8	417	7.5
6b	DWR Pump Plant 2, north	1	02/03/2000 10:50	12.4	5.0	454	7.6
6b	DWR Pump Plant 2, north	2	02/11/2000 12:40	12.3	6.4	437	7.9
6b	DWR Pump Plant 2, north	2	02/12/2000 11:15	10.9	4.2	253	7.6
6b	DWR Pump Plant 2, north	2	02/13/2000 10:50	11.1	8.3	249	7.2
6b	DWR Pump Plant 2, north	2	02/14/2000 10:50	12.3	8.4	224	7.7
6b	DWR Pump Plant 2, north	2	02/15/2000 10:35	12.3	5.8	306	6.5
6b	DWR Pump Plant 2, north	3	02/21/2000 12:45	14.1	7.0	450	7.9
6b	DWR Pump Plant 2, north	3	02/22/2000 11:20	12.7	7.2	522	7.9
6b	DWR Pump Plant 2, north	3	02/23/2000 11:10	11.4	7.4	450	7.4
6b	DWR Pump Plant 2, north	3	02/24/2000 10:50	10.4	5.8	331	6.5
6b	DWR Pump Plant 2, north	3	02/25/2000 09:55	11.2	6.5	408	7.1
7	Gisizer Sl. at Bogue Rd.	1	01/31/2000 10:10	13.2	8.5	428	8.3
7	Gisizer Sl. at Bogue Rd.	1	01/31/2000 14:55	12.6	8.6	121	7.8
7	Gisizer Sl. at Bogue Rd.	1	02/02/2000 11:05	14.2	6.7	912	8.3
7	Gisizer Sl. at Bogue Rd.	1	02/03/2000 09:10	12.4	6.5	872	8.3
7	Gisizer Sl. at Bogue Rd.	2	02/11/2000 13:03	13.0	9.5	305	8.5
7	Gisizer Sl. at Bogue Rd.	2	02/12/2000 02:10	9.8	9.6	52	8.0
7	Gisizer Sl. at Bogue Rd.	2	02/12/2000 09:40	10.2	8.9	161	7.5
7	Gisizer Sl. at Bogue Rd.	2	02/12/2000 14:45	12.4	7.6	247	8.0
7	Gisizer Sl. at Bogue Rd.	2	02/12/2000 17:57	11.8	9.1	155	7.8
7	Gisizer Sl. at Bogue Rd.	2	02/12/2000 21:37	11.8	8.8	128	7.8
7	Gisizer Sl. at Bogue Rd.	2	02/13/2000 02:05	11.7	8.7	94	7.7

Appendix 2, Table 3. -- *Continued*.

[°C, degrees Celsius; mg/L, milligram per liter; uS/cm, microsiemens per centimeter at 25°C; R., River; Cr., Creek; Sl., Slough; --, no data avalable]

Site No.	Site name	Storm event number	Date / Time mm/dd/yyyy hr:min	Temp. (°C)	Diss. Oxygen (mg/l)	Spec. Cond. (uS/cm)	pH
7	Gisizer Sl. at Bogue Rd.	2	02/13/2000 09:15	10.3	11.1	34	7.8
7	Gisizer Sl. at Bogue Rd.	2	02/13/2000 13:55	11.0	10.1	54	7.3
7	Gisizer Sl. at Bogue Rd.	2	02/13/2000 17:20	11.8	10.0	93	7.7
7	Gisizer Sl. at Bogue Rd.	2	02/13/2000 21:45	12.0	9.8	57	7.7
7	Gisizer Sl. at Bogue Rd.	2	02/14/2000 10:00	13.0	9.4	58	7.6
7	Gisizer Sl. at Bogue Rd.	2	02/14/2000 14:40	15.2	8.4	262	7.8
7	Gisizer Sl. at Bogue Rd.	2	02/14/2000 17:50	13.9	8.1	314	8.0
7	Gisizer Sl. at Bogue Rd.	2	02/14/2000 21:45	12.6	6.3	525	8.1
7	Gisizer Sl. at Bogue Rd.	2	02/15/2000 11:50	15.5	8.5	932	7.6
7	Gisizer Sl. at Bogue Rd.	3	02/21/2000 11:15	14.9	9.6	268	7.7
7	Gisizer Sl. at Bogue Rd.	3	02/22/2000 09:45	12.8	9.3	987	8.3
7	Gisizer Sl. at Bogue Rd.	3	02/22/2000 14:00	12.9	9.8	174	7.8
7	Gisizer Sl. at Bogue Rd.	3	02/22/2000 17:30	12.0	7.9	86	7.9
7	Gisizer Sl. at Bogue Rd.	3	02/22/2000 21:50	--	--	--	7.7
7	Gisizer Sl. at Bogue Rd.	3	02/23/2000 09:55	10.3	8.5	143	7.2
7	Gisizer Sl. at Bogue Rd.	3	02/23/2000 17:05	14.9	5.3	498	8.3
7	Gisizer Sl. at Bogue Rd.	3	02/24/2000 14:45	15.7	7.7	992	8.4
7	Gisizer Sl. at Bogue Rd.	3	02/24/2000 17:35	14.9	8.1	971	8.4
7	Gisizer Sl. at Bogue Rd.	3	02/24/2000 21:55	13.2	7.3	795	8.4
7	Gisizer Sl. at Bogue Rd.	3	02/25/2000 13:10	18.0	10.0	908	8.2
8	Feather R. at Yuba City	1	01/30/2000 11:50	10.3	10.4	116	7.4
8	Feather R. at Yuba City	1	01/31/2000 15:05	10.2	10.9	122	7.5
8	Feather R. at Yuba City	1	02/01/2000 12:30	10.4	12.1	112	7.7
8	Feather R. at Yuba City	1	02/02/2000 13:45	11.0	10.2	115	7.1
8	Feather R. at Yuba City	1	02/03/2000 13:30	11.0	9.9	116	6.9
8	Feather R. at Yuba City	2	02/11/2000 14:00	10.9	10.6	--	7.3
8	Feather R. at Yuba City	2	02/12/2000 13:45	10.3	9.7	131.1	6.6
8	Feather R. at Yuba City	2	02/13/2000 13:45	10.1	10.4	98	6.5
8	Feather R. at Yuba City	2	02/14/2000 13:00	11.3	10.1	78	7.5
8	Feather R. at Yuba City	2	02/15/2000 12:20	12.2	9.6	83	7.4
8	Feather R. at Yuba City	3	02/21/2000 15:50	10.7	11.6	103	6.9
8	Feather R. at Yuba City	3	02/22/2000 12:50	9.6	11.5	99	7.4
8	Feather R. at Yuba City	3	02/23/2000 12:15	9.3	11.7	97	7.6
8	Feather R. at Yuba City	3	02/24/2000 12:45	9.1	10.9	95	8.3
8	Feather R. at Yuba City	3	02/25/2000 12:30	9.1	12.0	99	8.4
9	Yuba R. at Marysville	2	02/11/2000 14:30	10.1	10.9	87	7.9
9	Yuba R. at Marysville	2	02/12/2000 13:50	9.5	8.2	81	7.7
9	Yuba R. at Marysville	3	02/21/2000 15:00	11.0	12.1	65	7.8
9	Yuba R. at Marysville	3	02/22/2000 14:30	9.5	10.9	68	7.5
10	Wadsworth Canal	1	01/31/2000 09:40	10.4	7.7	340	7.8
10	Wadsworth Canal	1	01/31/2000 11:18	11.0	7.6	333	7.9
10	Wadsworth Canal	1	02/01/2000 15:00	12.7	8.6	406	7.7
10	Wadsworth Canal	1	02/02/2000 10:40	12.5	7.8	451	7.5

Appendix 2, Table 3. -- *Continued*.

[°C, degrees Celsius; mg/L, milligram per liter; uS/cm, microsiemens per centimeter at 25°C; R., River; Cr., Creek; Sl., Slough; --, no data avalable]

Site No.	Site name	Storm event number	Date / Time mm/dd/yyyy hr:min	Temp. (°C)	Diss. Oxygen (mg/l)	Spec. Cond. (uS/cm)	pH
10	Wadsworth Canal	1	02/03/2000 10:00	12.9	7.7	496	8.0
10	Wadsworth Canal	2	02/07/2000 10:30	13.2	7.4	495	7.4
10	Wadsworth Canal	2	02/09/2000 10:49	14.6	7.8	552	7.6
10	Wadsworth Canal	2	02/11/2000 13:35	12.2	8.0	412	7.9
10	Wadsworth Canal	2	02/12/2000 01:45	10.6	9.5	207	7.9
10	Wadsworth Canal	2	02/12/2000 09:10	10.2	8.4	232	7.8
10	Wadsworth Canal	2	02/12/2000 14:20	9.5	9.4	248	7.8
10	Wadsworth Canal	2	02/12/2000 17:40	10.4	8.7	257	7.8
10	Wadsworth Canal	2	02/12/2000 21:10	10.7	8.6	252	7.7
10	Wadsworth Canal	2	02/13/2000 01:30	10.8	8.4	257	7.7
10	Wadsworth Canal	2	02/13/2000 09:35	10.4	9.8	172	7.6
10	Wadsworth Canal	2	02/13/2000 13:30	10.7	9.7	162	7.7
10	Wadsworth Canal	2	02/13/2000 16:55	10.9	9.2	153	7.8
10	Wadsworth Canal	2	02/13/2000 21:25	11.3	9.5	128	7.6
10	Wadsworth Canal	2	02/14/2000 09:40	12.1	8.8	135	7.6
10	Wadsworth Canal	2	02/14/2000 11:11	12.4	8.6	136	7.3
10	Wadsworth Canal	2	02/14/2000 13:50	13.1	8.9	145	7.4
10	Wadsworth Canal	2	02/14/2000 17:20	13.5	7.6	155	7.5
10	Wadsworth Canal	2	02/14/2000 21:25	13.6	7.1	171	7.6
10	Wadsworth Canal	2	02/15/2000 11:25	12.2	7.7	217	7.6
10	Wadsworth Canal	3	02/22/2000 09:18	13.3	9.2	439	7.9
10	Wadsworth Canal	3	02/22/2000 14:50	12.8	9.2	444	8.0
10	Wadsworth Canal	3	02/22/2000 17:00	12.6	7.6	439	8.0
10	Wadsworth Canal	3	02/22/2000 21:25	12.0	7.1	345	7.9
10	Wadsworth Canal	3	02/23/2000 09:20	9.6	10.1	177	--
10	Wadsworth Canal	3	02/23/2000 16:40	11.5	7.5	216	7.7
10	Wadsworth Canal	3	02/24/2000 14:20	11.2	8.3	335	7.5
10	Wadsworth Canal	3	02/24/2000 17:00	11.4	7.7	345	7.7
10	Wadsworth Canal	3	02/24/2000 21:30	11.9	7.8	356	--
10	Wadsworth Canal	3	02/25/2000 12:45	12.4	8.9	390	7.6
11	Jack Slough	1	01/30/2000 13:20	10.5	8.2	147	7.5
11	Jack Slough	1	01/31/2000 14:10	9.8	9.0	133	7.6
11	Jack Slough	1	02/01/2000 14:00	11.1	9.1	134	7.6
11	Jack Slough	1	02/02/2000 12:45	11.7	8.2	144	7.1
11	Jack Slough	1	02/03/2000 12:30	12.0	7.8	148	7.4
11	Jack Slough	2	02/11/2000 14:30	10.4	8.3	112	6.9
11	Jack Slough	2	02/12/2000 14:30	9.4	8.7	97.3	6.8
11	Jack Slough	2	02/13/2000 14:45	10.1	9.6	89	6.7
11	Jack Slough	2	02/14/2000 13:40	12.8	8.3	79	7.5
11	Jack Slough	2	02/15/2000 13:00	12.1	8.1	82	7.8
11	Jack Slough	3	02/21/2000 14:30	13.7	8.5	145	6.9
11	Jack Slough	3	02/22/2000 13:30	12.1	8.6	137	6.9
11	Jack Slough	3	02/23/2000 12:50	9.6	9.7	88	7.2

Appendix 2, Table 3. -- *Continued*.

[°C, degrees Celsius; mg/L, milligram per liter; uS/cm, microsiemens per centimeter at 25°C; R., River; Cr., Creek; Sl., Slough; --, no data avalable]

Site No.	Site name	Storm event number	Date / Time mm/dd/yyyy hr:min	Temp. (°C)	Diss. Oxygen (mg/l)	Spec. Cond. (uS/cm)	pH
11	Jack Slough	3	02/24/2000 13:15	10.2	8.7	94	7.1
11	Jack Slough	3	02/25/2000 13:00	10.8	9.2	104	7.8
12	Butte Sl. at Lower Pass Rd.	1	01/30/2000 15:20	10.7	7.5	209	7.3
12	Butte Sl. at Lower Pass Rd.	1	01/31/2000 12:45	10.1	8.2	218	7.5
12	Butte Sl. at Lower Pass Rd.	1	02/01/2000 11:30	10.2	9.0	215	7.6
12	Butte Sl. at Lower Pass Rd.	1	02/02/2000 11:35	10.4	7.4	214	7.3
12	Butte Sl. at Lower Pass Rd.	1	02/03/2000 11:30	11.2	6.8	219	7.5
12	Butte Sl. at Lower Pass Rd.	2	02/11/2000 12:00	12.2	7.3	264	7.0
12	Butte Sl. at Lower Pass Rd.	2	02/12/2000 12:00	10.8	7.8	248	6.7
12	Butte Sl. at Lower Pass Rd.	2	02/13/2000 11:30	10.1	11.0	160	6.7
12	Butte Sl. at Lower Pass Rd.	2	02/14/2000 11:15	10.7	11.3	125	7.4
12	Butte Sl. at Lower Pass Rd.	2	02/15/2000 11:10	10.4	10.5	103	7.4
12	Butte Sl. at Lower Pass Rd.	3	02/21/2000 13:40	11.0	10.5	146	7.2
12	Butte Sl. at Lower Pass Rd.	3	02/22/2000 11:30	10.5	10.9	144	7.3
12	Butte Sl. at Lower Pass Rd.	3	02/23/2000 11:00	10.2	11.0	141	7.7
12	Butte Sl. at Lower Pass Rd.	3	02/24/2000 11:15	9.4	10.9	132	7.6
12	Butte Sl. at Lower Pass Rd.	3	02/25/2000 11:15	9.6	11.2	128	7.6
13	Sacramento R.at Colusa	1	01/30/2000 16:20	11.2	10.9	135	7.6
13	Sacramento R.at Colusa	1	01/31/2000 10:45	10.0	11.7	131	7.8
13	Sacramento R.at Colusa	1	02/01/2000 10:00	10.6	13.0	115	8.0
13	Sacramento R.at Colusa	1	02/02/2000 09:45	10.4	11.3	123	7.4
13	Sacramento R.at Colusa	1	02/03/2000 09:50	10.6	11.3	128	7.3
13	Sacramento R.at Colusa	2	02/11/2000 10:30	10.4	5.1	139	7.6
13	Sacramento R.at Colusa	2	02/12/2000 11:00	10.4	10.3	158	6.4
13	Sacramento R.at Colusa	2	02/13/2000 10:20	10.1	8.3	115	7.2
13	Sacramento R.at Colusa	2	02/14/2000 10:00	12.0	11.2	111	7.6
13	Sacramento R.at Colusa	2	02/15/2000 09:40	10.9	10.9	106	8.2
13	Sacramento R.at Colusa	3	02/21/2000 12:20	11.8	11.3	146	7.3
13	Sacramento R.at Colusa	3	02/22/2000 10:35	10.9	11.2	143	7.7
13	Sacramento R.at Colusa	3	02/23/2000 10:15	10.5	11.3	146	7.6
13	Sacramento R.at Colusa	3	02/24/2000 09:50	9.8	11.2	129	7.5
13	Sacramento R.at Colusa	3	02/25/2000 10:05	10.8	11.9	133	8.4
14	Butte Cr. nr Gridley	1	01/30/2000 13:15	9.8	8.8	210	7.6
14	Butte Cr. nr Gridley	1	01/31/2000 12:15	9.2	9.0	161	8.1
14	Butte Cr. nr Gridley	1	02/01/2000 13:25	9.5	9.8	180	7.6
14	Butte Cr. nr Gridley	1	02/02/2000 13:00	10.8	9.0	198	7.6
14	Butte Cr. nr Gridley	1	02/03/2000 11:03	11.5	8.4	212	7.6
14	Butte Cr. nr Gridley	2	02/11/2000 10:10	10.9	9.3	149	7.7
14	Butte Cr. nr Gridley	2	02/12/2000 00:38	10.1	9.5	176.0	8.1
14	Butte Cr. nr Gridley	2	02/12/2000 08:05	9.6	9.2	144.6	8.0
14	Butte Cr. nr Gridley	2	02/12/2000 12:15	9.5	9.3	--	7.7
14	Butte Cr. nr Gridley	2	02/12/2000 16:35	9.7	9.3	128	7.8
14	Butte Cr. nr Gridley	2	02/12/2000 20:15	9.5	9.1	133	7.7

Appendix 2, Table 3. -- *Continued*.

[°C, degrees Celsius; mg/L, milligram per liter; uS/cm, microsiemens per centimeter at 25°C; R., River; Cr., Creek; Sl., Slough; --, no data avalable]

Site No.	Site name	Storm event number	Date / Time mm/dd/yyyy hr:min	Temp. (°C)	Diss. Oxygen (mg/l)	Spec. Cond. (uS/cm)	pH
14	Butte Cr. nr Gridley	2	02/13/2000 00:16	9.5	9.4	136	7.8
14	Butte Cr. nr Gridley	2	02/13/2000 08:10	9.5	10.0	138	8.0
14	Butte Cr. nr Gridley	2	02/13/2000 12:20	9.6	10.1	136	7.6
14	Butte Cr. nr Gridley	2	02/13/2000 15:50	9.5	10.1	130	7.7
14	Butte Cr. nr Gridley	2	02/13/2000 20:10	9.7	9.9	115	7.7
14	Butte Cr. nr Gridley	2	02/14/2000 08:25	10.4	9.8	100.0	8.2
14	Butte Cr. nr Gridley	2	02/14/2000 12:25	11.3	8.9	98.5	7.6
14	Butte Cr. nr Gridley	2	02/14/2000 16:20	11.9	8.9	99.4	7.6
14	Butte Cr. nr Gridley	2	02/14/2000 20:20	11.7	7.9	96	7.7
14	Butte Cr. nr Gridley	2	02/15/2000 09:20	10.3	9.2	89	7.4
14	Butte Cr. nr Gridley	3	02/21/2000 12:40	11.6	10.4	168	7.6
14	Butte Cr. nr Gridley	3	02/22/2000 08:10	12.1	6.3	159	7.6
14	Butte Cr. nr Gridley	3	02/22/2000 12:20	11.5	--	161	7.8
14	Butte Cr. nr Gridley	3	02/22/2000 16:00	11.0	9.1	165	7.7
14	Butte Cr. nr Gridley	3	02/22/2000 20:20	10.6	6.9	169	7.9
14	Butte Cr. nr Gridley	3	02/23/2000 08:10	9.3	10.8	126	7.5
14	Butte Cr. nr Gridley	3	02/23/2000 15:35	10.1	8.3	113	7.7
14	Butte Cr. nr Gridley	3	02/24/2000 12:20	9.6	9.3	117	7.3
14	Butte Cr. nr Gridley	3	02/24/2000 16:05	9.5	9.5	122	7.7
14	Butte Cr. nr Gridley	3	02/24/2000 20:20	9.3	9.2	127	7.7
14	Butte Cr. nr Gridley	3	02/25/2000 10:05	9.5	9.2	136	7.3
15	Cherokee Canal	2	02/11/2000 10:35	9.0	11.2	--	7.4
15	Cherokee Canal	2	02/12/2000 12:35	9.9	9.2	--	7.7
15	Cherokee Canal	3	02/21/2000 13:05	13.3	8.8	169	7.8
15	Cherokee Canal	3	02/22/2000 12:30	12.3	7.5	143	7.6
16	Main Canal	1	01/30/2000 14:45	9.5	7.3	250	7.8
16	Main Canal	1	01/31/2000 12:40	10.1	6.9	245	7.7
16	Main Canal	1	02/01/2000 14:00	12.2	8.1	259	7.6
16	Main Canal	1	02/02/2000 13:30	12.4	7.0	282	7.6
16	Main Canal	1	02/03/2000 23:23	12.0	5.6	238	7.7
16	Main Canal	2	02/11/2000 11:05	11.4	5.5	308	7.7
16	Main Canal	2	02/12/2000 00:55	10.8	7.6	243	7.7
16	Main Canal	2	02/12/2000 08:20	9.4	7.4	186	7.6
16	Main Canal	2	02/12/2000 12:55	9.6	8.0	200	7.7
16	Main Canal	2	02/12/2000 16:50	10.5	7.5	215	7.7
16	Main Canal	2	02/12/2000 20:25	10.9	7.8	225	7.7
16	Main Canal	2	02/13/2000 00:40	10.9	7.3	234	7.7
16	Main Canal	2	02/13/2000 08:30	10.5	7.9	235	7.7
16	Main Canal	2	02/13/2000 12:35	10.6	8.5	195	7.7
16	Main Canal	2	02/13/2000 16:10	10.8	8.5	171	7.6
16	Main Canal	2	02/13/2000 20:25	11.2	8.4	161	7.7
16	Main Canal	2	02/14/2000 08:50	12.2	8.2	168	7.6
16	Main Canal	2	02/14/2000 13:00	13.0	8.2	175	7.7

Appendix 2, Table 3. -- *Continued*.

[°C, degrees Celsius; mg/L, milligram per liter; uS/cm, microsiemens per centimeter at 25°C; R., River; Cr., Creek; Sl., Slough; --, no data avalable]

Site No.	Site name	Storm event number	Date / Time mm/dd/yyyy hr:min	Temp. (°C)	Diss. Oxygen (mg/l)	Spec. Cond. (uS/cm)	pH
16	Main Canal	2	02/14/2000 16:30	14.8	7.4	180	7.5
16	Main Canal	2	02/14/2000 20:35	14.7	6.3	188	7.5
16	Main Canal	2	02/15/2000 09:50	10.9	7.7	219	7.3
16	Main Canal	3	02/21/2000 13:20	13.6	8.3	327	7.7
16	Main Canal	3	02/22/2000 08:25	12.5	7.0	355	7.8
16	Main Canal	3	02/22/2000 12:45	12.2	7.2	362	7.8
16	Main Canal	3	02/22/2000 16:15	12.2	7.8	363	7.7
16	Main Canal	3	02/22/2000 20:40	11.4	6.9	350	7.8
16	Main Canal	3	02/23/2000 08:35	9.1	9.1	198	7.9
16	Main Canal	3	02/23/2000 15:55	12.9	6.9	211	7.7
16	Main Canal	3	02/24/2000 12:40	10.4	7.8	306	7.7
16	Main Canal	3	02/24/2000 16:20	12.0	7.9	319	7.7
16	Main Canal	3	02/24/2000 20:30	12.0	7.6	322	7.7

Appendix 3

QC data tables

Appendix 3, Table 1. Blank sample data analyzed by ELISA.
[FB, field blank; RB, rinse blank; <, less than]

Site No.	Site name	Date / Time	Sample type	ELISA Diazinon (ppt)	Event
1	Sac R at Alamar	1/30/2000 11:00	FB	< 30	1
1	Sac R at Alamar	2/11/2000 16:10	FB	< 30	2
1	Sac R at Alamar	2/21/2000 15:00	FB	< 30	3
1	Sac R at Alamar	2/22/2000 13:25	FB	< 30	3
2	CBD	1/30/2000 13:15	FB	< 30	1
2	CBD	2/11/2000 14:05	FB	< 30	2
2	CBD	2/22/2000 10:30	FB	< 30	3
3	Feather R nr Nicolaus	1/31/2000 12:30	FB	< 30	1
3	Feather R nr Nicolaus	2/12/2000 10:30	FB	< 30	2
3	Feather R nr Nicolaus	2/22/2000 10:30	FB	< 30	3
4	DWR Pump Plant 1	1/31/2000 12:55	FB	< 30	1
4	DWR Pump Plant 1	2/12/2000 12:45	FB	< 30	2
4	DWR Pump Plant 1	2/22/2000 12:20	FB	< 30	3
5	Bear River	1/30/2000 16:00	FB	< 30	1
5	Bear River	1/31/2000 13:10	RB	< 30	1
5	Bear River	2/11/2000 14:30	FB	< 30	2
5	Bear River	2/12/2000 11:30	RB	< 30	2
5	Bear River	2/21/2000 15:30	FB	< 30	3
5	Bear River	2/22/2000 12:10	RB	< 30	3
7	Gisizer Slough at Bogue Rd.	1/30/2000 19:00	FB	< 30	1
7	Gisizer Slough at Bogue Rd.	2/11/2000 13:03	FB	< 30	2
7	Gisizer Slough at Bogue Rd.	2/21/2000 11:15	FB	< 30	3
8	Feather R at Yuba City	1/31/2000 15:05	FB	< 30	1
8	Feather R at Yuba City	2/11/2000 14:00	FB	< 30	2
8	Feather R at Yuba City	2/12/2000 13:45	FB	< 30	2
8	Feather R at Yuba City	2/22/2000 12:50	FB	< 30	3
9	Yuba R at Marysville	1/31/2000 14:10	FB	< 30	1
9	Yuba R at Marysville	2/12/2000 13:50	FB	< 30	2
9	Yuba R at Marysville	2/22/2000 14:30	FB	< 30	3
10	Wadsworth Canal	1/31/2000 09:40	FB	< 30	1
10	Wadsworth Canal	2/12/2000 14:20	FB	< 30	2
10	Wadsworth Canal	2/22/2000 14:50	FB	< 30	3
11	Jack Slough	1/30/2000 13:20	FB	< 30	1
11	Jack Slough	2/11/2000 14:30	FB	< 30	2
11	Jack Slough	2/21/2000 14:30	FB	< 30	3
12	Butte Slough at Lower Pass Rd	1/30/2000 15:20	FB	< 30	1
12	Butte Slough at Lower Pass Rd	2/1/2000 11:30	RB	< 30	1
12	Butte Slough at Lower Pass Rd	2/11/2000 12:00	FB	< 30	2
12	Butte Slough at Lower Pass Rd	2/12/2000 12:00	RB	< 30	2
12	Butte Slough at Lower Pass Rd	2/21/2000 13:40	FB	< 30	3
12	Butte Slough at Lower Pass Rd	2/22/2000 11:30	RB	< 30	3
13	Sac River at Colusa	1/31/2000 10:45	FB	< 30	1

Appendix 3, Table 1. -- *Continued.*

[FB, field blank; RB, rinse blank; <, less than]

Site No.	Site name	Date / Time	Sample type	ELISA Diazinon (ppt)	Event
13	Sac River at Colusa	2/12/2000 11:00	FB	< 30	2
13	Sac River at Colusa	2/22/2000 10:35	FB	< 30	3
14	Butte Cr nr Gridley	1/30/2000 13:15	FB	< 30	1
14	Butte Cr nr Gridley	2/11/2000 10:10	FB	< 30	2
14	Butte Cr nr Gridley	2/21/2000 12:40	FB	< 30	3
15	Cherokee Canal	1/31/2000 18:15	FB	< 30	1
15	Cherokee Canal	2/12/2000 12:35	FB	< 30	2
15	Cherokee Canal	2/22/2000 12:30	FB	< 30	3
16	Main canal	1/30/2000 14:45	FB	< 30	1
16	Main canal	1/31/2000 18:40	RB	< 30	1
16	Main canal	2/11/2000 11:05	FB	< 30	2
16	Main canal	2/12/2000 12:55	RB	< 30	2
16	Main canal	2/22/2000 12:45	RB	< 30	3
6a	Pump Plant 2, north	2/13/2000 12:01	FB	< 30	2
6b	Pump Plant 2, south	1/31/2000 13:48	FB	< 30	1
6b	Pump Plant 2, south	1/31/2000 13:48	RB	< 30	1
6b	Pump Plant 2, south	2/12/2000 11:15	FB	< 30	2
6b	Pump Plant 2, south	2/12/2000 11:15	RB	< 30	2
6b	Pump Plant 2, south	2/22/2000 11:20	FB	< 30	3
6b	Pump Plant 2, south	2/22/2000 11:20	RB	< 30	3

Sources and Concentrations of Diazinon in the Sacramento Watershed during the 1994 Orchard Dormant Spray Season

July 2000

Central Valley Regional Water Quality Control Board

Prepared by:

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Forward

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EXECUTIVE SUMMARY

A million pounds of insecticide active ingredients are applied annually in the Central Valley on half a million acres of dormant stonefruit and almond orchards in January and February. Diazinon accounts for about half the use. In an earlier investigation (Kuivila and Foe, 1995), toxic concentrations of diazinon were measured in the San Joaquin and in the Sacramento River in February 1993 after each of the three largest storms of the month. Diazinon was traced as far seaward in the Sacramento-San Joaquin Delta/Estuary as the City of Martinez. Diazinon-caused toxicity was observed 60 miles downstream of Sacramento. These findings are of regulatory significance because the Central Valley Regional Water Quality Control Board's (CVRWQCB) Basin Plan contains a narrative toxicity objective stating that "all waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses . . . in aquatic life." Based upon this toxicity water quality objective, the CVRWQCB placed the Sacramento River and Sacramento-San Joaquin Delta-Estuary on the Clean Water Act's 303(d) list of impaired water bodies and identified diazinon and other toxic chemicals, including chlorpyrifos, as the cause of the toxicity.

Objectives of this study were threefold: (1) Determine diazinon concentrations in the Sacramento River after three rainstorms in January/February 1994 to ascertain whether insecticide pulses were present; (2) If pulses were observed, determine the geographic sources of the insecticide; and (3) Compare the accuracy and precision of enzyme-linked immunosorbent assey (ELISA) and gas chromatograph/mass spectrophotometer (GC/MS) methods to determine the utility of the ELISA procedure for analyzing surface water samples

As in February 1993 (Kuivila and Foe, 1995), flow and diazinon concentrations increased in the Sacramento River at Sacramento in January/February 1994 after each of the three largest rain storms. The primary source of diazinon at the City of Sacramento during the first storm was the Feather River drainage. Important sources to the Feather River were Jack Slough and the Bear River. The primary sources of diazinon in the Sacramento River at Sacramento during the second and third storms were, respectively, the upper Sacramento Basin above Colusa and the Sacramento Slough drainage. The principal sources of diazinon in the upper Sacramento River were not ascertained, but appeared to be the area between Bend and Vina. Important sources of diazinon in Sacramento Slough were the Main Drain inputs, Wadsworth Canal, and the Department of Water Resources (DWR) pumping stations at O'Banion and Sacramento Avenue.

Comparison of instream diazinon concentrations with the California Department of Fish and Game's (DFG) recommended water quality criteria for protection of aquatic life demonstrated that the Sacramento River at Sacramento in January/February 1994 exceeded the DFG acute and chronic criteria for nine and 19 days, respectively. Similar multiple exceedances were also observed in the Sacramento River at Colusa, the Feather River at Yuba City and at HWY 99, Sacramento Slough at Pass Road and at Karnak, and at Colusa Drain. The frequency of exceedance of the diazinon criteria was greater than recommended by DFG in several areas of the Sacramento watershed in January/February 1994.

One hundred and fifty-five field samples were analyzed by both ELISA and GC/MS. No statistically significant difference was noted in the accuracy or precision of the two methods, suggesting that the diazinon ELISA procedure is acceptable for monitoring of surface waters.

INTRODUCTION

The Sacramento River watershed encompasses over 16 million acres with about one percent (171,000 acres) of the land mass planted in stonefruit and almond orchards. Almonds and prunes constitute 90 percent of this acreage (Table 1). The highest density of orchards typically occurs in the deeper, well-drained soil adjacent to waterways in Butte, Glenn, Colusa, Yuba, and Sutter counties. An annual application of dormant spray is recommended for all almond and stonefruit orchards in early winter, primarily for the control of boring insects.

Approximately 500,000 pounds of insecticide active ingredients are applied annually to dormant orchards in the Central Valley, including the Sacramento River watershed, on half a million acres of stonefruit and almond orchards, primarily to control boring insects. The pesticides are typically applied in January and February. Four insecticides are primarily employed, with diazinon accounting for about half the applications. In Butte, Glenn, Sutter, Tehama, Yolo, and Yuba counties approximately 73,000 pounds of diazinon were applied to orchards during February 1994. Toxic concentrations of diazinon were measured in the San Joaquin and in the Sacramento Rivers in February 1993 after the three largest storms of the month (Kuivila and Foe, 1995). Dormant spray concentrations in the San Joaquin River at Vernalis caused 100 percent *Ceriodaphnia* mortality in U.S. EPA three species bioassay procedures (U.S. EPA, 1989) for 12 days, while acute toxicity was observed in the Sacramento River at the City of Sacramento for one day. Diazinon pulses from both watersheds were traced as far seaward in the Sacramento/San Joaquin Estuary as the City of Martinez, 75 miles below the City of Sacramento. Toxicity was observed as far west as Chipps Island, 60 miles downstream of Sacramento.

These findings are of regulatory significance because the Central Valley Regional Water Quality Control Board's (CVRWQCB's) Basin Plan contains a narrative toxicity objective: "all waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses . . . in aquatic life." In 1989, U.S. EPA endorsed (54FR23868) use of the EPA three species bioassays in assessing compliance with state narrative toxicity objectives. Both the Sacramento and San Joaquin Rivers and the downstream Estuary have been placed on the Clean Water Act 303(d) list by the CVRWQCB as impaired water bodies, in part because of toxic concentrations of diazinon during the dormant spray season.

Follow-up studies in the San Joaquin River Basin confirmed that the application of dormant spray on orchards was the primary source of diazinon (Foe, 1995; Domagalski, 1996; Kratzer 1997). Loading studies (Kratzer, 1997) demonstrated that the Tuolumne and Merced Rivers and several small westside tributaries in Stanislaus County were the primary source of the insecticide. The results were surprising, as some of the largest acreage of orchards is along the Stanislaus River, where little off site movement of diazinon was observed. These results are significant as they help focus control measures on the primary locations responsible for most of the pesticide loading into the San Joaquin River and the southern Estuary.

No similar studies have been conducted in the Sacramento River Basin to determine the source of the diazinon observed in the Sacramento River. Enyme linked immunosorbent assays (ELISA) are a procedure that use antibodies to measure chemical concentration. An ELISA procedure has been developed specifically for diazinon. The procedure is appealing because it has a low detection limit, is relatively inexpensive, and may be completed within hours, facilitating rapid follow-up studies. Traditionally, state agencies have employed a capillary gas chromatograph/ion trap mass spectrometer (GC/MS) to quantify chemical concentrations. The GC/MS analysis is time consuming and analytical data are often not available for weeks. The accuracy and precision of the ELISA procedure for surface water samples has not been assessed.

Objectives of this study were threefold. First, monitor diazinon concentrations in the Sacramento River watershed after rainstorms to ascertain whether pulses were present. Second, if concentrations of concern were observed, determine the sources of the insecticide. Third, compare the accuracy and precision of ELISA and GC/MS methods to determine the utility of the ELISA procedure on field samples.

METHODS AND MATERIALS

Site Description And Sampling Locations: Water samples were collected at 30 sites (Figure 1) on the Sacramento River and tributaries in the winter of 1994. Sampling was associated with rainstorms. All samples were subsurface grab samples collected in one liter amber glass bottles. Samples were placed on ice for transport to the laboratory where they were stored at 4°C until analysis. Seven primary sampling sites were selected for daily monitoring after rainstorms (Table 2). These were located on the Sacramento River and on its major tributaries downstream of high densities of orchards. Orchards in Butte and Glenn Counties are predominately located along the upper Sacramento River and its tributaries. Water samples collected in the town of Colusa (Site 7) should detect any insecticides in stormwater runoff from the upper Sacramento River, with the exception of central Butte County. Orchards in central Butte County drain to Butte Slough above Pass Road (Site 5). Orchards in Sutter County predominately drain to Sacramento Slough between Pass Road and Karnak (Site 4). Orchards in Yuba County are located along the east side of the Feather River between Yuba City and HWY 99. Rainwater runoff from this area should be reflected in the insecticide loads from the Feather River at HWY 99 (Site 2). Flow information was available for each primary site, enabling calculation of diazinon loads.

Secondary sampling sites were located along tributaries to the Sacramento River, Feather River, and Butte Slough for the purpose of identifying major sources of diazinon within each subbasin (Table 3). Samples were to be collected at least once during each rainfall event at the secondary sites.

Flow data were not available for some locations, making source identification more qualitative in nature. Limited sampling occurred on the upper Sacramento River between Colusa and Red Bluff when it became apparent that a notable portion of the diazinon load originated in those areas. Sampling was from major bridges crossing the river (Table 2).

Precipitation: Rainfall data were obtained from the Desert Research Center's Atmospheric Science Center for four locations in the northern Central Valley: Sacramento, Colusa, Marysville, and Red Bluff. Rainfall information was collected for these four sites as the valley is over 100 miles long and precipitation at any one location is not likely to be representative of the entire watershed.

Diazinon Analysis: Diazinon analyses were by Millipore ELISA at UC Davis and GC/MS at the U.S. Geological Survey (USGS) central laboratory in Arvada, Colorado and/or GC/MS at the USGS laboratory in Sacramento.

Enzyme-Linked Immunosorbent Assay: All water samples (n=332) were analyzed by ELISA following Millipore recommended procedures (1993) at U.C. Davis Aquatic Toxicology Laboratory within 14 days of collection. ELISA kits used in this study were obtained from Millipore Corporation. The ELISA detection limit for diazinon is 30 ng/L. An ELISA quality assurance program was conducted on 178 samples (47 percent of the total sample number): (1) 12 blank samples were analyzed, (2) 15 duplicate analyses were performed on the same sample, (3) 152 samples were analyzed by GC/MS; 38 by the USGS in Sacramento, and 114 by the USGS central laboratory, and (4) approximately 16 percent of the samples were analyzed by GC/MS at both USGS facilities.

Gas Chromatograph Mass Spectrometer Analysis: Within ten days of collection, forty percent (n=152) of the samples were filtered through a 0.7 micron glass fiber filter and then extracted on solid phase C18 resin column cartridges. The cartridges were then stored in a freezer until shipped to the USGS central laboratory for elution and analysis by GC/MS. The central laboratory detection limit and mean percent recovery for diazinon are 8 ng/L and 77 percent, respectively (Table 4). No correction was made in this study for the less than complete recovery of diazinon. Complete details of the analytical procedure are described by Zaugg *et al.* (1995).

Ten percent (n=48) of the samples were prepared in a similar fashion for analysis at the USGS Sacramento laboratory which uses the same procedures (Zaugg *et al.*, 1995). The detection limit and mean percent recovery for diazinon at the USGS laboratory in Sacramento was 38 ng/L and 74 percent, respectively (Table 5). The Sacramento USGS GC/MS analysis was needed because methidathion, another dormant spray insecticide, was not reported in the central laboratory scan.

A quality assurance program was also performed on samples analyzed by GC/MS to assess accuracy and precision of the analytical process. Twenty deionized blank water samples were submitted to the USGS central laboratory to ascertain background contamination. These were prepared in the same way as the field samples. Five samples (three percent of the total) were split and were submitted blind to the USGS central laboratory as intralaboratory splits to ascertain repeatability of the analytical method. In addition, a surrogate deuterated diazinon sample was amended into USGS central laboratory samples to establish the efficiency of diazinon extraction and analysis.

Diazinon Degradation Experiment: A degradation experiment was conducted to assess the rate of loss of diazinon held in amber glass containers in the dark at <4.0^0 C. These experiments were necessary because some field samples were held for 14 days before analysis. The experiment consisted of spiking three, one-liter samples of both laboratory and Butte Creek water with 350 ng/L diazinon and measuring insecticide concentration 0, 10, 38, and 60 days later (spiked samples stored in dark at 4°C). Results were compared by analysis of variance to establish whether a loss occurred through time.

Water Flow Data: Flow data were obtained from the 1994 USGS's Water Data Report (USGS, 1994) and the Department of Water Resources' (DWR) California Data Exchange Center (CDEC, 1995). CDEC flow data was used almost exclusively at all primary sampling locations except at the HWY 99 bridge on the Feather River (Site 2). No flow information is available for the Feather River at its confluence with the Sacramento River. Therefore, the flow of the Feather River was estimated by summing the flow of the Sacramento River at the City of Colusa with that of Colusa Basin Drain and Sacramento Slough and subtracting the flow of the Sacramento River at Verona.

Diazinon Mass Loading Calculations: Estimations of mass loading are helpful in determining sources of chemical contaminants. Loads were calculated by multiplying the measured diazinon concentration at a site by the mean daily flow (results expressed as kilograms diazinon per day). If multiple estimates of diazinon concentration were available, then values were averaged to calculate a mean concentration for use in the mass load estimate.

Travel Time: To compare loads at different points in a watershed, one must have some estimate of water mass travel time. The travel time of water masses between the confluence of each Sacramento River tributary and the City of Sacramento was estimated from distance and water velocity measurements (DWR, 1962 - Table 6). Travel time estimates between 12 and 36 hours were rounded to one day while estimates falling between 36 and 60 hours were rounded to two days. Velocity measurements were not available for Butte Creek or the Feather River. Travel times were calculated by assuming a velocity of 1.25 miles per hour (Table 6).

RESULTS AND DISCUSSION

A major objective was to determine exceedances of the California Department of Fish and Game (DFG) Hazard Assessment criteria for diazinon (Menconi and Cox, 1994) and locate the geographic source(s) of diazinon observed in the river at Sacramento after rainstorms. Diazinon concentrations and loads are presented for both tributaries and the mainstem Sacramento River during dry and wet weather. Data from the analytical quality assurance/quality control program is summarized in the first section below with an emphasis on determining whether ELISA procedures might be substituted for GC/MS analysis. Information on other common pesticides detected during storm flows also is summarized.

Quality Assurance and Quality Control Program

A quality assurance and quality control (QA/QC) program was carried out to assess the reliability of both the GC/MS and ELISA, and to determine whether the ELISA procedure could be used in place of GC/MS analysis for field monitoring.

GC/MS: The GC/MS program consisted of the submission of blanks, intra- and interlaboratory splits of the same sample, and amendments of deuterated diazinon. First, no chemicals including diazinon, were measured in any of the 20 blank samples analyzed at the USGS's central laboratory. Second, five intralaboratory split samples were analyzed at the USGS central laboratory. In these five samples, the mean percent difference in diazinon concentration was 22 percent. Third, 25 interlaboratory split samples were analyzed by both the USGS Sacramento laboratory and the central laboratory. The mean percent difference was 19 percent (Appendix A, Table 2A). These data are plotted in Figure 1A, Appendix A and the relationship was found to have a r^2 value of 0.93. Paired samples were compared by t-test to establish whether a difference might exist. None was noted (P>0.10) so both data sets were combined for subsequent analysis. Finally, the mean percent recovery of 164 deuterated diazinon amendments was 95 percent (Appendix A, Table 3A).

ELISA: The ELISA QA/QCprogram at UC Davis Aquatic Toxicology Laboratory consisted of laboratory blanks, intralaboratory splits and interlaboratory comparisons employing ELISA and GC/MS analyses. No diazinon was detected in any of the 12 blank samples analyzed by ELISA. Fifteen samples were reanalyzed by ELISA to ascertain the repeatability of the results. The mean percent difference was 20 percent (Appendix A, Table 4A). This value appears similar to the 22 percent difference observed in duplicate GC/MS analyses of other field samples.

Both ELISA and GC/MS were used to analyze 155 samples (Appendix A, Table 1A). Thirty-eight of these GC/MS analyses were conducted at the Sacramento USGS laboratory and 117 at the central laboratory. Data are plotted in Figure 2A, Appendix A ($r^2 = 0.75$). A paired t-test was used to assess whether a difference might exist between methods; none was detected (P>0.3). Thus, the ELISA and GC/MS results were considered comparable and were combined in the subsequent analysis.

In conclusion, results of both the GC/MS and ELISA QA/QC program appeared satisfactory. Furthermore, no difference was evident in the accuracy and precision of the two methods, suggesting that ELISA is an acceptable procedure for determining diazinon concentrations in surface water monitoring.

Diazinon degradation: No change was noted in the concentration (analyzed by ELISA) of diazinon amended into laboratory and Butte Creek water after two months storage in amber glass containers at <4^0C ($P>0.05$, ANOVA; Appendix A, Figure 3A) suggesting that little error was caused by delaying the analysis of some field samples for up to 14 days.

Sources

Diazinon concentration and load data are presented below for portions of the Sacramento Watershed draining areas of high orchard density. Information on diazinon concentration is important as it indicates locations where insecticides may be a threat to aquatic life. To assess whether toxicity impacts on aquatic life could exist, diazinon concentrations were compared to the DFG Hazard Assessment criteria (Menconi and Cox, 1994). Load information is important because it indicates the major sources of contamination. Such information is needed to identify areas where control action is necessary to insure the protection of aquatic organisms. The strategy consisted of collecting concentration and load information at key locations in each basin during both dry and wet periods, as well as conducting detailed follow-up work in those locations which appeared to contribute the greatest amount of diazinon.

Precipitation: Water year 1994 was classified as critically dry in the Sacramento basin. Water year types are classified in California according to the natural water production from the major basins. Rainfall patterns at the Cities of Red Bluff, Colusa, Marysville, and Sacramento are presented in Table 7. Two significant storms occurred during the study: the first in late January and the second in early February. Each storm produced 1.5 inches or more of rain throughout the Central Valley. A third, smaller storm occurred in late February. Daily precipitation patterns at all locations appeared similar with the following exceptions: rainfall during the first storm was nearly an inch more at Marysville than at either Colusa or Sacramento while precipitation totals for the third storm at Red Bluff were at least double those at all other locations. The second storm appeared to be of similar magnitude throughout the Valley.

Dormant Spray Usage: During the 1993/94 season, 75 percent of the total diazinon applied in the Sacramento Basin was during January 1994 (Figure 2). Presumably, most of the insecticide was sprayed during the first three weeks of the month, as the last week was wet (i.e., rainfall at Red Bluff between January 23 to 26 was 2.5 inches – Table 7). Butte, Glenn, Sutter and Yuba Counties accounted for 90 percent of the use. Diazinon application rates, with the exception of Colusa County, were consistent with the reported orchard acreage (Table 1, Figure 2). Colusa County is reported to have a larger acreage in trees than was reflected in the pesticide use data.

DRY WEATHER

Diazinon Concentrations: Diazinon concentrations were measured on five occasions during dry weather in 1994: 12, 17, 21, and 31 January and 4 February (Figure 3 and Appendix B, Table 1B). These dates were selected because they were preceded by at least three days of dry weather (Table 7). The highest diazinon concentrations were observed in Sacramento Slough at Karnak (Site 4). On all occasions diazinon concentrations in the Slough exceeded the DFG chronic water quality criterion, and on three days the acute criterion. In contrast, the chronic criterion was only exceeded elsewhere on four occasions (Colusa Basin Drain on 31 January, Feather River on 12 January, and Sacramento River at Sacramento on 17 and 31 January). The Karnak data are noteworthy as the Sutter National Wildlife Refuge is immediately upstream and the watershed supports a late fall salmon run. Juvenile salmon from the fall run would be migrating down Sacramento Slough during February (Reynolds et. al., 1993).

No upstream dry-weather pesticide data were collected for either the Feather or Sacramento Rivers as neither watershed routinely exceeded the DFG hazard assessment criteria. However, limited information was obtained at Pass Road on Butte Creek, some 36 miles upstream of Karnak, because of the diazinon exceedances. The Pass Road site is above the Sutter National Wildlife Refuge. Potential diazinon sources here are from orchards in the vicinity of Chico draining into Upper Butte Creek and from orchards surrounding the Main Drain site (Figure 1). Diazinon concentrations were always lower at Pass Road than at Karnak suggesting that major inputs from below Pass Road (Figure 4). However, on all dates diazinon concentrations at the Pass Road site exceeded the DFG's chronic water quality criterion.

Diazinon Loads: Daily dry-weather diazinon loads were similar (196-258 gms/day) in all tributaries where orchards are a major land use with the exception of Colusa Basin Drain (Figure 5; Appendix B, Table 2B). This observation is notable as the flow of the Sacramento and Feather Rivers are about seven times greater than Sacramento Slough. High concentrations of diazinon in Sacramento Slough are responsible for its contribution to load. The Colusa Basin Drain always exported negligible amounts of diazinon.

Dry-weather diazinon load information is available only for upper Butte Creek at Pass Road (Figure 6). On each sampling date the load increased downstream at Karnack. Mean daily loads were about four times greater at Karnak than at Pass Road suggesting that about 25 percent of the diazinon originated above Pass Road and about 75 percent below this point. The major sources of diazinon below Pass Road are likely to be Wadsworth Canal and the DWR O'Banion pumping station at Sacramento Avenue.

WET WEATHER

First Storm - Diazinon Concentrations: Two inches of rain fell between 22 and 25 January in Sacramento after a ten-day dry period, and three inches were recorded at the Cities of Marysville and Red Bluff (Table 7).

Baseline dry weather diazinon concentration and river flow before the storm at Sacramento ranged from <30 to 50 ng/L and from 10,000 to 15,000 CFS, respectively (Figure 7; Appendix B, Table 2B). Flow and diazinon concentrations began to increase at the City of Sacramento on 24 January, peaked on the 27th at 24,000 CFS and 236 ng/L and returned to background levels by 4 February. Eighty-five miles upstream at Colusa, diazinon concentrations also began to rise on January 24th, but peaked a day later on the 25th at 90 ng/L and returned to baseline by the 29th (Figure 8).

Sacramento River diazinon concentrations exceeded the DFG Hazard Assessment acute criterion for one day at Colusa (25 January) and for five days (24 to 28 January) at Sacramento (Figure 9, Table 8). The diazinon four-day running average exceeded the DFG chronic criterion at Colusa for five days (24 to 28 January) and at Sacramento for eleven days (24 January to 3 February; Table 8). It is assumed, although no data were collected, that the 85 miles of river between Colusa and Sacramento also exceeded the chronic criterion for the five-day time period between 24 to 28 January, as both the up and downstream locations were above the criterion throughout that time period. DFG advises (Menconi and Cox, 1994) that the acute criterion may be exceeded for only one hour and the chronic criterion for up to four days only once every three years.

Higher diazinon concentrations were observed in the Feather River than in the Sacramento River (Figure 10). Diazinon concentration in the Feather River at Hwy 99 began to rise on 25 January, peaked on the 26th and returned to baseline by the 29th. Twenty miles upstream at Yuba City, diazinon concentrations were rising on the 24th, peaked on the 25th and decreased to background concentrations by the 28th (Figure 10).

Feather River diazinon concentrations exceeded the DFG hazard assessment acute water quality criterion for four days at both Yuba City (24 to 27 January) and at HWY 99 (25 to 28 January; Table 8, Figure 10). Furthermore, the Sacramento River four-day running average exceeded the DFG chronic criterion at Yuba City for five days (24 to 28 January) and at HWY 99 for eight days (24 to 31 January). Comparison of the timing of up and downstream exceedances suggest that the intervening 20 miles of River between Yuba City and HWY 99 likely exceeded the DFG acute and chronic water quality criteria for at least three (25 to 27 January) and five (24 to 28 January) days, respectively. Diazinon concentrations were measured in tributaries only on 24 January (Figure 10). All sample concentrations, except for the Yuba River at Marysville, exceeded the DFG acute water quality criterion.

During the first storm, the highest diazinon concentrations were observed in Sacramento Slough (Figure 9). Diazinon concentrations at Pass Road began to rise by 24 January, peaked on the 26th, but had not returned to baseline by the 28th when sampling ceased (Figure 11). Thirty-six miles downstream at Karnak, diazinon concentration began to rise on the 25th, a day later than at

Pass Road, peaked on the 27th at 1400 ng/L, but had not returned to baseline by the last day of sampling (31 January). All diazinon concentrations recorded at Pass Road, and seven of eight measurements at Karnak, exceeded the DFG acute water quality criterion (Figure 11, Table 8). Diazinon concentration was measured on 24 January only in the primary agricultural tributaries to the lower Sacramento Slough/Butte Creek between Karnak (Site 4) and Pass Road (Site 5). The 24th was at least one day prior to the highest pesticide concentrations. Concentrations in the Main Drain (Site 15), Wadsworth Canal (Site 14), DWR pumping station at O'Banion (Site 13), and at Sacramento Avenue (Site 12) all exceeded the DFG acute water quality criterion (Figure 11).

Diazinon concentrations in Colusa Basin Drain were the lowest recorded for any major input to the lower Sacramento River (Figure 9). Diazinon concentrations exceeded the DFG acute water quality criterion on 27 January (94 ng/L) only, while the four-day running average concentration exceeded the chronic criterion for five days (24 to 28 January, Table 8).

<u>First Storm - Diazinon Loads:</u> Measured diazinon loads (kg/day) in the Sacramento River at Sacramento and predicted contribution from each tributary are presented in Figure 12. Measured loads were calculated by multiplying the daily flow rate of the river at a site by the observed diazinon concentration at that site. Predicted loads were estimated by summing the contribution of each tributary after accounting for travel time to Sacramento. Differences between the predicted and measured loads are an indication of the reliability of the load estimates. Substantial error may have occurred in estimating travel time, due to employing a single daily grab sample to estimate pesticide concentrations, and because of analytical errors in measuring diazinon concentrations and river flow rates. The largest single source of error was probably that of basing loads on a single daily grab sample.

The sum (four-day total) of the predicted daily loads from tributaries over-estimated actual measurements at Sacramento by about 60 percent during the first storm (Figure 12). The largest difference occurred on 27 January when the measured load was only about 40 percent of the predicted one.

At Sacramento, maximum load was measured on 27 January (Figure 12). About 90 percent of the load appeared to have originated from the Feather River. One possible reason why the predicted load was greater than measured is that the maximum diazinon concentration in the river at Sacramento may have been about double the measured value and may have persisted for less than a day. Similar pulses with high amplitude and short duration have been observed in the San Joaquin River basin after large storms (Kratzer, 1997). Diazinon loads decreased at Sacramento in succeeding days mainly because of decreased contributions from the Feather River. The maximum load from Sacramento Slough peaked one day later than the Feather River and declined slowly. This resulted in the pesticide pulse at Sacramento having a "tail." Contributions from the Sacramento River above Colusa were similar throughout the storm at about 1.2 kg/day, while Colusa Basin Drain contributed less than one percent of the total load.

Comparison of the diazinon load of the Feather River at Yuba City and at HWY 99 demonstrate that the watershed above Yuba City contributed only 250-400 gms/day or about 4 percent of the total load at HWY 99 (Figure 13). Therefore, 96 percent of the diazinon must have originated from below Yuba City. The load estimate at Yuba City does not include input from Jack Slough, which enters the river on the side opposite from our sampling site. While limited concentration information is available for the tributaries, it is likely that Jack Slough and the Bear River were major sources of diazinon to the Feather River below Yuba City (Figure 10).

Sacramento Slough was the second largest source of diazinon in the Sacramento River at the Sacramento site (Figure 12). On average, the load at Pass Road was only about 25 percent of that at Karnak (Figure 14). This implies that about 75 percent of the diazinon load measured at Karnak entered below Pass Road. Again, while little information is available for the lower portion of the slough, likely sources appear to be Wadsworth Canal and the DWR pumping stations at O'Banion and Sacramento Avenue (Figure 11).

Second Storm - Diazinon Concentrations: The second rainfall event was preceded by a seven-day dry period and occurred between 6 and 11 February. Flow and diazinon concentrations increased in the Sacramento River and peaked on 10 February at Sacramento (Figure 7; Appendix B, Table 1A). At Colusa, flow and insecticide maxima occurred two days earlier, as in the first storm, on 8 February at 25,000 CFS and 200 ng/L, respectively (Figure 8).

The DFG acute criterion was exceeded for two days in the Sacramento River at Colusa (8 and 9 February) and for four days at Sacramento (8 and 11 February; Figure 15, Table 8). The four-day running average concentration at both cities exceeded the DFG chronic criterion for six days (7 to 12 February). It seems safe to assume that the intervening eighty-five river miles between Colusa and Sacramento exceeded the DFG acute water quality criterion for at least two days (8 and 9 February) and the chronic criterion for six days (7 to 12 February) as both up and downstream sites did during the same time period.

On the Feather River, diazinon concentrations peaked at both Yuba City and at HWY 99 on 8 February at 120 and 147 ng/L (Figure 10), respectively. Both sites exceeded the DFG water quality criterion of 80 ng/L on 8 and 9 February. The four-day running average concentration exceeded the chronic water quality criterion at Yuba City for four days (7 to 10 February) and at HWY 99 for eight days (7 to 13 February, Table 8).

Lower Feather River tributaries were sampled on three dates (8 to 10 February) during the second storm (Figure 10). All measurements taken on Jack Slough exceeded the DFG acute water quality criterion while only one Yuba River sample did so. Measurements on Honcut Creek exceeded the chronic criterion while diazinon concentrations in the Bear River were below detection (Figure 10).

Diazinon concentrations were measured for eight days in Sacramento Slough at Karnak and Pass Road (7 to 14 February) and for three days in the principal agricultural tributaries (8 to 10 February; Figure 11). Diazinon concentrations at Pass Road were greater than at Karnak for the first three days of the storm whereupon concentrations became larger downstream. All tributaries except the pumping stations at O'Banion and Sacramento Avenue discharged water with higher concentrations than at the Karnak site on all three days monitored. O'Banion and Sacramento Avenue inputs provided dilution flows. The high diazinon concentrations at Karnak may have originated in Wadsworth Canal, as it discharged water with 1,900 to 4,500 ng/L diazinon. All diazinon concentrations measured in the Sacramento Slough drainage exceeded the DFG acute water quality criterion, some by as much as 40 to 60 fold (Appendix B, Table 1B).

Insecticide concentrations were measured for eight days in the Colusa Basin Drain (Figure 15; Appendix B, Table 1B). Diazinon concentrations were about three times greater than during the first storm and averaged 244 ng/L. Diazinon concentrations exceeded the DFG acute criterion for seven days at this site (Table 8).

<u>Second Storm - Diazinon Loads:</u> The difference between the predicted and measured diazinon loads at Sacramento during the second storm was less than in the first storm (Figure 16), with the exception of the first day (9 February). The average difference between the observed and measured loads was 25 percent. In contrast to the first storm, the diazinon load at Sacramento exceeded the predicted load. Flow data were not available for the Feather River on 9 February, so an estimate of Feather River diazinon loads is impossible to make and this undoubtedly contributed to the large difference between predicted and measured loads for that date.

The largest loads at the beginning of the storm were from the Sacramento River above Colusa and to a lesser extent from the Feather River. As the storm progressed, inputs from Sacramento Slough increased while loads from the upper Sacramento River and from the Feather River declined. Colusa Basin Drain never contributed a significant diazinon load. The observation that the Sacramento River above Colusa might be a major source of diazinon was unexpected and, consequently, no monitoring sites existed to ascertain the source(s) in the upper Sacramento River.

The second most important source of diazinon was Sacramento Slough. Forty-seven to 66 percent of the load originated below Pass Road (Figure 14), similar to the first storm. Major sources of diazinon below Pass Road were likely to have been from Wadsworth Canal and from the DWR pumping stations at O'Banion and Sacramento Avenue, as on each occasion the concentrations of diazinon at these two sites were the highest in Sacramento Slough. The Main Drain may have been a major source of diazinon to Butte Creek above Pass Road.

Diazinon loads in the Feather River, while less important than from the upper Sacramento River and from Sacramento Slough, were also estimated. The results demonstrate, similar to the first storm, that approximately 60 to 90 percent of the load originated below Yuba City (Figure 13). A major source may have been Jack Slough (Figure 10).

Third Storm--Diazinon Concentrations: The third storm was the smallest with about an inch of rain in Sacramento on 17 and 19 February (Table 7). Twice this amount fell in Redding. As with the first two storms, the flow of the Sacramento River at Sacramento increased and peaked on the 22nd, two to three days after the last precipitation (Figure 7). However, unlike previous storms, only a small increase in ambient diazinon concentration was observed. The average four-day concentration at Sacramento, between the 21st and the 24th, exceeded the DFG chronic water quality criterion (Figure 17). Kuivila and Foe (1995) also noted a marked decrease in diazinon concentrations in the Sacramento River during the third storm of the month in 1993. The cause is unknown, the first two storms may have been sufficient to 'cleanse' the watershed of diazinon after dormant spray applications.

In the Sacramento River at Colusa, both flow and diazinon concentration increased rapidly and peaked on 21 February at 20,900 CFS and 105 ng/L, respectively (Figure 8). Diazinon concentrations exceeded the DFG acute criterion for one day (21 February) and the four day running average value exceeded the chronic criterion for four days (18 to 21 February, Figure 17;

Appendix B, Table 1B). Limited sampling was conducted above Colusa (Table 9). These data are difficult to interpret as no flow measurements were available for Tehama and Hamilton City. However, the results suggested that one or more sources drain into the Sacramento River between Bend and Vina. As a result, 27 miles of river (Red Bluff to Vina) exceeded the DFG acute criterion on the 17th, 49 miles (Vina to Butte City) on the 19th, and 40 miles (Ord Bend to Colusa) on the 21st. More sampling is required to determine the location of the sources of diazinon in the upper Sacramento River.

The Feather River, consistent with other storms, reacted the most rapidly of all the Sacramento River tributaries and had a peak diazinon concentration at HWY 99 on the 17th, the first day of the storm (Figure 10). Diazinon concentration on the 17th was 58 ng/L (Appendix B, Table 1). Jack Slough again appeared to be an important diazinon source. The DFG acute water quality criterion was exceeded in the Slough on all four sampling dates.

Sacramento Slough, as during previous storms, had the highest diazinon concentrations of any monitored tributary (Figure 17). Concentrations at Karnak were above the DFG acute criterion for five days (17 to 21 February) and above the chronic criterion for all seven days monitored (Figure 11; Appendix B, Table 1B). Diazinon concentrations did not appear to change rapidly at the Karnak site. Concentrations in the Slough at the beginning of the third storm appeared similar to those measured at the end of the second one (Appendix B, Table 1B). So, it is not known whether the diazinon measured during the third storm resulted primarily from continued runoff from the second one or was 'new' runoff. Upstream monitoring suggested that the Main Drain, Wadsworth Canal, and DWR pumping stations at O'Banion and Sacramento Avenue were important sources (Figure 11). Sixteen of twenty samples collected at these four sites exceeded the DFG acute criterion; 17 samples exceeded the chronic criterion.

Diazinon concentrations in Colusa Basin Drain also increased, producing a double peak on the 21st and 24th (Figure 17). The cause of the bimodal peak is not known though it may have been due to the bimodal rainfall pattern. Diazinon concentrations exceeded the DFG acute and four day running average criterion for two and seven days, respectively (Figure 17; Appendix B, Table 1B).

<u>Third Storm - Diazinon Loads:</u> Fourteen and a half kilograms of diazinon were exported from the Sacramento River Basin during the third storm (Appendix B, Table 2B). This is about a third of the load transported by the river through Sacramento during each of the two previous storms (i.e., during the first and second storms, 39.1 and 43.6 kg, respectively, of diazinon were exported). Whether the decrease in diazinon load occurred because thc third storm had the smallest amount of rain or whether the previous two storms "washed off" most of the available insecticide is unknown. Kuivila and Foe (1995) also noted a decrease in loads exported from both the Sacramento and San Joaquin basins after the second storm of the month.

The majority of the diazinon load originated from the upper Sacramento River during the third storm (Figure 18). As previously explained, the sources of the insecticide are not known, though much of it appeared to have originated in the 40-mile reach between Bend and Vina (Table 9).

Sacramento Slough was the second most important source of diazinon (Figure 18), exporting an estimated 2.5 kg/day of diazinon, or about 17 percent of the total load, from the Sacramento

River watershed (Appendix B, Table 2B). Unlike previous storms, the load seems to have come about equally from above and below Pass Road (Figure 14). As noted above, major sources appear to be the Main Drain, Wadsworth Canal, and the DWR pumping stations at O'Banion and Sacramento Avenue.

As in February 1993 (Kuivila and Foe, 1995), flow and diazinon concentrations increased in the Sacramento River at Sacramento after the three largest rain storms of the month, peak concentrations being 236, 253, and 51 ng/L. Eighty-five miles upstream at Colusa, flow and diazinon concentrations also increased after each rainstorm, maximum concentrations being 88, 200, and 105 ng/L. The primary source of the diazinon during the first storm was from the Feather River. Important Feather River sources were Jack Slough and the Bear River. The primary sources of diazinon in the Sacramento River during the second and third storms were from the Sacramento River above Colusa and from Sacramento Slough. The principal source(s) of diazinon in the upper Sacramento River were not identified, but appear to be located between Bend and Vina. Important sources of diazinon in Sacramento Slough were the Main Drain, Wadsworth Canal and the DWR pumping stations at O'Banion and Sacramento Avenue. Colusa Basin Drain was never a major source of diazinon.

Diazinon concentrations in the Sacramento River at Sacramento during January/February 1994 exceeded DFG's acute and chronic water quality criteria for nine and 19 days, respectively (Table 8). Similar multiple exceedances also were observed in the Sacramento River at Colusa, the Feather River at Yuba City and at HWY 99, Sacramento Slough at Pass Road and Karnak, and in Colusa Basin Drain. DFG recommends that their acute criterion may not be exceeded more than once every three years for an hour and their chronic criterion for no more than four days. The frequency of exceedance of both the acute and chronic diazinon criteria during January/February 1994 in many Sacramento Basin waterways was greater than recommended by DFG.

Other Chemicals: Thirty pesticides were detected by the USGS central laboratory in their analysis of 141 samples (Appendix C, Table 1C). No chemical concentration, with the exception of diazinon, was above a recommended water quality criterion or toxicity effect level found in the published literature. This included chlorpyrifos and malathion, two other dormant spray insecticides. Pyrethroids were not included in the analysis. Pesticides identified in the GC/MS scan at USGS Sacramento laboratory are listed in Appendix C, Table 2C.

The herbicide simazine was ubiquitous at relatively low concentrations throughout the basin (detected in 94 percent of all samples – Appendix C, Table 1C). Simazine is commonly applied in the watershed on almonds and along roadways (Department of Pesticide Regulation, 1997). Atrazine, another triazine herbicide, was common (detected in 46 of all samples) in the Sacramento River at Colusa, the Feather River at HWY 99, and at Colusa Basin Drain. Concentrations of atrazine increased in Sacramento Slough at Karnak and in samples collected at the DWR pumping station at Sacramento Avenue after 17 February, suggesting a recent local application. Atrazine is commonly applied to corn and along road sides (Department of Pesticide Regulation, 1997).

Carbofuran and molinate were detected in the discharge from all waterways where rice is grown. Thiobencarb, another commonly used rice herbicide, was detected in only 58 percent of the samples. The three chemicals are typically applied in rice culture in May and June. The Central

Valley Water Quality Control Plan for the Sacramento River has a conditional prohibition for discharge of irrigation return flows containing carbofuran, molinate, and thiobencarb if concentrations are above the Basin Plan performance goals. Measured concentrations were well below performance goals for all three pesticides (Appendix C, Table 2C).

ACKNOWLEDGMENTS

We thank Michael Marchetti for assisting in the collection of samples, and Dr. Joseph Domagalski for managing the USGS contract. Bob Languell prepared the figures for this report. Dennis Westcot, Jerry Bruns, Val Connor, and Michael Perrone provided valuable comments on a previous draft.

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Tables

Table 1. Stonefruit and almond acreage in the northern Sacramento River Valley. (Source: County Agricultural Commissioners' Data, California Agricultural Statistics Service, 1998).

	Orchards			
County	Almonds	Peaches	Prunes	County Total
Butte	31,117	2,140	11,205	44,462
Colusa	20,150		3,900	24,050
Glenn	21,339		7,516	28,855
Sutter	4,026	9,622	20,599	34,247
Tehama	5,650		9,684	15,334
Yolo	5,879		6,093	11,972
Yuba	1,181	5,539	12,200	18,920
Total	89,342	17,301	71,197	177,840

Table 2. Primary sampling sites, description of location, and rationale for selection.

Site No.	Location	Sampling Site Description	Sampling Rationale
1	Sacramento R @ Sacramento	Tower Bridge at Capitol Mall	Integrates all inputs from the Sacramento Basin.
2	Feather R. @ Hwy. 99	Hwy. 99 Bridge	Integrates all upstream inputs to Feather River.
3	Feather R. @ Yuba City	West bank below Hwy. 20 Bridge	Integrates all inputs from upper Feather River Basin except Jack Slough. Source of Yuba City drinking water.
4	Sacramento Sl. @ Karnak	Bridge off Ely Rd.	Integrates all exports from Butte Slough.
5	Butte Creek @ Pass Rd.	Pass Road Bridge	Inputs from Chico area carried down Butte Creek.
6	Colusa Basin Drain @ Knights Landing	Road 99 E Bridge	Inputs from orchards along Coastal range draining to Colusa Drain.
7	Sacramento R. @ Colusa	Bridge on River Road at City of Colusa	Inputs from all orchards located along the upper River above Colusa including inputs from the Chico area.

Table 3. Secondary sampling sites.

Site No.	Location	Tributary to:
8	Bear River @ Berry Rd.	Feather River
9	Yuba River @ Marysville	Feather River
10	Jack Sl. @ 14th Street in Marysville	Feather River
11	Honcut Cr. @ Chandler Rd.	Feather River
12	Sacramento Outfall @ DWR pumping plant on Sacramento Rd.	Butte Slough
13	O'Banion Outfall @ DWR pumping plant on O'Banion Rd.	Butte Slough
14	Wadsworth Canal @ Franklin Rd.	Butte Slough
15	Main drainage canal to Cherokee Canal @ Colusa Hwy.	Butte Slough
16	Butte City @ Hwy. 162 Bridge	Mainstem Sacramento River
17	Ord Bend @ Ord Bend Road Bridge	Mainstem Sacramento River
18	Hamilton @ Hwy. 32 Bridge	Mainstem Sacramento River
19	Vina @ South Avenue Bridge	Mainstem Sacramento River
20	Tehama @ Aramayo Way Bridge	Mainstem Sacramento River
21	Red Bluff @ Balls Ferry Bridge	Mainstem Sacramento River
22	Bend @ Bend Ferry Road Bridge	Mainstem Sacramento River

Table 4. Recovery of pesticides spiked at 100 ng/L into laboratory water at the U.S. Geological Survey Central Laboratory.

Compound	Mean recovery (%)	Estimated MDL (ng/L)
Alachlor	86	9
Atrazine	89	17
Chlorpyrifos	83	5
Cyanazine	96	13
Dacthal (DCPA)	82	4
Diazinon	77	8
EPTC	80	5
Ethafluralin	54	13
Ethoprop	80	12
HCH, alpha-	77	7
Malathion	90	14
Metoachlor	92	9
Metribuzin	42	12
Molinate	82	7
Napropamide	83	10
Parathion-methyl	73	35
Pendimethalin	46	18
Phorate	77	11
Prometon	77	8
Simazine	76	8
Tebuthiuron	88	15
Terbufos	74	12
Thiobencarb	85	8
Trifluralin	47	12
Atrazine, desethyl	12	3
Carbayl	151	46
Carbofuran	108	13
Terbacil	75	30
Dimethoate	11	24

MDL, method detection limit

Table 5. Recovery of insecticides spiked at 100 ng/L into organic free Sacramento River water.

Compound	Mean recovery (%)	Estimated MDL (ng/L)
Carbofuran	82	44
Diazinon	74	38
Methidathion	75	31
Molinate	89	110
Simazine	74	60

MDL, method detection limit

Table 6. Distance and estimated travel time of water to the city of Sacramento (Site 1) from primary orchard sampling sites. Travel times are rounded to whole days (i.e., 12 – 36 hours = 1 day, 36 – 60 hours = 2 days). River velocities from DWR (1962).

Location (Site #)	River miles above Sacramento	Velocity (mph)	Travel Time (Hours)	(Days)
City of Colusa (7)	85	1.50	60	2
Colusa Basin Drain (6)	30	1.25	24	1
Karnak (4)	21	1.25	17	1
Feather River (2)	20	1.25	16	1

Table 7. Daily precipitation (inches) at Red Bluff, Colusa, Marysville, and Sacramento for January 1 through February 28, 1994 (Desert Research Institute, 1997).

Location	Date																													
Red Bluff	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	23	24	26	27	28	29	30	31
January	0.21	0	0	0.11	0.01	0	0	0.11	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0.16	1.16	0.59	0.68	0.02	0	0	0	0	
February	0	0	0	0	0	1.43	0.71	0.14	0	0.34	0	0	0	0	0	0	1.16	0	1.09	0.22	0.13	0	0	0	T	0.61	0	0			
Colusa																															
January	0	0.05	0	0.03	0.12	0	0	0.08	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0.44	0.06	0.38	0.02	0	0	0	0
February	0	0	0	0	0	0.58	1.22	0.14	0	0.03	0.01	0	0	0	0	0	0.35	T	T	0.49	0	0	0	0	0	0.12	T	0			
Marysville																															
January	0	0	0	0.28	0.11	0	0	0	0.05	T	0	0	0	0	0	0	0	0	0	0	0	0	0.98	0.64	0.6	0.62	0	0	0	0	0
February	0	0	0	0	0	0.2	1.5	0.3	0	0.01	0.08	0	0	0	0	0	0.5	0.05	0	0.6	0.08	0	0	0	0	0.19	0.03	0			
Sacramento																															
January	T	0	T	0.06	0	0	0	0.12	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.47	0.79	0.43	0	0	0	0	0	0
February	0	0	0	0	T	0.82	0.67	0.23	0	0.03	0	0	0	0	0	0.09	0.54	0.01	0.54	0	0.03	0	0	0	0	0.19	0	0			

T = Trace

Table 8. Number of days that the California DFG water quality criteria for protection of aquatic life were exceeded in the Sacramento Basin during the 1994 orchard dormant spray season.

Location	First Storm (days)		Second Storm (days)		Third Storm (days)		All Storms (days)	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Sacramento R. @ Sacramento	5	11	4	6	0	2	9	19
Sacramento R. @ Colusa	1	5	2	6	1	1	4	12
Feather R. @ Yuba City	4	5	2	4	0	0	6	9
Feather R. HWY 99	4	8	2	7	0	0	6	15
Sacramento Sl. @ Pass Road	5	5	7	8	5	6	17	19
Sacramento Sl. @ Karnak	7	8	8	8	5	7	20	23
Colusa Basin Drain	1	5	5	5	2	7	8	17

Table 9. Diazinon concentration and loads in the upper Sacramento River Basin during the third storm of 1994. The distance (miles) and travel time (days) between each site and the City of Colusa are indicated in the last two rows. Blanks indicate that no sample was collected.

	Diazinon concentration (ng/L) / diazinon load (kg/day)							
Date	Bend	Red Bluff	Tehama	Vina	Hamilton	Ord Bend	Butte City	Colusa
17 Feb	<30[1]/	80/1.8	120/	168/4.5	50/	<30/		17/0.3
18 Feb	<30/		50/	120/4.3	134/	90/3.5	110/4.1	41/4.6
19 Feb			<30/	<30/	30/	36/1.1		40/1.4
20 Feb	<30/							33/1.1
21 Feb			<30/	65/2.3	70/	100/4.4		105/5.4
Distance (miles)	114	101	85	74	55	40	25	0
Travel time (days)[2]	2	1	1	1	1	1	0	0

[1] ELISA detection limit.
[2] Assumes a travel velocity of 3.0 miles per hour (Department of Water Resources, 1962).

Figures

Figure 1. Map of Sampling Sites

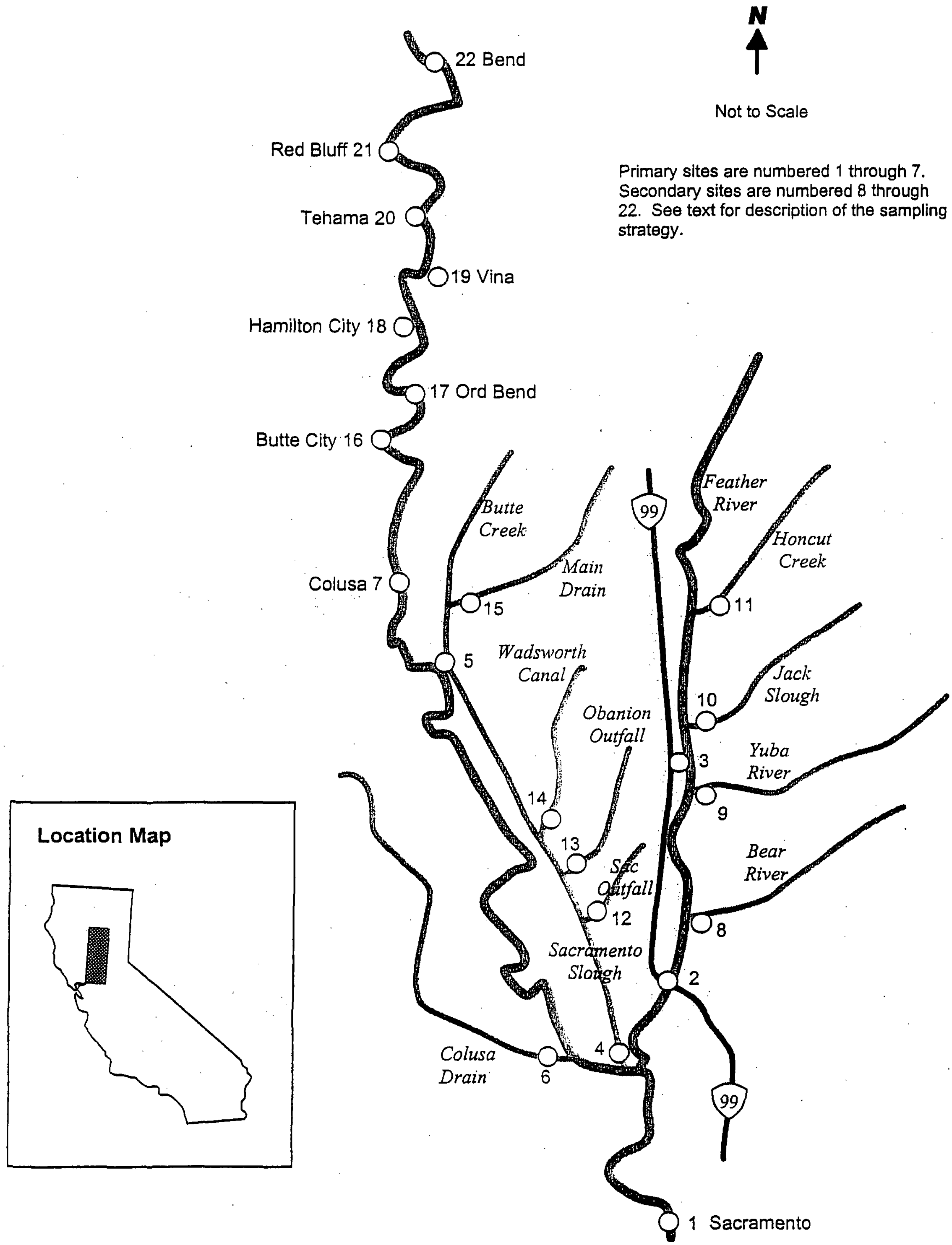


Figure 2. Diazinon Use on Stonefruit and Almond Orchards in the Sacramento River Watershed by County during 1993-94.

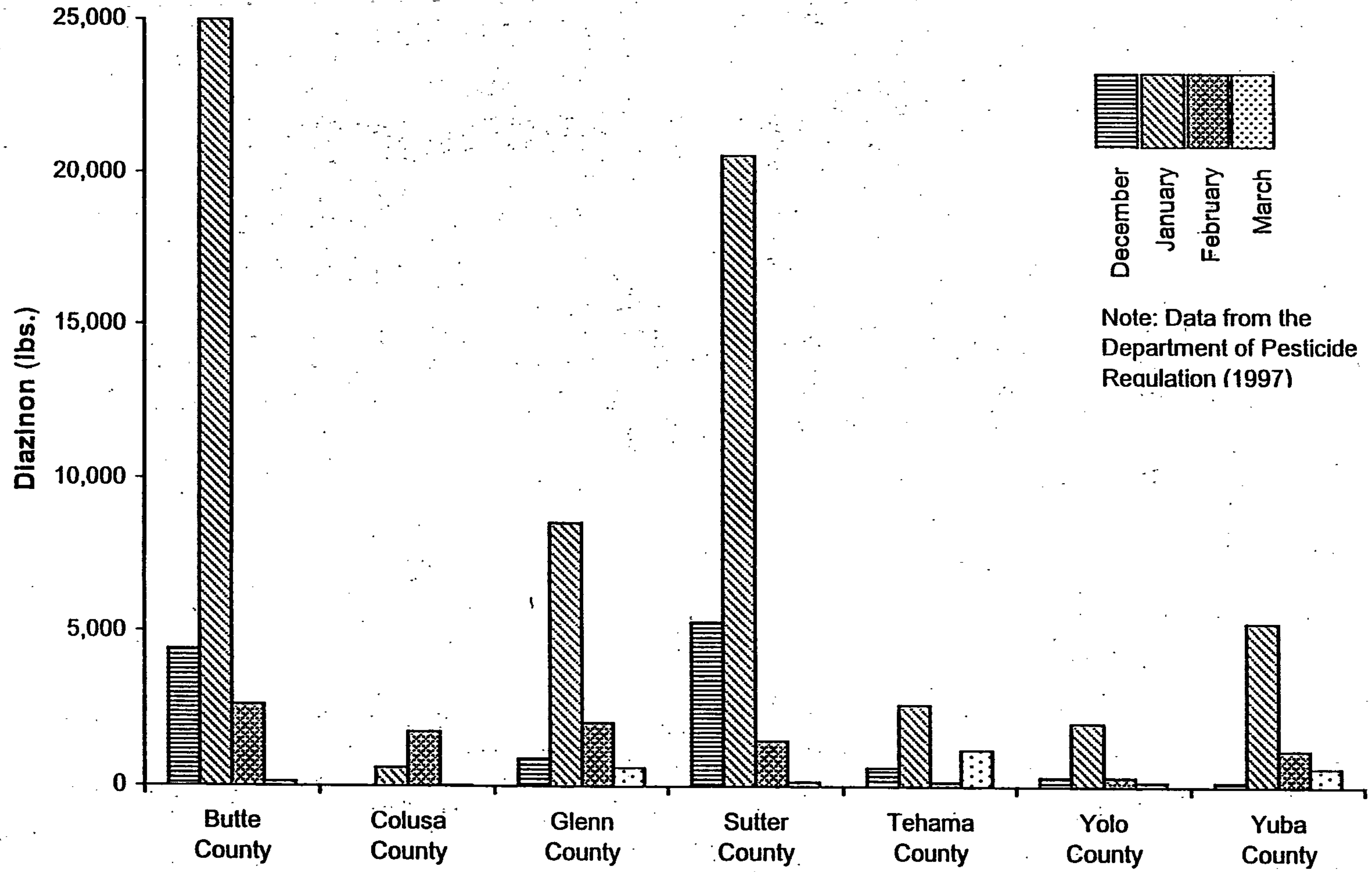


Figure 3. Diazinon Concentrations in the Sacramento River at Sacramento and in Principal Tributaries Draining Orchard Areas during Dry Weather in 1994.

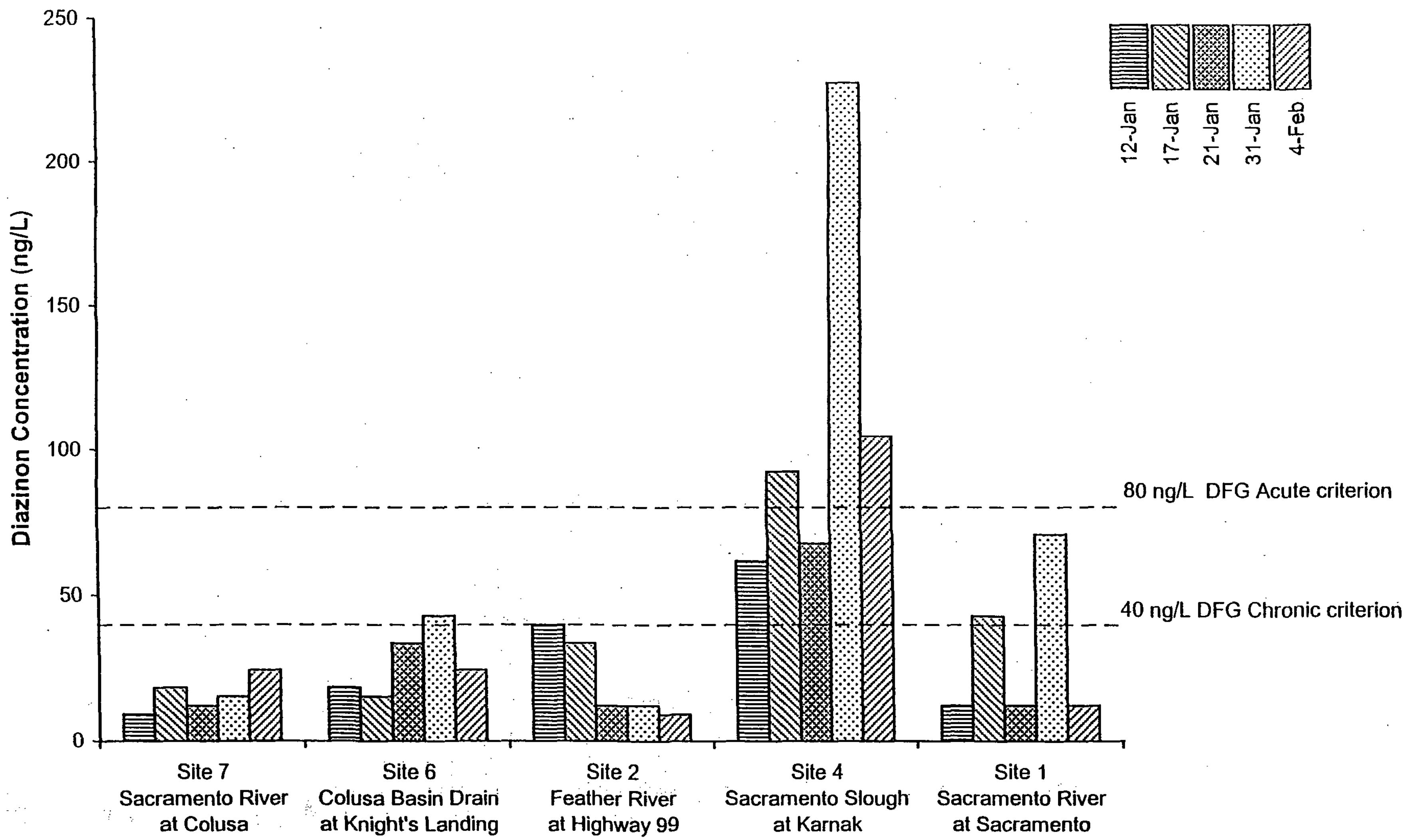


Figure 4. Diazinon Concentrations in Sacramento Slough at Karnak and 36 Miles Upstream at Pass Road during Dry Weather.

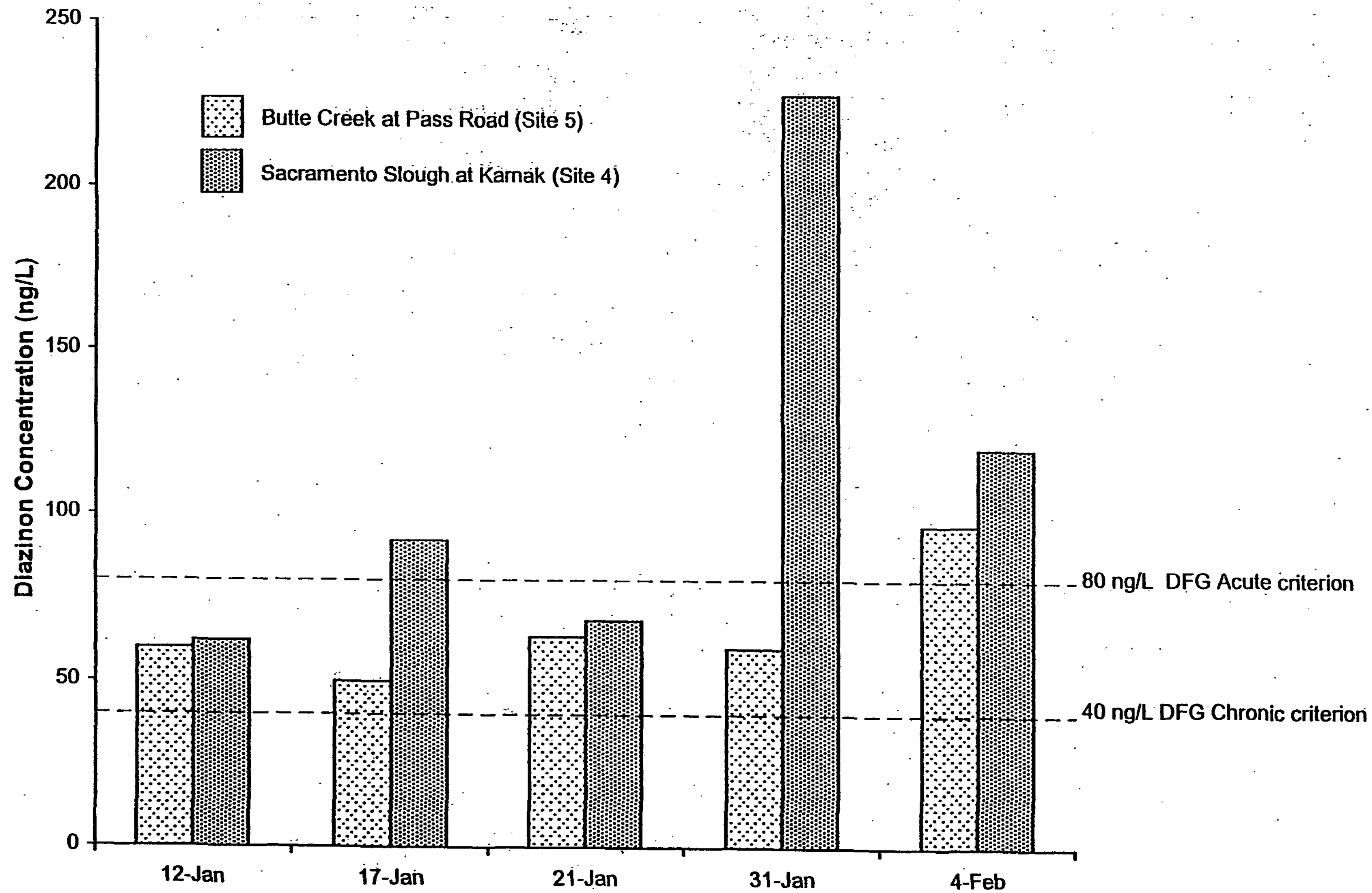


Figure 5. Predicted Diazinon Loads in the Sacramento River at the City of Sacramento Contributed by Principal Upstream Waterways Draining Orchard Areas (Winter Dry Periods).

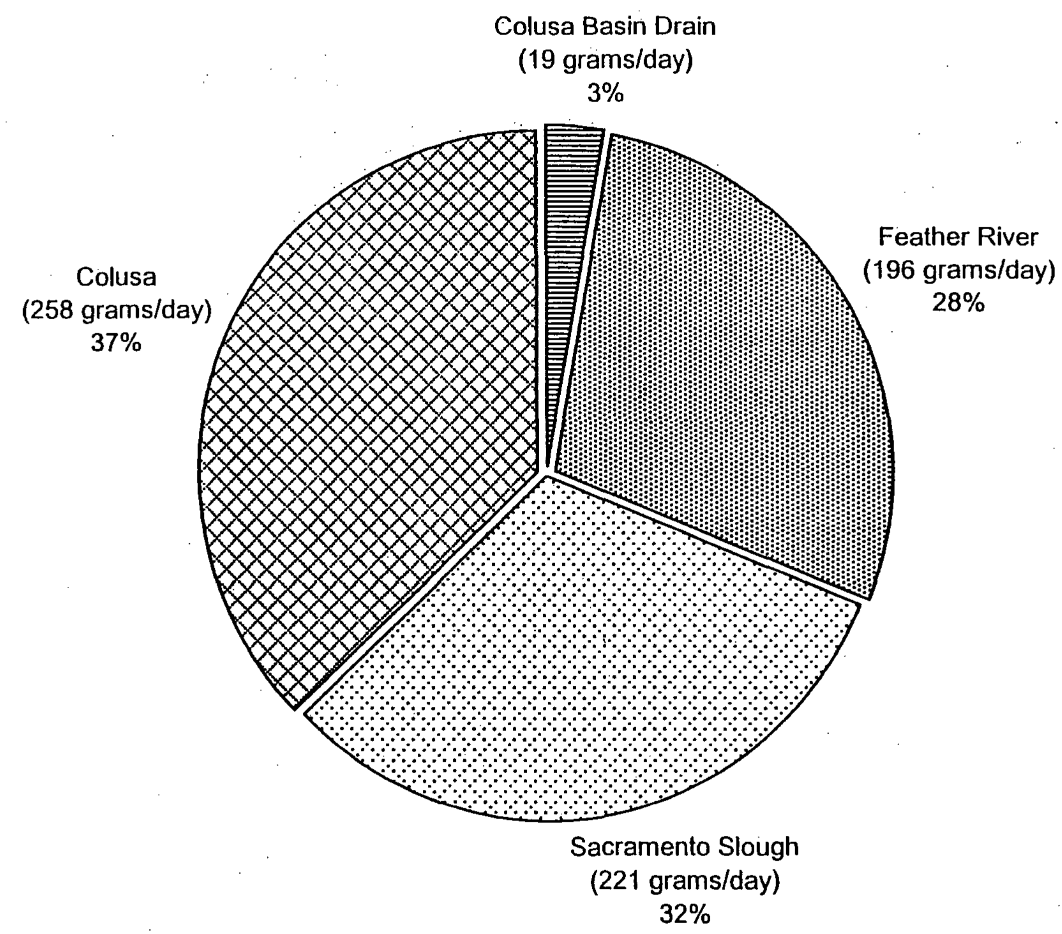


Figure 6. Diazinon Loads (grams/day) during Dry Weather at Karnak at Sacramento Slough (Site 4) and 36 Miles Upstream on Butte Creek at Pass Road (Site 5).

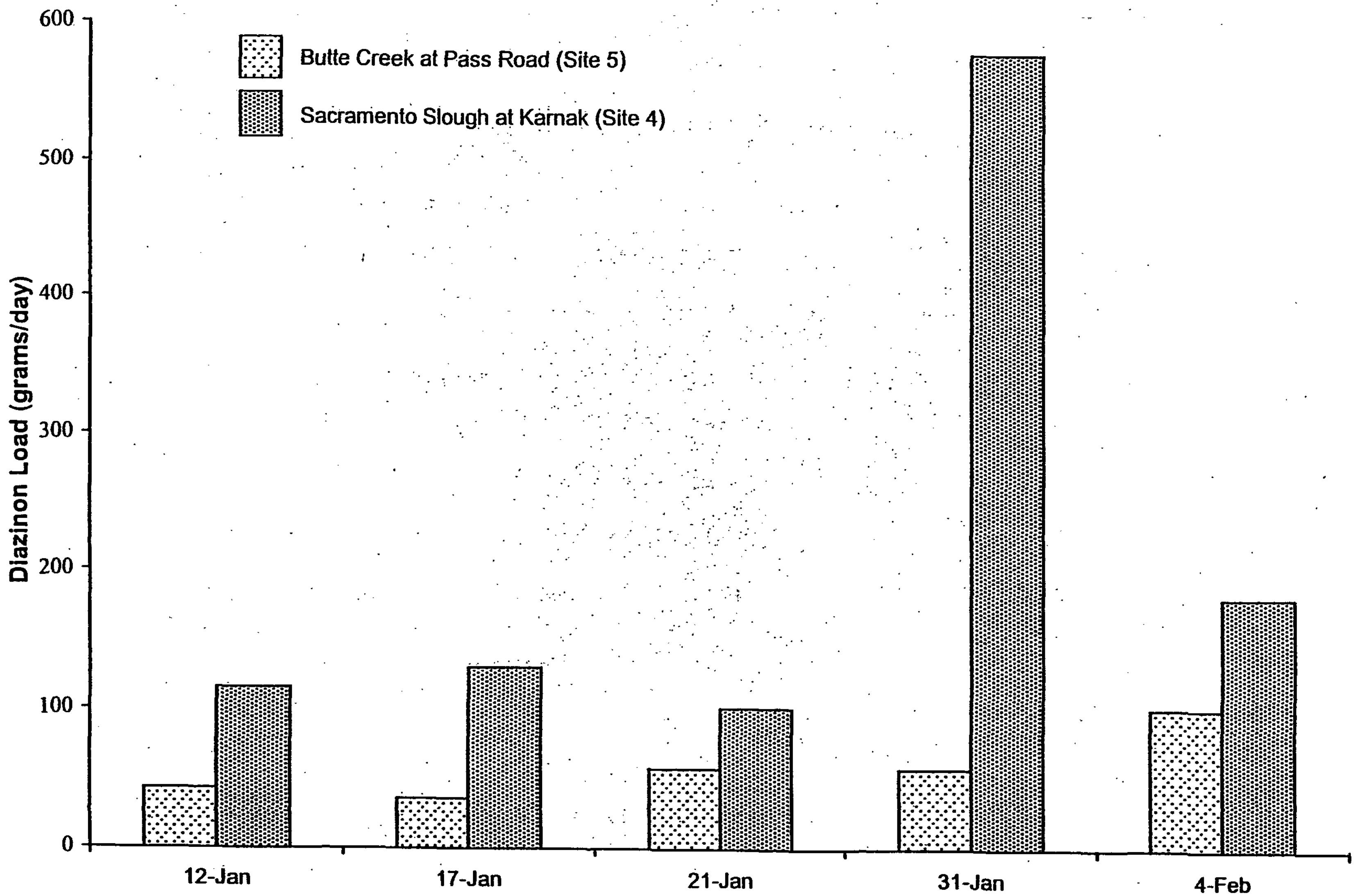


Figure 7. Rainfall, Flow, and Diazinon Concentration for the Sacramento River at Sacramento in January and February 1994.

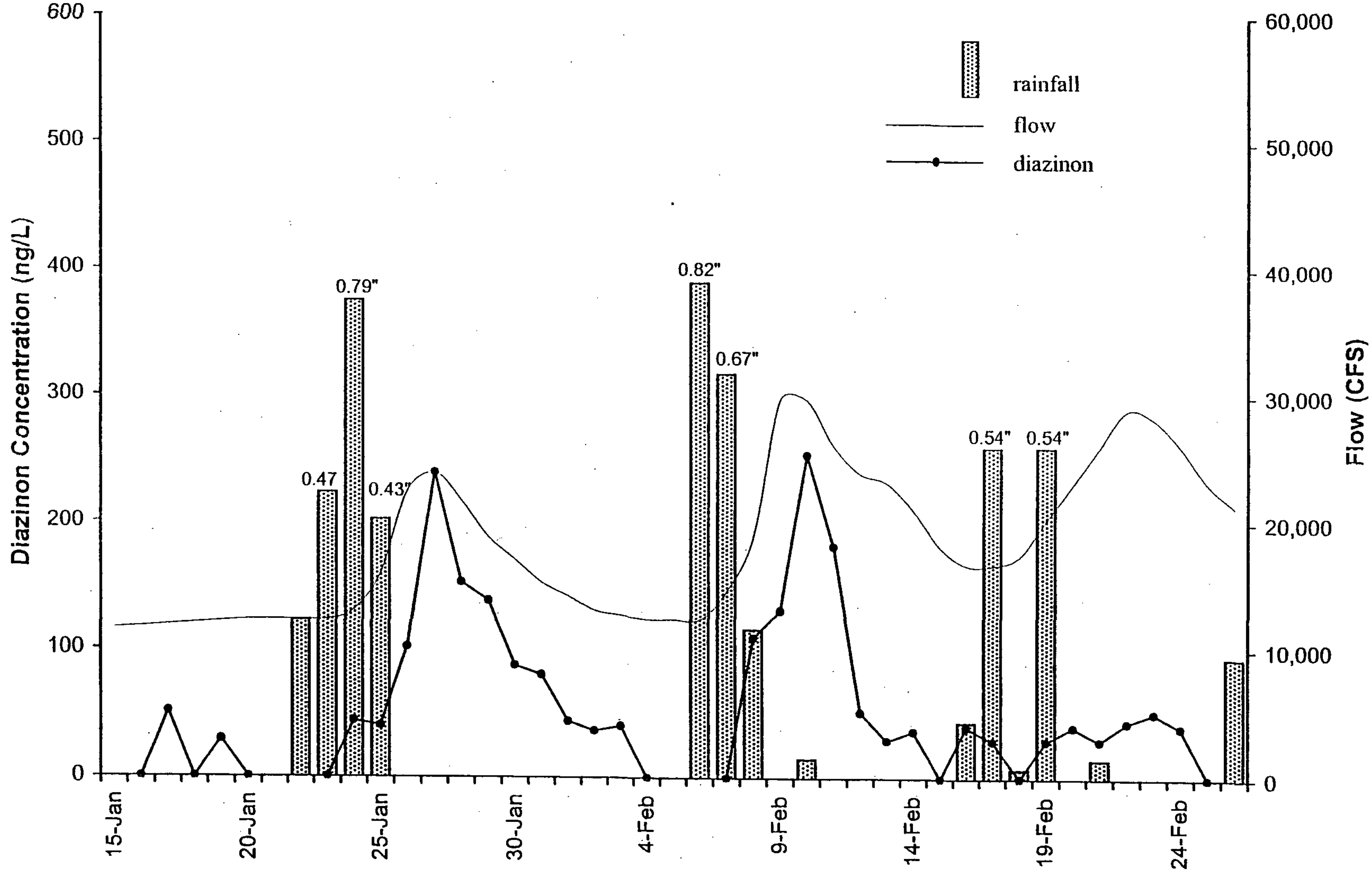


Figure 8. Rainfall, Flow, and Diazinon Concentration for the Sacramento River at Colusa in January and February 1994.

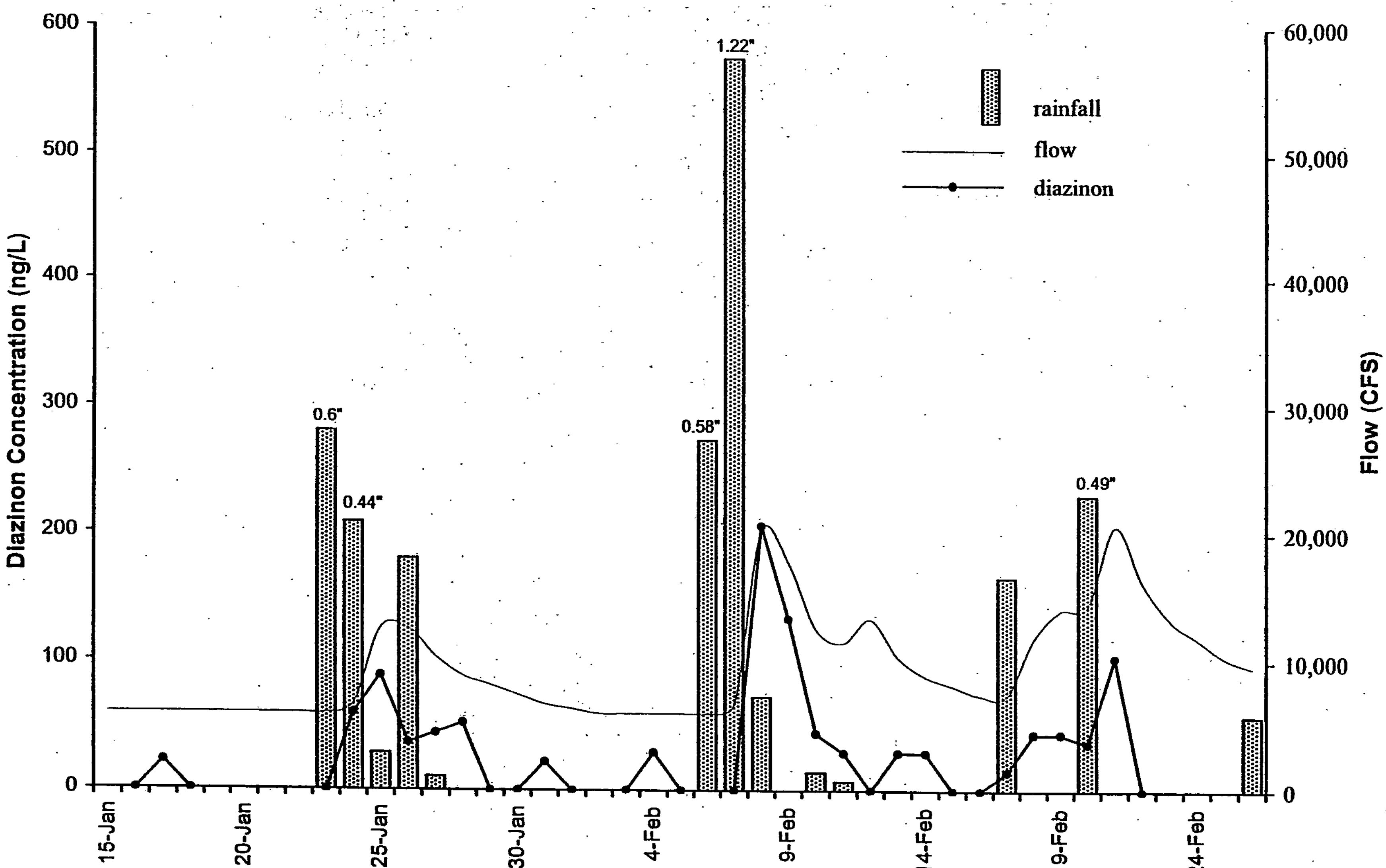


Figure 9. Diazinon Concentration in Sacramento River and in Principle Orchard Tributaries between Colusa and Sacramento for the First Storm.

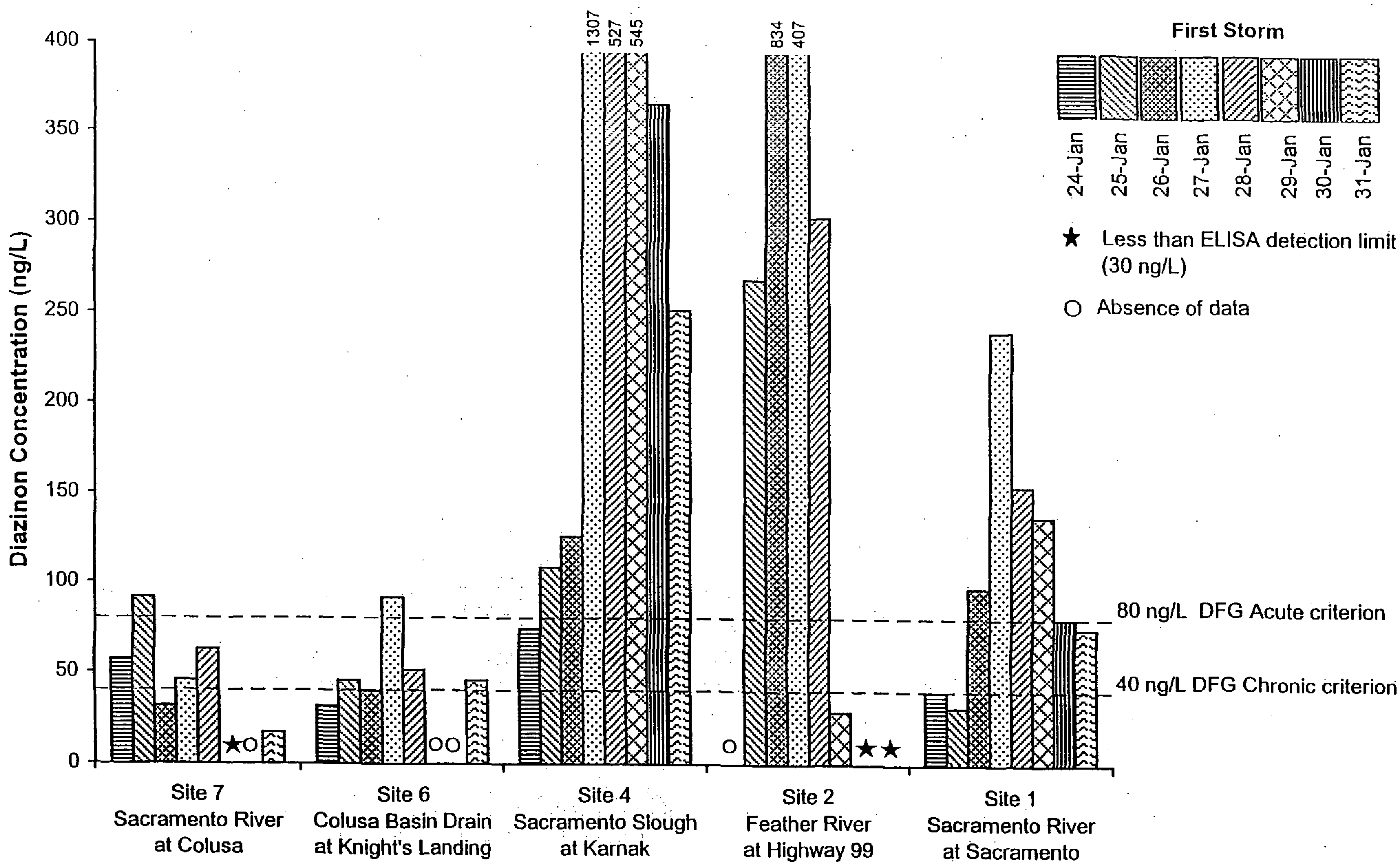


Figure 10. Diazinon Concentrations in Feather River Watershed during each of Three Storms.

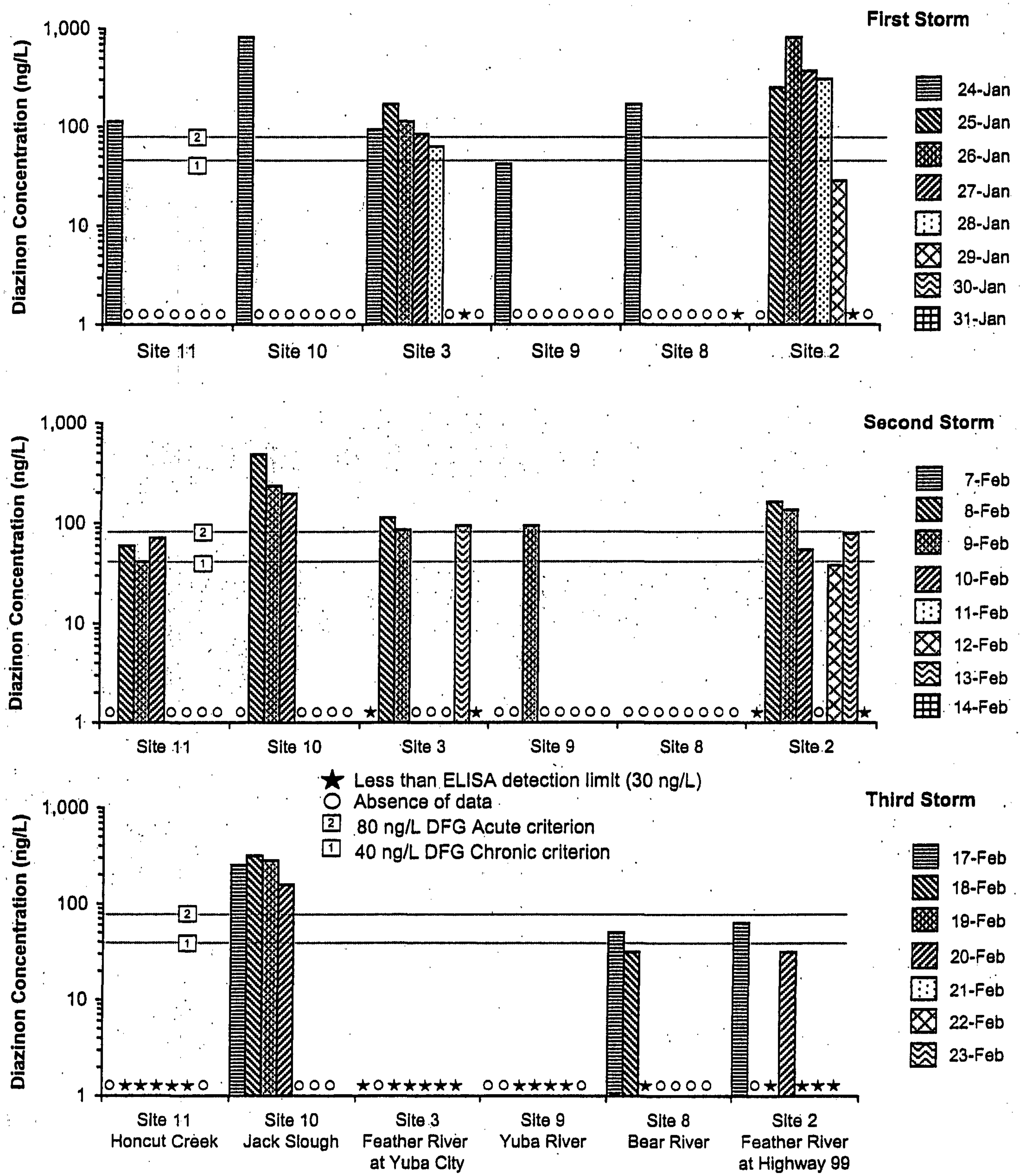


Figure 11. Diazinon Concentrations in Butte Creek, Sacramento Slough, and selected Tributaries during each of Three Storms.

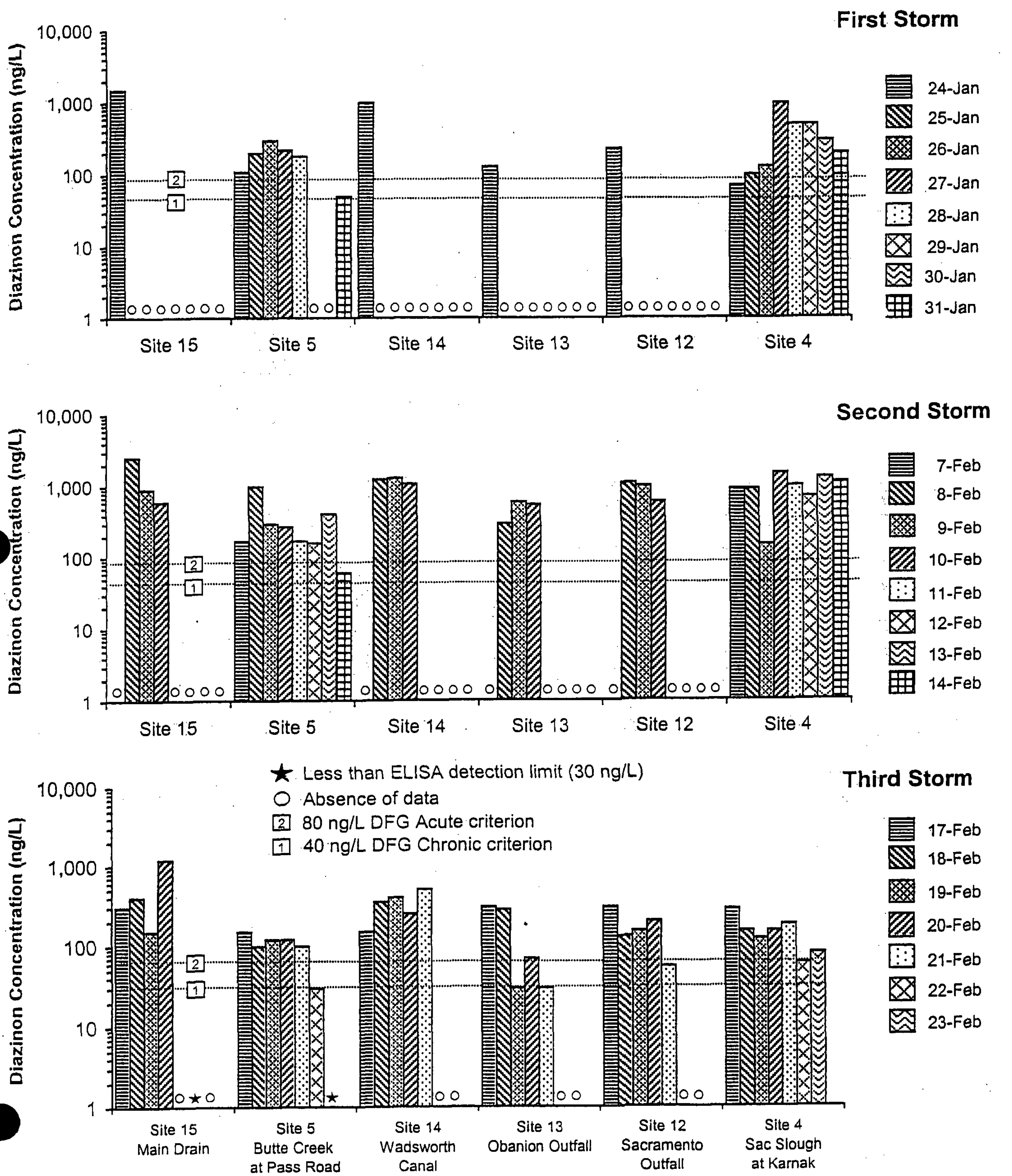


Figure 12. Predicted and Measured Diazinon Mass Loads in the Sacramento River at Sacramento during First Storm - January 26 to 29.

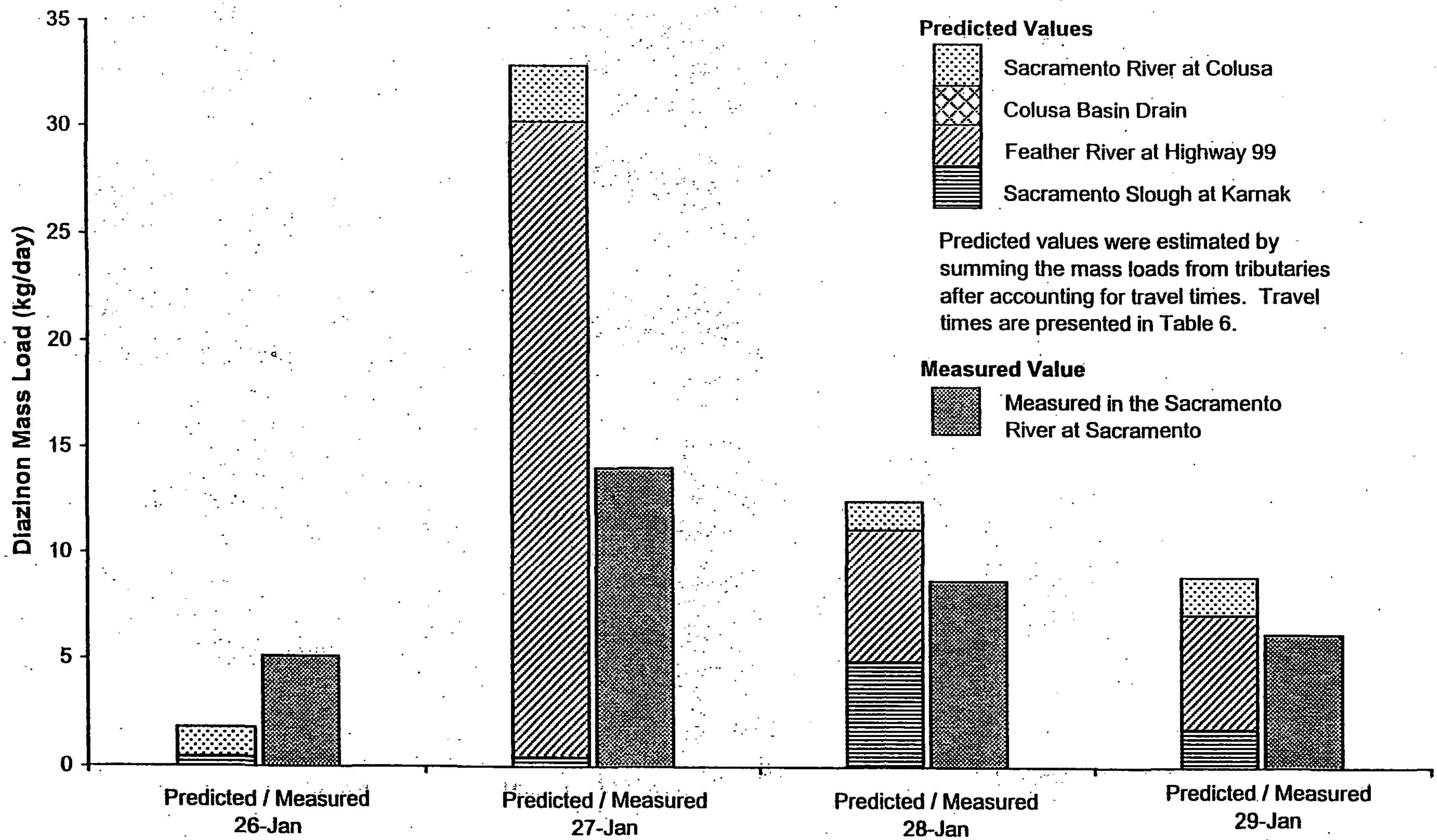


Figure 13. **Comparison of Diazinon Loads in the Feather River at Yuba City and at Highway 99 for each of Three Storms.**

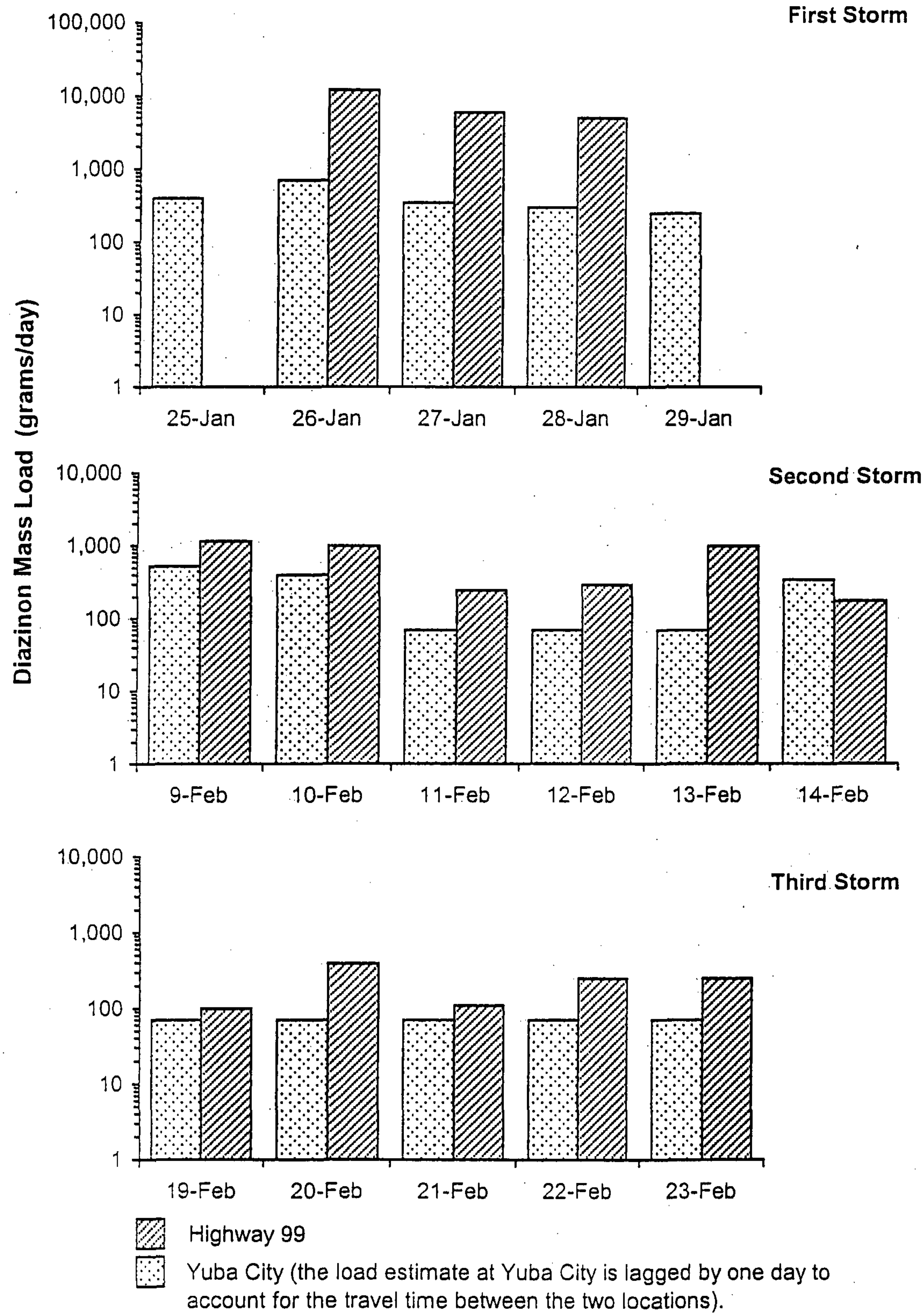


Figure 14. Comparison of Diazinon Loads in Butte Creek at Pass Road and in Sacramento Slough at Karnak for each of Three Storms.

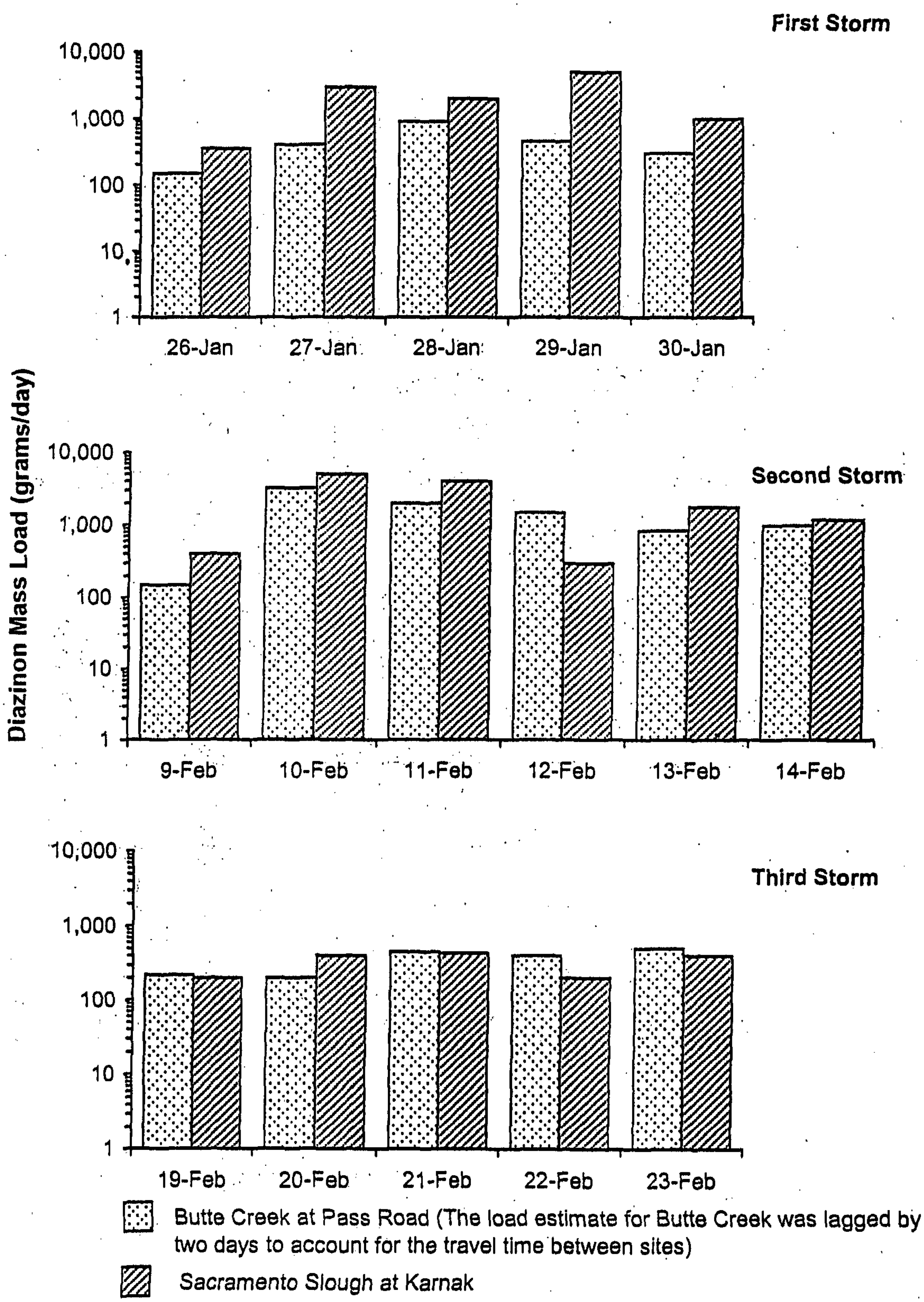


Figure 15. Diazinon Concentration (ng/L) in the Scramento River and Principal Orchard Tributaries between the Cities of Colusa and Sacramento for the Second Storm.

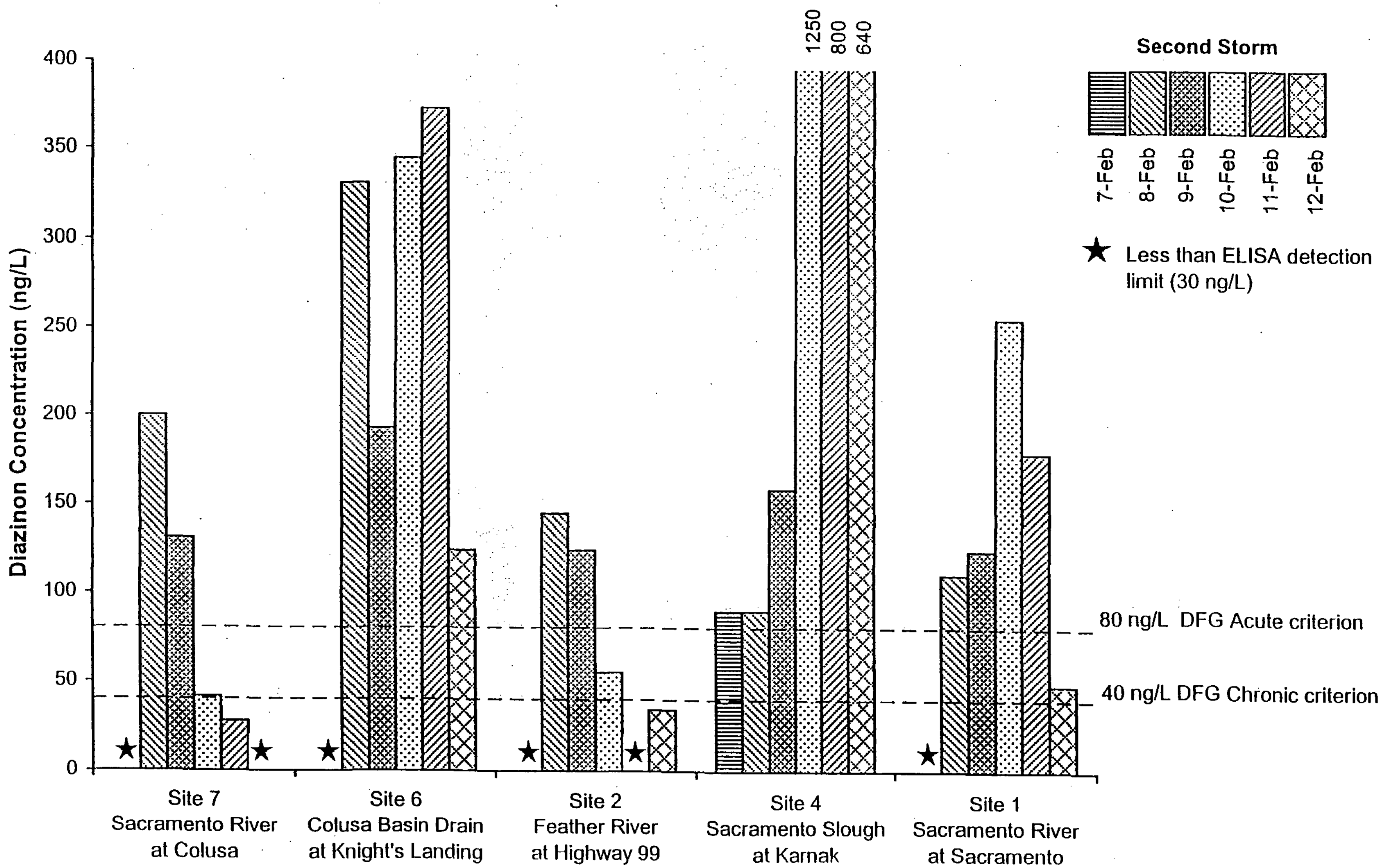


Figure 16. Predicted and Measured Diazinon Mass Loads in the Sacramento River at Sacramento during Second Storm - February 9 to 13.

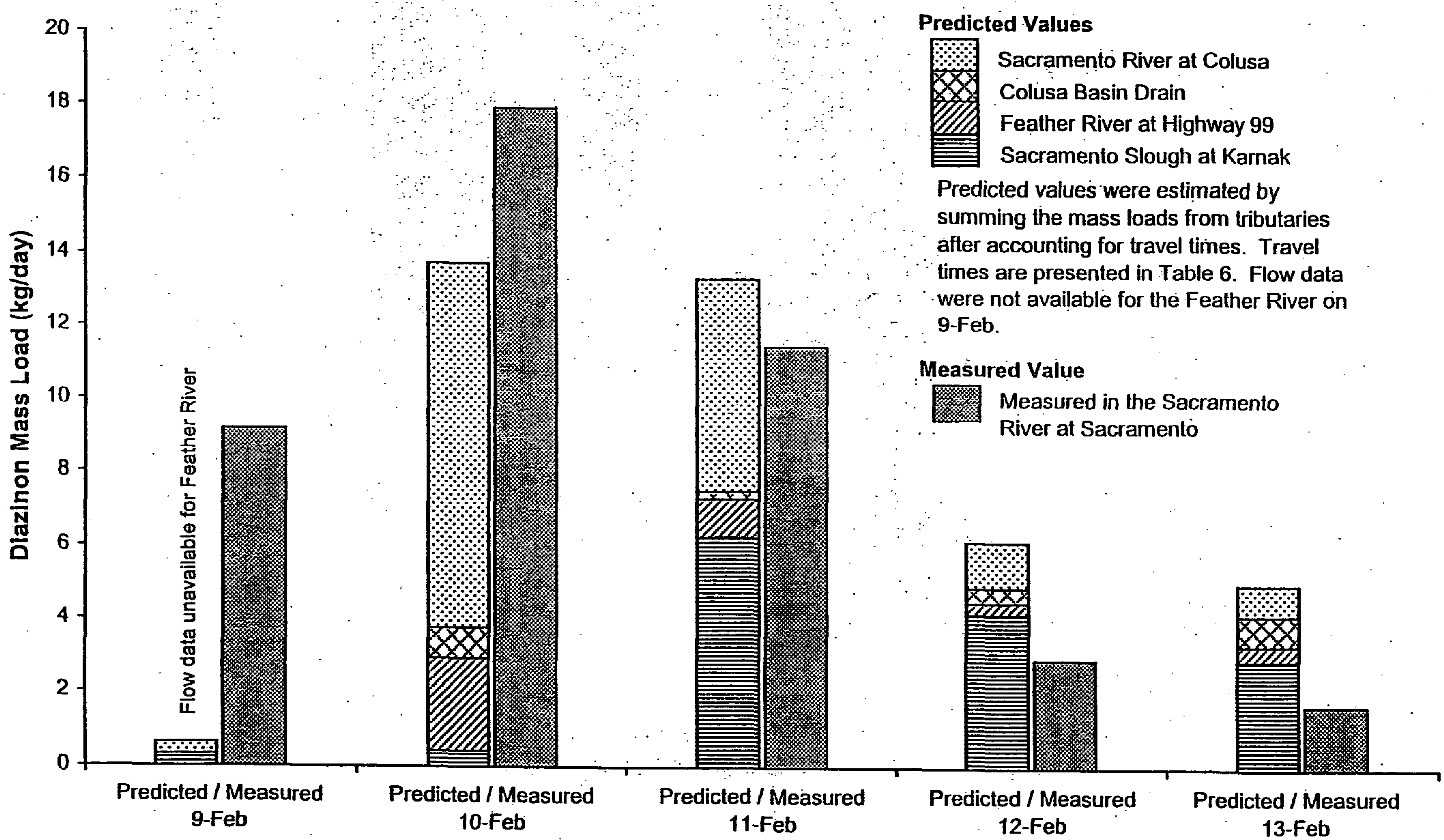


Figure 18. Predicted and Measured Diazinon Mass Loads in the Sacramento River at Sacramento during Third Storm - February 19 to 24.

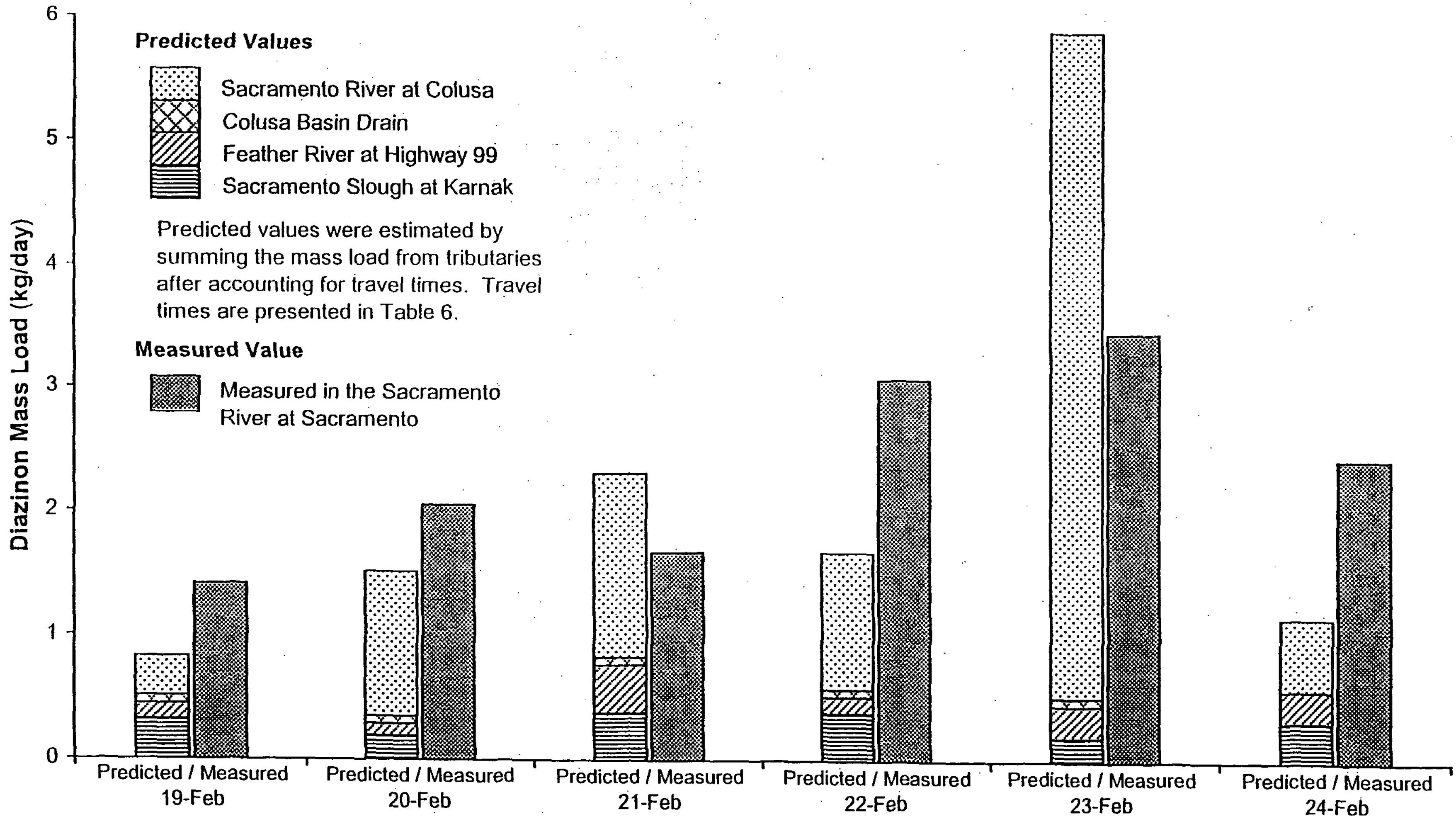
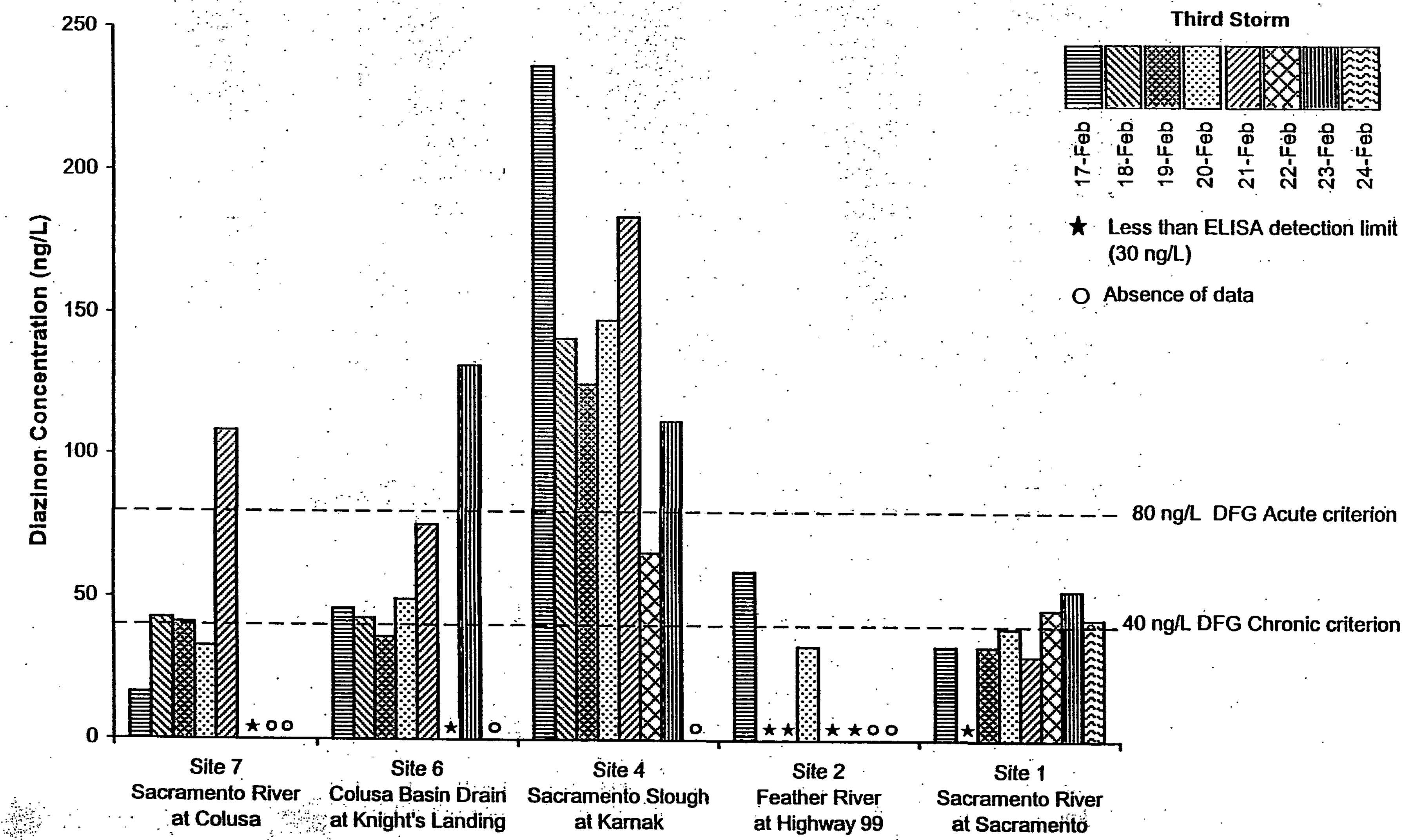


Figure 17. Diazinon Concentrations (ng/L) in the Scramento River and Principal Orchard Tributaries between Colusa and Sacramento for the Third Storm.



Appendix A: Quality Assurance and Quality Control Tables and Figures

Table 1A. Difference in diazinon concentrations (ng/L) in split samples analyzed by GC/MS at USGS Central Laboratory and by ELISA at UC Davis. (Mean difference was 30 percent)

Location	Site	Date	ELISA	GC(Sac)	GC(Colo)	% difference*
Feather River @ Hwy 99	2	01/04	30		40	25
		01/25	270/260	293		10
		01/26	960	782		19
		01/26	960		760	21
		01/27	420/460	379		14
		01/27	420/460		370	16
		01/28	440/450	150		66
		01/28	440/450		180	60
		02/08	155		140	10
		02/09	145		110	24
		02/13	140		21	85
Feather River @ Yuba City	3	01/04	16		36	55
		01/24	100		66	34
		01/25	160	171		6
		01/27	95	63		34
		01/28	85	38		55
		02/08	90		150	40
		02/09	100		100	0
Sacramento Slough @ Karnak	4	01/12	30		82	63
		01/12	30	86		65
		01/17	110		87	21
		01/21	60/65		93/83	29
		01/24	44	89		51
		01/24	44		89	51
		01/25	88	106		17
		01/25	88		130	32
		01/26	130	104		20
		01/26	130		140	7
		01/27	1400	1120		20
		01/27	1400		1400	0
		01/28	440	502		12
		01/28	440		640	31
		01/29	500		590	15
		01/30	320		410	22
		01/31	175		320	45
		02/04	80	86		7
		02/04	80		180	56
		02/11	850		800	6
		02/12	590		480	19
		02/13	500		290	42
		02/14	250/230		220	8
		02/17	290		170	41
		02/18	95		180	47
		02/19	90		150	40
		02/20	130		160	19
		02/21	190		170	11

Table 1A (continued)

Location	Site	Date	ELISA	GC(Sac)	GC(Colo)	% difference*
Butte Creek at Pass Rd.	5	01/04	28		57	51
		01/12	35	79		56
		01/24	145	105		28
		01/24	145		110	24
		01/25	180	226		20
		01/26	300		350	14
		01/26	300	353		15
		01/27	230	219		5
		01/28	190	161		15
		02/04	125	62		50
		02/08	1000		1000	0
		02/09	330		280	15
		02/10	300		240	20
		02/11	180		160	11
		02/12	170		150	12
		02/13	450		160	64
		02/17	180		140	22
		02/20	165		81	51
		02/21	80		110	27
Colusa Drain	6	01/24	30		36	17
		01/24	30	36		17
		01/26	30	42		29
		01/26	30		53	43
		01/27	42	60		30
		01/27	42		180	77
		01/28	48	55		13
		01/28	48		53	9
		01/31	42		49	14
		02/08	360		300	17
		02/09	210		170	19
		02/10	350		340	3
		02/11	380		360	5
		02/12	230		22	90
		02/13	420		120	71
		02/14	81		84	4
		02/17	38		49	22
		02/18	30		54	44
		02/19	30		44	32
		02/20	57		41	28
		02/21	65		80	19
Sac. River @ Colusa	7	01/24	60		52	13
		01/24	60	55		8
		01/27	42	46		9
		01/28	90	38		58
		02/04	48		20/17	61
		02/04	48	13		73
		02/08	180		220	18

Table 1A (continued)

Location	Site	Date	ELISA	GC(Sac)	GC(Colo)	% difference*
Sac. River @ Colusa	7	02/09	125		140	11
		02/10	30		57	47
		02/13	34		23	32
		02/20	41/30		28	21
		02/21	80		130	38
Bear River	8	01/24	135	203		33
		01/04	160		120	25
Yuba River @ Marysville	9	01/24	48	35		27
		02/09	190		2	99
Jack Slough	10	01/04	95		200	53
		01/24	1250	767		39
		01/24	1250		390	69
		02/08	330		640	48
		02/09	280		250	11
		02110	300		190	37
		02/17	230		210	9
		02/18	400		220	45
		02/19	290		190	34
		02/20	220		32/160	56
Honcut Creek	11	01/04	200		150	25
		01/24	73/130	105		3
DWR Pump Plant @ Sac. Rd	12	01/04	200		420	52
		01/24	270	230		15
		01/24	270		290	7
		02/08	1800		2800	36
		02/09	940		1000	6
		02/10	700		500	29
		02/17	370		190	49
		02/18	110		150	27
		02/19	140		160	13
		02/20	290		150	48
DWR Pump Plant @ Obanion Rd.	13	01/04	280		130	54
		01/24	115	122		6
		02/08	350		300	14
		02/09	580		760	24
		02/10	580		530	8
		02/17	340/270		220/220	28
		02/18	210		270	22
Wadsworth Canal	14	01/04	700		170	76
		01/24	1250	569		54
		01/24	1250		740	41

Table 1A (continued)

Location	Site	Date	ELISA	GC(Sac)	GC(Colo)	% difference*
Wadsworth Canal	14	02/08	2000		4800	58
		02/10	1800		2000	10
		02/17	190		140	26
		02/18	310/330		360/380	14
		02/19	420		430	2
		02/20	290		220	24
		02/21	550		550	0
Main Drainage Canal	15	01/04	57		200	72
		01/24	1350	1342		1
		01/24	1350		1500	10
		02/08	2000		2900	31
		02/09	800		1000	20
		02/10	600		550	8
		02/17	340		230	32
		02/18	400		360	10
		02/19	95/165		180	28
Butte City	16	02/18	155		64	59
Hamilton	18	02/18	230		38	83
Vina	19	02/17	165		170	3
		02/18	210		29	86

*Percent difference: (high-low concentration) ÷ high x 100

Table 2A. Difference in diazinon concentration (ng/L) in split samples analyzed by GC/MS at the USGS Central and Sacramento Laboratories.

Location	Site	Date	Central Lab	Sacramento	% difference*
Feather R.@ Hwy 99	2	01/26	760	782	3
		01/27	370	379	2
		01/28	180	150	17
Sac Slough @ Karnak	4	01/12	82	86	5
		01/24	89	89	0
		01/25	130	106	17
		01/26	140	104	26
		01/27	1400	1120	20
		01/28	640	502	22
		02/04	180	86	52
Butte Creek	5	01/24	110	105	5
		01/26	350	353	1
Colusa Basin Drain	6	01/12	18	20	10
		01/24	36	36	0
		01/25	60	30	50
		01/26	53	42	21
		01/27	180	60	67
		01/28	53	55	4
		02/04	29	25	14
Sac R.@Colusa	7	01/24	52	55	5
		02/04	20/17	13	30
Jack Slough	10	01/24	390	767	49
DWR Pump Plant@Sac Rd.	12	01/24	290	230	21
Wadsworth Canal	14	01/24	740	569	23
Main Drainage Canal	15	01/24	1500	1342	11
					x = 19%

*Percent difference: (high-low concentration) ÷ high concentration x 100.

Table 3A. Percent recoveries from 164 deuterated diazinon spikes into laboratory water at USGS Central Laboratory. Analysis by GC/MS.

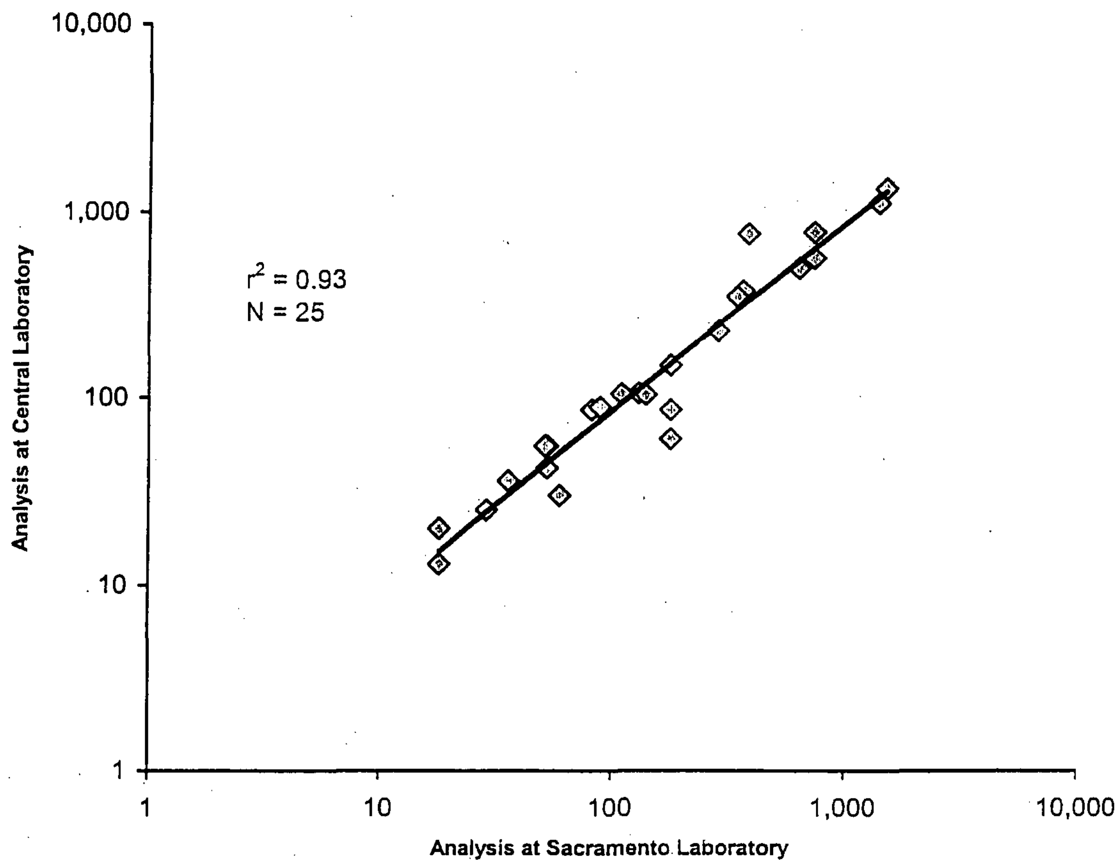
% Recovery			
90	100	100	70
90	100	100	100
100	80	90	100
100	100	90	100
90	100	100	100
80	100	90	100
80	100	100	90
80	100	100	100
80	100	90	100
100	100	100	100
90	100	100	100
90	100	80	100
90	100	90	80
80	90	100	90
80	100	90	100
90	100	100	100
80	100	100	100
80	100	100	100
80	100	100	100
80	100	90	90
90	100	100	90
80	100	100	100
80	100	100	100
100	100	100	
100	100	100	
100	100	100	
100	100	100	
100	100	100	
100	100	100	
100	100	100	
100	100	100	
90	100	100	
80	100	100	
80	100	100	
80	100	100	
100	90	100	
90	100	100	
100	100	100	
90	100	100	
90	100	100	
80	100	100	
80	100	100	
100	100	100	
100	100	100	
80	100	90	
100	90	100	
70	80	100	

Table 4A. Differences in diazinon concentration (ng/L) in duplicate ELISA analyses of same sample.

Location	Site	Date	Split 1	Split 2	% difference*
Sac R. @ Tower Bridge	1	01/19	28	33	18
		01/24	42	43	2
		02/02	32	30	6
		02/17	28	32	14
		02/23	53	49	8
Feather R. @ Hwy 99	2	02/25	270	260	4
		02/27	420	460	10
		02/28	440	450	2
Sac Slough @ Karnak	4	01/21	60	65	8
		02/14	250	230	8
Sac R. @ Colusa	7	02/20	41	30	27
Honcut Creek	11	01/24	73	130	78
O'Banion	13	02/17	340	270	21
Wadsworth Canal	14	02/18.	310	330	6
Main Drainage Canal	15	02/19	95	165	74
					x=19%

* Percent difference: as (high-low concentration) ÷ high concentration x 100.

Figure 1A. Correlation of Diazinon Concentration (ng/L) in Samples Analyzed using GC/MS at the Central Laboartory and Sacramento Laboratory.



Note: Data are presented in Table 2A.

Figure 2A. Correlation of Diazinon Concentration (ng/L) in Samples Analyzed at the USGS Central Laboratory and Sacramento Laboratory using GC/MS, and at UC Davis using ELISA.

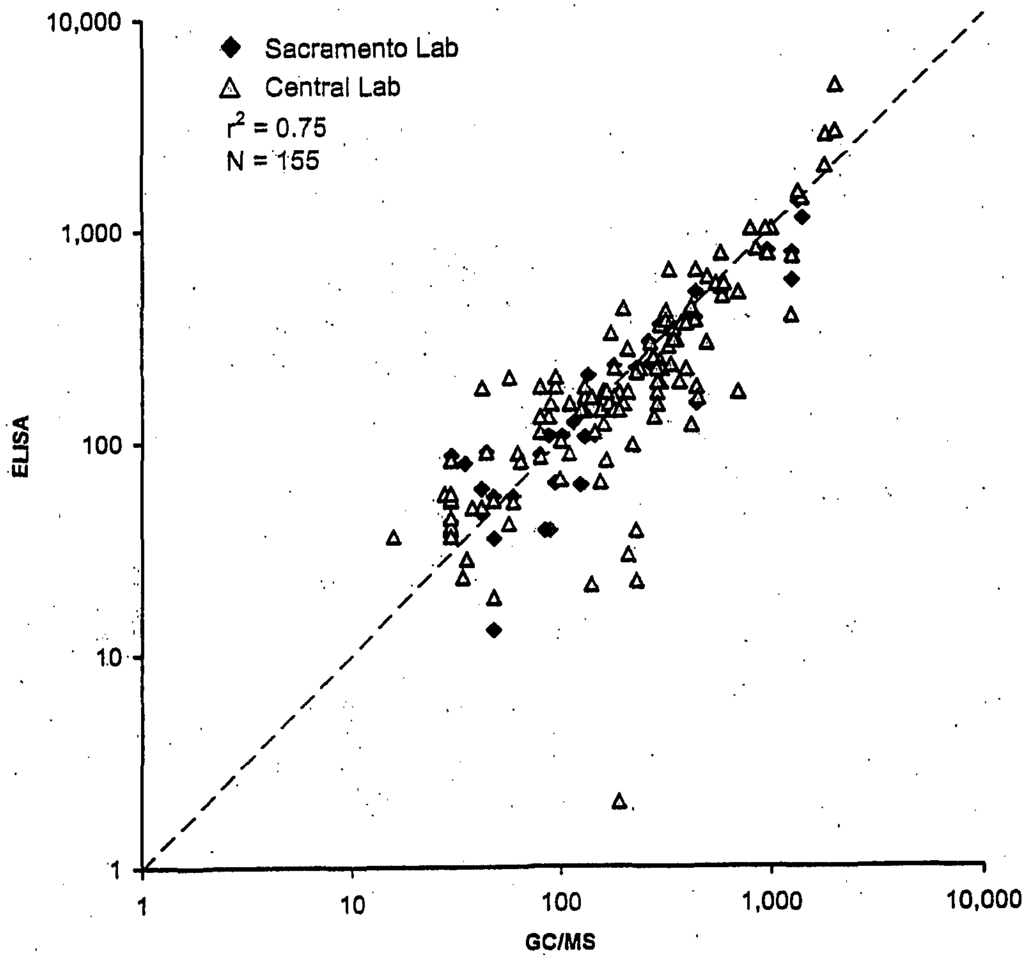
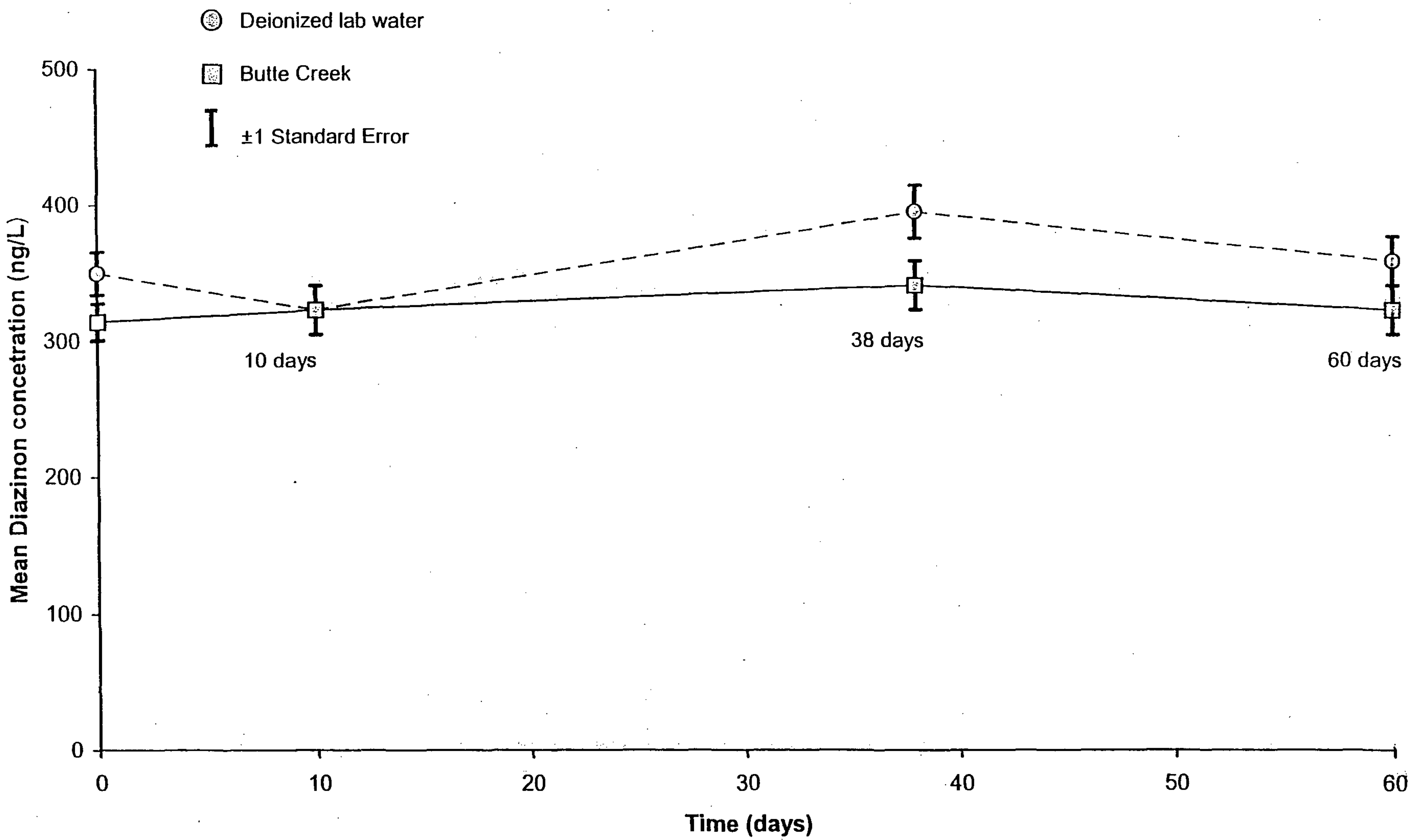


Figure 3A. Mean Change in Diazinon Concentration (ng/L)

Laboratory water and surface water samples from Butte Creek spiked with diazinon into three replicate flasks and held for a 60 day period. Analysis by ELISA.



Appendix B: Summary of Diazinon Concentrations and Loads

Site 3

8				
9				
10				
11				
12	bdt		33	33
13				
14				
15				
16				
17	bdt			bdt
18				
19				
20				
21	bdt			bdt
22				
23				
24	100	66		83
25	160		171	165.5
26	100			100
27	95		63	79
28	85		38	61.5
29				
30				
31	bdt			bdt
Feb 1				
2				
3				
4	bdt		12	12
5				
6				
7	bdt			bdt
8	90	150		120
9	100	100		100
10	bdt			bdt
11	bdt			bdt
12	bdt			bdt
13	90			90
14	bdt			bdt
15				
16				
17	bdt			bdt
18	bdt			bdt
19	bdt			bdt
20	bdt			bdt
21	bdt			bdt
22	bdt			bdt
23	bdt			bdt
24				
25				
26				
27				
28	bdt			bdt
Mar 1				
2				
3				
4	bdt			bdt

Site 4: Sacramento Slough @ Karnak	ELISA	GC/MS Arvada Colorado	GC/MS Sacramento California	Average
Jan 1				
2				
3				
4	180			180
5		100		100
6				
7				
8				
9				
10				
11				
12	30	82	86	66
13				
14				
15				
16				
17	110	87		98.5
18				
19				
20				
21	60/65	83/93		75.25
22				
23				
24	44	89	89	74
25	88	130	106	108
26	130	140	104	124.66
27	1400	1400	1120	1306.66
28	440	640	502	527.33
29	500	590		545
30	320	410		365
31	175	320		247.5
Feb 1				
2				
3				
4	80	180	86	115.33
5				
6				
7	90			90
8	90			90
9	160			160
10		1500		1500
11	800	850		825
12	590	480		540
13	500	290		395
14	250/230	220		233.33
15				
16				
17	290	170		230
18	95	180		137.5
19	90	150		120
20	130	160		145
21	190	170		180
22	65			65
23	77			77
24				
25				
26				
27				
28	90			90
Mar 1				
2				
3				
4	44			44

Site 5: Butte Creek	ELISA	GC/MS Arvada Colorado	GC/MS Sacramento California	Average
Jan 1				
2				
3				
4	28	57		42.5
5				
6				
7				
8				
9				
10				
11				
12	35		79	57
13				
14				
15				
16				
17	48			48
18				
19				
20				
21	62			62
22				
23				

Table 1B. Average Diazinon Concentration (ng/l) by Site and Date.

Site 1: Tower Bridge @ Sacramento	ELISA	GC/MS Arvada Colorado	GC/MS Sacramento California	Average
Jan 1				
2				
3	bdt			bdt
4				
5	bdt			bdt
6				
7	bdt			bdt
8				
9				
10	bdt			bdt
11				
12	bdt			bdt
13				
14	bdt			bdt
15				
16				
17	46			46
18				
19	28/33			30.5
20				
21	bdt			bdt
22				
23				
24	42/43			42.5
25	40			40
26	97			97
27	236			236
28	151			151
29	133			133
30	82			82
31	76			76
Feb 1	41			41
2	32/30			31
3	39			39
4	bdt			bdt
5				
6				
7	bdt			bdt
8	107			107
9	126			126
10	253			253
11	180			180
12	46			46
13	28			28
14	33			33
15	bdt			bdt
16	40			40
17	28/32			30
18	bdt			bdt
19	31			31
20	38			38
21	29			29
22	44			44
23	53/49			51
24	41			41
25	bdt			bdt
26	bdt			bdt
27				
28				
Mar 1				
2				
3				
4				

Site 2: Feather River @ H. 99	ELISA	GC/MS Arvada Colorado	GC/MS Sacramento California	Average
Jan 1				
2				
3				
4	30	40		35
5				
6				
7				
8				
9				
10				
11				
12	bdt		44	44
13				
14				
15				
16				
17	36			36
18				
19				
20				
21	bdt			bdt
22				
23				
24	bdt			bdt
25	270/260		293	274.33
26	960	760	782	834
27	420/460	370	379	407.25
28	440/450	180	150	305
29	30			30
30	bdt			bdt
31	bdt			bdt
Feb 1				
2				
3				
4	bdt		12	12
5				
6				
7	bdt			bdt
8	155	140		147
9	145	110		127.5
10	55			55
11	bdt			bdt
12	37			37
13	140	21		80.5
14	bdt			bdt
15				
16				
17	58			58
18	bdt			bdt
19	bdt			bdt
20	30			30
21	bdt			bdt
22	bdt			bdt
23	bdt			bdt
24				
25				
26				
27				
28	bdt			bdt
Mar 1				
2				
3				
4	bdt			bdt

Site 3: Feather R. River @ Yuba City	ELISA	GC/MS Arvada Colorado	GC/MS Sacramento California	Average
Jan 1				
2				
3				
4	16	36		26
5				
6				
7				

Butte Creek (Site 5)

24	145	110	105	120
25	180		226	203
26	300	350	353	334.33
27	230		219	224.5
28	190		161	175.5
29				
30				
31	60			60
Feb 1				
2				
3				
4	125		62	93.5
5				
6				
7	150			150
8	1000	1000		1000
9	330	280		305
10	300	240		270
11	180	160		170
12	170	150		160
13	450	160		305
14	63			63
15				
16				
17	180	140		160
18	100			100
19	120			120
20	165	81		123
21	80	110		95
22	30			30
23	bdt			bdt
24				
25				
26				
27				
28	60			60
Mar 1				
2				
3				
4	45		45	45

Site 6: Colusa Drain	ELISA	GC/MS Arvada Colorado	GC/MS Sacramento California	Average
Jan 1				
2				
3				
4	bdt			bdt
5		41		41.
6				
7				
8				
9				
10				
11				
12	bdt	18	20	19
13				
14				
15				
16				
17	bdt	17		17
18				
19				
20				
21	bdt	36		36
22				
23				
24	30	36	36	34
25	bdt	60	30	45
26	30	53	42	41.66
~~27~~	~~42~~	180	60	94
28	48	53	55	52
29				
30				
31	42	49		45:5
Feb 1				
2				
3				
4	bdt	29	25	27
5				
6				
7	bdt			bdt
8	360	300		330
9	210	170		190
10	350	340		345
11	380	360		370
12	230	22		126
13	420	120		270
14	81	84		82.5
15				
16				
17	38	49		43.5
18	30	54		42
19	30	44		37
20	57	41		49
21	65	80		72.5
22	bdt			bdt
23	125			125
24				
25				
26				
27				
28	bdt			bdt
Mar 1				
2				
3				
4	bdt			bdt

Site 7: Sacramento River @ Colusa	ELISA	GC/MS Arvada Colorado	GC/MS Sacramento California	Average
Jan 1				
2				
3				
4	bdt			bdt
5		25		25
6				
7				
8				
9				
10				
11				
12	bdt		10	10
13				
14				
15				
16				
17	bdt	21		21
18				
19				
20				
21	bdt			bdt
22				
23				
24	60	52	55	55.66
25	80		95	87.5
26	34			34
27	42		46	44
28	90		38	64
29				
30				
31	bdt	18		18
Feb 1				
2				
3				
4	48	20/17	13	24.5
5				
6				
7	bdt			bdt
8	180	220		200

9	125	140		132.5
10	30	57		43.5
11	bdt	29		29
12	bdt			bdt
13	34	23		28.5
14	bdt/bdt	29		29
15				
16				
17	bdt	17		17
18	bdt	41		41
19	bdt	40		40
20	41/30	28		33
21	80	130		105
22	bdt			bdt
23	bdt			bdt
24				
1025				
26				
27				
28	bdt			bdt
Mar 1				
2				
3				
4	bdt			bdt

Site 8: Bear River	ELISA	GC/MS Arvada Colorado	GC/MS Sacramento California	Average
Jan 1				
2				
3				
4	160	120		140
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24	135		203	169
25				
26				
27				
28				
29				
30				
31				
Feb 1				
2				
3				
4				
5				
6				
7				
8	bdt			bdt
9	bdt			bdt
10	bdt			bdt
11				
12				
13				
14				
15				
16				

17	50			50
18	30			30
19	bdt			bdt
20				
21				
22				
23				
24				
25				
26				
27				
28				
Mar 1				
2				
3				
4				

Site 9: Yuba River @ Marysville	ELISA	GC/MS Arvada Colorado	GC/MS Sacramento California	Average
Jan 1				
2				
3				
4	bdt			bdt
5		5		5
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24	48		35	41.5
25				
26				
27				
28				
29				
30				
31				
Feb 1				
2				
3				
4				
5				
6				
7				
8	bdt			bdt
9	190	2		96
10	bdt			bdt
11				
12				
13				
14				
15				
16				
17	bdt			bdt
18	bdt			bdt
19	bdt			bdt
20	bdt			bd[illegible]
21	bdt			b[illegible]
22				
23				
24				

25				
26				
27				
28				
Mar 1				
2				
3				
14				

Site 10: Jack Slough	ELISA	GC/MS Arvada Colorado	GC/MS Sacramento California	Average
Jan 1				
2				
3				
4	95	200		147.5
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24	1250	390	767	802.33
25				
26				
27				
28				
29				
30				
31				
Feb 1				
2				
3				
4				
5				
6				
7				
8	330	640		485
9	280	250		265
10	300	190		245
11				
12				
13				
14				
15				
16				
17	230	210		220
18	400	220		310
19	290	190		240
20	220	32 160		137.33
21				
22				
23				
24				
25				
26				
27				
28				
Mar 1				
2				
3				
4				

Site 11 – Honcut Creek	ELISA	GC/MS Arvada Colorado	GC/MS Sacramento California	Average
Jan 1				
2				
3				
4	200	150		175
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24	73/130		105	102.66
25				
26				
27				
28				
29				
30				
31				
Feb 1				
2				
3				
4				
5				
6				
7				
8	60			60
9	40			40
10	75			75
11				
12				
13				
14				
15				
16				
17	bdt			bdt
18	bdt			bdt
19	bdt			bdt
20	bdt			bdt
21				
22				
23				
24				
25				
26				
27				
28				
Mar 1				
2				
3				
4				

Site 12: DWR Pump Plant @ Sac. Rd.	ELISA	GC/MS Arvada Colorado	GC/MS Sacramento California	Average
Jan 1				
2				
3				
4	200	420		310
5				

6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24	270	290	230	263.33
25				
26				
27				
28				
29				
30				
31				
Feb 1				
2				
3				
4				
5				
6				
7				
8	1800	2800		2300
9	940	1000		970
10	700	500		600
11				
12				
13				
14				
15				
16				
17	370	190		280
18	110	150		130
19	140	160		150
20	290	150		220
21	57			57
22				
23				
24				
25				
26				
27				
28				
Mar 1				
2				
3				
4				

Site 13: DWR Pump Plant @ Obanion Rd.	ELISA	GC/MS Arvada Colorado	GC/MS Sacramento California	Average
Jan 1				
2				
3				
4	280	130		205
5				
6				
7				
8				
9				
10				
11				
12				
13				

14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24	115		122	118.5
25				
26				
27				
28				
29				
30				
31				
Feb 1				
2				
3				
4				
5				
6				
7				
8	350	300		325
9	580	760		670
10	580	530		555
11				
12				
13				
14				
15				
16				
17	340/270	220/220		262.5
18	210	270		240
19	30			30
20	66			66
21	30			30
22				
23				
24				
25				
26				
27				
28				
Mar 1				
2				
3				
4				

Site 14: Wadsworth Canal	ELISA	GC/MS Arvada Colorado	GC/MS Sacramento California	Average
Jan 1				
2				
3				
4	700	170		435
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				

22				
23				
24	1250	740	569	853
25				
26				
27				
28				
29				
30				
31				
Feb 1				
2				
3				
4				
5				
6				
7				
8	2000	4800		3400
9		4500		4500
10	1800	2000		1900
11				
12				
13				
14				
15				
16				
17	190	140		165
18	310/330	360/380		345
19	420	430		425
20	290	220		255
21	550	550		550
22				
23				
24				
25				
26				
27				
28				
Mar 1				
2				
3				
4				

Site 15: Main Drainage Canal	ELISA	GC/MS Arvada Colorado	GC/MS Sacramento California	Average
Jan 1				
2				
3				
4	57	2[illegible]		128.5
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24	1350	1500	1342	1397.33
25				
26				
27				
28				
29				
30				
31				
Feb 1				
2				
3				
4				
5				
6				
7				
8	2000	2900		2450
9	800	1000		900
10	600	550		575
11				
12				
13				
14				
15				
16				
17	340	230		285
18	400	360		380
19	95/165	180		146.66
20		1100		1100
21	bdt			bdt
22				
23				
24				
25				
26				
27				
28				
Mar 1				
2				
3				
4				

Site 16: Butte City	ELISA	GC/MS Arvada Colorado	GC/MS Sacramento California	Average
Jan 1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
Feb 1				
2				
3				
4				
5				
6				

7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18	155	64		109.5
19	40			40
20				
21	160			160
22				
23				
24				
25				
26				
27				
28				
Mar 1				
2				
3				
4				

Site 18: Hamilton	ELISA	GC/MS Arvada Colorado	GC/MS Sacramento California	Average
Jan 1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
Feb 1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17	50			50
18	230	38		134
19	30			30
20				
21	70			7[illegible]
22				
23				
24				
25				
26				
27				
28				
Mar 1				
2				
3				
4				

Site 19: Vina	ELISA	GC/MS Arvada Colorado	GC/MS Sacramento California	Average
Jan 1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
Feb 1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17	165	170		167.5
18	210	29		119.[illegible]
19	bdl			bdl
20				
21	65			65
22				

23				
24				
25				
26				
27				
28				
Mar 1				
2				
3				
4				

Table 2B. **Diazinon Mass Loading Calculations.** (One **half the ELISA detection limit (i.e., 30 ng/l) was** used to estimate loads when the concentration was below **detection).**

Site 1: Tower Bridge @ Sacramento	Diazinon Concentration (ng/l) * Average	Discharge (cfs)	Concentration And Discharge	Result % 2.445x10⁻³ = Diazinon g/day
Jan 1				
2				
3	bdt	14200	213000	521
4				
5	bdt	13600	204000	499
6				
7	bdt	12800	192000	469
8				
9				
10	bdt	12600	189000	462
11				
12	bdt	12400	186000	455
13				
14	bdt	11700	175500	429
15				
16				
17	46	11900	547400	1338
18				
19	30.5	12200	372100	910
20				
21	bdt	12200	183000	447
22				
23				
24	42.5	13200	561000	1372
25	40	15900	636000	1555
26	97	21800	2114600	5170
27	236	24000	5664000	13848
28	151	22100	3337100	8159
29	133	19200	2553600	6244
30	82	17000	1394000	3408
31	76	15500	1178000	2880
Feb 1	41	14200	582200	1423
2	31	13200	409200	1000
3	39	12600	491400	1201
4	bdt	12300	184500	451
5				
6				
7	bdt	13400	201000	491
8	107	19900	2129300	5206
9	126	29800	3754800	9180
10	253	29900	75664700	18496
11	180	26400	4752000	11619
12	46	23800	1094800	2677
13	28	23400	655200	1602
14	33	21500	709500	1735
15	bdt	19200	288000	704
16	40	17300	692000	1692
17	30	16200	486000	1188
18	bdt	17100	256500	627
19	31	19400	601400	1470
20	38	23500	893000	2183
21	29	25000	725000	1773
22	44	28900	1271600	3109
23	51	28200	1438200	3516
24	41	25500	1045500	2556
25	bdt	22900	343500	840
26	bdt	20800	312000	763
27				
28				
Mar 1				
2				
3				
4				

Site 2: Feather River @ H. 99	Diazinon Concentration (ng/l) * Average	Discharge (cfs)	Concentration And Discharge	Result % 2.445x10⁻³ = Diazinon g/day
Jan 1				
2				
3				
4	35	3618	126630	310
5				
6				
7				
8				
9				
10				
11				
12	44	3227	141988	347
13				
14				
15				
16				
17	36	3186	114696	280
18				
19				
20				
21	bdt	3236	48540	119
22				
23				
24	bdt	3074	46110	113
25	274.33			
26	834	14943	12462462	30471
27	407.25	6444	2624319	6416
28	305	7322	2233210	5460
29	30			
30	bdt			
31	bdt	3739	56085	137
Feb 1				
2				
3				
4	12	3245	38940	95
5				
6				
7	bdt	3354	50310	123
8	147.5			
9	127.5	8000	1020000	2494
10	55	8374	460570	1126
11	bdt	6705	100575	246
12	37	3659	135383	331
13	80.5	5281	425120.5	1039
14	bdt	5197	77955	191
15				
16				
17	58	4036	234088	572
18	bdt	2650	39750	97
19	bdt	2734	41010	100
20	30	4952	148560	363
21	bdt	3112	46680	114
22	bdt	6697	100455	246
23	bdt	6673	100095	245
24				
25				
26				
27				
28	bdt	3299	49485	121
Mar 1				
2				
3				
4	bdt			

Table 2B - continued

Site 5: Butte Creek	Diazinon Concentration (ng/l) * Average	Discharge (cfs)	Concentration And Discharge	Result % 2.445x10-3 = Diazinon g/day
Jan 1				
2				
3				
4	42.5	266	11305	28
5				
6				
7				
8				
9				
10				
11				
12	57	278	15846	39
13				
14				
15				
16				
17	48	311	14928	37
18				
19				
20				
21	62	385	23870	58
22				
23				
24	120	496	59520	146
25	203	827	167881	410
26	334.33	1120	374449.6	916
27	224.5	890	199805	489
28	175.5	685	120217.5	294
29				
30				
31	60	409	24540	60
Feb 1				
2				
3				
4	93.5	446	41701	102
5				
6				
7	150	394	59100	145
8	1000	1320	1320000	3227
9	305	2620	799100	1954
10	270	2110	569700	1393
11	170	1860	316200	773
12	160	2400	384000	939
13	305	1740	530700	1295
14	63	1100	69300	169
15				
16				
17	160	588	94080	230
18	100	799	79900	195
19	120	1460	175200	428
20	123	1240	152520	373
21	95	2210	209950	513
22	30	2360	70800	173
23				
24				
25				
26				
27				
28	60	803	48180	118
Mar 1				
2				
3				
4	45	605	27225	67

Site 6: Colusa Drain	Diazinon Concentration (ng/l) * Average	Discharge (cfs)	Concentration And Discharge	Result % 2.445x10[illegible] = Diazi[illegible] g/day
Jan 1				
2				
3				
4	bdt	185	2775	7
5	41	184	7544	18
6				
7				
8				
9				
10				
11				
12	19	181	3439	8
13				
14				
15				
16				
17	17	24	408	1
18				
19				
20				
21	36	391	14076	34
22				
23				
24	34	403	13702	34
25	45	433	19485	48
26	41.66	366	15247.56	37
27	94	454	42676	104
28	52	499	25948	63
29				
30				
31				
Feb 1				
2				
3				
4	27	231	6237	15
5				
6				
7	bdt	548	8220	20
8	330	851	280830	687
9	190	249	47310	116
10	345	621	214245	524
11	370	897	331890	811
12	126	675	85050	208
13	270	655	176850	432
14	82.5	436	35970	88
15				
16				
17	43.5	480	20880	51
18	42	493	20706	51
19	37	337	12469	30
20	49	428	20972	51
21	72.5	241	17472.5	43
22	bdt	279	4185	10
23	125	658	82250	201
24				
25				
26				
27				
28	bdt	395	5925	14
Mar 1				
2				
3				
4	bdt	571	8565	21

Site 7: Sacramento River @ Colusa	Diazinon Concentration (ng/l) * Average	Discharge (cfs)	Concentration And Discharge	Result % $2.445x10^{-3}$ = Diazinon g/day
Jan 1				
2				
3				
4	bdt	6660	99900	244
5	25	6620	165500	405
6				
7				
8				
9				
10				
11				
12	10	5740	57400	140
13				
14				
15				
16				
17	21	5740	120540	295
18				
19				
20				
21	bdt	5680	85200	208
22				
23				
24	55.66	7020	390733.2	955
25	87.5	12600	1102500	2696
26	34	12300	418200	1022
27	44	10900	479600	1173
28	64	9040	578560	1415
29				
30				
31	18	6710	120780	295
Feb 1				
2				
3				
4	24.5	5890	144305	353
5				
6				
7	bdt	8050	120750	295
8	200	20400	4080000	9976
9	132.5	18200	2411500	5896
10	43.5	12200	530700	1298
11	29	11400	330600	808
12	bdt	13200	198000	484
13	28.5	10200	290700	711
14	29	8860	256940	628
15				
16				
17	17	7480	127160	311
18	41	11600	475600	1163
19	40	13900	556000	1359
20	33.00	13900	458700	1122
21	105	20900	2194500	5366
22	bdt	16500	247500	605
23	bdt	13500	202500	495
24				
25				
26				
27				
28	bdt	10500	157500	385
Mar 1				
2				
3				
4	bdt	8590	128850	315

Site9: Yuba River @ Marysville	Diazinon Concentration (ng/l) * Average	Discharge (cfs)	Concentration And Discharge	Result % $2.445x10^{-3}$ = Diazinon g/day
Jan 1				
2				
3				
4	bdt	1200	18000	44
5	5	1210	6050	15
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24	41.5	1400	58100	142
25				
26				
27				
28				
29				
30				
31				
Feb 1				
2				
3				
4				
5				
6				
7				
8	bdt	1490	22350	55
9	96	1220	117120	286
10	bdt	1160	17400	43
11				
12				
13				
14				
15				
16				
17	bdt	1140	17100	42
18	bdt	1570	23550	58
19	bdt	1300	19500	48
20	bdt	1450	21750	53
21	bdt	1350	20250	50
22				
23				
24				
25				
26				
27				
28				
Mar 1				
2				
3				
4				

Site 16 – Butte City	Diazinon Concentration (ng/l) * Average	Discharge (cfs)	Concentration And Discharge	Result % 2.445x10-3 = Diazinon g/day
Jan 1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
Feb 1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18	109.5	15400	1686300	4123
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
Mar 1				
2				
3				
4				

Site 17 – Ord Bend	Diazinon Concentration (ng/l) * Average	Discharge (cfs)	Concentration And Discharge	Result % 2.445x10-3 = Diazinon g/day
Jan 1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
Feb 1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17	bdt	7579	113685	278
18	90	15692	1412280	3453
19	36	12004	432144	1057
20				
21	100	18105	1810500	4427
22				
23				
24				
25				
26				
27				
28				
Mar 1				
2				
3				
4				

Table 2B - continued

Site 19 – Vina	Diazinon Concentration (ng/l) * Average	Discharge (cfs)	Concentration And Discharge	Result % 2.445×10^{-3} = Diazinon g/day
Jan 1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
Feb 1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17	167.5	11038	1848865	4520
18	119.5	14559	1739800.5	4254
19	bdt	11046	165690	405
20				
21	65	14325	931125	2277
22				
23				
24				
25				
26				
27				
28				
Mar 1				
2				
3				
4				

Site 21: Red Bluff	Diazinon Concentration (ng/l) * Average	Discharge (cfs)	Concentration And Discharge	Result % 2.445×10^{-3} = Diazinon g/day
Jan 1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
Feb 1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17	80	9250	740000	1809
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
Mar 1				
2				
3				
4				

Table 2B - continued

Site 22: Bend.	Diazinon Concentration (ng/l) * Average	Discharge (cfs)	Concentration And Discharge	Result % 2.445x10-3 = Diazinon g/day
Jan 1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
Feb 1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18	bdt	9683	145245	355
19	bdt	8690	130350	319
20				
21	bdt	10563	158445	387
22				
23				
24				
25				
26				
27				
28				
Mar 1				
2				
3				
4				

Note: Diazinon concentration average derived from Table 1B.
* = ½ the ELISA detection limit used for calculation when value was below detection limit (bdt).

Appendix C: Summary of Other Chemicals Detected in Study

Table 1C. Summary of all pesticide concentrations (ng/L) measured above the USGS Central Laboratory detection limit.

	site	date	alachlor	alpha bhc	atrazine	carbaryl	carbofuran	chlorpyrifos	cyanazine	depa	deethyl atrazine	diazinon	dimethoate	epte	ethafluralin	ethoprop	malathion	methyl parathion	metolachlor	metribuzin	molinate	napropamide	pendimethalin	phorate	prometon	pronamide	simazine	tebuthiuron	terbacil	terbufos	thiobencarb	trifluralin
Feather R. @ Hwy 99	2	01/04										40															14					
		01/26			7		27			2		760							3		22						200					
		01/27			7		36			2		370							3		29						260					
		01/28			6		32			2		180							3		33						170	5				
		02/08			5		23			2		140							3		24						290					
		02/09			10					2		110							2		24						280	52				
		02/13			8		21			1		21									30						110					
Feather R. @ Yuba City	3	01/04										36															4					
		01/24								2		66															22					
		02/08			6	16				2		150													11		50					
		02/09			37					2		100													9		75					
Sac Slough @ Karnak	4	01/05					56					100		10					3		89										7	
		01/12					21					82		7					3		100										9	
		01/17					69					87									83						8					
		01/21					63					93									99						8				5	
		01/21					55					83									100						5				6	
		01/24					64					89									130						9				5	
		01/25					79					130									120						45	110			6	
		01/26					75					140							6		130						67	30			4	
		01/27	7				70					1400							4		130						57	25			5	
		01/28	9				83					640							4		120						140	9			5	
		01/29					81					590							4		110						200				6	
		01/30					70					410							4		100						140				5	
		01/31					71					320									100						130				5	
		02/04					65					180									80						70					
		02/10					58					1500		7					3		75						200	10				
		02/11					51					850							6		91						280					
		02/12					58					480							5		89						230					
		02/13				10	52			2		290		8					6		78						210					
		02/14					56					220		10					8		66						170				4	
		02/17			23		58					170							7		65						150					
		02/18			14		64					180		4					5		59						160					

Table 1C (continued)

	site	date	alachlor	alpha bhc	atrazine	carbaryl	carbofuran	chlorpyrifos	cyanazine	dcpa	deethyl atrazine	diazinon	dimethoate	eptc	ethalfluralin	ethoprop	malathion	methyl parathion	metolachlor	metribuzin	molinate	napropamide	pendimethalin	phorate	prometon	pronamide	simazine	tebuthiuron	terbacil	terbufos	thiobencarb	trifluralin
		02/18			14		64					180		4					5		59						160					
		02/19			20		61					150		4					4		62						180	12				
		02/20			12		62					160							6		53						210					
		02/21					73					170							3		72					5	130					
Butte Cr.	5	01/04		1			46			1		57		15					5		93						11				9	3
		01/24					60			1		110		2					3		[illegible]						11				5	1
		01/26			6	5	55			2		350							4		110						260	9	11		7	
		02/08			6		48			3		1000		2					2		84						440				5	
		02/09			6		44			3		280		2					2		120						270				4	
		02/10			5		42			3		240		3					4		76	7					300		7			2
		02/11			4		40			4		160		23					8		75					16	190				8	4
		02/12			3		48			3		150		18					7		81					18	170				7	3
		02/13			5		49			2		160		7					6		72					17	160				9	2
		02/17			4		66			2		140		2					3		87					17	150				1	3
		02/20			4		58			2		81							3		89					14	130				3	1
		02/21			52					2		110							2		[illegible]	7				17	260					
Colusa Drain	6	01/05			3		39			2		41		2					2		86	8					17	4			21	3
		01/12			4		25			1		18							2		73						22				12	
		01/17			4		27			1		17		1							72						11	6			14	
		01/21					29					36									85						14				15	
		01/24					35			2		36									130	8					13				10	3
		01/25			5		46			3		60		2					4		120	10					410	23			12	2
		01/26					27	19		3		53							2		81	76				68	68	4	34		21	3
		01/27			17		50		21	15		180		1					56	6	110	30			320	60	400	13			13	4
		01/28			6		49			3		53							6		140	7					430	70			13	3
		01/31			41		68			4		49		1					4		180					14	360	21			12	1
		02/04			8		39			2		29				8			2		120						97	13			10	
		02/08			5	7	31	5	42	17		300			41				7		75	440	3				900				10	23
		02/09			29		47	9	9	26		170		3					35		100	200	3			36	980	48		12	6	
		02/10			77		56			6	3	340							310	8	100	85	2			250	840	30			10	6
		02/11			49		62		13	16		360		3					130	16	110	41			270	160	570	13			10	5
		02/12			3		30			1		22									71					64	18	6			14	
		02/13			11		48		16	13		120		2					36		100	19			260	36	390	13			11	4
		02/14			10		38		17	6		84							20		95	12		16	150	24	300	11			9	3
		02/17			5		26		20	7		49							8		75	7			94	18	220	9			9	3
		02/18			6		29		75	3		54							9		84				85	18	300				10	3
		02/19			6		23		34	6		44							8		83	57			67	17	290				11	3

Table 1C (continued)

	site	date	alachlor	alpha bhc	atrazine	carbaryl	carbofuran	chlorpyrifos	cyanazine	depa	deethyl atrazine	diazinon	dimethoate	epte	ethafluralin	ethoprop	malathion	methyl parathion	metolachlor	metribuzin	molinate	napropamide	pendimethalin	phorate	prometon	pronamide	simazine	tebuthiuron	terbacil	terbufos	thiobencarb	trifluralin
		02/20			4		24		19	5		41							5		86	13			59	14	240	4			11	3
		02/21			14				32	3	1	80	10					33		81	110		18	58	17	780				7	8	
Sac. R. @ Colusa	7	01/05								1		25																				
		01/17										21																				
		01/24										52																				
		01/31			5							18										4					28					
		02/04			3							20															10					
		02/04										17																				
		02/08			85					3		220							2			9				17	440					
		02/09			28					2		140							1								280					
		02/10			17					1		57							1			17					170		14	40		
		02/11			13					1		29							2								100					
		02/13			20					1		23	18													14	89					
		02/14			11							29															56		11			
		02/17			5	5				1		17															29					
		02/18			16					3		41															320					2
		02/19			35					2		40															110					
		02/20			26					2		28							1								97					
		02/21			82					2	2	130							3							16	470					
Bear R. @ Berry Rd.	8	01/04					110					120							3		55						66					
Yuba R. @ Marysville	9	01/05										5															9					
		02/09										2															55					
Jack Sl. @ 14[th] St.	10	01/04					160					200									220						19					
		01/24					210					390									270						460					
		02/08					120			4		640					8				160						590	9			2	
		02/09					220					250									330						200					
		02/10					310					190									420						140					
		02/17					340					210									360						470					
		02/18					340					220									360						240					
		02/19					370					190									340						150	10				
		02/20					68					32									46						500					
		02/20					290					160									260						940	11				
Honcut Cr.	11	01/04					94					150									38						21					

Table 1C (continued)

	site	date	alachlor	alpha bhc	atrazine	carbaryl	carbofuran	chlorpyrifos	cyanazine	dcpa	deethyl atrazine	diazinon	dimethoate	eptc	ethafluralin	ethoprop	malathion	methyl parathion	metolachlor	metribuzin	molinate	napropamide	pendimethalin	phorate	prometon	pronamide	simazine	tebuthiuron	terbacil	terbufos	thiobencarb	trifluralin
@Chandler Rd.																																
DWR Pump Plant @ Sac. Rd.	12	01/04					220					420		5							400						33	170			32	
		01/24					290					290		5							420						740	1000			42	
		02/08	22				130	10		4		2800		13							350						270	100			11	9
		02/09	34				140			4		1000		5							280						160	93			14	
		02/10	37				170			3		500		8				23		11	380						110	46			15	
		02/17			5300		180			2	12	190		5							300						760				16	
		02/18			5100		260			2	9	150		4							310						1200	9			29	
		02/19			3100		260				7	160									260						610	25			29	
		02/20			1400		260				5	150									290						620	47			28	
DWR Pump Plant @ Obanion Rd.	13	01/04					55					130									96											
		02/08					66			3		300									140						490					
		02/09					48			17		760		5			20				79				9		720				3	
		02/10					69			6		530									120						220					
		02/17					29			8		220									55						170					
		02/17					31			7		220									59						160					
		02/18					28			6		270									53						160					
Wadsworth Canal @ Franklin Rd.	14	01/04					24					170									54											
		01/24					30					740									47						47				44	
		02/08					42			3		4800		3							54						460				3	
		02/09				16	62					4500									79						430					
		02/10				28	56					2000									90						370				3	
		02/17					29					140		3							44						220					
		02/18			5	8	50					360		4							70						170				5	
		02/18					51					380		4							72						170				7	
		02/19			3		40					430									62						300					
		02/20					32					220									41						150					
		02/21					41					550		8					3		50						640					
Main Drainage Canal to Cherokee Canal @ Colusa Hwy	15	01/04					88					200									170											
		01/24					81					1500									170						21				5	

Table 1C (continued)

	site	date	alachlor	alpha bhc	atrazine	carbaryl	carbofuran	chlorpyrifos	cyanazine	depa	deethyl atrazine	diazinon	dimethoate	epte	ethafluralin	ethoprop	malathion	methyl parathion	metolachlor	metribuzin	molinate	napropamide	pendimethailn	phorate	prometon	pronamide	simazine	tebuthiuron	terbacil	terbufos	thiobencarb	trifluralin
		02/08					85			4		2900					9				160						210				6	
		02/09					83					1000									170						68				3	
		02/10					94					550									150						40					
		02/17					160					230									240						11					
		02/18					120					360									200						34					
		02/19					94					180									150						16					
		02/20					91			3		1100					26				160						48				4	
Butte City	16	02/18			51							64															110					
Hamilton	18	02/18			26							38															78					
Vina	19	02/17			140							170															130					
		02/18			29	5				2		29															75					

Table 2C. Pesticides identified in GC/MS scan at USGS Sacramento Laboratory (values are ng/L).

	Site	Date	Diazinon	Molinate	Carbofuran	Simazine	Methidathion
Feather R. @ Hwy 99	2	01/12	44	11	13		
		01/25	293			329	143
		01/26	782	37		251	26
		01/27	379			279	
		01/28	150			172	
		02/04	12				
Feather R. @ Yuba City	3	01/12	33				56
		01/25	171				
		01127	63			62	
		01/28	38				
		02/04	12				
Sac. Slough @ Karnak	4	01/12	86	116	35		
		01/24	89	121	38		
		01/25	106	132	42		
		01/26	104	165	37	48	
		01/27	1120	134	52	142	104
		01/28	502	168	55	215	75
		02/04	86	113	28	110	
Butte Creek @ Pass Road	5	01/12	79	140	49	8	
		01/24	105	128 [handwritten: =129]	50		
		01/25	226	150	36	85	
		01/26	353	142 [handwritten: =126]	30	263	
		01/27	219	127	44	154	
		01/28	161	147	64	125	
		02/04	62	84	13 [handwritten: 7]		
Colusa Drain	6	01/12	20	98	27		
		01/24	36	131	31		
		01/25	30	108	26		
		01/26	42	109	20	117	665
		01/27	60	165	49	523	
		01/28	55	166	55	613	
		02/04	25	168	25.4	120	
Sac R. @ Colusa	7	01/12	10				
		01/24	55				
		01/25	95			750	
		01/27	46			322	
		01/28	38			151	
		02/04	13			22	
Bear R. @ Berry Rd.	8	01/24	203	91	82	132	57
Yuba R. @ Marysville	9	01/24	35			36	
Jack Slough	10	01/24	767	264	135	1348	1102
Honcut Creek @ Chandler Rd.	11	01/24	105		21		

(Continued)

Table 2C (continued)

	Site	Date	Diazinon	Molinate	Carbofuran	Simazine	Methidathion
DWR Pump Plant @ Sac. Rd.	12	01/24	230	475	157	803	49
DWR Pump Plant @ Obanion Rd.	13	01/24	122	272	41	30	
Wadsworth Canal	14	01/24	569	57	15	86	58
Main Drainage Canal to Cherokee Canal @ Colusa Hwy	15	01/24	1342	200	45		55

From: Robert Holmes
To: Spector, Christy
Date: 8/28/01 8:40AM
Subject: Re: Jack Slough

Hi Christy,
o.k. - here's a description - Jack Slough is lovely (not really) watershed that originates in the foothills of northern Yuba County. Jack is primarily dominated by agricultural activities. Parts of Jack appear natural with a nice riparian zone and migrating channel - however, other parts are constructed channels with heavy irrigation management. It receives year-round irrigation water (return and supply) - I believe from the Yuba River. The predominate land use is rice in the upper watershed. However, there is a dense group of orchards near the lower part of the drainage. Although no loading data existed from the 94 study because we did not have any flow data - Jack Slough was considered at least partly responsible for contributing diazinon loads to the Feather River in winter of 93/94. Because of where we sampled - Jack slough concentrations of diazinon would not be detected in the Feather at Yuba City (only downstream at Hwy 99). Hope this helps - Maybe we should put together a tour guide for Central Valley Ag Drains?
thanks, Robert

>>> Christy Spector 08/27/01 12:11PM >>>
Hi Robert,

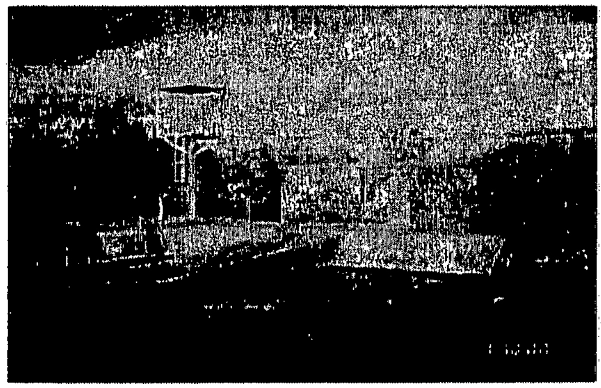
Now I am working on a Jack Slough Diaz fact sheet....cant recall if your 1994 study talked much about Jack Slough. I am looking for a good watershed description for JS. Let me know if you can think of a good ref.

Thanks,
Christy

(P.S. is there anything quirky or complicated about JS, like there is for Butte Slough?)

Thanks Robert!

Lower Butte Creek



Lower Butte Creek Project – Sutter Basin Butte Sink Water Users Association, Reclamation District 1004, RD 70, Butte Slough Irrigation Company, RD 1500, Butte Sink Waterfowl Association, Western Canal, RD 1660

Lower Butte Creek, Butte Sink and Sutter Bypass: on the main migration corridor for Butte Creek spring-run salmon, The Nature Conservancy, California Waterfowl Association and NCWA are working with local water user and fishery agencies to determine the feasibility of reducing or eliminating fish passage and entrainment problems. The group has already completed the first phase of this project, and is moving into the second phase, which will include preliminary engineering and design that have already led to the construction of an earlier fish ladder.

	Butte Slough at Lower Pass Road									
site	name	conc	samp_date	stud						
Butte Slough at Lower Pass	carbofur	0.049	04-Jan-94	48	1994 study 48					
Butte Slough at Lower Pass	carbofur	0.049	12-Jan-94	48						
Butte Slough at Lower Pass	carbofur	0.05	24-Jan-94	48						
Butte Slough at Lower Pass	carbofur	0.06	24-Jan-94	48						
Butte Slough at Lower Pass	carbofur	0	25-Jan-94	48						
Butte Slough at Lower Pass	carbofur	0.055	26-Jan-94	48						
Butte Slough at Lower Pass	carbofur	0	26-Jan-94	48						
Butte Slough at Lower Pass	carbofur	0.044	27-Jan-94	48						
Butte Slough at Lower Pass	carbofur	0.064	28-Jan-94	48						
Butte Slough at Lower Pass	carbofur	0	04-Feb-94	48						
Butte Slough at Lower Pass	carbofur	0.048	08-Feb-94	48						
Butte Slough at Lower Pass	carbofur	0.044	09-Feb-94	48						
Butte Slough at Lower Pass	carbofur	0.042	10-Feb-94	48						
Butte Slough at Lower Pass	carbofur	0.04	11-Feb-94	48						
Butte Slough at Lower Pass	carbofur	0.048	12-Feb-94	48						
Butte Slough at Lower Pass	carbofur	0.049	13-Feb-94	48						
Butte Slough at Lower Pass	carbofur	0.066	17-Feb-94	48						
Butte Slough at Lower Pass	carbofur	0.058	20-Feb-94	48						
Butte Slough at Lower Pass	carbofur	0	14-Apr-95	17	1995 study 17 1/17					
Butte Slough at Lower Pass	carbofur	0	16-May-95	17						
Butte Slough at Lower Pass	carbofur	0	23-May-95	17						
Butte Slough at Lower Pass	carbofur	0.57	30-May-95	17						
Butte Slough at Lower Pass	carbofur	0	01-Jun-95	17						
Butte Slough at Lower Pass	carbofur	0.37	06-Jun-95	17						
Butte Slough at Lower Pass	carbofur	0	08-Jun-95	17						
Butte Slough at Lower Pass	carbofur	0	13-Jun-95	17						
Butte Slough at Lower Pass	carbofur	0	15-Jun-95	17						
Butte Slough at Lower Pass	carbofur	0.37	20-Jun-95	17						
Butte Slough at Lower Pass	carbofur	0	22-Jun-95	17						
Butte Slough at Lower Pass	carbofur	0	27-Jun-95	17						
Butte Slough at Lower Pass	carbofur	0	29-Jun-95	17						
Butte Slough at Lower Pass	carbofur	0.5	03-Jul-95	17						
Butte Slough at Lower Pass	carbofur	0	06-Jul-95	17						
Butte Slough at Lower Pass	carbofur	0	11-Jul-95	17						
Butte Slough at Lower Pass	carbofur	0	18-Jul-95	17						
Butte Slough at Lower Pass	carbofur	0	01-Apr-96	30	1996 study 30 7/19					
Butte Slough at Lower Pass	carbofur	0	23-Apr-96	30						
Butte Slough at Lower Pass	carbofur	0	30-Apr-96	30						
Butte Slough at Lower Pass	carbofur	0	07-May-96	30						
Butte Slough at Lower Pass	carbofur	0	09-May-96	30						
Butte Slough at Lower Pass	carbofur	0	14-May-96	30						
Butte Slough at Lower Pass	carbofur	0.44	16-May-96	30						
Butte Slough at Lower Pass	carbofur	1.04	18-May-96	30						
Butte Slough at Lower Pass	carbofur	0.83	21-May-96	30						
Butte Slough at Lower Pass	carbofur	0.89	23-May-96	30						
Butte Slough at Lower Pass	carbofur	0.73	26-May-96	30						
Butte Slough at Lower Pass	carbofur	0.59	28-May-96	30						

Butte Slough at Lower Pass	carbofur	0.5	30-May-96	30					
Butte Slough at Lower Pass	carbofur	0	04-Jun-96	30					
Butte Slough at Lower Pass	carbofur	0	06-Jun-96	30					
Butte Slough at Lower Pass	carbofur	0	11-Jun-96	30					
Butte Slough at Lower Pass	carbofur	0	13-Jun-96	30					
Butte Slough at Lower Pass	carbofur	0.63	18-Jun-96	30					
Butte Slough at Lower Pass	carbofur	0	25-Jun-96	30					
Butte Slough at Lower Pass	carbofur	0	31-Mar-97	34	1997 study 34 2/17				
Butte Slough at Lower Pass	carbofur	0	22-Apr-97	34					
Butte Slough at Lower Pass	carbofur	0	29-Apr-97	34					
Butte Slough at Lower Pass	carbofur	0.59	06-May-97	34					
Butte Slough at Lower Pass	carbofur	0.55	08-May-97	34					
Butte Slough at Lower Pass	carbofur	0	13-May-97	34					
Butte Slough at Lower Pass	carbofur	0	15-May-97	34					
Butte Slough at Lower Pass	carbofur	0.39	20-May-97	34					
Butte Slough at Lower Pass	carbofur	0.37	22-May-97	34					
Butte Slough at Lower Pass	carbofur	0	27-May-97	34					
Butte Slough at Lower Pass	carbofur	0	29-May-97	34					
Butte Slough at Lower Pass	carbofur	0	03-Jun-97	34					
Butte Slough at Lower Pass	carbofur	0	05-Jun-97	34					
Butte Slough at Lower Pass	carbofur	0	10-Jun-97	34					
Butte Slough at Lower Pass	carbofur	0	12-Jun-97	34					
Butte Slough at Lower Pass	carbofur	0	17-Jun-97	34					
Butte Slough at Lower Pass	carbofur	0	24-Jun-97	34					
Butte Slough at Lower Pass	carbofur	0	31-Mar-98	40	1998 study 40 0/17				
Butte Slough at Lower Pass	carbofur	0	05-May-98	40					
Butte Slough at Lower Pass	carbofur	0	12-May-98	40					
Butte Slough at Lower Pass	carbofur	0	19-May-98	40					
Butte Slough at Lower Pass	carbofur	0	21-May-98	40					
Butte Slough at Lower Pass	carbofur	0	26-May-98	40					
Butte Slough at Lower Pass	carbofur	0	28-May-98	40					
Butte Slough at Lower Pass	carbofur	0	02-Jun-98	40					
Butte Slough at Lower Pass	carbofur	0	04-Jun-98	40					
Butte Slough at Lower Pass	carbofur	0	09-Jun-98	40					
Butte Slough at Lower Pass	carbofur	0	11-Jun-98	40					
Butte Slough at Lower Pass	carbofur	0	16-Jun-98	40					
Butte Slough at Lower Pass	carbofur	0	18-Jun-98	40					
Butte Slough at Lower Pass	carbofur	0	23-Jun-98	40					
Butte Slough at Lower Pass	carbofur	0	25-Jun-98	40					
Butte Slough at Lower Pass	carbofur	0	30-Jun-98	40					
Butte Slough at Lower Pass	carbofur	0	07-Jul-98	40					
Butte Slough at Lower Pass	diazinon	0	04-Jan-94	48					
Butte Slough at Lower Pass	diazinon	0.057	04-Jan-94	48					
Butte Slough at Lower Pass	diazinon	0.079	12-Jan-94	48					
Butte Slough at Lower Pass	diazinon	0.035	12-Jan-94	48					
Butte Slough at Lower Pass	diazinon	0.048	17-Jan-94	48					
Butte Slough at Lower Pass	diazinon	0.062	21-Jan-94	48					
Butte Slough at Lower Pass	diazinon	0.145	24-Jan-94	48					

Butte Slough at Lower Pass	diazinon	0.11	24-Jan-94	48				
Butte Slough at Lower Pass	diazinon	0.105	24-Jan-94	48				
Butte Slough at Lower Pass	diazinon	0.226	25-Jan-94	48				
Butte Slough at Lower Pass	diazinon	0.18	25-Jan-94	48				
Butte Slough at Lower Pass	diazinon	0.353	26-Jan-94	48				
Butte Slough at Lower Pass	diazinon	0.3	26-Jan-94	48				
Butte Slough at Lower Pass	diazinon	0.35	26-Jan-94	48				
Butte Slough at Lower Pass	diazinon	0.219	27-Jan-94	48				
Butte Slough at Lower Pass	diazinon	0.23	27-Jan-94	48				
Butte Slough at Lower Pass	diazinon	0.19	28-Jan-94	48				
Butte Slough at Lower Pass	diazinon	0.161	28-Jan-94	48				
Butte Slough at Lower Pass	diazinon	0.06	31-Jan-94	48				
Butte Slough at Lower Pass	diazinon	0.062	04-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.125	04-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.15	07-Feb-94	48				
Butte Slough at Lower Pass	diazinon	1	08-Feb-94	48				
Butte Slough at Lower Pass	diazinon	1	08-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.33	09-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.28	09-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.24	10-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.3	10-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.18	11-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.16	11-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.17	12-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.15	12-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.45	13-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.16	13-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.063	14-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.18	17-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.14	17-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.1	18-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.12	19-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.165	20-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.081	20-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.08	21-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.11	21-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.03	22-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0	23-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.06	28-Feb-94	48				
Butte Slough at Lower Pass	diazinon	0.045	04-Mar-94	48				
Butte Slough at Lower Pass	thiobenc	0.009	04-Jan-94	48				
Butte Slough at Lower Pass	thiobenc	0	24-Jan-94	48				
Butte Slough at Lower Pass	thiobenc	0	26-Jan-94	48				
Butte Slough at Lower Pass	thiobenc	0	08-Feb-94	48				
Butte Slough at Lower Pass	thiobenc	0	09-Feb-94	48				
Butte Slough at Lower Pass	thiobenc	0.008	11-Feb-94	48				
Butte Slough at Lower Pass	thiobenc	0	12-Feb-94	48				
Butte Slough at Lower Pass	thiobenc	0.009	13-Feb-94	48				

Butte Slough at Lower Pass	thiobenc	0	17-Feb-94	48					
Butte Slough at Lower Pass	thiobenc	0	20-Feb-94	48					
Butte Slough at Lower Pass	thiobenc	0	14-Apr-95	17					
Butte Slough at Lower Pass	thiobenc	0	16-May-95	17					
Butte Slough at Lower Pass	thiobenc	0	23-May-95	17					
Butte Slough at Lower Pass	thiobenc	0	30-May-95	17					
Butte Slough at Lower Pass	thiobenc	0	01-Jun-95	17					
Butte Slough at Lower Pass	thiobenc	0	06-Jun-95	17					
Butte Slough at Lower Pass	thiobenc	0	08-Jun-95	17					
Butte Slough at Lower Pass	thiobenc	0	13-Jun-95	17					
Butte Slough at Lower Pass	thiobenc	1.1	15-Jun-95	17					
Butte Slough at Lower Pass	thiobenc	0	20-Jun-95	17					
Butte Slough at Lower Pass	thiobenc	1.3	22-Jun-95	17					
Butte Slough at Lower Pass	thiobenc	0	27-Jun-95	17					
Butte Slough at Lower Pass	thiobenc	0	29-Jun-95	17					
Butte Slough at Lower Pass	thiobenc	0	03-Jul-95	17					
Butte Slough at Lower Pass	thiobenc	0	06-Jul-95	17					
Butte Slough at Lower Pass	thiobenc	0	01-Apr-96	30					
Butte Slough at Lower Pass	thiobenc	0	23-Apr-96	30					
Butte Slough at Lower Pass	thiobenc	0	30-Apr-96	30					
Butte Slough at Lower Pass	thiobenc	0	07-May-96	30					
Butte Slough at Lower Pass	thiobenc	0	09-May-96	30					
Butte Slough at Lower Pass	thiobenc	0	14-May-96	30					
Butte Slough at Lower Pass	thiobenc	1.3	16-May-96	30					
Butte Slough at Lower Pass	thiobenc	2.04	18-May-96	30					
Butte Slough at Lower Pass	thiobenc	0	21-May-96	30					
Butte Slough at Lower Pass	thiobenc	0.9	23-May-96	30					
Butte Slough at Lower Pass	thiobenc	0	26-May-96	30					
Butte Slough at Lower Pass	thiobenc	0	28-May-96	30					
Butte Slough at Lower Pass	thiobenc	0	30-May-96	30					
Butte Slough at Lower Pass	thiobenc	1.4	04-Jun-96	30					
Butte Slough at Lower Pass	thiobenc	1.1	06-Jun-96	30	%				
Butte Slough at Lower Pass	thiobenc	0.7	11-Jun-96	30	73%				
Butte Slough at Lower Pass	thiobenc	0	13-Jun-96	30					
Butte Slough at Lower Pass	thiobenc	0	18-Jun-96	30					
Butte Slough at Lower Pass	thiobenc	1.2	25-Jun-96	30					
Butte Slough at Lower Pass	thiobenc	0	31-Mar-97	34					
Butte Slough at Lower Pass	thiobenc	0	22-Apr-97	34					
Butte Slough at Lower Pass	thiobenc	0	29-Apr-97	34					
Butte Slough at Lower Pass	thiobenc	0	06-May-97	34					
Butte Slough at Lower Pass	thiobenc	0	08-May-97	34					
Butte Slough at Lower Pass	thiobenc	0.5	15-May-97	34					
Butte Slough at Lower Pass	thiobenc	1	20-May-97	34					
Butte Slough at Lower Pass	thiobenc	1.5	22-May-97	34					
Butte Slough at Lower Pass	thiobenc	2.2	27-May-97	34					
Butte Slough at Lower Pass	thiobenc	1.6	29-May-97	34					
Butte Slough at Lower Pass	thiobenc	1	03-Jun-97	34					
Butte Slough at Lower Pass	thiobenc	1	05-Jun-97	34					
Butte Slough at Lower Pass	thiobenc	6	10-Jun-97	34					

Butte Slough at Lower Pass	thiobenc	0	12-Jun-97	34					
Butte Slough at Lower Pass	thiobenc	0	17-Jun-97	34					
Butte Slough at Lower Pass	thiobenc	0	24-Jun-97	34					
Butte Slough at Lower Pass	thiobenc	0	31-Mar-98	40					
Butte Slough at Lower Pass	thiobenc	0	05-May-98	40					
Butte Slough at Lower Pass	thiobenc	0	12-May-98	40					
Butte Slough at Lower Pass	thiobenc	0	19-May-98	40					
Butte Slough at Lower Pass	thiobenc	0	21-May-98	40					
Butte Slough at Lower Pass	thiobenc	0	26-May-98	40					
Butte Slough at Lower Pass	thiobenc	0	28-May-98	40					
Butte Slough at Lower Pass	thiobenc	0	02-Jun-98	40					
Butte Slough at Lower Pass	thiobenc	0.6	04-Jun-98	40					
Butte Slough at Lower Pass	thiobenc	0.6	09-Jun-98	40					
Butte Slough at Lower Pass	thiobenc	0.6	11-Jun-98	40					
Butte Slough at Lower Pass	thiobenc	1.9	16-Jun-98	40					
Butte Slough at Lower Pass	thiobenc	1.2	18-Jun-98	40					
Butte Slough at Lower Pass	thiobenc	0.6	23-Jun-98	40					
Butte Slough at Lower Pass	thiobenc	0	25-Jun-98	40					
Butte Slough at Lower Pass	thiobenc	0	30-Jun-98	40					
Butte Slough at Lower Pass	thiobenc	0	07-Jul-98	40					
	Bear River at Berry Road			Also: USGS samples not included here					
site	name	conc	samp_date	udy_cd					
Bear River at Berry Road	diazinon	0.12	04-Jan-94	48					
Bear River at Berry Road	diazinon	0.16	04-Jan-94	48					
Bear River at Berry Road	diazinon	0.203	24-Jan-94	48					
Bear River at Berry Road	diazinon	0.135	24-Jan-94	48					
Bear River at Berry Road	diazinon	0	08-Feb-94	48					
Bear River at Berry Road	diazinon	0	09-Feb-94	48					
Bear River at Berry Road	diazinon	0	10-Feb-94	48					
Bear River at Berry Road	diazinon	0.05	17-Feb-94	48					
Bear River at Berry Road	diazinon	0.03	18-Feb-94	48					
Bear River at Berry Road	diazinon	0	19-Feb-94	48					
study 17: Gorder, N., K. Newhart, and J.M. Lee. 1995. Ir									
study 30: Gorder, N., K. Newhart, and J.M. Lee. 1996. Ir									
study 34: Gorder, N., K. Newhart, and J.M. Lee. 1997. Ir									
study 40: Gorder, N., K. Newhart, and J.M. Lee. 1998. Ir									
study 48: Holmes, R., C. Foe, and V. de Vlaming. 1998. Sources and concentrations of diazinon in the Sacramento									
USGS: Dileanis, P.D., J.L. Domagalski, and K.P. Bennett. 2000. Occurrence and transport of diazinon in the Sacra									
site	name	conc	samp_date	stud	samp_type_desc	lab_c	sa	anly_met	loq
Butte Slough at Lower Pass	molinate	0.093	04-Jan-94	48	Single whole water	9992	0	GC/MS---	0.007
Butte Slough at Lower Pass	molinate	0.14	12-Jan-94	48	Single whole water	5000	0	GC/MS---	0.11
Butte Slough at Lower Pass	molinate	0.13	24-Jan-94	48	Single whole water	9992	0	GC/MS---	0.007
Butte Slough at Lower Pass	molinate	0.128	24-Jan-94	48	Single whole water	5000	0	GC/MS---	0.11
Butte Slough at Lower Pass	molinate	0.15	25-Jan-94	48	Single whole water	5000	0	GC/MS---	0.11
Butte Slough at Lower Pass	molinate	0.142	26-Jan-94	48	Single whole water	5000	0	GC/MS---	0.11

Butte Slough at Lower Pass	molinate	0.11	26-Jan-94	48	Single whole water	9992	0	GC/MS---	0.007
Butte Slough at Lower Pass	molinate	0.127	27-Jan-94	48	Single whole water	5000	0	GC/MS---	0.11
Butte Slough at Lower Pass	molinate	0.147	28-Jan-94	48	Single whole water	5000	0	GC/MS---	0.11
Butte Slough at Lower Pass	molinate	0	04-Feb-94	48	Single whole water	5000	0	GC/MS---	0.11
Butte Slough at Lower Pass	molinate	0.084	08-Feb-94	48	Single whole water	9992	0	GC/MS---	0.007
Butte Slough at Lower Pass	molinate	0.12	09-Feb-94	48	Single whole water	9992	0	GC/MS---	0.007
Butte Slough at Lower Pass	molinate	0.076	10-Feb-94	48	Single whole water	9992	0	GC/MS---	0.007
Butte Slough at Lower Pass	molinate	0.075	11-Feb-94	48	Single whole water	9992	0	GC/MS---	0.007
Butte Slough at Lower Pass	molinate	0.081	12-Feb-94	48	Single whole water	9992	0	GC/MS---	0.007
Butte Slough at Lower Pass	molinate	0.072	13-Feb-94	48	Single whole water	9992	0	GC/MS---	0.007
Butte Slough at Lower Pass	molinate	0.087	17-Feb-94	48	Single whole water	9992	0	GC/MS---	0.007
Butte Slough at Lower Pass	molinate	0.089	20-Feb-94	48	Single whole water	9992	0	GC/MS---	0.007
Butte Slough at Lower Pass	molinate	0	14-Apr-95	17	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	0	16-May-95	17	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	0	23-May-95	17	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	6.4	30-May-95	17	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	7.4	01-Jun-95	17	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	8.4	06-Jun-95	17	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	6.1	08-Jun-95	17	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	3.4	13-Jun-95	17	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	3.9	15-Jun-95	17	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	8.5	20-Jun-95	17	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	6.3	22-Jun-95	17	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	7.3	29-Jun-95	17	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	7	29-Jun-95	17	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	6.2	03-Jul-95	17	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	3.1	06-Jul-95	17	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	2.7	11-Jul-95	17	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	2.1	18-Jul-95	17	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	0	01-Apr-96	30	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	0	23-Apr-96	30	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	0	30-Apr-96	30	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	0	07-May-96	30	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	0	09-May-96	30	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	0	14-May-96	30	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	2.47	16-May-96	30	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	5.94	18-May-96	30	Whole water	4323	0	GC/Nitro	0.5
Butte Slough at Lower Pass	molinate	3.74	21-May-96	30	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	8.69	23-May-96	30	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	14.8	26-May-96	30	Whole water	4323	0	GC/Nitro	0.5
Butte Slough at Lower Pass	molinate	13.6	28-May-96	30	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	14.45	30-May-96	30	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	15.7	04-Jun-96	30	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	11.15	06-Jun-96	30	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	13.23	11-Jun-96	30	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	11.91	13-Jun-96	30	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	7.55	18-Jun-96	30	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	3.11	25-Jun-96	30	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	0	31-Mar-97	34	Whole water	9996	0	GC/Nitro	1

Butte Slough at Lower Pass	molinate	0	22-Apr-97	34	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	0	29-Apr-97	34	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	0	06-May-97	34	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	1.67	08-May-97	34	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	9.83	13-May-97	34	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	11.22	15-May-97	34	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	15.16	20-May-97	34	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	11.04	22-May-97	34	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	16.42	27-May-97	34	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	12.12	29-May-97	34	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	11.62	03-Jun-97	34	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	8.27	05-Jun-97	34	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	7.16	10-Jun-97	34	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	6	12-Jun-97	34	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	2.85	17-Jun-97	34	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	2.41	24-Jun-97	34	Whole water	9996	0	GC/Nitro	1
Butte Slough at Lower Pass	molinate	0	31-Mar-98	40	Whole water	9996	0	HPLC/Po	1
Butte Slough at Lower Pass	molinate	0	05-May-98	40	Whole water	9996	0	HPLC/Po	1
Butte Slough at Lower Pass	molinate	0	12-May-98	40	Whole water	9996	0	HPLC/Po	1
Butte Slough at Lower Pass	molinate	0	19-May-98	40	Whole water	9996	0	HPLC/Po	1
Butte Slough at Lower Pass	molinate	0	21-May-98	40	Whole water	9996	0	HPLC/Po	1
Butte Slough at Lower Pass	molinate	0	26-May-98	40	Whole water	9996	0	HPLC/Po	1
Butte Slough at Lower Pass	molinate	0	28-May-98	40	Whole water	9996	0	HPLC/Po	1
Butte Slough at Lower Pass	molinate	0	02-Jun-98	40	Whole water	9996	0	HPLC/Po	1
Butte Slough at Lower Pass	molinate	2.21	04-Jun-98	40	Whole water	9996	0	HPLC/Po	1
Butte Slough at Lower Pass	molinate	8.27	09-Jun-98	40	Whole water	9996	0	HPLC/Po	1
Butte Slough at Lower Pass	molinate	6.75	11-Jun-98	40	Whole water	9996	0	HPLC/Po	1
Butte Slough at Lower Pass	molinate	12.17	16-Jun-98	40	Whole water	9996	0	HPLC/Po	1
Butte Slough at Lower Pass	molinate	7.6	18-Jun-98	40	Whole water	9996	0	HPLC/Po	1
Butte Slough at Lower Pass	molinate	5.04	23-Jun-98	40	Whole water	9996	0	HPLC/Po	1
Butte Slough at Lower Pass	molinate	3.14	25-Jun-98	40	Whole water	9996	0	HPLC/Po	1
Butte Slough at Lower Pass	molinate	5.82	30-Jun-98	40	Whole water	9996	0	HPLC/Po	1
Butte Slough at Lower Pass	molinate	2.46	07-Jul-98	40	Whole water	9996	0	HPLC/Po	1

Butte Slough - molinate

Information on Rice Pesticides Submitted to the California Regional Water Quality Control Board Central Valley Region

December 28, 1995

by

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California Environmental Protection Agency
Department of Pesticide Regulation
Environmental Monitoring and Pest Management Branch
Environmental Hazards Assessment Program
1020 N Street, Sacramento, California 95814-5624

Table 3. 1995 Pesticide Concentrations at the Colusa Basin Drain near Highway 20 in Colusa County (CBD5) in parts per billion (ppb). Samples collected by the Department of Pesticide Regulation unless noted otherwise.

	Molinate		Thiobencarb		Carbofuran		Methyl parathion		Malathion	
Laboratory	Primary	QC	Primary	QC	Primary	QC	Primary	QC	Primary	QC
Reporting limit	1.0	0.50	0.50	0.50	0.35	0.10	0.05	0.10	0.05	0.10
Date										
4/14	ND (ND)	ND	ND (ND)	ND	ND (ND)	ND	ND (ND)	ND	ND (ND)	ND
5/16	9.3	NS	ND	NS	0.70	NS	0.079	NS	1.033	NS
5/18	[8.2]	11.9	0.6	1.20	0.42	0.368	ND	ND	0.245	0.28
5/23	[15.4]	NS	[0.8]	NS	0.67	NS	0.0560	NS	ND	NS
5/25	25	32.9	0.7	0.870	ND	0.329	0.0675	ND	ND	ND
5/30	19	NS	1.2	NS	ND	NS	ND	NS	ND	NS
6/1	18	16.5	2.3	2.68	0.56	0.355	ND	ND	ND	ND
6/6	16.5 (11.8)	NS	1.3 (1.2)	NS	0.45 (0.44)	NS	ND (ND)	NS	ND (ND)	NS
6/8	17.8 (17.4)	18.4	3.5 (3.8)	3.7	0.34 (ND)	0.260	ND (ND)	ND	ND (ND)	ND
6/13	10.7 (10.7)	NS	1.7 (1.8)	NS	0.39 (0.35)	NS	ND (ND)	NS	ND (ND)	NS
6/15	13.9	13.3	0.8	0.872	ND	ND	ND	ND	ND	ND
6/20	10.4	NS	0.5	NS	ND	NS	ND	NS	ND	NS
6/22	8.5	10.1	0.5	0.758	0.40	ND	ND	ND	ND	ND
6/27	8.0	NS	1.8	NS	ND	NS	ND	NS	ND	NS
6/29	10	14.2	1.4	2.17	ND	0.314	ND	ND	ND	ND
7/3	8.5	NS	0.5	NS	ND	NS	ND	NS	ND	NS
7/6	5.1	5.23	0.6	0.682	ND	0.141	ND	ND	ND	ND
7/11	9.8	NS	ND	NS	ND	NS	ND	NS	ND	NS
7/13	3.2	3.19	ND	0.5	ND	0.124	ND	ND	ND	ND
7/18	3.3	NS	ND	NS	ND	NS	ND	NS	ND	NS
7/20	2.8	2.9	ND	ND	ND	0.178	ND	ND	ND	ND

Results in parentheses from samples collected by Klienfelder, Inc.
Results in brackets are the results of backup sample analyses

QC Quality Control
Blank Cells Results not yet reported

ND Not Detected
NS Not Sampled

Performance goals (ppb):

molinate	10	methyl parathion	0.13
thiobencarb	1.5	malathion	0.1
carbofuran	0.4		

*PRELIMINARY DATA--
SUBJECT TO CHANGE*

Table 4. 1995 Pesticide Concentrations at Butte Slough at Lower Pass Road in Sutter County in parts per billion (ppb). Samples collected by Klienfelder, Inc.

	Molinate	Thiobencarb	Carbofuran	Methyl parathion	Malathion
Date	Primary	Primary	Primary	Primary	Primary
4/14	ND	ND	ND	ND	ND
5/16	ND	ND	ND	ND	ND
5/23	[ND]	ND	ND	ND	ND
5/30	6.4	ND	0.57	ND	ND
6/1	7.4	ND	ND	0.187	ND
6/6	8.4	ND	0.37	ND	ND
6/8	6.1	ND	ND	ND	ND
6/13	3.4	ND	ND	ND	ND
6/15	3.9	1.1	ND	ND	ND
6/20	8.5	ND	0.37	ND	ND
6/22	6.3	1.3	ND	ND	ND
6/27	7.3	ND	ND	ND	0.639
6/29	7.0	ND	ND	ND	ND
7/3	6.2	ND	0.5	ND	ND
7/6	3.1	ND	ND	ND	ND
7/11	2.7	ND	ND	ND	ND
7/18	2.1	ND	ND	ND	ND

Results in brackets are the results of backup sample analyses.

Blank Cells Results not yet reported

ND Not Detected

Performance goals (ppb):

molinate	10
thiobencarb	1.5
carbofuran	0.4
methyl parathion	0.13
malathion	0.1

PRELIMINARY DATA--
SUBJECT TO CHANGE

Butte Slough – molinate

Information on Rice Pesticides Submitted to the California Regional Water Quality Control Board Central Valley Region

December 31, 1996

by

Nancy K. N. Gorder, J. Marshall Lee, and KayLynn Newhart

California Environmental Protection Agency
Department of Pesticide Regulation
Environmental Monitoring and Pest Management Branch
Environmental Hazards Assessment Program
1020 N Street, Sacramento, California 95814-5624

PRELIMINARY DATA/SUBJECT TO CHANGE

Table 4. 1996 Pesticide Concentrations at Butte Slough at Lower Pass Road in Sutter County in parts per billion (ppb). Samples collected by Kleinfelder, Inc. under contract with the California Rice Industry Association.

	Molinate	**Thiobencarb**	**Carbofuran**	**Methyl parathion**	**Malathion**
Laboratory type	Primary	Primary	Primary	Primary	Primary
Reporting limit (ug/l)	1.0	0.5	0.35	0.05	0.05
Date					
4/1	ND	ND	ND	ND	ND
4/23	ND	ND	ND	ND	ND
4/30	ND	ND	(ND)	ND	ND
5/7	ND	ND	ND	ND	ND
5/9	ND	ND	ND	ND	ND
5/14	ND	ND	ND	ND	ND
5/16	2.47	(1.3)	0.44	ND	ND
5/18[1]	5.94	2.04	1.04	NA	NA
5/21	3.74	ND	0.83	ND	ND
5/23	8.69	0.9	0.89	ND	ND
5/26[1]	14.80	ND	0.730	NA	NA
5/28	13.60	ND	0.59	ND	ND
5/30	14.45	ND	0.50	ND	ND

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Table 4. 1996 Pesticide Concentrations at Butte Slough at Lower Pass Road in Sutter County in parts per billion (ppb). Samples collected by Kleinfelder, Inc. under contract with the California Rice Industry Association.

	Molinate	Thiobencarb	Carbofuran	Methyl parathion	Malathion
Laboratory type	Primary	Primary	Primary	Primary	Primary
Reporting limit (ug/l)	1.0	0.5	0.35	0.05	0.05
Date					
6/4	15.70	1.4	ND	ND	ND
6/6	11.15	1.1	ND	ND	ND
6/11	13.23	0.7	ND	ND	ND
6/13	11.91	ND	ND	ND	ND
6/18	7.55	ND	ND	ND	ND
6/25	3.11	1.2	ND	ND	ND

Blank cells — Results not yet reported
ND — Not detected
NA — Not analyzed
( ) — Backup-split sample analyzed

PERFORMANCE GOALS (ppb):

molinate	10	methyl parathion	0.13	carbofuran	0.4
thiobencarb	1.5	malathion	0.1		

1 All samples on these dates were collected by the Department of Pesticide Regulation and analyzed by the California Department of Food and Agriculture analytical laboratory

PRELIMINARY DATA/SUBJECT TO CHANGE

Gorder & Lee, 1997. (CDPR) - Butte Slough - molinate

Department of Pesticide Regulation
Information on Rice Pesticides
Submitted to the Central Valley Regional Water Quality Control Board
December 23, 1997

Programs have been implemented by the Department of Pesticide Regulation (DPR) since 1983 to reduce discharges of the rice herbicides molinate (Ordram®) and thiobencarb (Bolero® and Abolish®) into surface waterways. In 1990, the objectives of these control efforts were clarified and expanded, following the adoption of amendments to the Central Valley Regional Water Quality Control Board's (Regional Board) Water Quality Control Plan (Basin Plan). This plan established performance goals for molinate and thiobencarb beginning in 1990, and for the insecticides carbofuran (Furadan®), methyl parathion, and malathion beginning in 1991. Regional Board staff are currently in the process of amending the pesticide section of the Basin Plan. This Basin Plan amendment will include defining numeric water quality objectives for the rice pesticides addressed in this program.

The following review describes the factors affecting quantities of molinate, thiobencarb, carbofuran, methyl parathion, and malathion discharged to agricultural drains and the Sacramento River and efforts to meet the performance goals in 1997. A summary of pertinent water quality monitoring efforts is provided. Programs implemented in 1997 helped control discharges of molinate, thiobencarb, carbofuran, methyl parathion, and malathion from rice fields to comply with the performance goals and the water quality objective for toxicity in the Basin Plan.

REVIEW OF 1997 PROGRAM

Discussion

A summary of the 1997 Rice Pesticides Program can be found in the following sections. Program requirements were implemented by county agricultural commissioners using restricted material permits. A description of the 1997 rice pesticide program requirements can be found in the guidelines provided to the county agricultural commissioners by the Director of DPR in a memorandum dated March 8, 1995 (see Appendix A). The 1995 permit conditions were determined appropriate for use in 1997. The commissioners also provided information to growers on the voluntary malathion program. Additional efforts were taken by DPR staff to continue improved communication about the seepage and drift problems to the rice industry. Aspects of the 1995-7 program that were different from the 1994 program are summarized in Appendix B.

Table 4. 1997 Pesticide Concentrations at Butte Slough at Lower Pass Road in Sutter County in parts per billion (ppb).

	Molinate	Thiobencarb	Carbofuran	Methyl parathion	Malathion
Laboratory type	Primary	Primary	Primary	Primary	Primary
Reporting limit (ug/l)	1.0	0.5	0.35	0.05	0.05
Date					
3/31	ND	ND	ND	ND	ND
4/22	ND	ND	ND	ND	ND
4/29	ND	ND	ND	ND	ND
5/06	ND	ND	0.59	ND	ND
5/08	1.67	ND	0.55	0.07	ND
5/13	9.83	ND	ND	ND	ND
5/15	11.22	ND	ND	ND	ND
5/20	15.16	1.0	0.39	ND	ND
5/22	11.04	1.5	0.37	ND	ND
5/27	16.42	2.2	ND	ND	ND
5/29	12.12	1.6	ND	ND	ND

Samples collected by Kleinfelder, Inc. under contract with the California Rice Industry Association.
Continued on next page...

Table 4, continued. 1997 Pesticide Concentrations at Butte Slough at Lower Pass Road in Sutter County in parts per billion (ppb).

	Molinate	Thiobencarb	Carbofuran	Methyl parathion	Malathion
Laboratory type	Primary	Primary	Primary	Primary	Primary
Reporting limit (ug/l)	1.0	0.5	0.35	0.05	0.05
Date					
6/3	11.62	1.0	ND	ND	ND
6/5	8.27	1.0	ND	ND	0.05
6/10	7.16	0.6	ND	ND	ND
6/12	6.00	ND	ND	ND	ND
6/17	2.85	ND	ND	ND	ND
6/24	2.41	ND	ND	ND	ND

Key to designations on rice water monitoring table for Butte Slough:

Blank cells	Results not yet reported
ND	Not detected
NS	Not sampled

PERFORMANCE GOALS (ppb):

molinate	10	methyl parathion	0.13
thiobencarb	1.5	malathion	0.1
carbofuran	0.4		

Butte Slough - molinate

Information on Rice Pesticides
Submitted to the
California Regional Water Quality Control Board
Central Valley Region

December 31, 1998

by

Nancy K. N. Gorder and KayLynn Newhart

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Department of Pesticide Regulation
Environmental Monitoring and Pest Management Branch
Environmental Hazards Assessment Program
830 K Street, Sacramento, California 95814-3510

PRELIMINARY DATA/SUBJECT TO CHANGE

Table 6. 1998 Pesticide Concentrations at Butte Slough at Lower Pass Road in Sutter County in parts per billion (ppb).

	Molinate	Thiobencarb	Carbofuran	Methyl parathion	Malathion
Laboratory type	Primary	Primary	Primary	Primary	Primary
Reporting limit (ug/l)	1.0	0.5	0.35	0.05	0.05
Date					
3/31	ND	ND	ND	ND	ND
5/05	ND	ND	ND	ND	ND
5/12	ND	ND	ND	ND	ND
5/19	ND	ND	ND	ND	ND
5/21	ND	ND	ND	ND	ND
5/26	ND	ND	ND	ND	ND
5/28	ND	ND	ND	ND	ND
6/02	ND	ND	ND	ND	ND
6/04	2.21	0.60	ND	ND	ND
6/09	8.27	0.60	ND	ND	ND
6/11	6.75	0.60	ND	ND	ND
6/16	12.17	1.9	ND	ND	ND

Samples collected by Kleinfelder, Inc. under contract with the California Rice Industry Association.

Key to designations on rice water monitoring tables:

Blank cells	Results not yet reported
ND	Not detected
NS	Not sampled

PERFORMANCE GOALS (ppb):

molinate	10.0	methyl parathion	0.13
thiobencarb	1.5	malathion	0.10
carbofuran	0.4		

PRELIMINARY DATA/SUBJECT TO CHANGE

Table 6. 1998 Pesticide Concentrations at Butte Slough at Lower Pass Road in Sutter County in parts per billion (ppb), continued.

	Molinate	Thiobencarb	Carbofuran	Methyl parathion	Malathion
Laboratory type	Primary	Primary	Primary	Primary	Primary
Reporting limit (ug/l)	1.0	0.5	0.35	0.05	0.05
Date					
6/18	7.60	1.20	ND	ND	ND
6/23	5.04	0.60	ND	ND	ND
6/25	3.14	ND	ND	ND	ND
6/30	5.82	ND	ND	ND	ND
7/07	2.46	ND	ND	ND	ND

Samples collected by Kleinfelder, Inc. under contract with the California Rice Industry Association.

Key to designations on rice water monitoring tables:

PERFORMANCE GOALS (ppb):

Blank cells	Results not yet reported				
ND	Not detected	molinate	10.0	methyl parathion	0.13
NS	Not sampled	thiobencarb	1.5	malathion	0.10
		carbofuran	0.4		

Butte Slough - molinate

Information on Rice Pesticides Submitted to the California Regional Water Quality Control Board Central Valley Region

December 31, 1999

by

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Environmental Monitoring and Pest Management Branch
Environmental Hazards Assessment Program
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PRELIMINARY DATA/SUBJECT TO CHANGE

Table 4. 1999 Pesticide Concentrations at Butte Slough at Lower Pass Road in Sutter County in parts per billion (ppb).

	Molinate	Thiobencarb	Carbofuran	Methyl parathion	Malathion
Laboratory type	Primary	Primary	Primary	Primary	Primary
Reporting limit (ug/L)	1.0	0.5	0.35	0.05	0.05
Date					
4/13	ND	ND	ND	ND	ND
4/27	NS	NS	ND	ND	ND
5/4	NS	NS	ND	ND	ND
5/11	NS	ND	ND	ND	ND
5/18	4.0	ND	0.77	ND	ND
5/25	5.0	0.6	ND	0.051	ND
6/1	9.0	1.1	ND	ND	ND
6/8	6.8	4.1	ND	ND	0.067
6/15	5.0	0.7	ND	ND	ND
6/22	ND	ND	ND	NA	NA

Samples collected by Kleinfelder, Inc. under contract with the California Rice Research Board.
Refer to key for Butte Slough (BS1) designations listed at the end of data table for Sacramento River at Village Marina (SR1)

Butte Slough - molinate

Information on Rice Pesticides

Submitted to the California Regional Water Quality Control Board

December 31, 2000

By

KayLynn Newhart, DeeAn Jones, Sainey Ceesay

California Environmental Protection Agency

Department of Pesticide Regulation

Environmental Monitoring and Pest Management Branch

Environmental Hazards Assessment Program

830 K Street, Sacramento, California 95814-3510

Table 3. 2000 Pesticide Concentrations at Butte Slough at Lower Pass Road in Sutter County in parts per billion (ppb).

	Molinate	Thiobencarb	Carbofuran	Methyl Parathion	Malathion
Sample type	Primary	Primary	Primary	Primary	Primary
Reporting Limit (ppb)	1.0	0.5	0.35	0.05	0.05
Date					
10-Apr	ND	ND	ND	ND	ND
25-Apr	NS	NS	ND	ND	ND
2-May	NS	NS	ND	ND	ND
9-May	NS	ND	ND	ND	ND
16-May	2.07	1.6	ND	ND	ND
23-May	6.65	1.0	ND	ND	ND
30-May	11.5	1.6	ND	ND	ND
06-Jun	5.73	1.1	ND	ND	ND
13-Jun	10.5	1.1	ND	ND	ND
20-June	NS	ND	ND	ND	ND

Samples collected by Kleinfelder, Inc. under contract with California Rice Research Board.
Key to designations for rice water monitoring table for CBD5:

QC	Quality Control	PERFORMANCE GOALS(ppb):			
ND	Not Detected	molinate	10.0	carbofuran	0.4
NS	Not Sampled	thiobencarb	1.5	malathion	0.1
NA	Not Analyzed	methyl parathion	0.13		

Black Butte Res. -
Hg

B.1.7 Black Butte Reservoir, Mercury

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region (Regional Board) recommends the addition of Black Butte Reservoir to California's Clean Water Act Section 303(d) list due to impairment by mercury. Information available to the Regional Board on mercury levels in fish tissue samples indicates that water quality objectives are not being attained in Black Butte Reservoir. The description for the basis for this determination is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Black Butte Reservoir	**Pollutants/Stressors**	Mercury
Hydrologic Unit	522.12	**Sources**	Resource Extraction (abandoned mines)
Total Waterbody Size	4,500 acres	**TMDL Priority**	
Size Affected	4,500 acres	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	All of Black Butte Reservoir	**TMDL End Date (Mo/Yr)**	

Watershed Characteristics

Black Butte Reservoir is located on Stony Creek along the eastern side of the California Coast Ranges. The reservoir straddles Glenn and Tehama Counties, which are primarily agricultural counties in the Central Valley. Black Butte Reservoir is operated by the U.S. Army Corps of Engineers. Water storage in this reservoir began in 1963. The reservoir covers a maximum of about 4,500 acres of water (Brodberg and Pollock, 1999). This is a warm water reservoir that supports primarily largemouth bass, crappie, catfish, and bluegill. Sport fishing is popular on the reservoir.

Water Quality Objectives Not Attained

The narrative objective for toxicity is not being attained for mercury in Black Butte Reservoir. The narrative toxicity objective in the Basin Plan states, in part, "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life." The narrative toxicity objective further states that "The Regional Water Board will also consider … numerical criteria and guidelines for toxic substances developed by the State Water Board, the California Office of Environmental Health Hazard Assessment, the California Department of Health Services, the U.S. Food and Drug Administration, the National Academy of Sciences, the U.S. Environmental Protection Agency, and other appropriate organizations to evaluate compliance with this objective" (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/~rwqcb5/bsnplnab.pdf).

Numeric criteria for mercury in fish tissue have been developed for both human health and wildlife protection. The U.S. Environmental Protection Agency (USEPA) recently established a human health protection criterion of 0.3 milligrams per kilogram (mg/kg; equivalent to parts per million [ppm]) methylmercury in the edible portions of fish (USEPA, 2001b). This criterion is used to determine attainment of the narrative toxicity objective.

Evidence of Impairment

The Office of Environmental Health Hazard Assessment (Brodberg and Pollock, 1999) collected trophic level 3 (carp, crappie and channel catfish) and level 4 (largemouth bass) fish tissue samples for Black Butte Reservoir. Trophic level 3 fish feed on zooplankton, phytoplankton, and benthic invertebrates. Trophic level 4 fish consume trophic level 3 fish as part of their diet. Methylmercury and total mercury bioaccumulate in aquatic organisms and tend to be present in higher concentrations with increasing trophic levels (USEPA, 1997a).

Fish were collected from three regions of the reservoir: Burris Creek Arm, Stony Creek Arm, and Angler's Cove (the area including Fisherman's Cove and extending to the dam). Samples were collected on November 25, and December 4 and 5, 1997. Muscle tissues from individual fish were combined into composite samples for chemical analysis. One composite sample of carp (three fish) and one composite sample of crappie (three fish) were prepared. Nine composite samples of largemouth bass (three fish each) were prepared- two from Angler's Cove, four from Stony Creek Arm and three from Burris Creek Arm. Eight composite samples of channel catfish (four fish each) were prepared-- one was from Angler's Cove, four were from Stony Creek Arm, and three were from Burris Creek Arm.

Mercury concentrations in the carp and crappie composite samples were 0.3 and 0.34 ppm, respectively. The average mercury concentration in the channel catfish composite samples was 0.4 ppm. The eight catfish composite samples had mercury values ranging from 0.34 to 0.5 ppm. The average mercury concentration in the largemouth bass composite samples was 0.7 ppm. The nine bass composite samples had mercury values ranging from 0.37 to 1.3 ppm (Brodberg and Pollock, 1999). See Table B-2 for a summary of mercury concentrations in the composite samples based on trophic level.

In 2000, OEHHA issued a draft health advisory for Black Butte Reservoir and guidelines for fish consumption due to elevated mercury levels in fish (OEHHA, 2000).

Table B-2. Summary of Mercury Concentrations in Fish Tissue Composite Samples from Black Butte Reservoir

Data Source	Brodberg and Pollock (1999)
Sample Date	11/25/97, 12/4-5/97
Trophic Level 3 Fish	
Number of Composite Samples	38
Mean Mercury Concentration (ppm)	0.39
Range of Mercury Concentrations (ppm)	0.30 – 0.50
Percent of Samples at or above USEPA Criterion (0.3 ppm)	100%
Trophic Level 4 Fish	
Number of Composite Samples	27
Mean Mercury Concentration (ppm)	0.70
Range of Mercury Concentrations (ppm)	0.37 – 1.3
Percent of Samples at or above USEPA Criterion (0.3 ppm)	100%

Extent of Impairment

Since fish were sampled in various parts of the reservoir and all samples were above the USEPA mercury criterion (0.3 ppm), the evidence suggests the entire waterbody (4,500 acres) is impaired by mercury.

Potential Sources

The predominant sources of mercury in Black Butte Reservoir were from cinnabar deposits, which were mined for mercury in the Black Butte Reservoir watershed.

Back up data for
Black Butte + San Pablo Hg
fact sheets

Cooke

PREVALENCE OF SELECTED TARGET CHEMICAL CONTAMINANTS IN SPORT FISH FROM TWO CALIFORNIA LAKES: PUBLIC HEALTH DESIGNED SCREENING STUDY

FINAL PROJECT REPORT

EPA Assistance Agreement No. CX 825856-01-0

Prepared by

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Pesticide and Environmental Toxicology Section
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California Environmental Protection Agency
301 Capitol Mall, Second Floor
Sacramento, California 95814

June 1999

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1. STUDY OBJECTIVES AND BACKGROUND

The objective of this study, hereafter referred to as the California Lakes Study, was to measure the levels of selected target chemicals in fish from two California lakes in order to provide an initial data base to determine whether additional sampling and health evaluation of the data are warranted in either lake. San Pablo Reservoir and Black Butte Reservoir were selected primarily because geological data suggested that the levels of mercury in some sport fish in these lakes might reach levels of concern for frequent fish consumers. Also, populations consuming high amounts of fish (e.g., subsistence fishers) were believed to fish in these lakes.

Black Butte Reservoir is on the eastern side of the California coast range. The lake straddles Glenn and Tehama Counties, which are primarily agricultural counties in the Central Valley, and is located north of other more populated urban areas such as Sacramento. Cinnabar deposits were mined for mercury throughout the coast range and fish consumption advisories based primarily on mercury concentrations in fish muscle tissue remain in force on several lakes in the coast range. There are consumption advisories for fish in Lake Berryessa and Clear Lake which are near Black Butte Reservoir (OEHHA,1987). This suggested that other lakes in this mountain range might contain bioavailable mercury that could build up to levels of concern in higher trophic level fish. The Toxic Substances Monitoring Program collected a very limited number of samples of fish from Black Butte in 1984 and 1985 (Water Resources Control Board, 1990). Two fillet sample of largemouth bass contained 0.18 and 0.26 ppm mercury and two fillet samples of crappie contained 0.05 and 0.42 ppm of mercury, respectively.

Black Butte Reservoir is operated by the U.S. Army Corps of Engineers. Storage in this reservoir began in 1963 and the lake covers a maximum of about 4500 surface acres of water. This is a warm water reservoir that supports primarily largemouth bass, crappie, catfish (channel, and some white and bullheads), and bluegill. There are three boat ramps, a small marina, and camping and day-use areas. Boat launching fees are charged and a California fishing license is required for sport fishers. Many fishers fish from boats but shore fishing sites are also available. According to staff in the local Women Infants and Children Program (WIC), Black Butte Reservoir is a popular fishing site for Hmong living in the northern Central Valley.

San Pablo Reservoir is also located in the coast range but it is on the western side near San Francisco Bay. San Pablo Reservoir is in Contra Costa County, which is a highly populated suburban county in the San Francisco Bay area. There are existing fish consumption advisories for fish in several lakes in a watershed in nearby Santa Clara County due to mercury levels in fish tissue (California Department of Health Services, 1987). There is also a consumption advisory for San Francisco Bay fishes due primarily to mercury and levels of PCBs in fish tissue (OEHHA, 1994). Prior to this study, no fish samples had been collected and analyzed for chemical contaminants from this lake. A survey by the Asian Pacific Environmental Network (APEN) found that this is a very popular fishing location for many fishers from the Laotian community in Contra Costa County (APEN, 1998).

San Pablo Reservoir is operated by the East Bay Municipal Utility District. The lake covers about 860 surface acres of water. The Reservoir is operated as a day-use facility for about nine months during the year. It closes to the public in mid-November and reopens in mid-February. Picnicking facilities are available and there are two boat ramps and a small rental marina. A separate fee is charged for parking, fishing or launching boats. A California fishing license is also required. These fees help support a large fish stocking program. The lake is stocked with rainbow trout and channel catfish. Fish are stocked as often as 1-3 times a week depending on the season. Typically about 1,000 pounds of a species are added at each stocking. In addition to these stocked species, this warm water reservoir also contains largemouth bass, crappie, bluegill, carp and some sturgeon which were previously planted.

2. FISH SAMPLING AND COMPOSITING

The fish sampling and sample preparation methods used in this study are described in more detail in the Quality Assurance Project Plan (QAPP, Appendix 1). In general, fish were collected from a boat using electroshocking, fyke nets or gill nets. After capture, fish were maintained in a live well until they could be processed for transport to the analytical laboratory. The weight and length of individual fish were measured on shore and the fish were identified according to species, wrapped in aluminum foil bags and frozen on dry ice for transport.

The desired target species for collection and an approximate number of fish to be collected per lake were identified in consultation with the USEPA contract manager and USEPA Region 9 staff before the field sampling was initiated. Fish samples were grouped by species and size (total length). The actual number of composites of each species and the number and sizes of fish in individual sample composites were decided after the collection at each lake was completed. Fish species were selected and composites were organized with the intent of maximizing the amount of information on popular sport fish of different species and sizes that are caught and consumed from each lake. Composites were made from muscle tissue of individual fish as described in the QAPP (Appendix 1).

Fish samples were collected at San Pablo Reservoir on November 5, 6, 12 and 13, 1997. The target species selected were largemouth bass, crappie, carp, rainbow trout and channel catfish. Samples of largemouth bass, rainbow trout and carp were collected along the shoreline using electroshocking. Crappie were collected in fyke nets, and channel catfish were collected primarily by gill netting. Samples were designated as being collected in the north (the dam is in the north area) or south reaches of this smaller oval lake. Additional details on the collection locations, times and methods are included in the Environmental Chemistry Data and Quality Assurance Report (Department of Fish and Game, 1999)(Appendix 2).

Fish samples from San Pablo Reservoir were made into twelve composites. In some cases, fish of the same species from the northern location were included with individuals from the south area to maintain size classes. This was done because analyzing more samples based on consistent size classes was deemed to be more important than comparing fish caught at different locations. Differences in chemical contamination at different locations were not expected in this small lake and would have required collecting more replicate samples to increase the probability of detecting differences. Two composites were made of rainbow trout (three fish each), channel catfish (four fish each), and carp (four fish each). Five composites were made of largemouth bass (three fish each), and one composite of crappie (four fish each). The average length, weight and estimated age of fish in these composites are given in Table 1.

Fish samples were collected at Black Butte Reservoir on November 25, and December 4 and 5, 1997. The target species selected for Black Butte were largemouth bass and channel catfish. Crappie and carp were taken as by-catch. Samples of largemouth bass were collected along the shoreline using electroshocking. Crappie, carp and channel catfish were collected primarily by gill netting. This lake has two creek inlets and other irregular coves and these features were used to identify three sample stations. Samples were collected from Burris Creek Arm, Stony Creek Arm, and Angler's Cove (Fisherman's Cove and extending to the dam). Additional details on the collection locations, times and analytical methods are included in the Environmental Chemistry Data and Quality Assurance Report (Department of Fish and Game, 1999)(Appendix 2).

Fish samples from Black Butte Reservoir were made into nineteen composites. One composite of carp (three fish) and one composite of crappie (three fish) were included to get some information on these species in this lake. The crappie composite had to be made from fish from two locations. The carp composite was from Angler's Cove. Nine composites were made of largemouth bass (three fish each), and eight composites were made of channel catfish (four fish each). Two largemouth bass composites and one channel catfish composite were from Angler's Cove. Four largemouth bass and four channel catfish composites were from the Stony Creek Arm. And three largemouth bass and three channel catfish composites were from the Burris Creek Arm. The average length, weight and estimated age of fish in these composites are given in Table 2.

3. CHEMICAL ANALYSIS

Chemical analyses were done as described in the QAPP. The California Department of Fish and Game Water Pollution Control Laboratory (WPCL) dissected fish muscle tissue, made it into the designated composites discussed above, and homogenized the tissue composites. Nine composites were split and 100 grams of homogenized tissue were delivered to the California Department of Toxic Substances Control Hazardous Materials Laboratory (HML) for analysis of dioxins/furans and three PCB congeners. Homogenates of one composite each of rainbow trout, channel catfish, largemouth bass, crappie and carp from San Pablo Reservoir were extracted and analyzed by HML. Homogenates of two composites each of largemouth bass and channel catfish from Black

Butte Reservoir were extracted and analyzed by HML. HML analyzed these samples for 7 chlorinated dibenzodioxin compounds, 10 chlorinated dibenzofuran compounds and three coplanar PCB congeners. See the HML data report (May 19, 1998)(Appendix 3) for additional details. WPCL extracted and analyzed all composite homogenates for 4 metals and 35 organic compounds, plus 46 PCB congeners. See the Environmental Chemistry Data and Quality Assurance Report (Department of Fish and Game, 1999) for additional details on the chemicals analyzed, analytical methods, and detection limits (Appendix 2).

4. ANALYTICAL RESULTS AND QUALITY ASSURANCE

The chemical results and quality assurance measures are discussed in more detail in the HML data report (Petreas, May 19, 1998) (Appendix 3) and the Environmental Chemistry Data and Quality Assurance Report (Department of Fish and Game, 1999) (Appendix 2), and memoranda from Dr. Gerald Pollock, (June 17, 1998; December 30, 1998; June 7, 1999) the project quality assurance officer (Appendix 4).

Some problems were noted in the analyses. Disulfoton, a target chemical analyte being analyzed for the first time, was not successfully measured by the method used. Further investigation showed that it was lost on the Florisil column used in a cleanup step. Since a relatively small amount of disulfoton was applied to crops in California (0.05% of total pound applied in 1995, Department of Pesticide Regulation, 1996) the loss of this analyte was not critical. Low level PCB contamination in glassware was also observed for some congeners. The level was low enough that it did not impact the evaluation of samples for health concerns. Overall there were no major problems that compromised the analytical results.

The final data reported by both laboratories were judged to pass Quality Assurance as outlined in the QAPP (Dr. Pollock, June 7, 1999). Therefore, these data, as qualified by the analytical laboratories, may be used for evaluation of tissue concentrations of chemicals of human health concern in sport fish from San Pablo Reservoir and Black Butte Reservoir.

5. COMPARISON OF CHEMICAL RESULTS TO SCREENING VALUES

Screening Values were established in the QAPP for a number of chemicals specifically for the California Lakes Study. The Screening Value (SV) approach is recommended by USEPA (1995) to identify chemical contaminants in fish tissue at concentrations which may be of human health concern for frequent consumers of sport fish. The SVs are not intended as levels at which consumption advisories should be issued but are useful as a guide to identify fish species and chemicals from a limited data set, such as this one, for which more intensive sampling, analysis or health evaluation are to be recommended. The USEPA has recommended SVs for 25 specific chemical contaminants that have been observed to bioaccumulate in fish tissues in various waterways throughout the United

States. Some of the chemicals for which USEPA has recommended SVs were not used extensively in California. Screening Values specific to the California Lakes Study (CLS-SVs) were described and calculated in the QAPP for chemicals that were used in California and were more likely to bioaccumulate in sport fish in California lakes. The USEPA and CLS-SVs for these chemicals are reproduced from the QAPP in Table 3.

Table 4 shows the range of chemical concentrations measured in fish from San Pablo Reservoir for which there are CLS-SVs in Table 3. The CLS-SVs for individual chemicals were not exceeded in any samples in most species. The shaded boxes in Table 4 indicate fish species for which at least a portion of the chemical concentration range exceeded the CLS-SV. These chemicals and species are examined closely in the next section.

The CLS-SVs for chlordane, total DDT, dieldrin, heptachlor expoxide, toxaphene, PCBs and dioxin TEQ were exceeded by all channel catfish samples from San Pablo Reservoir. Channel catfish are stocked in this lake and show the highest levels of a number of canceled pesticides, PCBs and dioxin TEQ. Therefore, it is possible to postulate that some of these chemicals were accumulated from environmental or feed exposures at the fish farm(s) at which the catfish were raised. The stocked rainbow trout did not show this same pattern of chemicals. They only exceeded the CLS-SVs for dieldrin and PCBs. And levels of these chemicals in trout were about ten times lower than for the same chemicals in the channel catfish.

Among resident fish species at San Pablo Reservoir, carp exceeded the CLS-SVs for chlordane, dieldrin, PCBs and dioxin TEQ. Their levels of these chemicals were about one-fourth of those measured in the catfish. Largemouth bass also exceeded the CLS-SVs for dieldrin and PCBs, but not chlordane and dioxin TEQ; and the levels in bass were lower than in carp. Largemouth bass, however, were the only species for which any and all samples exceeded the CLS-SV for mercury in San Pablo Reservoir. The single crappie sample had the lowest level for all CLS-SV chemicals and just barely exceeded the CLS-SV for dieldrin.

Table 5 shows the range of chemical concentrations measured in fish from Black Butte Reservoir for which there are CLS-SVs in Table 3. Even fewer CLS-SVs were exceeded in fish in this lake than in San Pablo Reservoir. Again, the shaded boxes in Table 5 indicate fish species for which some portion of the range of chemical concentration exceeds the CLS-SV. These chemicals and species are examined closely in the next section.

All samples in all fish species (i.e., carp, crappie, channel catfish and largemouth bass) in Black Butte Reservoir exceeded the CLS-SV for mercury. Channel catfish are the only species for which any of the CLS-SVs for pesticides are exceeded. In this case the toxaphene CLS-SV was exceeded in some samples. Some largemouth bass samples just barely exceeded the CLS-SV for PCBs. In general, the data suggest that fewer organic chemicals accumulated in fish in this lake.

6. EVALUATION OF FISH EXCEEDING SCREENING VALUES IN EACH RESERVOIR

The mean total length, weight, percent lipid, and estimated age of the fish in all composites from San Pablo and Black Butte Reservoirs are given in Tables 1 and 2, respectively. These data are summarized from Appendix 2 (Department of Fish and Game, 1999). The mean chemical concentrations in each fish species from San Pablo and Black Butte Reservoirs for chemicals for which there are CLS-SVs are given in Tables 6 and 7, respectively. The information in these Tables is referred to in the discussion below.

Stocked and resident fish species can be caught from San Pablo Reservoir so both were sampled in this study. The stocked fish collected for this study were captured from the lake and their residence time in San Pablo Reservoir prior to capture is not known. The estimated ages of rainbow trout and channel catfish given in Table 1 are not an accurate indicator of residence time because fish of different sizes and ages are stocked in the lake.

Two composites of rainbow trout from San Pablo Reservoir were analyzed. Only the CLS-SVs for dieldrin and PCBs were exceeded in these samples. The larger and older trout in composite A had 4.6 ppb dieldrin which is twice the dieldrin CLS-SV of 2 ppb. The smaller and younger trout in composite B had 1.6 ppb dieldrin which is essentially at the CLS-SV. Both trout composites showed essentially the same concentrations of PCBs (i.e., 20 and 18 ppb Aroclor 1254). This is right at the CLS-SV of 20 ppb for PCBs expressed as Aroclors and the mean PCB level in trout (19 ppb) is just below the CLS-SV. This is a limited sample of this species and it would be worthwhile to collect and analyze additional samples to better characterize the levels of the chemicals in the trout population that are at the CLS-SV levels. This stocked species could be sampled directly from the fish farm(s).

Two samples of channel catfish from San Pablo Reservoir were analyzed. The chemical concentrations in the composite of larger-sized and medium-sized catfish were well above (at least twice the value) the CLS-SVs for chlordane (30 ppb), dieldrin (2 ppb), toxaphene (30 ppb), PCBs (20 ppb) and dioxin TEQ (0.3 ppt). The concentrations of total DDT (SV 100 ppb) and heptachlor expoxide (SV 4 ppb) also exceeded the CLS-SVs but by less than twice the value, even in the composite of larger sized catfish. These fish have accumulated several pesticides, as well as PCBs to concentrations above the CLS-SVs. Although the dioxin TEQ also exceeded the CLS-SV, this observed concentration is within the USEPA background range for fish (1.2 ± 1.6 ppt) and similar to the level found in some fish from San Francisco Bay (Pollock, May 27, 1998). Two composites is a limited sample of this species and it would be important to collect and analyze additional samples to better characterize the levels of all chemicals in the catfish population that are at or above the CLS-SV level.

Two samples of carp from San Pablo Reservoir were analyzed, and one was analyzed in duplicate. The concentrations of chlordane, dieldrin, PCBs and dioxin TEQ exceeded the

CLS-SVs in both carp composites analyzed. Because carp are bottom feeders and have high lipid content they are more likely than the other two resident species sampled to accumulate these hydrophobic chemicals. The highest values for chlordane and dioxin TEQ in carp were about twice their respective CLS-SVs. The dioxin TEQ value was within the USEPA range for background levels of dioxin in fish tissue (see above). The highest values for dieldrin and PCBs in carp were greater than twice their respective CLS-SVs. Two composites is a limited sample of this species and it would be worthwhile to collect and analyze additional samples to better characterize the levels of those chemicals in the catfish population that are at or above the CLS-SV level.

The resident carp have feeding habits similar to the channel catfish introduced into San Pablo Reservoir (both are bottom feeders). A comparison of the concentrations of chlordane, total DDT, dieldrin, heptachlor expoxide, toxaphene, PCBs and dioxin TEQ for these two species showed less accumulation on a wet weight basis in the carp than in the channel catfish (see Tables 4 and 6). In general, the concentrations of these chemicals in channel catfish were about three to four times greater than in the carp, although the catfish are of equal or smaller size (see ratios in Table 8). One hypothesis to explain this difference is that since the channel catfish were a stocked species it is possible that some of the contamination was due to exposure during the raising of these fish.

A comparison between the concentration of lipophilic organic chemicals in the stocked channel catfish and the resident carp can be used to test this hypothesis. If exposed to equal concentrations of lipophilic organic chemicals these species are expected to bioaccumulate similar levels of these chemicals due to their similar feeding habits (bottom feeders) and high lipid content of their muscle tissue (catfish mean lipid, 11.2%; carp mean lipid, 7.3%). A comparison with other resident species would be less appropriate because the crappie and largemouth bass are not bottom feeders and had low lipid content (0.3% and 0.6%, respectively).

Table 8 shows the ratios of the concentration of chlordane, total DDT, dieldrin, heptachlor expoxide, toxaphene, PCBs and dioxin TEQ in channel catfish and carp from San Pablo Reservoir. The relative pattern of abundance of these chemicals in these two species was very similar. The concentrations of all of these lipophilic organic chemicals in channel catfish were about 3-4 times that in the carp. A comparison between the ratios of lipid normalized and age normalized concentrations of chemicals for these species is also shown in Table 8. These data were normalized to see if the higher lipid content and/or greater age of the channel catfish might account for this large and consistent difference in chemical concentrations between these species. Normalizing the chemical concentration data is a simple way of discovering whether the factor used to adjust the concentration accounts for some of the variation in the data. The analysis discussed here and shown in Table 8 is limited because the data base for carp (2 composites) and channel catfish (2 composites) is small. More sophisticated and powerful statistical methods could be used if more replicate samples were available.

The normalized results in Table 8 showed that lipid content and age contribute to this difference in concentration. Adjusting for lipid content approximately reduced the unadjusted ratio by 50% and adjusting for age reduced the apparent higher bioaccumulation in catfish to a ratio of 1.5 or less for all chemicals. This showed that much of the variation in chemical concentration between the carp and the catfish was due to differences in the age and/or lipid content of these species. Although the conclusion is limited by the small data base, this suggests that the differences in chemical concentration observed between these species may be accounted for by differences in age and lipid content and are not because catfish were raised and exposed elsewhere part of their lives. The pattern of relative abundance of these chemicals in these two species also supports a common exposure. The catfish were approximately 7-11 years old and had probably survived several years in San Pablo Reservoir after stocking. So, it appears unlikely that the catfish bioaccumlated much of their observed tissue concentration from a source other than San Pablo Reservoir. To eliminate this possibility, additional samples should be collected directly from the fish farm(s) providing channel catfish and the results compared to additional samples collected from the reservoir.

The CLS-SV for dieldrin was also exceeded in all five composites of largemouth bass from San Pablo Reservoir by two to four times the CLS-SV value. All of these composites were near the CLS-SV for PCBs expressed as Aroclors. One of these composites was of large-sized fish, two were medium-sized and two were small-sized fish. Only the composite from the largest (mean total length 543 mm) and oldest (about 8 years of age) fish was above the SV for PCBs. However, largemouth bass of all legal sizes (above 305 mm) and ages (about 3-8 years) exceeded the CLS-SV for mercury (300 ppb). The mercury concentration increased with the average size and age of the fish in these composites. These are based on an adequate number of samples and distribution of fish sizes to characterize the largemouth bass population for this lake. Therefore, the results can be considered representative of chemical concentrations in the largemouth bass population.

Only one composite of crappie was available for analysis so this was a very limited sample. The concentrations of most chemicals were lower in crappie than in the other sampled species. The dieldrin concentration was at the CLS-SV. This was the only CLS-SV exceeded in this species in San Pablo Reservoir. Additional samples of this species should be collected and analyzed to better characterize the dieldrin levels in the crappie population at San Pablo Reservoir.

As noted in the previous section, very few CLS-SVs were exceeded in composites of fish sampled from Black Butte Reservoir (see Tables 5 and 7). Mercury was an exception; the mercury CLS-SV was reached or exceeded in all sampled species. These results were less compelling for carp and crappie because only one composite was analyzed for each of these species. The mercury CLS-SV is 300 ppb and the mercury concentrations in carp and crappie were 300 and 340 ppb, respectively. In channel catfish, however, all 8 composites exceeded the CLS-SV and the average mercury concentration was 400 ppb. All nine largemouth bass composites exceeded the CLS-SV and the average mercury concentration was 700 ppb. Mercury concentration tends to increase with increasing fish size and age in largemouth bass. However, this relationship was not evident in the channel catfish in Black Butte Reservoir.

A good number of samples and a distribution of fish sizes were obtained for the largemouth bass (9 composites, 2 large 3 medium and 4 small-sized) and channel catfish (8 composites, 4 large and 4 medium-sized) in Black Butte Reservoir. The chemical results for each respective species are consistent and are considered representative of the population of largemouth bass or channel catfish in the lake. Additional samples of carp and crappie should be collected and analyzed to better characterize the levels of mercury in these populations in the lake.. This is especially important because the levels measured in the limited sampling are very near the CLS-SV level.

The CLS-SV for toxaphene (30 ppb) was exceeded in one of 8 channel catfish composites (41.8 ppb). Oddly, this was the only composite sample in which the concentration of toxaphene was above the detection limit. This was one of the composites containing larger catfish, but there were two others composed of similar sized catfish in which toxaphene was not detected. This result was checked and verified by the WPCL and it was noted that other samples also contained indications of toxaphene, but below the detection limit (see Appendix 2). The mean concentration for all composites was 14 ppb which is half of the CLS-SV. Additional analyses could be considered to better characterize the concentration of toxaphene in catfish samples from Black Butte Reservior.

The CLS-SV for PCBs (20 ppb) was reached in one of nine largemouth bass samples. This composite SCA-B was not composed of larger fish and showed typical lipid content for largemouth bass. This result stood out since this was the only sample (of any fish species from this lake) in which any Aroclor was detected above the detection limit. Aroclor 1254 was detected at 20 ppb in this sample. No Aroclor 1248 or 1260 was detected at quantifiable levels in any composite of largemouth bass or other species in Black Butte Reservoir. The mean concentration for all largemouth bass composites was 2.2 ppb assuming that the other composites were truly at zero level, but this cannot be measured. This is an under-estimate since there were PCB congeners detected in other samples, but at concentrations below the quantition levels for Aroclors. Additional analyses could be considered to better characterize the concentration of PCBs in fish samples from Black Butte Reservior; although the health concerns for PCBs do not appear high.

7. DISCUSSION

The primary objective of this study was to measure the levels of selected target chemicals in fish from San Pablo Reservoir and Black Butte Reservoir in order to provide an initial data base to determine whether additional sampling or evaluation of health concerns was warranted for either lake. Preliminary comparison of the measured levels of chemicals to CLS-SVs suggests that there are potential health concerns from consuming fish from both lakes. The chemicals of concern and the species of concern differ somewhat between the lakes. Further health evaluation of the data is warranted for both lakes. However, the data are limited on some of the species for which additional sampling is necessary.

San Pablo Reservoir and Black Butte Reservoir were selected for study because of the potential for mercury to be elevated in high trophic level fish (e.g., largemouth bass). The largemouth bass population in both lakes was well sampled in this study and chemical analysis showed that mercury concentrations in this species in both lakes were elevated above the CLS-SVs. In addition, the results showed that the other species sampled in Black Butte Reservoir (i.e., channel catfish, crappie, and carp) have elevated mercury levels. This result is most pertinent for the largemouth bass in San Pablo Reservoir and the largemouth bass and channel catfish in Black Butte Reservoir because a sufficient number of samples for these species were collected to characterize the populations in the lakes. The populations of crappie and carp in Black Butte Reservoir were not well characterized for mercury level and further sampling and analysis are recommended.

In Black Butte Reservoir, one sample in eight catfish composites exceeded the CLS-SV for toxaphene, and one in nine bass composites exceeded the CLS-SV for PCBs. The mean concentration of these chemicals in these well characterized species did not exceed the CLS-SV and, as such, the findings do not indicate a health concern.

For San Pablo Reservoir, additional samples and analysis are recommended for the following: chlordane, dieldrin, PCBs and dioxin TEQ in resident carp; dieldrin and PCBs in the stocked rainbow trout; and chlordane, dieldrin, PCBs, toxaphene and dioxin TEQ in channel catfish. This is based on cases where CLS-CVs are exceeded but only two composites of each species were collected and analyzed.

As discussed above, the stocked trout and channel catfish should also be sampled directly from the fish farm(s) to clarify whether significant exposure to organic chemicals occurs before they are put in this lake. This sampling and analysis should be discussed and coordinated with representatives of the East Bay Municipal Utility District.

The results of this study are important for all fishers at these lakes. They are especially pertinent to certain fishing populations as described below.

At San Pablo Reservoir it is important to further investigate the channel catfish contamination because catfish were noted as the most frequently consumed species by Laotian fishers (by 47.4% of surveyed fishers) in Contra Costa County in the APEN (1998) survey. And many of these ethnic fishers fish at San Pablo Reservoir (APEN, 1998). According to the APEN survey trout were consumed almost as often (by 40% of survey fishers) as catfish and, based on the data in this study, there was not a health concern due to chemical contamination of this stocked species in this lake.

There is no comparable survey of ethnic fishers for Central Valley lakes and rivers. According to a local health staff (Women, Infants and Children Program/Department of Health Services, personal communication) largemouth bass was the species favored by

Hmong fishers at Black Butte Reservoir. Consequently, the finding of elevated mercury concentrations in this species is especially pertinent to this fishing population.

The data collected from this project will be considered by OEHHA for an evaluation of the human health implications of consuming fish from San Pablo Reservoir and Black Butte Reservoir and for the development of fish consumption advisory options as appropriate.

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Table 1: Physical Characteristics of Fish in Composites from San Pablo Reservoir

Composite	Mean total length (mm)	Mean weight (gm)	Mean percent lipid	Mean estimated age (yrs)
Rainbow trout-A	519	1861	4.3	5
Rainbow trout-B	352	587	4.0	3
Channel catfish-A	582	2457	11.8	10
Channel catfish-B	509	1596	10.5	7
Largemouth bass-A	543	3141	0.8	8
Largemouth bass-B	462	1760	0.6	6
Largemouth bass-C	415	1226	0.7	5
Largemouth bass-D	353	612	0.3	3
Largemouth bass-E	405	1106	0.4	4
Crappie-A	252	263	0.3	3
Carp-A	523	2476	8.0	3
Carp-B	524	2331	6.5	3

Table 2: Physical Characteristics of Fish in Composites from Black Butte Reservoir

Composite	Mean total length (mm)	Mean weight (gm)	Mean percent lipid	Mean estimated age (yrs)
Crappie-MS-A	345	646	0.2	4
Carp-AC-A	478	1126	1.6	4
Largemouth bass-AC-A	[illegible]	2141	1.7	6
Largemouth bass-AC-B	402	960	0.3	4
Largemouth bass-SCA-A	372	716	0.1	4
Largemouth bass-SCA-B	312	398	0.1	3
Largemouth bass-SCA-C	308	388	0.2	3
Largemouth bass-SCA-D	302	384	0.1	3
Largemouth bass-BCA-A	507	2012	0.2	6
Largemouth bass-BCA-B	318	461	0.1	3
Largemouth bass-BCA-C	315	380	0.3	3
Channel catfish-AC-A	484	1016	2.4	6
Channel catfish-SCA-A	519	1227	2.3	7
Channel catfish-SCA-B	500	1142	3.8	7
Channel catfish-SCA-C	439	703	2.6	6
Channel catfish-SCA-D	426	647	1.8	5
Channel catfish-BCA-A	534	1460	4.9	8
Channel catfish-BCA-B	531	1382	3.0	8
Channel catfish-BCA-C	435	665	1.7	6

Table 3: USEPA and California Lakes Study Screening Values

CHEMICAL	USEPA Value[1] (ppb)	CLS-SV Study Value[2] (ppb)
Chlordane[3]	80	30
Chlorpyrifos	30,000	10,000
Total DDT[4]	300	100
Diazanon	900	300
Disulfoton	500	100
Dieldrin	7	2
Total endosulfan[5]	60,000	20,000
Endrin	3000	1000
Ethion	5000	2000
Heptachlor epoxide	10	4
Hexachlorobenzene	70	20
γ-hexachlorocyclohexane (lindane)	80	30
Toxaphene	100	30
PCBs[6]	10	20
Dioxin TEQ[7]	0.7 ppt	0.3 ppt
Arsenic[8]	3000	1000
Cadmium	10,000	3000
Mercury[9]	600	300
Selenium	50,000	20,000

1: USEPA SVs (USEPA, 1995) for carcinogens were calculated for a 70 kg adult using a cancer risk of 1x10-5. SVs for non-cancer effects were calculated for a 70 kg adult and exposure at the RfD (hazard quotient of 1). A fish consumption value of 6.5 g/day was used in both cases.
2: California SVs (CLS-SVs) specifically for this study were calculated according to USEPA guidance (USEPA, 1995). CLS-SVs for carcinogens were calculated for a 70 kg adult using a cancer risk of 1x10-5. CLS-SVs for non-cancer effects were calculated for a 70 kg adult and exposure at the RfD (hazard quotient of 1). A fish consumption value of 21 g/day was used in both cases. (see QAPP, 1998, Appendix 1)
3: Sum of alpha and gamma chlordane, cis- and trans-nonachlor and oxychlordane.
4: Sum of othro and para DDTs, DDDs and DDEs.
5: Sum of endosulfan I and II.
6: Expressed as the sum of Aroclor 1248, 1254 and 1260.
7: Expressed as the sum of TEQs for dibenzodioxin and dibenzofuran compounds which have an adopted TEF.
8: Measured as total arsenic in this study.
9: Measured as total mercury in this study.

Table 4: Range of Chemical Concentrations in Fish from San Pablo Reservoir for which there are California Lakes Study Screening Values (concentrations in ppb wet weight except as noted)

CHEMICAL	Rainbow trout	Channel catfish	Carp	Crappie	Largemouth bass
Chlordane	1.7 – 3.3	122.9 – 176	34 – 55.8	4.1	9.7 – 11.8
Chlorpyrifos	0.4* - 0.4*	0.4* - 0.4*	0.4* - 0.4*	0.4*	0.4* - 0.4*
Total DDT	8.4 – 10.4	104.9 – 160.8	29.9 – 49.2	4.6	3.8 – 14.2
Diazanon	12.5* - 12.5*	12.5* - 12.5*	12.5* - 12.5*	12.5*	12.5* - 12.5*
Disulfoton	LC	LC	LC	LC	LC
Dieldrin	1.6 – 4.6	42.4 – 54.2	14.1 – 20.1	2.5	4.4 – 8.9
Total endosulfan	4.2 – 6.3	4.4 – 6	4.4 – 6.9	3*	3* - 3*
Endrin	0.6* - 0.6*	0.6* - 0.6*	0.6* - 0.6*	0.6*	0.6* - 0.6*
Ethion	7.5* - 7.5*	7.5* - 16.2	7.5* - 7.5*	7.5*	7.5* - 7.5*
Heptachlor epoxide	0.3* - 0.7	5 – 6.4	1.5 – 2.2	0.3*	0.3* - 0.3*
Hexachloro-benzene	0.1* 0.3	0.6 – 0.8	0.3 – 0.4	0.1*	0.1* - 0.1*
γ-hexachloro-cyclohexane	0.1* - 0.1*	0.5 – 0.6	0.3 – 0.3	0.1*	0.1* - 0.1*
Toxaphene	10* - 10*	52.7 – 96.5	10* - 24.1	10*	10* - 20.5
PCBs as Aroclors	18 – 20	179 – 248	30 – 84	ND*	17 – 24
Dioxin TEQ (ppt)	0.19	1.5	0.61	0.08	0.14
Arsenic	290 – 310	240 – 370	260 – 440	260	120 - 180
Cadmium	5* - 5*	5* - 5*	5* - 5*	5*	5* - 5*
Mercury	30 – 30	70 –160	50 –60	160	370 - 770
Selenium	200 – 230	100 – 110	160 – 190	170	120 - 190

*: all values below Method Detection Limit (MDL).

ND: Not Detected and there is no numerical MDL for Aroclors determined by this method.

LC: chemical lost on extraction column, no result.

Shaded boxes indicate fish species for which a portion of the chemical concentration range exceeds the SV.

Table 5: Range of Chemical Concentrations in Fish from Black Butte Reservoir for which there are California Lakes Study Screening Values (concentrations in ppb wet weight except as noted)

CHEMICAL	Channel catfish	Carp	Crappie	Largemouth bass
Chlordane	1.8 – 4.2	2.2	0.5*	0.5* - 2
Chlorpyrifos	0.4* - 0.4*	0.4*	0.4*	0.4* - 0.4*
Total DDT	8.7 – 16.3	9.3	2.2*	2.5 – 10.7
Diazanon	12.5* - 12.5*	12.5*	12.5*	12.5* - 12.5*
Disulfoton	LC	LC	LC	LC
Dieldrin	0.3* - 1	0.3*	0.3*	0.3* - 0.3*
Total endosulfan	3* - 3.9	3*	3*	3* - 3*
Endrin	0.6* - 0.6*	0.6*	0.6*	0.6* - 0.6*
Ethion	7.5* - 7.5*	7.5*	7.5*	7.5* - 7.5*
Heptachlor epoxide	0.3* - 0.3*	0.3*	0.3*	0.3* - 0.3*
Hexachlorobenzene	0.1* - 0.1*	0.1*	0.1*	0.1* - 0.1*
γ-hexachloro-cyclohexane	0.1* - 0.1*	0.1*	0.1*	0.1* - 0.1*
Toxaphene	10* - 41.8	10*	10*	10* - 10*
PCBs as Aroclors	ND - ND*	ND*	ND*	ND - 20
Dioxin TEQ (ppt)	0.04* - 0.09	NA	NA	0.08* - 0.11
Arsenic	25 – 60	25	220	50 - 270
Cadmium	5* - 5*	10	5*	5* - 5*
Mercury	340 - 500	300	340	370 - 1300
Selenium	150 – 460	590	490	390 - 520

*: all values below Method Detection Limit (MDL).

ND: Not Detected and there is no numerical MDL for Aroclors determined by this method.

LC: chemical lost on extraction column, no result.

NA: not analyzed for dibenzodioxins or dibenzofurans.

Shaded boxes indicate fish species for which a portion of the chemical concentration range exceeds the SV.

Table 6: Mean Chemical Concentrations in Fish from San Pablo Reservoir for which there are California Lakes Study Screening Values (concentrations in ppb wet weight except as noted)

CHEMICAL	Rainbow trout	Channel catfish	Carp	Crappie	Largemouth bass
Chlordane	2.5	149.5	41.7	4.1	10.7
Chlorpyrifos	0.4*	0.4*	0.4*	0.4*	0.4*
Total DDT	9.4	132.9	39.6	4.6	11.3
Diazanon	12.5*	12.5*	12.5*	12.5*	12.5*
Disulfoton	LC	LC	LC	LC	LC
Dieldrin	3.1	48.3	16.2	2.5	6.8
Total endosulfan	5.3	5.2	5.5	3*	3*
Endrin	0.6*	0.6*	0.6*	0.6*	0.6*
Ethion	7.5*	11.9	7.5*	7.5*	7.5*
Heptachlor epoxide	0.5	5.7	1.9	0.3*	0.3*
Hexachloro-benzene	0.2	0.7	0.4	0.1*	0.1*
γ-hexachloro-cyclohexane	0.1*	0.6	0.3	0.1*	0.1*
Toxaphene	10*	74.6	18	10*	14.1
PCBs as Aroclors	19	213.5	54.3	ND*	19.4
Dioxin TEQ (ppt)	0.19	1.5	0.61	0.08	0.14
Arsenic	300	310	310	260	150
Cadmium	5*	5*	5*	5*	5*
Mercury	30	120	60	160	520
Selenium	220	110	180	170	170

*: all values below Method Detection Limit (MDL).

ND: Not Detected and there is no numerical MDL for Aroclors determined by this method.

LC: chemical lost on extraction column, no result.

Shaded boxes indicate fish species for which a portion of the chemical concentration range exceeds the SV.

Table 7: Mean Chemical Concentrations in Fish from Black Butte Reservoir for which there are California Lakes Study Screening Values *(concentrations in ppb wet weight except as noted)*

CHEMICAL	Channel catfish	Carp	Crappie	Largemouth bass
Chlordane	2.6	2.2	0.5*	0.8
Chlorpyrifos	0.4*	0.4*	0.4*	0.4*
Total DDT	13	9.3	2.2*	4.4
Diazanon	12.5*	12.5*	12.5*	12.5*
Disulfoton	LC	LC	LC	LC
Dieldrin	0.4	0.3*	0.3*	0.3*
Total endosulfan	3.2	3*	3*	3*
Endrin	0.6*	0.6*	0.6*	6*
Ethion	7.5*	7.5*	7.5*	7.5*
Heptachlor epoxide	0.3*	0.3*	0.3*	0.3*
Hexachlorobenzene	0.1*	0.1*	0.1*	0.1*
γ-hexachloro-cyclohexane	0.1*	0.1*	0.1*	0.1*
Toxaphene	14	10*	10*	10*
PCBs as Aroclors	ND*	ND*	ND*	2.2
Dioxin TEQ (ppt)	0.07	NA	NA	0.1
Arsenic	40	25	220	160
Cadmium	5*	10	5*	5*
Mercury	400	300	340	700
Selenium	210	590	490	460

*: all values below Method Detection Limit (MDL).
ND: Not Detected and there is no numerical MDL for Aroclors determined by this method.
LC: chemical lost on extraction column, no result.
NA: not analyzed for dibenzodioxins or dibenzofurans.
Shaded boxes indicate fish species for which a portion of the chemical concentration range exceeds the SV.

Table 8: Comparison of Ratio of Selected* Organic Chemical Concentrations in Channel Catfish and Carp from San Pablo Reservoir

CHEMICAL	Channel catfish	Carp	Ratio catfish/carp	(ppb/ % lipid except as noted)	Channel catfish	Carp	Ratio catfish/carp	(ppb/year of age except as noted)	Channel catfish	Carp	Ratio catfish/carp
Chlordane	149.5	41.7	3.6	Lipid normalized Chlordane	1334.8	571.2	2.3	Age normalized Chlordane	17.6	13.9	1.3
Total DDT	132.9	39.6	3.4	Lipid normalized Total DDT	1186.6	542.5	2.2	Age normalized Total DDT	15.6	13.2	1.2
Dieldrin	48.3	16.2	3.0	Lipid normalized Dieldrin	431.3	221.9	1.9	Age normalized Dieldrin	5.7	5.4	1.1
Heptachlor epoxide	5.7	1.9	3.0	Lipid normalized Heptachlor epoxide	50.9	26.0	2.0	Age normalized Heptachlor epoxide	0.7	0.6	1.2
Toxaphene	74.6	18	4.1	Lipid normalized Heptachlor epoxide	666.1	246.6	2.7	Age normalized Heptachlor epoxide	8.8	6	1.5
PCBs as Aroclors	214.2	55.3	3.9	Lipid normalized PCBs as Aroclors	1912.5	757.5	2.5	Age normalized PCBs as Aroclors	25.2	18.4	1.4
Dioxin TEQ (ppt)	1.5	0.61	2.5	Lipid normalized Dioxin TEQ (ppt/% lipid)	13.4	8.4	1.6	Age normalized Dioxin TEQ (ppt/% lipid)	0.2	0.2	1
Mean % lipid	11.2	7.3	1.5								
Mean age in composite (years)	8.5	3	2.8								

Chemical concentrations in unshaded boxes are expressed on a wet weight basis. Concentrations in ppb and normalized ppb except as noted.
Chemical concentrations in shaded boxes are "normalized" by dividing the chemical concentration by the mean percent lipid value or age for that fish species. These lipid or age normalized values should not be compared to SVs or ATCs which are expressed on a wet weight basis.
*These organic chemicals were selected because they are hydrophobic and because the SV was exceeded in channel catfish from San Pablo Reservoir.

APPENDIX 1

QUALITY ASSURANCE PROJECT PLAN

FOR

PREVALENCE OF SELECTED TARGET CHEMICAL CONTAMINANTS IN SPORT FISH FROM TWO CALIFORNIA LAKES: PUBLICH HEALTH DESIGNED SCREENING STUDY

APPENDIX 2

ENVIRONMENTAL CHEMISTRY DATA AND QUALITY ASSURANCE REPORT

FOR THE

PREVALENCE OF SELECTED TARGET CHEMICAL CONTAMINANTS IN SPORT FISH FROM TWO CALIFORNIA LAKES: PUBLICH HEALTH DESIGNED SCREENING STUDY

WATER POLLUTION CONTROL LABORATORY

APPENDIX 3

HAZARDOUS MATERIALS LABORATORY DATA REPORT

FOR THE

PREVALENCE OF SELECTED TARGET CHEMICAL CONTAMINANTS IN SPORT FISH FROM TWO CALIFORNIA LAKES: PUBLICH HEALTH DESIGNED SCREENING STUDY

HAZARDOUS MATERIALS LABORATORY

APPENDIX 4

QUALITY ASSURANCE MEMORANDA FROM

Dr. GERALD A. POLLOCK

DRAFT

EVALUATION OF POTENTIAL HEALTH EFFECTS OF EATING FISH FROM BLACK BUTTE RESERVOIR (GLENN AND TEHAMA COUNTIES): GUIDELINES FOR SPORT FISH CONSUMPTION

MARCH 2000

Gray Davis
Governor
State of California

Winston H. Hickox
Agency Secretary
California Environmental Protection Agency

Joan E. Denton, Ph.D.
Director
Office of Environmental Health Hazard Assessment

www.oehha.ca.gov/fish/pdf/bbutte D1.pdf

DRAFT

EVALUATION OF POTENTIAL HEALTH EFFECTS OF EATING FISH FROM BLACK BUTTE RESERVOIR (GLENN AND TEHAMA COUNTIES): GUIDELINES FOR SPORT FISH CONSUMPTION

Pesticide and Environmental Toxicology Section
Office of Environmental Health Hazard Assessment
California Environmental Protection Agency

March 2000

DRAFT

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FOREWORD

This report provides recommended guidelines for consumption of largemouth bass and channel catfish from Black Butte Reservoir (Glenn and Tehama Counties) as a result of findings of high levels of mercury in fish tested from Black Butte Reservoir. These recommendations are made to protect against possible adverse health effects from methylmercury as consumed from mercury-contaminated fish. The report provides background information and a description of the data and criteria used to develop the guidelines.

To protect public health in the period while this technical support document was being prepared for public comment, the County of Glenn Health Services Agency, Division of Environmental Health, and the County of Tehama Health Services, in consultation with the Office of Environmental Health Hazard Assessment, issued an interim public health advisory for fish from Black Butte Reservoir. This advisory is included in Appendix I. Once finalized, the advisory contained herein will become the final state advisory.

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EXECUTIVE SUMMARY

The Office of Environmental Health Hazard Assessment (OEHHA) performed a study, "Prevalence of Selected Target Chemical Contaminants in Sport Fish from Two California Lakes: Public Health Designed Screening Study," (California Lakes Study) of chemical contamination in sport fish from Black Butte Reservoir. Sampling design for this study was limited by the screening nature of the study and the funding available. The results of that study are used in this evaluation of the potential health effects of consuming sport fish from Black Butte Reservoir. The goal of the health evaluation is to assess the likelihood and degree of exposure to chemical contaminants in fish from Black Butte Reservoir and to determine whether a potential exists for possible adverse effects from this exposure to sport fish consumers using this lake. The study data are used to determine the nature and extent of chemical contamination in sport fish from Black Butte Reservoir. A copy of this report is available at www.oehha.ca.gov.

Mercury, in the form of methylmercury, is identified as the chemical of concern for persons consuming sport fish from Black Butte Reservoir. Methylmercury is the primary form of mercury in fish to which humans are exposed; it causes adverse effects on the neurological system. Of particular concern are the developmental effects in fetuses exposed *in utero*. Consumption of contaminated sport fish is the primary exposure route for mercury exposure to humans. Exposure under different scenarios for the amount and frequency of fish consumption were evaluated for persons consuming fish caught from Black Butte. Exposures via consumption of largemouth bass and channel catfish could be well characterized because an adequate number of samples of these fish species were collected and analyzed. Exposures via consumption of carp and crappie could not be well characterized due to the small number of samples collected and analyzed for these species.

The health evaluation found that fishers consuming largemouth bass or channel catfish from Black Butte Reservoir are potentially exposed to levels of methylmercury above the reference level set by the U.S. Environmental Protection Agency (U.S. EPA).

A health evaluation for consumption of carp and crappie could not be done using the limited samples collected and analyzed. However, these species have similar feeding habits to channel catfish and similar mercury concentrations were found in all three species at Black Butte Reservoir. This suggests that methylmercury is accumulating in all three species and that exposures from consumption of carp and crappie are likely to be similar to those from consumption of channel catfish.

Based on the health evaluation, OEHHA recommends the following consumption guidelines for fish taken from Black Butte:

Due to the elevated level of mercury, pregnant women, nursing women and women who may soon become pregnant (the most sensitive population) should eat no more than one meal (eight ounces) per month of largemouth bass, channel catfish, carp and crappie. Mercury is a potent neurotoxin, so children and adults should also follow the same advice. Meal sizes may be adjusted to body weight as described on page 15 and Table 6.

INTRODUCTION

OEHHA conducted a study to sample selected sport fish species and measure the levels of target chemicals in these fish from Black Butte Reservoir. This study was part of a cooperative agreement with the U.S. EPA in which two lakes in California were sampled. The objective of the study was to provide an initial database to determine whether additional sampling and health evaluation was warranted in either lake. Although the extent of the study in each lake was restricted by the funding available, it was possible to sample several species of popular sport fish from Black Butte Reservoir.

The Final Project Report (FPR), "Prevalence of Selected Target Chemical Contaminants in Sport Fish from Two California Lakes: Public Health Designed Screening Study" (Brodberg and Pollock, 1999) concluded that a health evaluation of the results was warranted for people eating largemouth bass and channel catfish from Black Butte Reservoir. This health evaluation is based on the potential levels of exposure to methylmercury by persons consuming typical sport fish caught from Black Butte Reservoir, and the associated potential health hazards. Nearly all fish (sport and commercial) contain mercury at a measurable level. While the measurements are made as total mercury, most of the mercury in fish is present as methylmercury, which is the most toxic form of mercury. The health risk from consumption of fish containing methylmercury depends on the concentration of methylmercury in the fish and the amount of fish being consumed.

OEHHA is the agency responsible for evaluating potential public health risks from chemical contamination of sport fish, and issuing advisories, when appropriate, for the State of California. OEHHA's authorities to conduct these activities are based on mandates in the California Health and Safety Code, Section 205 (protecting public health), and Section 207 (advising local health authorities). Fish advisories developed by OEHHA are published in the California Sport Fishing Regulations and California Sport Fish Consumption Advisories (OEHHA, 1999).

BACKGROUND

Under the cooperative agreement, OEHHA and U.S. EPA jointly selected sites and fish species to be sampled and chemicals to be analyzed. Black Butte Reservoir was selected for this study due to a combination of characteristics. First, it is in the California Coast Range where mercury contamination had been observed in fish in similar lakes. Second, it is a more rural recreational facility operated by the U.S. Army Corps of Engineers, and third, it is a popular fishing site for Hmong fishers living nearby in the Central Valley (personal communication, Glenn County Health Department). The lake itself straddles Glenn and Tehama Counties and is also used for camping, boating, and hunting.

Four sport fish species were collected for analysis of chemical contaminants from Black Butte. The species collected and analyzed were largemouth bass, channel catfish, crappie, and carp. Fish were collected from three regions of the lake (see Figure 1): Burris Creek Arm, Stony Creek Arm, and Angler's Cove (the area including Fisherman's Cove and extending to the dam). Samples were collected on November 25, and December 4 and 5, 1997. Muscle tissue from individual fish was combined into composites for chemical analysis. One composite of carp and one crappie composite were prepared. Nine composites of largemouth bass (two from Angler's Cove, four from Stony Creek Arm, and three from Burris Creek Arm) were prepared. Eight composites of channel catfish (one from Angler's Cove, four from Stony Creek Arm, and three from Burris Creek Arm) were prepared. The average size, weight, and other characteristics of fish in these composites are shown in Table 1. The California Department of Fish and Game (DFG) Water Pollution Control Laboratory (WPCL) sampled fish and prepared composites. Fish sampling and sample preparation methods are described in more detail in the FPR (Brodberg and Pollock, 1999).

OEHHA and U.S. EPA jointly selected the chemical contaminants to be analyzed. The chemicals analyzed for this study included four metals, 35 organic compounds plus 46 polychlorinated biphenyl (PCB) congeners, and chlorinated dibenzodioxin and dibenzofuran (dioxins/furans) compounds that could potentially accumulate in fish in California lakes. The reason for including a broad spectrum of chemicals and fish species in the analysis was to screen for those chemicals and fish species that posed the greatest potential health concern. Using this method, future monitoring might be limited to specific species and fewer chemicals. DFG WPCL analyzed metals and organic compounds. The California Department of Toxic Substances Control Hazardous Materials Control Laboratory analyzed composite tissue samples for dioxins/furans and three coplanar PCB congeners. The chemicals analyzed and the analytical methods are described in more detail in the FPR (Brodberg and Pollock, 1999).

This study was designed to incorporate U.S. EPA (1995) guidance for sampling and analysis of fish potentially used for fish advisories. U.S. EPA (1995) recommended using screening values (SVs) to identify chemical contaminants in sport fish tissue at concentrations, which may be of human health concern for frequent consumers of sport fish. Specific SVs were established for this study to determine fish species and/or chemicals for which more detailed sampling and/or health evaluations should be conducted. A more detailed discussion of the SVs and a comparison between them and the chemical concentrations in the sport fish species sampled from Black Butte Reservoir is presented in the FPR (Brodberg and Pollock, 1999). The mean (i.e., average) chemical concentrations for chemicals of potential health concern in Black Butte fish are presented in Table 2. The average concentrations are used in this health evaluation because chemical concentrations in individual species of fish from different collection sites are similar. Fishers are likely to eat some fish of a specific species that have higher concentrations of a chemical and some with lower concentrations. It is reasonable to assume that a consumer's exposure from several meals will be closer to the averaged concentration for a chemical than the lowest or highest concentration. Thus, the lakewide average (mean) chemical concentration of mercury in a fish species represents the typical catch and consumption exposure for consumers eating that species from the lake.

Mercury is the only chemical that exceeded the study SV; consequently it is the only chemical for which a health evaluation is warranted. As discussed in the FPR (Brodberg and Pollock, 1999), a health evaluation for consuming largemouth bass and channel catfish from Black Butte Reservoir is warranted due to the elevated mercury concentrations. This evaluation of the potential health risk of eating these fish is presented below. FPR concluded that the data available for carp and crappie were too limited (i.e., too few samples) to be representative of the population of these fish species at Black Butte Reservoir. These data are not sufficient without corroborating information for performing a health evaluation. However, qualitatively it is evident that mercury is also accumulating in carp and crappie. The level of accumulation in these species is similar to that in channel catfish. Consequently, the potential health concerns in carp and crappie are likely to be similar to those for channel catfish. Additional samples and mercury analyses for these species from Black Butte are needed to characterize the concentration of mercury in carp and crappie, to confirm the validity of the analytical results, and support a health evaluation.

METHYLMERCURY TOXICOLOGY AND HAZARD IDENTIFICATION

Methylmercury is the predominant form of mercury in finfish. It usually accounts for >95 percent of the total mercury measured in fish tissue (May et al., 1987). Chemical analyses of mercury in fish tissue usually measure total mercury since it makes up close to 100 percent of the mercury present, and because the analysis for total mercury is less expensive than that for methylmercury. The resulting measure of total mercury in finfish is assumed to be 100 percent methylmercury for this risk assessment. Total mercury was analyzed in this study.

The potential toxic effects of methylmercury are well established due to an extensive database for human exposure at high levels as the result of several incidents of human poisoning. People in Japan consumed highly contaminated fish and shellfish from Minamata Bay and Niigata Prefecture (Harada, 1978, and Mishima, 1993). People in Iraq consumed bread made from seed-grain that had been treated with a methylmercury pesticide formulation (Bakir, et al., 1973). Some of the people exposed in these poisoning incidents eventually died. Clinical findings from these exposures showed that the nervous system was the main target of methylmercury in adults, children, and developing fetuses and that high exposures were lethal. Common signs of toxicity in adults were paresthesia (numbness and tingling), loss of sensation in the extremities, ataxia (loss of muscular coordination), auditory and visual sensory impairment, and mental disturbances (U.S. EPA, 1997; and the Agency for Toxic Substances and Disease Registry [ATSDR], 1999). Pathological changes in the nervous system were also observed. Some children exposed *in utero* were born with clinical symptoms to mothers who did not show clinical effects. This leads to the conclusion that the developing nervous system of fetuses is the most sensitive target of methylmercury toxicity. Effects observed in children exposed *in utero* included: delayed developmental milestones (e.g., walking and talking); irritability, paresthesia, altered muscle tone and tendon reflexes, incoordination, blindness, inability to speak, and seizures (IRIS, 1999).

Damage to the kidneys from acute and chronic methylmercury exposures has been observed in humans and in animal studies (ATSDR, 1999), however, the neurological endpoints are more sensitive to damage following methylmercury exposure than the kidney. Mice exposed to methylmercury chloride showed an increased incidence of tumors leading International Agency for Research on Cancer (IARC) (1993) to classify methylmercury compounds as possible human carcinogens (B2). Based on IARC's action, OEHHA administratively listed methylmercury compounds on the Proposition 65 list of carcinogens. However, a cancer potency factor has not been developed for methylmercury.

Methylmercury in food is almost completely absorbed from the gastrointestinal tract and is distributed in the blood throughout the body. Methylmercury crosses the placenta and the blood-brain barrier. In the brain, it is apparently metabolized to inorganic mercury. Methylmercury elimination is primarily in the bile, but it is also excreted in the feces, urine, and breast milk. The biological half-life of methylmercury in humans is about 70 days (Harada, 1995).

DOSE-RESPONSE ASSESSMENT FOR METHYLMERCURY

In order to determine a reference level of methylmercury exposure, it is necessary to determine the lowest exposure dose that does not have an adverse effect on human health. In the case of methylmercury, the critical effect is developmental neurotoxicity and it is possible to estimate a dose without adverse effects from human epidemiological studies. U.S. EPA calculate an oral reference dose (RfD) for methylmercury (IRIS, 1999) using data collected in the aftermath of the Iraqi grain poisoning incident to estimate exposures associated with clinical developmental effects in children. U.S. EPA describes an RfD as an estimate of a daily exposure level to humans that is likely to be without an appreciable risk of deleterious effects during a lifetime. RfD's are established for non-cancer health effects for which it is assumed that there are no adverse health effects below some threshold of exposure. RfDs are established to include sensitive subgroups in the human population. Exposure to a level above the RfD does not mean that adverse effects will occur.

ATSDR used data from a study in the Seychelles Islands to estimate a no-effect level for methylmercury (ATSDR, 1999). This population is chronically exposed to methylmercury in the fish they consume. ATSDR calculated a minimal risk level (MRL) for methylmercury exposure using the results of tests of neurological effects in exposed children. ATSDR describes an MRL as "an estimate of daily human exposure to a dose of chemical that is likely to be without an appreciable risk of adverse noncancerous effects over a specified duration of exposure." MRLs are established below levels that might cause adverse effects in the people most sensitive to a chemical-induced effect. Exposure to a level above the MRL does not mean that adverse effects will occur. These studies and derivation of dose-response values from them are discussed below. There are other human studies of the effects of methylmercury but thus far these two documents have provided the most reasonable descriptions of the dose-response assessment and calculation of reference levels.

U.S. EPA RfD

U.S. EPA used data from a study by Marsh et al. (1987) of 81 mother infant pairs from the Iraqi poisoning as the most appropriate data set to calculate an RfD. U.S. EPA focused on the Iraqi data partly because results from the Seychelles and Faroes Islands studies were not readily available and had not been thoroughly evaluated at the time. The data from this study included clinical neurological signs (e.g., cerebral palsy, changes in muscle tone and deep tendon reflexes) and observations of delayed developmental milestones (i.e., not walking by 18 months or talking by 24 months) in children exposed *in utero*. This was a retrospective study so exposure doses could not be measured directly. The mother's dose of methylmercury was estimated using total mercury concentrations in maternal hair taken from selected regions of the scalp. Mercury concentrations in maternal hair ranged from 1 to 674 parts per million (ppm). Mercury concentrations in maternal hair were correlated with the clinical effects in offspring to establish dose groupings. A benchmark dose method was used to fit a mathematical dose-response model to the dose-response data. The benchmark dose estimate was rounded to 11 ppm (mg/kg) in hair. The benchmark dose is considered roughly equivalent to a threshold level and is viewed as a conservative estimate of the traditional no-observed-adverse-effect-level (NOAEL) used for non cancer effects. The benchmark dose method calculated the dose associated with "extra risk." The 95 percent lower bound on the dose at the 10 percent extra risk effect level was calculated using a quantal Weibull curve fitting model (U.S. EPA, 1997; IRIS, 1999).

A ratio of 250:1 (µg mercury/mg in hair: µg mercury/L of blood) was used to calculate the level of mercury in blood corresponding to the level in hair. At 11 ppm this is 44 µg mercury/L blood. This was the initial step in calculating the average daily exposure for mothers at the benchmark dose level. A standard physiological and pharmacokinetic model was used to calculate the corresponding average daily dietary intake of mercury by mothers during pregnancy. This calculation assumes steady state conditions and first order kinetics, and uses the following parameters: mercury concentration in blood is 44 µg/L; the elimination constant is 0.014 $days^{-1}$; blood volume of a 60 kg woman is 5 L; and the absorption factor for mercury is 0.95 (unitless) from the diet and 0.05 into the blood. The resulting daily dietary intake is 1.1 µg/kg-day (U.S. EPA, 1997; IRIS, 1999).

$$\text{daily dietary intake} = \frac{(44\ \mu g/L)(0.014\ days^{-1})(5L)}{(0.95)(0.05)(60\ kg\ Body\ Weight)}$$

A data composite ~~uncertainty factor for variation in~~ the human hair to blood ratio for mercury, variation in the half-life of mercury, the lack of a two-generation study, and the lack of data on possible sequelae developing later in life (e.g., adult paresthesia), a longer duration of exposure was applied to the daily dietary exposure dose to derive a RfD. The final methylmercury RfD calculated by U.S. EPA is $1x10^{-4}$ mg/kg-day to protect children from exposure to methylmercury during gestation (U.S. EPA, 1997; IRIS, 1999). U.S. EPA suggests that this RfD be used for the adult population as well because of uncertainty as to whether the threshold for adult paresthesia from chronic exposure to methylmercury was observable in the Iraqi study.

ATSDR MRL

Two recent independent studies of health effects from methylmercury exposure have been conducted in the Seychelles and Faroe Islands. The levels of methylmercury exposure from fish consumption in the Seychelles study are more typical of United States fish consumers. The levels of exposure in the Faroe Islands are similar to the Seychelles but may be more variable as a result of consumption of whale meat containing high levels of methylmercury. Results of the Faroe study demonstrate an adverse neurological effect in children exposed *in utero* (Grandjean et al., 1997), but the Seychelles study did not show an adverse effect at 66 months of age (Davidson et al., 1998). ATSDR used the Seychelles study to calculate an MRL for methylmercury based on determination of a NOAEL for the most sensitive subpopulation, children exposed *in utero*. ATSDR determined that the Seychelles study was better for developing the MRL because (a) the subjects consumed a large quantity (typically 12 fish meals per week) of a variety of ocean fish containing mercury, (b) the range of mercury concentration in these fish (0.004-0.75 ppm) was comparable to that in fish available to the United States population, (c) the relatively clean environment reduces the possibility that other environmental chemical exposures will confound the results, and (d) the population was literate, cooperative, and generally healthy, with low levels of both maternal alcohol consumption and tobacco use.

ATSDR used testing results at 66 months of age by Davidson et al. (1998) for 711 mother-infant pairs from the Seychelles Islands to calculate an MRL. Children in this study were exposed during gestation and also after birth through breast milk and consumption of fish. Children in the Seychelles were evaluated using age-appropriate neurodevelopmental tests at 6.5, 19, 29 and 66 months, and they are currently being tested at eight years of age. At 66 months, the test battery administered was designed to assess global functioning for multiple developmental domains including general cognition, language ability, reading and math abilities, visual-spatial ability, and social and adaptive behavior. The results of the 66 month tests showed no adverse effects (i.e. could be used to determine the NOAEL) that could be attributed to methylmercury exposure from maternal fish consumption. A small decrease in subjectively measured activity levels noted in boys in the 29-month observations was not apparent at 66 months (ATSDR, 1999).

Maternal exposures in the Seychelles studies were not measured directly but were estimated from maternal hair levels during pregnancy. Maternal hair levels ranged from 0.5-26.7 ppm with a mean of 6.8 ppm for mothers in the 66-month cohort. Children's hair levels determined in the 66-month cohort ranged from 0.9-25.8 ppm with a mean of 6.5 ppm. Because no adverse effects were observed in the 66-month cohort, the mean maternal hair concentration (15.3 ppm) in the group with the highest exposure in this cohort was considered a NOAEL (ATSDR, 1999). As in the U.S. EPA calculations, a hair:blood ratio of 250:1 was used to transform this hair concentration into a mercury concentration in blood of 0.061 mg/L. The same physiological based pharmacokinetic equation was used to convert this blood level to a daily intake, but some of the parameters differed from those used by U.S. EPA. In this regard, ATSDR used the following parameters: mercury concentration in blood is 61 ug/L; the elimination constant is 0.014 $days^{-1}$; blood volume of a 60 kg woman is 4.2 L; and the absorption factor for mercury is 0.95 (unitless) in the diet and 0.05 into the blood. Applying this model yields a NOAEL of $1.3x10^{-3}$ mg/kg/day. ATSDR applied modifying a factor of three to account for human pharmacokinetic and pharmacodynamic variability and a factor 1.5 to account for domain specific negative effects seen in a different test battery used in the Faroe study but not observed in the Seychelles studies (i.e., total modifying factor of 4.5). The final methylmercury MRL calculated by ATSDR is $3x10^{-4}$ mg/kg-day which is intended to protect the fetus exposed to methylmercury during gestation (ATSDR, 1999).

CHOICE OF REFERENCE LEVEL

Two measures of maternal hair levels (11 and 15.3 ppm mercury) have been derived from different studies and used by different agencies to represent a NOAEL. The relatively small difference between these two values shows a consistent identification of the dose-effect level for methylmercury. These dose levels were modeled to very similar daily dietary intake levels (1.1 and 1.3 mg/kg/day, respectively) and not too dissimilar reference exposure values (1 and $3x10^{-4}$ mg/kg/day). The three-fold difference between these final reference values is actually greater than the differences between the NOAELs. The greater difference in the final reference values is the result of the application of different uncertainty or modifying factors to calculate the daily dietary intake levels. The scientific evidence from these studies suggests that exposures resulting in maternal hair levels of less than or equal to about 11 to 15 ppm are not damaging to the developing fetus. However, it should be noted that the Faroe study suggests some effects may occur at less than a 10 ppm delivered dose (Grandjean et al., 1997). Other human studies are being conducted that might yield additional information on the lowest observed effect level of methylmercury exposure in humans.

OEHHA is evaluating the derivation of the U.S. EPA RfD and ATSDR MRL and the scientific strengths and weaknesses of the studies and assumptions used to calculate these values. Until this evaluation is complete, OEHHA will use the slightly more health protective U.S. EPA RfD of $1x10^{-4}$ mg/kg/day for risk assessments of methylmercury exposure via sport fish consumption.

EXPOSURE ASSESSMENT OF EATING SPORT FISH FROM BLACK BUTTE RESERVOIR

The exposure assessment of eating sport fish from Black Butte Reservoir estimates exposures currently experienced or anticipated under different conditions for sport fish consumers eating fish species from the reservoir. The chemical concentrations reported in the FPR are used as representative of the nature and extent of chemical contamination in sport fish species from the reservoir. Mean concentrations are used to represent the central tendency (average) of exposure for the population in question. Methylmercury was identified in the FPR as the chemical of concern for persons consuming sport fish from Black Butte Reservoir. In the United States, the primary route of exposure to methylmercury for most of the population is via consumption of finfish (U.S. EPA, 1997). This is especially true for sport fish consumers. The consumption of sport fish species from Black Butte Reservoir will be the only path of methylmercury exposure considered in this exposure assessment. The exposure assessment will be applicable to local consumers of fish from Black Butte Reservoir and other persons who eat fish caught in the lake.

Different exposure scenarios for the amount and frequency of fish consumption are used in the exposure assessment to calculate likely exposure for various segments of the population annually consuming fish caught from the reservoir. Consumption rates determined for a wide demographic of fishers in Santa Monica Bay will serve as a model for fish consumption in other water bodies in California including Black Butte Reservoir (Gassel, 1998). Consumption rates corresponding to three different segments of the population of fishers catching and consuming sport fish were selected for this exposure assessment: a median consumption rate; an average rate; and high end (90^{th} percentile) consumption rate. The median is the consumption rate representing the 50^{th} percentile in any study. An equal number of fish consumers in the study population consumed fish at more than this rate, and an equal number consumed fish at less than this rate. The reported median from the Santa Monica Bay study is 21 g/day (2.1×10^{-2} kg/day) (Southern California Coastal Water Research Project (SCCWRP) and MBC Applied Environmental Sciences, 1994; and Allen et al., 1996). In practical terms, this is equivalent to consuming less than three standard (eight ounce) meals per month of sport fish from Black Butte Reservoir during a year. Fishers consuming at the median are exposed at a relatively low level. The mean represents the mathematical average consumption rate. The reported mean from the Santa Monica Bay study is 50 g/day (5.0×10^{-2} kg/day) (SCCWRP and MBC, 1994; and Allen et al., 1996) which corresponds too less than seven standard meals per month of fish. This is representative of an average exposure. High-end consumers are viewed as those between the 90^{th} and 99.9^{th} percentile. The 90^{th} percentile was chosen in this case because the exposure assessment and risk characterization are based on consumers eating a single species at this rate from only this location. This is a conservative assumption because fishers are more likely to eat meals of different fish species from different locations during a year. Using a higher percentile for a single species assessment would lead to unrealistic exposure estimates based on few actual consumers in the extreme tail of the population distribution. The reported 90^{th} percentile from Santa Monica Bay is 107 g/day (10.7×10^{-2} kg/day) (SCCWRP and MBC, 1994; and Allen et al., 1996) which is equivalent to about 14 meals per month annually. This rate will be used to represent high-end (e.g., subsistence) consumers in the exposure assessment. These scenarios considered together characterize a reasonable range of consumption for the population fishing at the reservoir.

The concentrations of methylmercury used in the exposure assessment are based on the average (i.e., mean) concentration measured in the raw fish tissue as it was prepared for compositing. Largemouth bass, crappie, and carp tissues were all prepared with the skin on. Channel catfish tissues were prepared with the skin off. The average concentrations of mercury in the fish species sampled from Black Butte Reservoir were 700 parts per billion (ppb) for largemouth bass and 400 ppb for channel catfish (see Table 2).

The average concentrations measured in largemouth bass were based on nine composites each containing three fish. These composites represent a full size-range of largemouth bass from the lake: two composites were made of large fish (>500 mm in length); two composites were made of medium-sized fish (370-499 mm in length); and five composites were made of small fish at or over the legal size limit (see Table 1). These composites reflect the abundance of different size classes of largemouth bass during field collection so these samples are representative of what fishers are expected to catch and consume. The resulting mercury concentrations depart somewhat from a normal distribution. This is evident from the difference between the mean mercury concentration (700 ppb), the median concentration (530 ppb), and the geometric mean concentration (628 ppb) (see Table 3). This shift in the mean from the center of the distribution is due to the statistical effect that the higher mercury concentrations in the composites made of large-sized bass have on the computed mean. The average mercury concentration in this case is still a good measure of central tendency for mercury concentrations in bass because it will be representative of possible infrequent exposures to high concentrations (>1 ppm) from large fish. The average mercury concentration in largemouth bass will be used for estimating exposures of fishers catching and consuming this species from Black Butte Reservoir.

The average concentrations in channel catfish were based on eight composites, each containing four fish. Four of these composites were made of large-sized fish (>500 mm in length) and four were made of medium-sized fish (see Table 1). Smaller catfish were not evident in the field collections, so these samples are representative of what fishers are expected to catch and consume. Mercury concentrations in channel catfish are normally distributed. The mean mercury concentration (400 ppb), median concentration (380 ppb), and geometric mean concentration (398 ppb) are nearly the same (Table 3). Therefore, the mean should be a good representation of central tendency for methylmercury concentrations in channel catfish, and it will be used to represent typical methylmercury levels in this species to estimate exposures for fishers catching and consuming this channel catfish from Black Butte Reservoir.

Table 2 also gives values for the mercury concentrations in crappie (340 ppb) and carp (300 ppb). Only one composite was made for each of these species. These are not enough samples to be able to judge whether these concentrations are representative of the populations of these species in Black Butte Reservoir. The fact that these concentrations are similar to those in channel catfish suggests that methylmercury does accumulate in these fish species in this lake. This is not surprising since the feeding habits of channel catfish overlap those of carp and crappie. Although more samples of carp and crappie should be collected and analyzed, these similar mercury concentrations suggest the mercury level in these populations will be similar to that found in channel catfish. In contrast, largemouth bass have a more piscivorous feeding habit as is evident from the greater bioaccumulation of mercury in this fish species.

Human exposure estimates are calculated on a body weight basis so some reasonable assumption must be made about a typical fish consumer. Since the sensitive endpoint for methylmercury exposure is the nervous system in the developing fetus during gestation, the typical consumer whose methylmercury exposure is being modeled is a pregnant woman. A body weight of 65 kg was used in the exposure assessment to represent the body weight of pregnant women.

The formula for calculating the daily human exposure to methylmercury from fish consumption is shown below. In addition, the calculated daily exposures at different consumption levels for the mean mercury levels in Black Butte sport fish are shown in Table 4.

$$\text{mg Methylmercury/kg BW - day} = \frac{\text{(mg Methylmercury/kg Fish)(kg Fish/day)}}{\text{kg Body Weight}}$$

Where:

BW = body weight

POTENTIAL HEALTH HAZARD OF EATING SPORT FISH FROM BLACK BUTTE RESERVOIR

The potential health hazard of eating sport fish from Black Butte Reservoir depends on whether an individual's exposure level is greater or less than the reference level at which adverse effects are unlikely. In the case of methylmercury, the effect of concern is damage to the developing nervous system in the fetus, and the reference level chosen for this health evaluation is the U.S. EPA RfD of 1×10^{-4} mg/kg/day. When the estimated exposure level is less than the reference level, there is little risk of adverse health effects to the population in question from this chemical exposure. This comparison of estimated exposure to the reference level is expressed as a ratio called the hazard quotient or hazard index (HI). Exposures at HIs greater than "one" do not mean that adverse effects will occur. When the estimated exposure is more than the reference level, there is increasing risk of health effects in the exposed population, and when the exposure is a multiple of the reference level there is greater concern. Table 4 also shows HIs for methylmercury for consuming sport fish species from Black Butte Reservoir at different consumption rates.

HIs for largemouth bass and channel catfish are all greater than the value of one. Even the low consumption scenario results in an exposure greater than twice the methylmercury reference level for consumers of largemouth bass. Moderate consumption results in an exposure greater than five times the reference level and the high consumption scenario leads to an exposure from largemouth bass consumption 12 times the reference level. HI for the low consumption scenario is slightly above one for consumers of channel catfish. Moderate and high consumption of channel catfish leads to exposures three and almost seven times the reference level for methylmercury.

RISK CHARACTERIZATION OF EATING SPORT FISH FROM BLACK BUTTE RESERVOIR

HIs calculated for largemouth bass and channel catfish (see Table 4) are based on multiple composites of each of these species. These are adequate samples for human health evaluation because the sample size is large enough to be reasonably sure that the measured levels are accurate representations of the true levels in these fish populations. The risks of consuming largemouth bass and channel catfish from Black Butte Reservoir are characterized separately as if people ate exclusively one species. This serves to show which species contributes more to potential health risks. The risks of consuming crappie and carp from Black Butte Reservoir cannot be characterized because the number of samples were inadequate (one composite each) to estimate and characterize the methylmercury level in populations of these fish species. One sample is not adequate for quantitative human health evaluation because by chance it could be unusually high or low (i.e., it could be in a tail of the distribution of the chemical in the fish population). Additional composites of these fish species should be sampled and analyzed.

Ingestion of largemouth bass contaminated with methylmercury poses the greatest potential hazard to consumers of sport fish from Black Butte Reservoir. HIs from eating largemouth bass suggest that even consumers eating only a few meals a month (i.e., low consumers) are potentially at increased risk. Average and high consumers are exposed at increasing multiples of the methylmercury reference level. Persons consuming high amounts of bass (e.g., subsistence fishers) are estimated to be exposed at more than ten times the reference level.

Ingestion of channel catfish contaminated with methylmercury also poses a potential risk to consumers of sport fish from Black Butte Reservoir. Low consumers of channel catfish are marginally at risk. But average consumers and high consumers eating channel catfish at the average mercury concentration would be exposed to increasing multiples of the reference level for methylmercury.

Although the risk characterization indicates that there are potential hazards associated with consuming largemouth bass and channel catfish from Black Butte Reservoir, it does not follow that consumers will show adverse effects. This is because the reference dose incorporates some margins of safety to account for uncertainties. Among all consumers, the subpopulation of greatest concern is the pregnant or lactating women, or women who might become pregnant who frequently eat large amounts of bass or catfish from Black Butte Reservoir.

GUIDELINES FOR FISH CONSUMPTION

On the basis of adequate data on mercury levels in largemouth bass and channel catfish, and likely consumption rates for these species, the risk characterization has shown that the methylmercury levels found in these species from Black Butte Reservoir consistently exceed the HI. Pregnant women and high consuming populations (e.g., subsistence fishers) should be informed of the potential hazards from consuming these sport fish from Black Butte Reservoir and should be especially aware of potential hazards to developing fetuses and children. These populations are advised to limit their fish consumption to reduce methylmercury ingestion to a level near the reference level. Generalized consumption guidelines can be established so that people can determine whether their personal consumption is above or below the reference level and decide whether to change their consumption accordingly. These guidelines for fish consumption are a science based communication tool useful for enabling sport fish consumers to reduce their potential hazards associated with consumption of chemically contaminated fish.

Consumption guidelines based on the number and size of meals that people can eat without exceeding the reference level can be related to tissue concentrations at the reference level. Table 5 shows the tissue concentrations corresponding to the methylmercury reference level at three different consumption scenarios: three meals per week; one meal per week; and one meal per month. When actual tissue concentrations fall within these ranges, consumers can use the corresponding consumption scenario to modify their consumption to an exposure at or below the methylmercury reference level. Using these guidelines for tissue levels in this table, it would be safe for pregnant women and children to consume one meal per month of largemouth bass (0.7 ppm mean tissue concentration) and channel catfish (0.4 ppm mean tissue concentration) from Black Butte Reservoir.

It is recommended that pregnant and nursing women, and women who may become pregnant within a year, eat no more than one meal of largemouth bass or one meal of channel catfish a month to protect them from the potential health effects of exposure to methylmercury as a result of sport fish consumption. This advice should also be followed closely by children under age six. This advice is based on the most sensitive population (fetuses and developing children). Older children and adults are also advised to follow these guidelines although their health hazards may be less. Concentrations of methylmercury similar to those in channel catfish were also found in a limited sample of carp and crappie from Black Butte Reservoir. Because the feeding habits of these three species are similar, there is good reason to believe that methylmercury concentrations in the population of carp and crappie will be similar to those in the well characterized channel catfish population. In this case, channel catfish are a suitable interim exposure model for consumption of carp and crappie and the same consumption advice to reduce potential methylmercury exposure should be applied to all three fish species.

HEALTH ADVISORY FOR BLACK BUTTE RESERVOIR

Due to the elevated level of mercury, pregnant women, nursing women, and women who may soon become pregnant (the most sensitive population) should eat no more than one meal (eight ounces) per month of largemouth bass, channel catfish, carp, and crappie. Mercury is a potent neurotoxin, so children and adults should also follow the same advice. Meal sizes may be adjusted to body weight using the information in Table 6.

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FIGURE 1: MAP OF BLACK BUTTE RESERVOIR AND COLLECTION SITES

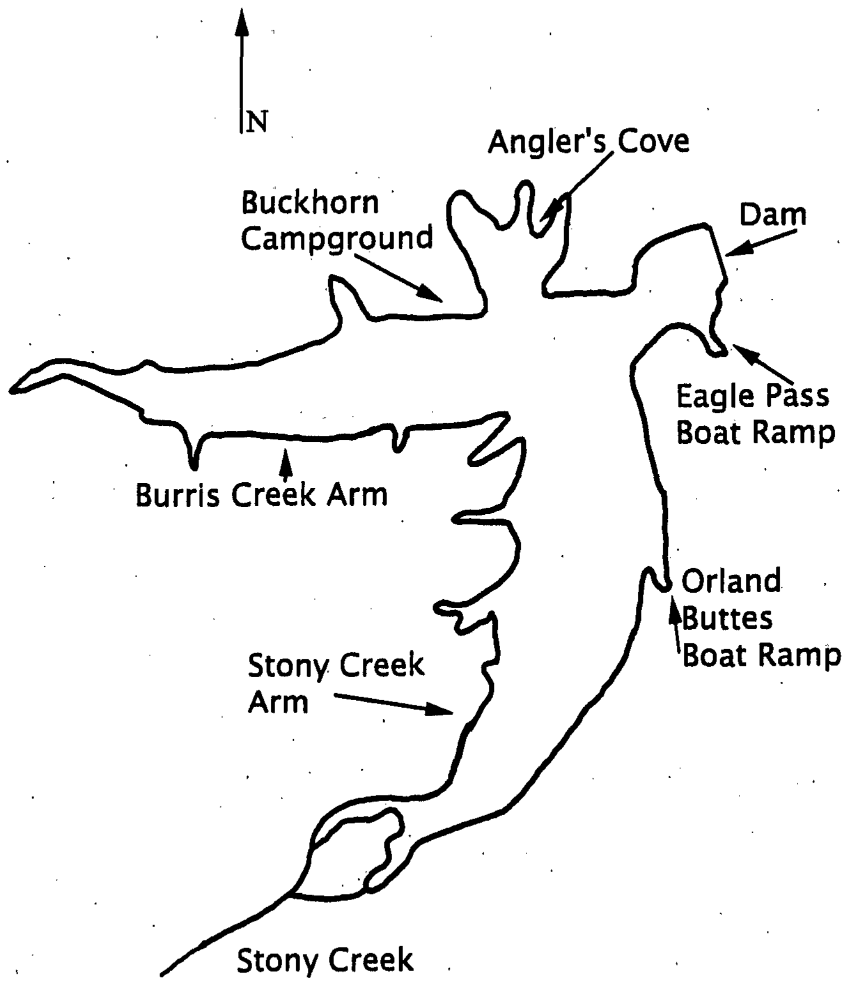

Table 1: Physical Characteristics of Fish in Composites from Black Butte Reservoir

Composite	Fish per composite	Total length (mm)	Weight (gm)	Percent lipid	Estimated age (yrs)
Crappie-MS-A	3	345	646	0.2	4
Carp-AC-A	3	478	1126	1.6	4
Largemouth bass-AC-A	3	503	2141	1.7	6
Largemouth bass-AC-B	3	402	960	0.3	4
Largemouth bass-SCA-A	3	372	716	0.1	4
Largemouth bass-SCA-B	3	312	398	0.1	3
Largemouth bass-SCA-C	3	308	388	0.2	3
Largemouth bass-SCA-D	3	302	384	0.1	3
Largemouth bass-BCA-A	3	507	2012	0.2	6
Largemouth bass-BCA-B	3	318	461	0.1	3
Largemouth bass-BCA-C	3	315	380	0.3	3
Channel catfish-AC-A	4	484	1016	2.4	6
Channel catfish-SCA-A	4	519	1227	2.3	7
Channel catfish-SCA-B	4	500	1142	3.8	7
Channel catfish-SCA-C	4	439	703	2.6	6
Channel catfish-SCA-D	4	426	647	1.8	5
Channel catfish-BCA-A	4	534	1460	4.9	8
Channel catfish-BCA-B	4	531	1382	3.0	8
Channel catfish-BCA-C	4	435	665	1.7	6

AC: composite collected from Angler's Cove
BCA: composite collected from Burris Creek Arm
SCA: composite collected from Stony Creek Arm
A, B, C, D: indicate different composites from the same area
Tabled values for length, weight, and percent lipid are the mean values for the fish in each composite.

Table 2: Mean Chemical Concentrations in Fish from Black Butte Reservoir for which there are California Lakes Study Screening Values (concentrations in ppb wet weight except as noted)

CHEMICAL	Channel catfish	Carp	Crappie	Largemouth bass
Chlordane	2.6	2.2	0.5*	0.8
Chlorpyrifos	0.4*	0.4*	0.4*	0.4*
Total DDT	13	9.3	2.2*	4.4
Diazinon	12.5*	12.5*	12.5*	12.5*
Disulfoton	LC	LC	LC	LC
Dieldrin	0.4	0.3*	0.3*	0.3*
Total endosulfan	3.2	3*	3*	3*
Endrin	0.6*	0.6*	0.6*	6*
Ethion	7.5*	7.5*	7.5*	7.5*
Heptachlor epoxide	0.3*	0.3*	0.3*	0.3*
Hexachlorobenzene	0.1*	0.1*	0.1*	0.1*
γ-hexachloro-cyclohexane	0.1*	0.1*	0.1*	0.1*
Toxaphene	14	10*	10*	10*
PCBs as Aroclors	ND*	ND*	ND*	2.2
Dioxin TEQ (ppt)	0.07	NA	NA	0.1
Arsenic	40	25	220	160
Cadmium	5*	10	5*	5*
Methylmercury	400	300	340	700
Selenium	210	590	490	460

*: all values below Method Detection Limit (MDL).
ND: Not Detected and there is no numerical MDL for Aroclors determined by this method.
LC: chemical lost on extraction column, no result.
NA: not analyzed for dibenzodioxins or dibenzofurans.
Shaded boxes indicate fish species for which the mean chemical concentration of the samples exceeds the SV.

Table 3: Descriptive Statistics for Methylmercury Concentration in Largemouth Bass and Channel Catfish

Composite	Methylmercury concentration in ppb	Size of fish in composite	Descriptive Statistics
Largemouth bass-AC-A	1100	Large	Mean: 700 ppb Standard deviation: ±360 Median: 530 ppb Geometric mean: 628 ppb Skew: 0.86 Kurtosis: -1.12
Largemouth bass-AC-B	700	Medium	
Largemouth bass-SCA-A	590	Medium	
Largemouth bass-SCA-B	470	Small	
Largemouth bass-SCA-C	430	Small	
Largemouth bass-SCA-D	410	Small	
Largemouth bass-BCA-A	1300	Large	
duplicate	1200	Large	
Largemouth bass-BCA-B	370	Small	
Largemouth bass-BCA-C	440	Small	
Channel catfish-AC-A	420	Medium	Mean: 400 ppb Standard deviation: ±56 Median: 380 ppb Geometric mean: 398 ppb Skew: 0.63 Kurtosis: -0.91
Channel catfish-SCA-A	350	Large	

Channel catfish-SCA-B	370	Large	
Channel catfish-SCA-C	380	Medium	
Channel catfish-SCA-D	350	Medium	
Channel catfish-BCA-A	500	Large	
Channel catfish-BCA-B	460	Large	
duplicate	440	Large	
Channel catfish-BCA-C	340	Medium	

Table 4: Methylmercury Concentration, Exposure Dose and Hazard Index for Fish from Black Butte Reservoir

Concentration level / consumption rate	Largemouth bass	Channel catfish
Methylmercury concentration in ppb wet weight		
Mean	700	400
Daily exposure in mg/kg/day x10^{-4}		
Low consumption 21 g/day	2.3	1.3
Moderate consumption 50 g/day	5.4	3.1
High consumption 107 g/day	12	6.6
Hazard Index (HI) ratio of daily exposure compared to methylmercury reference level (unitless)		
Low consumption 21 g/day	2.3	1.3
Average consumption 50 g/day	5.4	3.1
High consumption 107 g/day	12	6.6

Table 5. Guidelines for Tissue Levels at the Methylmercury Reference Level

Chemical of Concern	3 Meals/Week "General advisory" (97.2 g/day)	Meal/Week (32.4 g/day)	Meal/Month (7.5 g/day)	No Consumption
Methylmercury (ppm)				
pregnant women/fetuses/children	<0.07	0.07-0.20	0.21-0.87	≥0.88

NA: Not applicable

The recommended level for consumption of fish contaminated with a non-carcinogenic chemical such as methylmercury is below or equivalent to the chemical's reference level. People could eat more fish with a lower tissue concentration (before they exceed the reference level) than fish with a higher concentration. The following general equation can be used to calculate the fish tissue concentration (in mg/kg) at which the consumption exposure from a chemical with a non-carcinogenic effect is equal to the reference level for that chemical at any consumption level:

$$\text{Tissue concentration} = \frac{(\text{RfD mg/kg - day})(\text{kg Body Weight})(\text{RSC})}{\text{CR kg/day}}$$

where,

RfD	=	Chemical specific reference dose or other reference level
BW	=	Body weight of consumer
RSC	=	Relative source contribution of fish to total exposure
CR	=	Consumption rate as the daily amount of fish consumed

This equation was applied above to determine tissue concentrations of methylmercury in sport fish that would be below or equivalent to the chemical's reference level when eating different amounts of fish. The U.S. EPA RfD of 1×10^{-4} mg/kg-day was used as the reference level. A body weight of 65 kg was used to represent an average weight of pregnant women during gestation. It was assumed that fish represent 100 percent of the source of methylmercury to a fish consumer.

Meal Sizes used in this table:

Although people eat different meal sizes, their typical portion size is related to their individual body weight in a fairly consistent manner (see Table 6). The standard portion size eaten by an average adult (body weight 70 kg or 154 pounds) is eight ounces (227 g) (U.S. EPA, 1994). People tend to remember how many meals of a specific food they eat in a month and this interval is often used in consumption surveys (Gassel, 1999). A standard portion of one fish meal a month is equivalent to 7.5×10^{-3} kg/day, one meal per week is equivalent to 3.24×10^{-2} kg/day, and three meals per week is equivalent to 9.72×10^{-2} kg/day.

Table 6. Adjusting Fish Meal Size for Body Weight

Body Weight		Meal Size	
pounds	kilograms	ounces	grams
19	9	1	28
39	18	2	57
58	26	3	85
77	35	4	113
96	44	5	142
116	53	6	170
135	61	7	199
154	70	8	227
173	79	9	255
193	88	10	284
212	96	11	312
231	105	12	340
250	113	13	369
270	123	14	397
289	131	15	425
308	140	16	454

APPENDIX 1

INTERIM FISH CONSUMPTION ADVISORY FOR BLACK BUTTE RESERVOIR

COUNTY OF GLENN
HEALTH SERVICES AGENCY

Environmental Health
240 N. Villa
Willows, California 95988
530-934-6588 ✱ Fax: 530-934-6463
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Don Holm
ENVIRONMENTAL HEALTH SPECIALIST

Interim Fish consumption Advisory, Black Butte Lake

The Office of Environmental Health Hazard Assessment (OEHHA) of Cal/EPA has tested the fish from Black Butte Lake and has determined that they contain mercury at a level that may require a fish consumption advisory. Since OEHHA will not be able to complete it's advisory until sometime next year, the Glenn County Health Department is providing this interim fish consumption advisory based on a State advisory from Clear Lake, where mercury levels in the fish are similar. Bass species other then largemouth bass should be consumed at the same rate for equal sized largemouth bass. Catfish species other then channel catfish should be consumed at the same rate for equal sized channel catfish. Fish not listed should be consumed at the same rate as small crappie. Note that the fish consumption advisory finally published by OEHHA for Black Butte Lake may differ from the Clear Lake advisory.

Almost all fish, whether commercial or sport are contaminated with some level of mercury. Mercury is a naturally occurring element in Coast Range rock formations. Similar levels of mercury contamination in fish flesh have been found in many Northern California lakes and reservoirs. Following the consumption guidelines in this advisory provides a safe way to catch and enjoy your favorite sport fish.

CONSUMPTION RECOMMENDATIONS for CLEAR LAKE

1.Eating sport fish in amounts slightly greater than what is recommended should not present a health hazard if only done occasionally such as eating fish caught during an annual vacation.
2.Nursing and pregnant women and young children may be more sensitive to the harmful effects of some of the chemicals and should be particularly careful about following the advisories. Because contaminants take a long time to leave the body after they accumulate, women who plan on becoming pregnant should begin following the more restrictive consumption advice, a year before becoming pregnant. In this way, the levels of chemicals stored in the body can go down.
3.The limits given below for each species and area assume that no other contaminated fish is being eaten. If you consume several different listed species from the same area, or the same species from several areas, your total consumption still should not exceed the recommended amount. One simple approach is to just use the lowest recommended amount as a guideline to consumption.

Clear Lake (Lake County)
Because of elevated mercury levels, adults should eat no more than the amounts indicated below per month (See Note No. 3 above). **Women who are pregnant or may become pregnant, nursing mothers, and children under age six should not eat fish from these lakes.** Children 6-15 years of age should eat no more than one-half the amounts indicated for adults.

FISH SPECIES	CLEAR LAKE ADVICE
largemouth bass over 15"	1 lb
largemouth bass under 15"	2 lbs
channel catfish over 24"	1 lb
channel catfish under 24"	3 lbs
Crappie over 12"	1 lb
Crappie under 12"	3 lbs

Adjusting Fish Meal Size for Body Weight

In the site-specific guidance that follows, OEHHA often gives consumption advice in terms of meals for a given period such as a meal a week, and uses an eight-ounce meal size as the standard amount allowed for the "average" adult. The average adult weighs approximately 150 pounds (equivalent to 70 kg). Because you and your family members may weigh more or less than the average adult, you can use the chart below to adjust serving sizes to stay within the recommended consumption guidelines.

How big is a meal?

IF YOU WEIGH…		YOUR MEAL SIZE SHOULD NOT EXCEED	
Pounds or	kilograms	Ounces	or grams
19	9	1	28
39	18	2	57
58	26	3	85
77	35	4	113
96	44	5	142
116	53	6	170
135	61	7	199
154	70	8	227
173	79	9	255
193	88	10	284
212	96	11	312
231	105	12	340
250	113	13	369
270	123	14	397
289	131	15	425
308	140	16	454

B.1.12 Camanche Reservoir, Aluminum

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region, (Regional Board) recommends the addition of Camanche Reservoir to California's Clean Water Act Section 303(d) list due to impairment by aluminum. Information available to the Regional Board on aluminum levels in water samples indicates that water quality objectives are not being attained in Camanche Reservoir. A description for the basis for this determination is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Camanche Reservoir	**Pollutants/Stressors**	Aluminum
Hydrologic Unit	535.00	**Sources**	Resource extraction (abandoned mines)
Total Waterbody Size	7,622 acres	**TMDL Priority**	
Size Affected	7,622 acres	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	The entire reservoir	**TMDL End Date (Mo/Yr)**	

Watershed Characteristics

The Camanche Reservoir is approximately 10 miles downstream from Pardee Dam on the Mokelumne River at the intersection of Amador, Calaveras, and San Joaquin Counties. The Camanche Reservoir has a surface area of 7,622 acres and a 63-mile shoreline (EBMUD, 2000). When the reservoir is at full capacity, it extends upstream to Pardee Dam (USGS, 1976). Camanche Reservoir, working in tandem with Pardee Reservoir, stores water for irrigation and stream-flow regulation, providing flood control, water to the meet the needs of downstream water rights holders, and water for fisheries and riparian habitat (EBMUD, 2000). The East Bay Municipal Utility District (EBMUD) completed the Camanche Reservoir Project (downstream of Pardee) in 1964. EBMUD built a fish hatchery (the Mokelumne River Fish Installation, which the California Department of Fish and Game operates) immediately downstream of Camanche Dam. In addition, a power plant at the base of the dam was placed in service in 1983.

Water Quality Objectives Not Attained

The narrative objective for toxicity is not being attained for aluminum in Camanche Reservoir. The narrative toxicity objective in the Basin Plan states, in part, "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life." The narrative toxicity objective further states that "The Regional Water Board will also consider … numerical criteria and guidelines for toxic substances developed by the State Water Board, the California Office of Environmental Health Hazard Assessment, the California Department of Health Services, the U.S. Food and Drug Administration, the National Academy of Sciences, the U.S. Environmental Protection Agency, and other appropriate organizations to evaluate compliance with this objective (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/~rwqcb5/bsnplnab.pdf)."

The toxicity objective was evaluated for Camanche Reservoir by comparing aluminum concentrations measured in Camanche Reservoir to water quality guidelines and criteria developed for human health and wildlife protection. Available data was compared to the numeric United States Environmental Protection Agency (USEPA) National Recommended Ambient Water Quality Criteria (NRAWQ) maximum (1-hour average) total recoverable aluminum criterion for freshwater aquatic life protection of 750 micrograms per liter (μg/L) (Marshack, 2000). The USEPA maximum contaminant level (MCL) for drinking water protection is 1,000 μg/L of total recoverable aluminum (Marshack, 2000).

Evidence of Impairment
Between February 1993 and February 1996 (after the start up period of the treatment plant at Mine Run Creek), EBMUD analyzed samples collected throughout Camanche Reservoir for total aluminum concentrations (SCH EIR, 1996). Table 2 summarizes the EBMUD data for Camanche Reservoir. Between September 1999 and August 2000, EBMUD collected 12 samples from each of two locations in the Camanche Reservoir: 1,000 feet downstream from the inflow of Mine Run Creek into Camanche Reservoir, and 3,000 feet upstream of the Mine Run Creek inflow. The 12 downstream samples had concentrations ranging from less than 10 μg/l to 96.6 μg/l (CH2MHill, 2000b).

Table B-2. Summary of Available Total Aluminum Concentration Data for Camanche Reservoir (Data source: SCH EIR, 1996; CH2MHill, 2000b)

Location[a] (upstream to downstream)	# of Samples	Range of Concentrations (μg/l)	# [%] of Samples Exceeding MCL (1,000 μg/l)[b]	# [%] of Samples Exceeding NRAWQ Maximum Criterion (750 μg/l)[b]
Site A	48 (2/93 – 2/96)	< 5 – 880, 3,040[c]	1 [2.1%]	2 [4.2%]
Site Q	38 (2/93 – 2/96)	< 5 – 740, 3,130[c]	1 [2.6%]	1 [2.6%]
Site D	43 (2/93 – 2/96)	< 5 – 870, 2,750[c]	1 [2.3%]	2 [4.6%]
Other	131 (2/93 – 2/96)	< 5 – 1,100	5 [3.8%]	14 [11%]
CAMA[d]	12 (9/99 – 8/00)	<10.4 – 144	0 [0%]	0 [0%]
PENN20[d]	12 (9/99 – 8/00)	<10.4 – 96.6	0 [0%]	0 [0%]

[a] Site A: Camanche Reservoir, 0.5 miles upstream of Penn Mine.
Site Q: Point of discharge of Mine Run Creek to Camanche Reservoir.
Site D: Camanche Reservoir, 0.8 miles downstream of Penn Mine.
Other: Camanche Reservoir, 2 miles, 3 miles, and 10 miles downstream of Penn Mine.
CAMA: Camanche Reservoir, 0.57 miles upstream of Penn Mine (slightly upstream of Site A).
PENN20: Camanche Reservoir, 0.2 miles downstream of Penn Mine (downstream of Site D, slightly upstream of Site Q).

[b] MCL: USEPA primary maximum contaminant level for drinking water protection.
NRAWQ: USEPA National Recommended Ambient Water Quality Criteria maximum (1-hour average) total recoverable aluminum criterion for freshwater aquatic life protection.

[c] On March 16, 1995, total aluminum concentrations of 3,040, 3,130, and 2,750 μg/l were listed for Sites A, Q, and D in the EBMUD data set. Total suspended solids (TSS, a measure of turbidity) values of 24-25 milligrams per liter (mg/L) were measured at each of these locations on that date; these values are unusually high, given TSS values typically ranged between 1 and 10 mg/L.

[d] Only dissolved aluminum data were available for comparison to the water quality objectives; therefore, the actual number of exceedances may be greater than the number listed on this table.

Extent of Impairment
Camanche Reservoir covers 7,622 surface acres. The entire waterbody is impaired by aluminum due to the percent aluminum exceeding the maximum criterion at stations throughout the reservoir.

Potential Sources
Several historic copper and gold mines are within the lower Mokelumne River watershed upstream of Camanche Reservoir. Penn Mine, which historically operated for copper extraction from 1861 to 1956,

impacted the water quality of Camanche Reservoir. The Penn Mine site occupies a 22-acre area near the southeastern shore of Camanche Reservoir approximately 1.5 miles from the town of Campo Seco in Calaveras County. Penn Mine historically discharged to the reservoir via Mine Run Creek. Metal loading from Penn Mine led to fishery declines and fishkills in Camanche Reservoir, in the Mokelumne River Fish Installation downstream of Camanche Dam, and in the lower Mokelumne River; problems with toxic discharges from the Penn Mine continued through the 1960s and 1970s (Buer *et al*, 1979; SRWCB, 1990; CDFG, 1991; EDAW, Inc., 1992; EBMUD, 2000). Beginning in 1978, several abatement and restoration projects were conducted to decrease the impact of Penn Mine on Camanche Reservoir and the lower Mokelumne River; the most recent abatement project was completed in late 1999 (Buer *et al*, 1979; SCH EIR, 1996; CH2MHill, 2000a and 2000b). The recent sampling results indicate that aluminum sources upstream of Penn Mine (e.g., abandoned mine sites and natural sources) contribute enough aluminum to cause water entering Camanche Reservoir to exceed toxicity criteria.

B.3.2 Camanche Reservoir, Copper

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region, recommends changes to California's Clean Water Act Section 303(d) list for the impairment of the Camanche Reservoir by elevated dissolved copper concentrations. Camanche Reservoir was included on the 1998 303(d) list as part of the listing for the lower Mokelumne River. Regional Board staff has determined that listing reservoirs separately from their associated downstream drainages is more appropriate because watershed management strategies (and associated data needs) for reservoirs can be distinctly different from management strategies for the downstream drainages.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Camanche Reservoir*	**Pollutants/Stressors**	Copper
Hydrologic Unit	535.00	**Sources**	Resource extraction (abandoned mines)
Total Waterbody Size	7,622 acres	**TMDL Priority**	Low
Size Affected	7,622 acres	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	Entire lake.	**TMDL End Date (Mo/Yr)**	
Original 303(d) Listing Year	1992		

* Previously listed as part of the lower Mokelumne River.

Watershed Characteristics

The Camanche Reservoir is approximately 10 miles downstream from Pardee Dam on the Mokelumne River at the intersection of Amador, Calaveras, and San Joaquin Counties. The Camanche Reservoir has a surface area of 7,622 acres and a 63-mile shoreline (EBMUD, 2000). When the reservoir is at full capacity, it extends upstream to Pardee Dam (USGS, 1958-1992). Camanche Reservoir, working in tandem with Pardee Reservoir, stores water for irrigation and stream-flow regulation, providing flood control, water to the meet the needs of downstream water rights holders, and water for fisheries and riparian habitat (EBMUD, 2000). The East Bay Municipal Utility District (EBMUD) completed the Camanche Reservoir Project (downstream of Pardee) in 1964. EBMUD built a fish hatchery (the Mokelumne River Fish Installation, which the California Department of Fish and Game operates) immediately downstream of Camanche Dam. In addition, a power plant at the base of the dam was placed in service in 1983.

Several historic copper and gold mines are within the lower Mokelumne River watershed upstream of Camanche Reservoir. Penn Mine, which historically operated for copper extraction from 1861 to 1956, impacted the water quality of Camanche Reservoir. The Penn Mine site occupies a 22-acre area near the southeastern shore of Camanche Reservoir approximately 1.5 miles from the town of Campo Seco in Calaveras County. Penn Mine historically discharged to the reservoir via Mine Run Creek. Metal loading from Penn Mine led to fishery declines and fish kills in Camanche Reservoir, in the Mokelumne River Fish Installation downstream of Camanche Dam, and in the lower Mokelumne River. Problems with toxic discharges from the Penn Mine continued through the 1960s and 1970s (Buer *et al*, 1979; SRWCB, 1990; CDFG, 1991; EDAW, Inc., 1992; EBMUD, 2000). Beginning in 1978, several abatement and restoration projects were conducted to decrease the impact of Penn Mine on Camanche Reservoir and the lower Mokelumne River; the most recent abatement project was completed in late 1999 (Buer *et al*, 1979; SCH EIR, 1996; CH2MHill, 2000a and 2000b).

Water Quality Objectives Not Attained

The chemical constituents objective and California Toxics Rule were evaluated for Camanche Reservoir by comparing copper concentrations measured in Camanche Reservoir to water quality objectives and criteria developed for drinking water and aquatic life protection. The numeric United States Environmental

Protection Agency (USEPA) California Toxics Rule (CTR) hardness-dependent continuous (4-day average) and maximum (1-hour average) dissolved copper criteria for freshwater aquatic life protection are not being attained. The continuous and maximum criteria are 2.3 micrograms per liter (µg/L) and 2.9 µg/L, respectively, based on an assumed hardness of 20 milligrams per liter (mg/L) of calcium carbonate ($CaCO_3$) (Marshack, 2000). Hardness is assumed to be 20 mg/l of $CaCO_3$ because numerous studies (e.g., CH2MHill, 2000b & Buer *et al*, 1979) have indicated that Camanche Reservoir/Mokelumne River water has hardness values typical ranging from 10 to 25 mg/L. The California DHS primary maximum contaminant level (MCL) for drinking water protection is 1,300 µg/L of total recoverable copper (Marshack, 2000).

Evidence of Impairment

Elevated copper concentrations in water samples collected since 1958 indicate that copper impairs Camanche Reservoir. The data also indicate a strong seasonality to the copper loading; Penn Mine historically discharged more copper during wet seasons than during dry seasons. As illustrated by the data summaries below, a series of remediation projects at Penn Mine conducted in 1978, 1993, and 1999-2000 have significantly decreased the amount of copper leaving the mine site.

Water samples collected in Camanche Reservoir upstream of the Penn Mine discharge before the first remediation project had total copper concentrations of 10 µg/L (February 1958, wet season) and less than 10 µg/L (October 1977, dry season) (Buer *et al*, 1979). Downstream from the mine discharge, total copper concentrations were 3,800 µg/L and 40 µg/L, in 1958 and 1977, respectively (Buer *et al*, 1979). The downstream concentrations exceeded the toxicity criteria promulgated at that time, and were four to 380 times the upstream copper concentrations. Between February 1993 and February 1996 (after the start up period of the treatment plant at Mine Run Creek), EBMUD analyzed samples collected throughout Camanche Reservoir for total and dissolved copper concentrations (SCH EIR, 1996). Table B-2 summarizes the EBMUD data for Camanche Reservoir.

As a result of the most recent remediation activities at Penn Mine that took place in 1999, the copper load from Penn Mine decreased from approximately 19,372 to 23,122 pounds per year (before the 1999 project) to approximately 190.4 pounds per year, a decrease of approximately 99% (CH2MHill, 2000b). Recent data indicate that both the frequency and magnitude of CTR exceedances in Camanche Reservoir have decreased since 1992, and that dissolved copper concentrations in Camanche Reservoir now appear to be at or below the CTR criteria. However, future samples should be analyzed using a lower method detection limit (MDL) to determine long-term compliance with the CTR criteria. Between September 1999 and August 2000, EBMUD collected 12 samples from Camanche Reservoir, approximately 1,000 feet downstream from the inflow of Mine Run Creek (CH2MHill, 2000b). One sample, collected in February 2000, had a dissolved copper concentration of 3.54 µg/L (hardness, 18 mg/l), which slightly exceeds the hardness-adjusted CTR continuous and maximum criteria. The five samples collected in September 1999 through January 2000 contained dissolved copper concentrations below their method detection limit (MDL) of 2.08 µg/L (hardness, 10-25 mg/L), indicating that dissolved copper concentrations probably did not exceed the CTR criteria. However, the MDL for samples collected in February through August 2000 was 3.12 µg/L, which is slightly higher than the hardness-dependent CTR criteria for dissolved copper; therefore, dissolved copper concentrations in these samples may or may not have slightly exceeded the CTR criteria.

Table B-2. Summary of Available Copper Concentration Data for Camanche Reservoir (Data sources: SCH EIR, 1996; CH2MHill, 2000b)

Location[a] (upstream to downstream)	Total Copper Concentrations			Dissolved Copper Concentrations			
	# of Samples (Dates Collected)	Range of Concentrations (μg/l)	# [%] of Samples Exceeding MCL (1,300 μg/l)[b]	# of Samples (Dates Collected)	Range of Concentrations (μg/l)[c]	# [%] of Samples Exceeding CTR Criteria[b]: Maximum Criterion (2.9 μg/l)	# [%] of Samples Exceeding CTR Criteria[b]: Continuous Criterion (2.3 μg/l)
Site A	47 (2/93 – 2/96)	< 2 – 9	0 [0%]	18 (2/93 – 2/96)	< 1.5 – 5	5 [28%]	5 [28%]
Site Q	48 (2/93 – 2/96)	< 1 – 17	0 [0%]	16 (2/93 – 2/96)	< 2 – 17	7 [44%]	8 [50%]
Site D	43 (2/93 – 2/96)	< 1.5 – 14	0 [0%]	17 (2/93 – 2/96)	< 2 – 7	4 [24%]	4 [24%]
Other	131 (2/93 – 2/96)	< 1 – 16, 140[d]	0 [0%]	41 (2/93 – 2/96)	< 2 – 5	8 [20%]	8 [20%]
CAMA	/	/	/	12 (9/99 – 8/00)	< 2 – < 3.12	0 [0%]	0 [0%]
PENN20	/	/	/	12 (9/99 – 8/00)	< 2 – 3.54	1 [8%]	1 [8%]

[a] Site A: Camanche Reservoir, 0.5 miles upstream of Penn Mine.
Site Q: Point of discharge of Mine Run Creek to Camanche Reservoir.
Site D: Camanche Reservoir, 0.8 miles downstream of Penn Mine.
Other: Camanche Reservoir, 2 miles, 3 miles, and 10 miles downstream of Penn Mine.
CAMA: Camanche Reservoir, 0.57 miles upstream of Penn Mine (slightly upstream of Site A).
PENN20: Camanche Reservoir, 0.2 miles downstream of Penn Mine (downstream of Site D, slightly upstream of Site Q).

[b] MCL: California DHS primary maximum contaminant level for drinking water protection.
CTR: United States Environmental Protection Agency's California Toxics Rule (CTR) hardness-dependent continuous (4-day average) and maximum (1-hour average) dissolved copper criteria for freshwater aquatic life protection, based on an assumed hardness of 20 mg/L of $CaCO_3$ if hardness data were not available.

[c] Many samples were analyzed using methods with detection limits below the level needed to evaluate compliance with the CTR criteria; therefore, the actual number of exceedances may be greater than indicated by this table.

[d] On February 22, 1993, a total copper concentration of 140 μg/l was measured at the site 3 miles downstream of Penn Mine in the EBMUD data set. No high values were measured for other metals at this site or for total copper concentrations at other sites, on this date.

B.3.3 Camanche Reservoir, Zinc

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region, recommends changes to California's Clean Water Act Section 303(d) list for the impairment of the Camanche Reservoir by elevated dissolved zinc concentrations. Camanche Reservoir was included on the 1998 303(d) list as part of the listing for the lower Mokelumne River. Regional Board staff has determined that listing reservoirs separately from their associated downstream drainages is more appropriate because watershed management strategies (and associated data needs) for reservoirs can be distinctly different from management strategies for the downstream drainages.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Camanche Reservoir*	**Pollutants/Stressors**	Zinc
Hydrologic Unit	535.00	**Sources**	Resource extraction (abandoned mines)
Total Waterbody Size	7,622 acres	**TMDL Priority**	Low
Size Affected	7,622 acres	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	Entire lake.	**TMDL End Date (Mo/Yr)**	
Original 303(d) Listing Year	1992		

* Previously listed as part of the lower Mokelumne River.

Watershed Characteristics

The Camanche Reservoir is approximately 10 miles downstream from Pardee Dam on the Mokelumne River at the intersection of Amador, Calaveras, and San Joaquin Counties. The Camanche Reservoir has a surface area of 7,622 acres and a 63-mile shoreline (EBMUD, 2000). When the reservoir is at full capacity, it extends upstream to Pardee Dam (USGS, 1958-2000). Camanche Reservoir, working in tandem with Pardee Reservoir, stores water for irrigation and stream-flow regulation, providing flood control, water to the meet the needs of downstream water rights holders, and water for fisheries and riparian habitat (EBMUD, 2000). The East Bay Municipal Utility District (EBMUD) completed the Camanche Reservoir Project (downstream of Pardee) in 1964. EBMUD built a fish hatchery (the Mokelumne River Fish Installation, which the California Department of Fish and Game operates) immediately downstream of Camanche Dam. In addition, a power plant at the base of the dam was placed in service in 1983.

Several historic copper and gold mines are within the lower Mokelumne River watershed upstream of Camanche Reservoir. Penn Mine, which historically operated for copper extraction from 1861 to 1956, impacted the water quality of Camanche Reservoir. The Penn Mine site occupies a 22-acre area near the southeastern shore of Camanche Reservoir approximately 1.5 miles from the town of Campo Seco in Calaveras County. Penn Mine historically discharged to the reservoir via Mine Run Creek. Metal loading from Penn Mine led to fishery declines and fish kills in Camanche Reservoir, in the Mokelumne River Fish Installation downstream of Camanche Dam, and in the lower Mokelumne River; problems with toxic discharges from the Penn Mine continued through the 1960s and 1970s (Buer *et al*, 1979; SRWCB, 1990; CDFG, 1991; EDAW, Inc., 1992; EBMUD, 2000). Beginning in 1978, several abatement and restoration projects were conducted to decrease the impact of Penn Mine on Camanche Reservoir and the lower Mokelumne River; the most recent abatement project was completed in late 1999 (Buer *et al*, 1979; SCH EIR, 1996; CH2MHill, 2000a and 2000b).

Water Quality Objectives Not Attained

The chemical constituents objective and California Toxics Rule criteria were evaluated for Camanche Reservoir by comparing zinc concentrations measured in reservoir to water quality objectives and criteria developed for drinking water and aquatic life protection. The numeric United States Environmental Protection Agency (USEPA) California Toxics Rule (CTR) hardness-dependent continuous (4-day average) and maximum (1-hour average) dissolved zinc criteria for freshwater aquatic life protection are both 30 micrograms per liter (μg/L), based on an assumed hardness of 20 milligrams per liter (mg/L) of calcium carbonate ($CaCO_3$) (Marshack, 2000). The CTR continuous and maximum criteria adjusted for total recoverable zinc are not being attained. The criteria are both 31 μg/L, based on an assumed hardness of 20 mg/L of $CaCO_3$ (Marshack, 2000). (Hardness is assumed to be 20 mg/l of $CaCO_3$ because numerous studies (e.g., CH2MHill, 2000b & Buer *et al*, 1979) have indicated that Camanche Reservoir/Mokelumne River water has hardness values typical ranging from 10 to 25 mg/L.)

Evidence of Impairment

Elevated zinc concentrations in water samples collected since 1958 indicate that zinc impairs Camanche Reservoir. The data indicate a strong seasonality to the zinc loading; Penn Mine historically discharged more zinc during wet seasons than during dry seasons. As illustrated by the data summaries below, a series of remediation projects at Penn Mine conducted in 1978, 1993, and 1999-2000 have significantly decreased the amount of zinc leaving the mine site.

Water samples collected in Camanche Reservoir upstream of the Penn Mine discharge before the first remediation project had total zinc concentrations of 10 μg/L (February 1958, wet season) and 250 μg/L (October 1977, dry season) (Buer *et al*, 1979). Downstream from the mine discharge, total zinc concentrations were 37,600 μg/L and 1,120 μg/L, in 1958 and 1977, respectively (Buer *et al*, 1979). The downstream concentrations exceeded the toxicity criteria promulgated at that time, and were 4.5 to 3,760 times the upstream zinc concentrations. Between February 1993 and February 1996 (after the start up period of the treatment plant at Mine Run Creek), EBMUD analyzed samples collected throughout Camanche Reservoir for total and dissolved zinc concentrations (SCH EIR, 1996).

As a result of the most recent remediation activities at Penn Mine that took place in 1999, the zinc load from Penn Mine decreased from approximately 35,875 to 43,035 pounds per year (before the 1999 project) to approximately 1,907 pounds per year, a decrease of approximately 95% (CH2MHill, 2000b). Between September 1999 and August 2000, EBMUD collected samples from two locations at Camanche Reservoir, 1,000 feet downstream from the inflow of Mine Run Creek into Camanche Reservoir, and 3,000 feet upstream of the inflow. One downstream sample, collected in November 1999, had a dissolved zinc concentration of 31.9 μg/L (hardness, 16 mg/l), which slightly exceeds the hardness-adjusted CTR continuous and maximum criteria. Table B-2 summarizes the EBMUD data for Camanche Reservoir.

Table B-2 Summary of Available Zinc Concentration Data for Camanche Reservoir (Data sources: SCH EIR, 1996; CH2MHill, 2000b)

Location[a] (upstream to downstream)	**Dissolved Zinc Concentrations**		
	# of Samples (Dates Collected)	Range of Concentrations (µg/l)	# [%] of Samples Exceeding CTR Criteria[b] (30 µg/L)
Site A	18 (2/93 – 2/96)	< 3 – 63	1 [6%]
Site Q	16 (2/93 – 1/96)	3 – 95	8 [50%]
Site D	17 (2/93 – 2/96)	< 5 – 97	4 [24%]
Other	41 (2/93 – 2/96)	< 3 - 24	0 [0%]
CAMA	12 (9/99 – 8/00)	< 0.8 – 9.29	0 [0%]
PENN20	12 (9/99 – 8/00)	2.12 – 31.9	1 [8%]

[a] Site A: Camanche Reservoir, 0.5 miles upstream of Penn Mine.
Site Q: Point of discharge of Mine Run Creek to Camanche Reservoir.
Site D: Camanche Reservoir, 0.8 miles downstream of Penn Mine.
Other: Camanche Reservoir, 2 miles, 3 miles, and 10 miles downstream of Penn Mine.
CAMA: Camanche Reservoir, 0.57 miles (3,000 feet) upstream of Penn Mine, just upstream of Site A.
PENN20: Camanche Reservoir, 0.2 miles (1,000 feet) downstream of Penn Mine (downstream of Site D, slightly upstream of Site Q).

[b] CTR: United States Environmental Protection Agency's California Toxics Rule (CTR) hardness-dependent continuous (4-day average) and maximum (1-hour average) dissolved zinc criteria for freshwater aquatic life protection, based on an assumed hardness of 20 mg/L of $CaCO_3$ if hardness data were not available.

B.1.29 Lower Mokelumne River, Aluminum

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region, (Regional Board) recommends the addition of the lower Mokelumne River to California's Clean Water Act Section 303(d) list due to impairment by aluminum. Information available to the Regional Board on aluminum levels in water samples indicates that water quality objectives are not being attained in the lower Mokelumne River. A description for the basis for this determination is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Mokelumne River, Lower	**Pollutants/Stressors**	Aluminum
Hydrologic Unit	535.00	**Sources**	Resource extraction (abandoned mines)
Total Waterbody Size	28 miles	**TMDL Priority**	
Size Affected	28 miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	Camanche Dam to Delta	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	38° 13' 35"	**Upstream Extent Longitude**	121° 1' 21"
Downstream Extent Latitude	38° 12' 36"	**Downstream Extent Longitude**	121° 21' 55"

Watershed Characteristics

The lower Mokelumne River flows 28 miles from Camanche Dam to the legal Sacramento-San Joaquin Delta boundary in San Joaquin County. Camanche Reservoir, working in tandem with the upstream Pardee Reservoir, stores water for irrigation and stream-flow regulation, providing flood control, water to the meet the needs of downstream water rights holders, and water for fisheries and riparian habitat (EBMUD, 2000). The East Bay Municipal Utility District (EBMUD) completed the Camanche Reservoir Project (downstream of Pardee) in 1964. EBMUD built a fish hatchery (the Mokelumne River Fish Installation, which the California Department of Fish and Game operates) immediately downstream of Camanche Dam on the lower Mokelumne River. In addition, a power plant at the base of the dam was placed in service in 1983.

Water Quality Objectives Not Attained

The narrative objectives for toxicity and chemical constituents are not being attained for aluminum in the lower Mokelumne River. The narrative toxicity objective in the Basin Plan states, in part, "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life." The narrative toxicity objective further states that "The Regional Water Board will also consider ... numerical criteria and guidelines for toxic substances developed by the State Water Board, the California Office of Environmental Health Hazard Assessment, the California Department of Health Services, the U.S. Food and Drug Administration, the National Academy of Sciences, the U.S. Environmental Protection Agency, and other appropriate organizations to evaluate compliance with this objective (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/~rwqcb5/bsnplnab.pdf)."

The toxicity and chemical constituents objectives were evaluated for the lower Mokelumne River by comparing aluminum concentrations measured in the lower Mokelumne River downstream of Camanche Dam to water quality guidelines and criteria developed for human health and wildlife protection. Available data were compared to the numeric United States Environmental Protection Agency (USEPA) National Recommended Ambient Water Quality Criteria (NRAWQ) maximum (1-hour average) total recoverable aluminum criterion for freshwater aquatic life protection of 750 micrograms per liter (µg/L) (Marshack, 2000). The California DHS primary maximum contaminant level (MCL) for drinking water protection is 1,000 µg/L of total recoverable aluminum (Marshack, 2000).

Evidence of Impairment

Between 1988 and 1992, EBMUD measured total recoverable aluminum concentrations at three locations on the Mokelumne River downstream of Camanche Dam (USFWS, 1992). Table B-2 summarizes the available EBMUD aluminum data. The 1988-1992 data indicate that exceedances of the MCL and NRAWQ criteria occurred in the lower Mokelumne River immediately downstream of Camanche Dam. More recent aluminum data are not available.

Table B-2. Summary of Available Total Recoverable Aluminum Concentration Data for the Lower Mokelumne River (Data source: USFWS, 1992)

Location[a]	# of Samples (Dates Collected)	Range of Concentrations (µg/L)	# (%) of Samples Exceeding Objectives[b]	
			MCL (1,000 µg/L)	NRAWQ Maximum Criterion (750 µg/L)
CamC	146 (9/88 – 11/92)	<10 – 4,800	12 [8%][c]	19 [13%][d]
CamD	90 (5/88 – 11/92)	<10 –2,900	10 [11%]	14 [16%]
VAPK	21 (6/88-11/92)	20 – 1,900	2 [10%]	2 [10%]

[a] CamC: Discharge from Camanche Dam to the Mokelumne River.
CamD: Camanche Reservoir lower outlet to the Mokelumne River
VAPK: Mokelumne River at Van Assen Park, downstream of Camanche Dam.

[b] MCL: California DHS Drinking Water Standards Primary Maximum Contaminant Level (MCL) of 1,000 µg/l for total recoverable aluminum concentrations.
NRAWQ: U.S. Environmental Protection Agency National Recommended Ambient Water Quality Criteria (NRAWQ) for Freshwater Aquatic Life Protection; maximum criterion is a 1-hour average, for pH values of 6.5 to 9.

[c] The twelve samples with aluminum concentrations above 1,000 µg/l were collected within a 7-day period in March 1989.

[d] Eighteen of the 19 samples with aluminum concentrations above 750 µg/l were collected within an 8-day period in March 1989.

Extent of Impairment

The lower Mokelumne River flows 28 miles from Camanche Dam to the Delta. Data are available only for approximately one mile downstream of Camanche Dam. However, the entire 28-mile reach is probably impaired because there are no substantial input flows below the dam.

Potential Sources

Several historic copper and gold mines (including Argonaut, Newton, and Penn) are within the lower Mokelumne River watershed. Penn Mine, which historically operated for copper extraction from 1861 to 1956, impacted the water quality of both Camanche Reservoir and the lower Mokelumne River downstream of Camanche Dam. The Penn Mine site occupies a 22-acre area near the southeastern shore of Camanche Reservoir approximately 1.5 miles from the town of Campo Seco in Calaveras County. Penn Mine historically discharged to the reservoir via Mine Run Creek. Metal loading from Penn Mine led to fishery declines and fish kills in Camanche Reservoir, in the Mokelumne River Fish Installation downstream of Camanche Dam, and in the lower Mokelumne River; problems with toxic discharges from the Penn Mine continued through the 1960s and 1970s (Buer *et al*, 1979; SRWCB, 1990; CDFG, 1991; EDAW, Inc., 1992; EBMUD, 2000). Beginning in 1978, several abatement and restoration projects were conducted to decrease the impact of Penn Mine on Camanche Reservoir and the lower Mokelumne River; the most recent abatement project was completed in late 1999 (Buer *et al*, 1979; SCH EIR, 1996; CH2MHill, 2000a and 2000b).

B.3.12 Lower Mokelumne River, Copper - Change in Extent of Impairment

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region, recommends changes to California's Clean Water Act Section 303(d) list for the impairment of the lower Mokelumne River by elevated dissolved copper concentrations. Camanche Reservoir was included on the 1998 303(d) list as part of the listing for the lower Mokelumne River. Regional Board staff has determined that listing reservoirs separately from their associated downstream drainages is more appropriate because watershed management strategies (and associated data needs) for reservoirs can be distinctly different from management strategies for the downstream drainages.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Mokelumne River, Lower	**Pollutants/Stressors**	Copper
Hydrologic Unit	535.00	**Sources**	Resource extraction (abandoned mines)
Total Waterbody Size	28 miles	**TMDL Priority**	Low
Size Affected	28 miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	~~All of lower Mokelumne River.~~ Camanche Dam to Delta.	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	38° 13' 35"	**Upstream Extent Longitude**	121° 1' 21"
Downstream Extent Latitude	38° 12' 36"	**Downstream Extent Longitude**	121° 21' 55"
Original 303(d) Listing Year	1992		

Watershed Characteristics

The lower Mokelumne River flows 28 miles from Camanche Dam to the legal Sacramento-San Joaquin Delta boundary in San Joaquin County. Camanche Reservoir, working in tandem with the upstream Pardee Reservoir, stores water for irrigation and stream-flow regulation, providing flood control, water to the meet the needs of downstream water rights holders, and water for fisheries and riparian habitat (EBMUD, 2000). The East Bay Municipal Utility District (EBMUD) completed the Camanche Reservoir Project (downstream of Pardee) in 1964. EBMUD built a fish hatchery (the Mokelumne River Fish Installation, which the California Department of Fish and Game operates) immediately downstream of Camanche Dam on the lower Mokelumne River. In addition, a power plant at the base of the dam was placed in service in 1983.

Several historic copper and gold mines (including Argonaut, Newton, and Penn) are within the lower Mokelumne River watershed. Penn Mine, which historically operated for copper extraction from 1861 to 1956, impacted the water quality of both Camanche Reservoir and the lower Mokelumne River downstream of Camanche Dam. The Penn Mine site occupies a 22-acre area near the southeastern shore of Camanche Reservoir approximately 1.5 miles from the town of Campo Seco in Calaveras County. Penn Mine historically discharged to the reservoir via Mine Run Creek. Metal loading from Penn Mine led to fishery declines and fish kills in Camanche Reservoir, in the Mokelumne River Fish Installation downstream of Camanche Dam, and in the lower Mokelumne River; problems with toxic discharges from the Penn Mine continued through the 1960s and 1970s (Buer *et al*, 1979; SRWCB, 1990; CDFG, 1991; EDAW, Inc., 1992; EBMUD, 2000). Beginning in 1978, several abatement and restoration projects were conducted to decrease the impact of Penn Mine on Camanche Reservoir and the lower Mokelumne River; the most recent abatement project was completed in late 1999 (Buer *et al*, 1979; SCH EIR, 1996; CH2MHill, 2000a and 2000b).

Water Quality Objectives Not Attained

The chemical constituents objective and California Toxics Rule were evaluated for the lower Mokelumne River by comparing copper concentrations measured in the lower Mokelumne River downstream of Camanche Dam to water quality objectives and criteria developed for drinking water and aquatic life protection. The numeric United States Environmental Protection Agency (USEPA) California Toxics Rule (CTR) hardness-dependent continuous (4-day average) and maximum (1-hour average) dissolved copper criteria for freshwater aquatic life protection are not being attained. The continuous and maximum criteria are 2.3 micrograms per liter (µg/L) and 2.9 µg/L, respectively, based on an assumed hardness of 20 milligrams per liter (mg/L) of calcium carbonate ($CaCO_3$) (Marshack, 2000). Hardness is assumed to be 20 mg/l of $CaCO_3$ because numerous studies (e.g., CH2MHill, 2000b & Buer *et al*, 1979) have indicated that Camanche Reservoir/Mokelumne River water has hardness values typical ranging from 10 to 25 mg/L. The California DHS primary maximum contaminant level (MCL) for drinking water protection is 1,300 µg/L of total recoverable copper (Marshack, 2000).

Evidence of Impairment

Elevated copper concentrations in water samples collected since 1958 indicate that copper impairs the lower Mokelumne River. The data also indicate a strong seasonality to the copper loading; Penn Mine historically discharged more copper during wet seasons than during dry seasons. As illustrated by the data summaries below, a series of remediation projects at Penn Mine conducted in 1978, 1993, and 1999-2000 have significantly decreased the amount of copper leaving the mine site.

Between 1988 and 1992, EBMUD measured dissolved copper concentrations at three locations on the Mokelumne River downstream of Camanche Dam (USFWS, 1992). In addition, EBMUD collected monthly samples from the Mokelumne River immediately downstream of the Camanche Dam between August 1997 and June 2001 and analyzed the samples for dissolved copper using a method with a detection limit low enough to evaluate compliance with the hardness-dependent CTR criteria (EBMUD, 2001). Table B-2 summarizes the EBMUD dissolved copper data for the lower Mokelumne River. Although exceedances of the CTR criteria still occur each year in the lower Mokelumne River immediately downstream of Camanche Dam, both the frequency and magnitude of exceedances have decreased since 1992.

Table B-2. Summary of Available Copper Concentration Data for the Lower Mokelumne River Downstream of Camanche Dam (Data sources: USFWS, 1992; EBMUD, 2001)

Location[a]	Total Copper Concentrations			Dissolved Copper Concentrations			
	# of Samples (Dates Collected)	Range of Concentrations (µg/l)	# [%] of Samples Exceeding MCL (1,300 µg/l)[b]	# of Samples (Dates Collected)	Range of Concentrations (µg/l)	# [%] of Samples Exceeding CTR Criteria[b]: Maximum Criterion (2.9 µg/l)	# [%] of Samples Exceeding CTR Criteria[b]: Continuous Criterion (2.3 µg/l)
CamC	138 (9/88 – 11/92)	<2 – 88	0 [0%]	141 (2/89 – 11/92)	<2 – 50	70 [50%]	70 [50%]
CamD	92 (5/88 – 11/92)	<2 – 18	0 [0%]	84 (3/89 – 11/92)	<2 – 7, 320[c]	15 [18%]	15 [18%]
VAPK	23 (5/88 – 11/92)	<1 – 4	0 [0%]	17 (8/91 – 11/92)	<2 – 3	1 [6%]	1 [6%]
CamC				25 (8/97 – 8/99)	0.62 – 7.8[d]	6 [24%]	7 [28%]
CamD				25 (8/97 – 8/99)	0.8 – 9.1[d]	4 [16%]	5 [20%]
CamC				22 (9/99 – 6/01)	<0.3 – 5.8[d]	3 [14%]	3 [14%]
CamD				22 (9/99 – 6/01)	<0.3 – 4.2, 14[d,e]	2 [9%]	5 [23%]

[a] CamC: Discharge from Camanche Dam to the Mokelumne River.
CamD: Camanche Reservoir lower outlet to the Mokelumne River.
VAPK: Mokelumne River at Van Assen Park, downstream of Camanche Dam.

[b] MCL: California DHS primary maximum contaminant level for drinking water protection.
CTR: United States Environmental Protection Agency's California Toxics Rule (CTR) hardness-dependent continuous (4-day average) and maximum (1-hour average) dissolved copper criteria for freshwater aquatic life protection, based on an assumed hardness of 20 mg/L of $CaCO_3$ if hardness data were not available.

[c] On October 4, 1989, a dissolved copper concentration of 320 µg/l was listed for CamD in the EBMUD data set. Dissolved iron and zinc concentrations measured on that day were also more than a magnitude higher than any recorded during that period; total and dissolved aluminum concentrations were not unusually high. Total copper, iron, and zinc concentrations were not available for comparison. The dissolved and total copper concentrations measured at CamC on October 4, 1989 were less than 2 µg/l, and dissolved aluminum, iron, and zinc levels were also low; only the total aluminum and iron were unusually high at CamC on that day.

[d] Thirty-seven of the 47 samples collected at CamC between August 1997 and June 2001 had dissolved copper concentrations less than 2 µg/l. Thirty-five of the 47 samples collected at CamD between August 1997 and June 2001 had dissolved copper concentrations less than 2 µg/l.

[e] On March 1, 2000, a dissolved copper concentration of 14 µg/l was listed for CamD in the EBMUD data set; no other data were available for comparison to determine the nature of the outlier.

B.3.13 Lower Mokelumne River, Zinc - Change in Extent of Impairment

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region, recommends changes to California's Clean Water Act Section 303(d) list for the impairment of the lower Mokelumne River by elevated dissolved zinc concentrations. Camanche Reservoir was included on the 1998 303(d) list as part of the listing for the lower Mokelumne River. Regional Board staff has determined that listing reservoirs separately from their associated downstream drainages is more appropriate because watershed management strategies (and associated data needs) for reservoirs can be distinctly different from management strategies for the downstream drainages.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Mokelumne River, Lower	**Pollutants/Stressors**	Zinc
Hydrologic Unit	535.00	**Sources**	Resource extraction (abandoned mines)
Total Waterbody Size	28 miles	**TMDL Priority**	
Size Affected	28 miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	~~All of lower Mokelumne River.~~ Camanche Dam to Delta.	**TMDL End Date (Mo/Yr)**	12/11
Upstream Extent Latitude	38° 13' 35"	**Upstream Extent Longitude**	121° 1' 21"
Downstream Extent Latitude	38° 12' 36"	**Downstream Extent Longitude**	121° 21' 55"
Original 303(d) Listing Year	1992		

Watershed Characteristics

The lower Mokelumne River flows 28 miles from Camanche Dam to the legal Sacramento-San Joaquin Delta boundary in San Joaquin County. Camanche Reservoir, working in tandem with the upstream Pardee Reservoir, stores water for irrigation and stream-flow regulation, providing flood control, water to the meet the needs of downstream water rights holders, and water for fisheries and riparian habitat (EBMUD, 2000). The East Bay Municipal Utility District (EBMUD) completed the Camanche Reservoir Project (downstream of Pardee) in 1964. EBMUD built a fish hatchery (the Mokelumne River Fish Installation, which the California Department of Fish and Game operates) immediately downstream of Camanche Dam on the lower Mokelumne River. In addition, a power plant at the base of the dam was placed in service in 1983.

Several historic copper and gold mines (including Argonaut, Newton, and Penn) are within the lower Mokelumne River watershed. Penn Mine, which historically operated for copper extraction from 1861 to 1956, impacted the water quality of both Camanche Reservoir and the lower Mokelumne River downstream of Camanche Dam. The Penn Mine site occupies a 22-acre area near the southeastern shore of Camanche Reservoir approximately 1.5 miles from the town of Campo Seco in Calaveras County. Penn Mine historically discharged to the reservoir via Mine Run Creek. Metal loading from Penn Mine led to fishery declines and fish kills in Camanche Reservoir, in the Mokelumne River Fish Installation downstream of Camanche Dam, and in the lower Mokelumne River; problems with toxic discharges from the Penn Mine continued through the 1960s and 1970s (Buer *et al*, 1979; SRWCB, 1990; CDFG, 1991; EDAW, Inc., 1992; EBMUD, 2000). Beginning in 1978, several abatement and restoration projects were conducted to decrease the impact of Penn Mine on Camanche Reservoir and the lower Mokelumne River; the most recent abatement project was completed in late 1999 (Buer *et al*, 1979; SCH EIR, 1996; CH2MHill, 2000a and 2000b).

Water Quality Objectives Not Attained

The chemical constituents objective and California Toxics Rule criteria were evaluated for the lower Mokelumne River by comparing zinc concentrations measured in the lower Mokelumne River downstream of Camanche Dam to water quality objectives and criteria developed for drinking water and aquatic life protection. The numeric United States Environmental Protection Agency (USEPA) California Toxics Rule (CTR) hardness-dependent continuous (4-day average) and maximum (1-hour average) dissolved zinc criteria for freshwater aquatic life protection are not being attained. The continuous and maximum criteria are both 30 micrograms per liter (μg/L), based on an assumed hardness of 20 milligrams per liter (mg/L) of calcium carbonate ($CaCO_3$) (Marshack, 2000). Hardness is assumed to be 20 mg/l of $CaCO_3$ because numerous studies (e.g., CH2MHill, 2000b & Buer *et al*, 1979) have indicated that Camanche Reservoir/Mokelumne River water has hardness values typical ranging from 10 to 25 mg/L.

Evidence of Impairment

Elevated zinc concentrations in water samples collected since 1958 indicate that zinc impairs the lower Mokelumne River. The data indicate a strong seasonality to the zinc loading; Penn Mine historically discharged more zinc during wet seasons than during dry seasons. As illustrated by the data summaries below, a series of remediation projects at Penn Mine conducted in 1978, 1993, and 1999-2000 have significantly decreased the amount of zinc leaving the mine site.

Between 1988 and 1992, EBMUD measured dissolved zinc concentrations at three locations on the Mokelumne River downstream of Camanche Dam (USFWS, 1992). Table B-2 summarizes the available EBMUD dissolved zinc data. The 1988-1992 data indicate that exceedances of the CTR criteria still occurred in the lower Mokelumne River immediately downstream of Camanche Dam after the remediation activities conducted in the late 1970s. Dissolved zinc data for the period after the remediation activities conducted in the mid-late 1990s are not available.

Table B-2. Summary of Available Zinc Concentration Data for the Lower Mokelumne River Downstream of Camanche Dam (Data source: USFWS, 1992)

	Dissolved Zinc Concentrations		
Location [a]	# of Samples (Dates Collected)	Range of Concentrations (μg/l)	# [%] of Samples Exceeding CTR Criteria [b] (30 μg/L)
CamC	141 (2/89 – 11/92)	<3 – 450	15 [11%]
CamD	84 (3/89 – 11/92)	<3 – 140	4 [5%]
VAPK	17 (8/91 – 11/92)	<4 – 9	0 [0%]

[a] CamC: Discharge from Camanche Dam to the Mokelumne River.
CamD: Camanche Reservoir lower outlet to the Mokelumne River
VAPK: Mokelumne River at Van Assen Park, downstream of Camanche Dam.

[b] CTR: United States Environmental Protection Agency's California Toxics Rule (CTR) hardness-dependent continuous (4-day average) and maximum (1-hour average) dissolved zinc criteria for freshwater aquatic life protection, based on an assumed hardness of 20 mg/L of $CaCO_3$.

About East Bay Municipal Utility District

Site Map

Overview

The East Bay Municipal Utility District (EBMUD) supplies water and provides wastewater treatment for parts of Alameda and Contra Costa counties on the eastern side of San Francisco Bay in northern California. Approximately 1.3 million people are served by EBMUD's water system in a 325-square-mile area extending from Crockett on the north, southward to San Lorenzo (encompassing the major cities of Oakland and Berkeley), eastward from San Francisco Bay to Walnut Creek, and south through the San Ramon Valley. The wastewater system serves approximately 640,000 people in an 83-square-mile area of Alameda and Contra Costa counties along the Bay's east shore, extending from Richmond on the north, southward to San Leandro.

EBMUD's Oakland Administration Center

Site Map

EBMUD is a publicly owned utility formed under the Municipal Utility District Act passed by the California Legislature in 1921. The Act permits formation of multipurpose government agencies to provide public services on a regional basis. In accordance with the Act's provisions, voters in the area created EBMUD in 1923 to provide water service. The MUD Act was amended in 1941 to enable formation of special districts. In 1944, voters in six East Bay cities elected to form EBMUD's Special District No. 1 to treat wastewater released into the Bay. Wastewater treatment for those cities began in 1951 and was expanded 20 years later to include Kensington, El Cerrito and a part of Richmond. EBMUD has a seven-member Board of Directors publicly elected from wards within the EBMUD service area. The Board of Directors and management believe that EBMUD has a public responsibility to preserve the region's resources and set industry standards for the way water and wastewater utilities conduct themselves. EBMUD is a customer-oriented and environmentally sensitive public agency, firmly committed to serving people and the environment. In 1992, the Board of Directors adopted the EBMUD Mission Statement to guide the organization's work.

EBMUD's Mission Statement

To manage the natural resources with which the District is entrusted; to provide reliable, high quality water and wastewater services for the people of the East Bay; and to preserve and protect the environment for future generations.

In carrying out this mission, we will:

1. Exercise responsible financial management
2. Ensure fair rates and charges
3. Provide responsive customer service
4. Promote ethical behavior in the conduct of District business
5. Ensure fair and open processes involving the public
6. Provide a healthy work environment
7. Promote diversity and equality in personnel matters and contracting
8. Promote environmental responsibility

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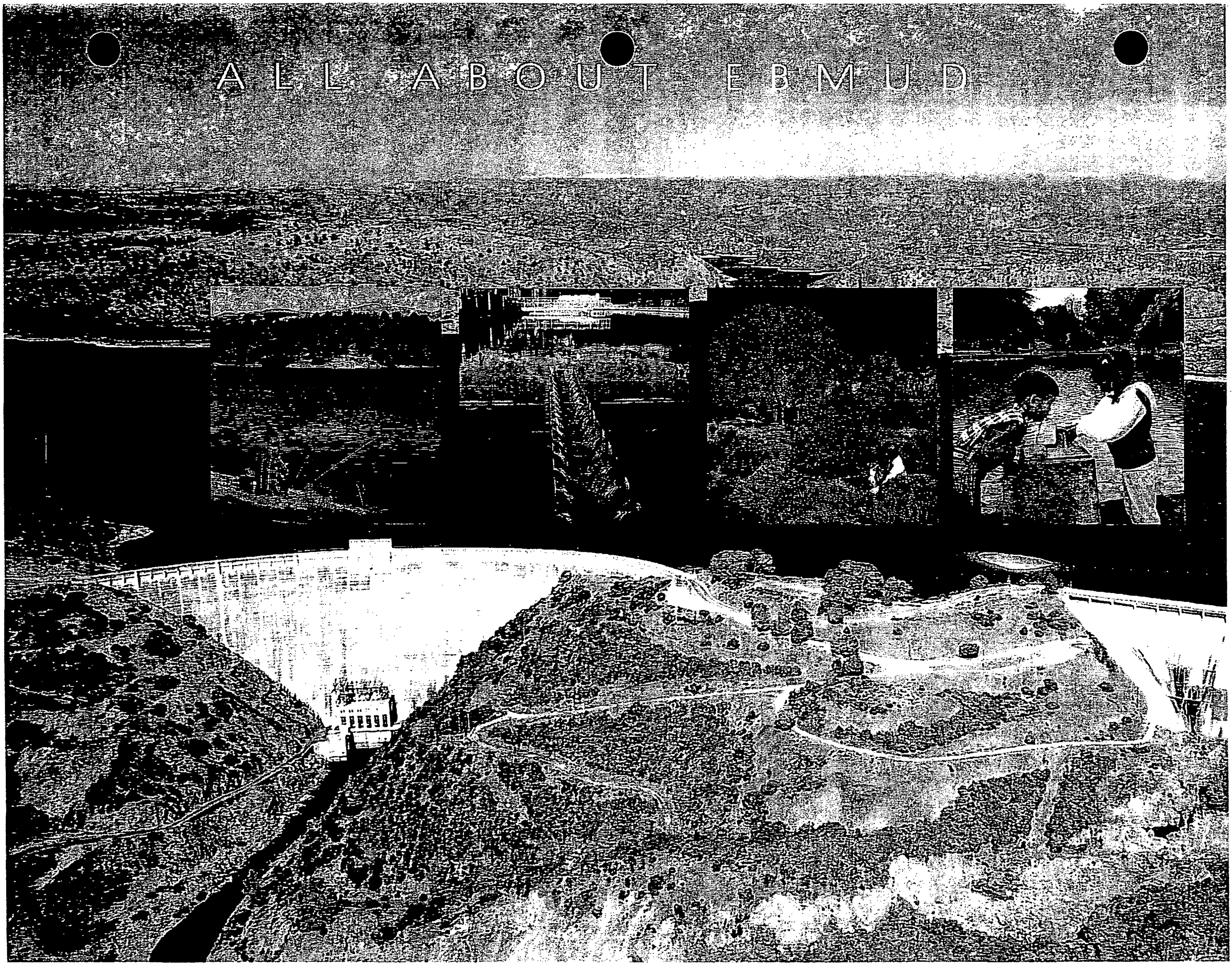
Last updated 10/24/2001

EBMUD Disclaimer

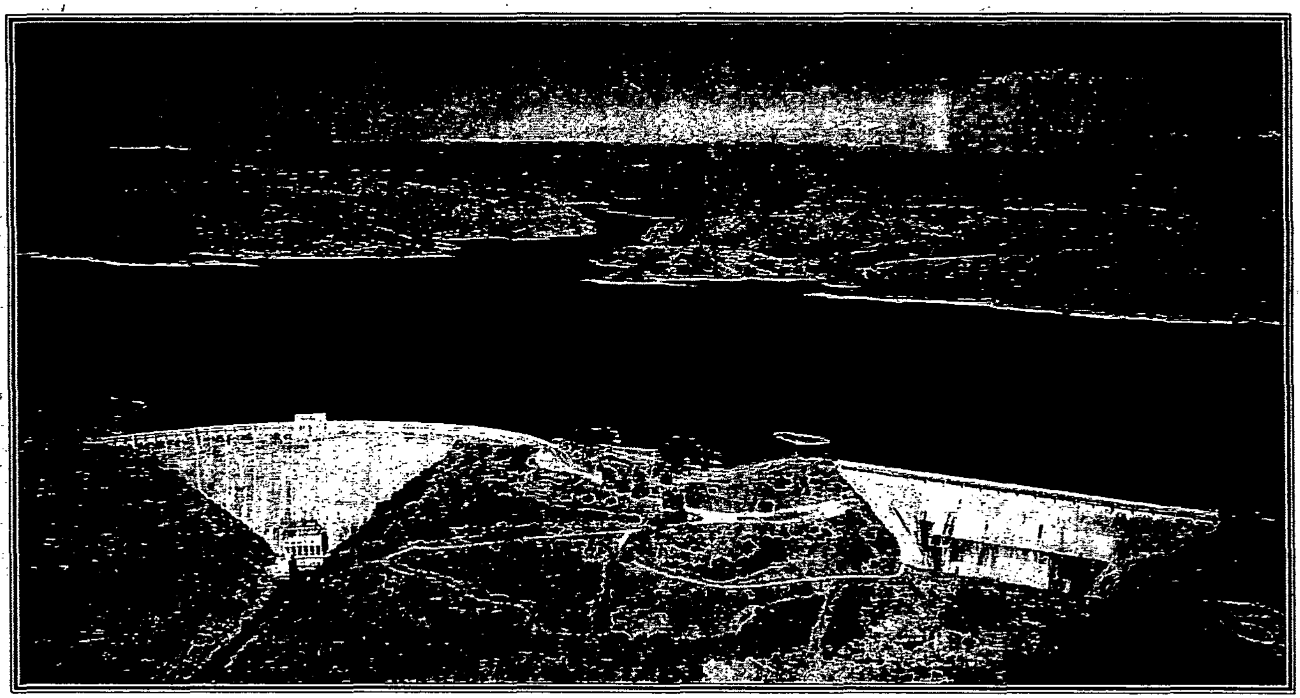
***Administration Center:** 375 - 11th Street, Oakland, CA 94607* ***Info:** (510) 835-3000*
***Webmaster:** collins@ebmud.com*


ALL ABOUT EBMUD

Overview

EBMUD is a publicly owned utility committed to serving people and the environment.

The East Bay Municipal Utility District supplies water and provides wastewater treatment for parts of Alameda and Contra Costa counties. Approximately 1.2 million people are served by the District's water system in a 325-square-mile area extending from Crockett on the north, southward to San Lorenzo (encompassing the major cities of Oakland and Berkeley and the island city, Alameda), eastward from San Francisco Bay to Walnut Creek, and south through the San Ramon Valley. The wastewater system serves approximately 610,000 people in an 83-square-mile area of Alameda and Contra Costa counties along the Bay's east shore, extending from Richmond on the north, southward to San Leandro.

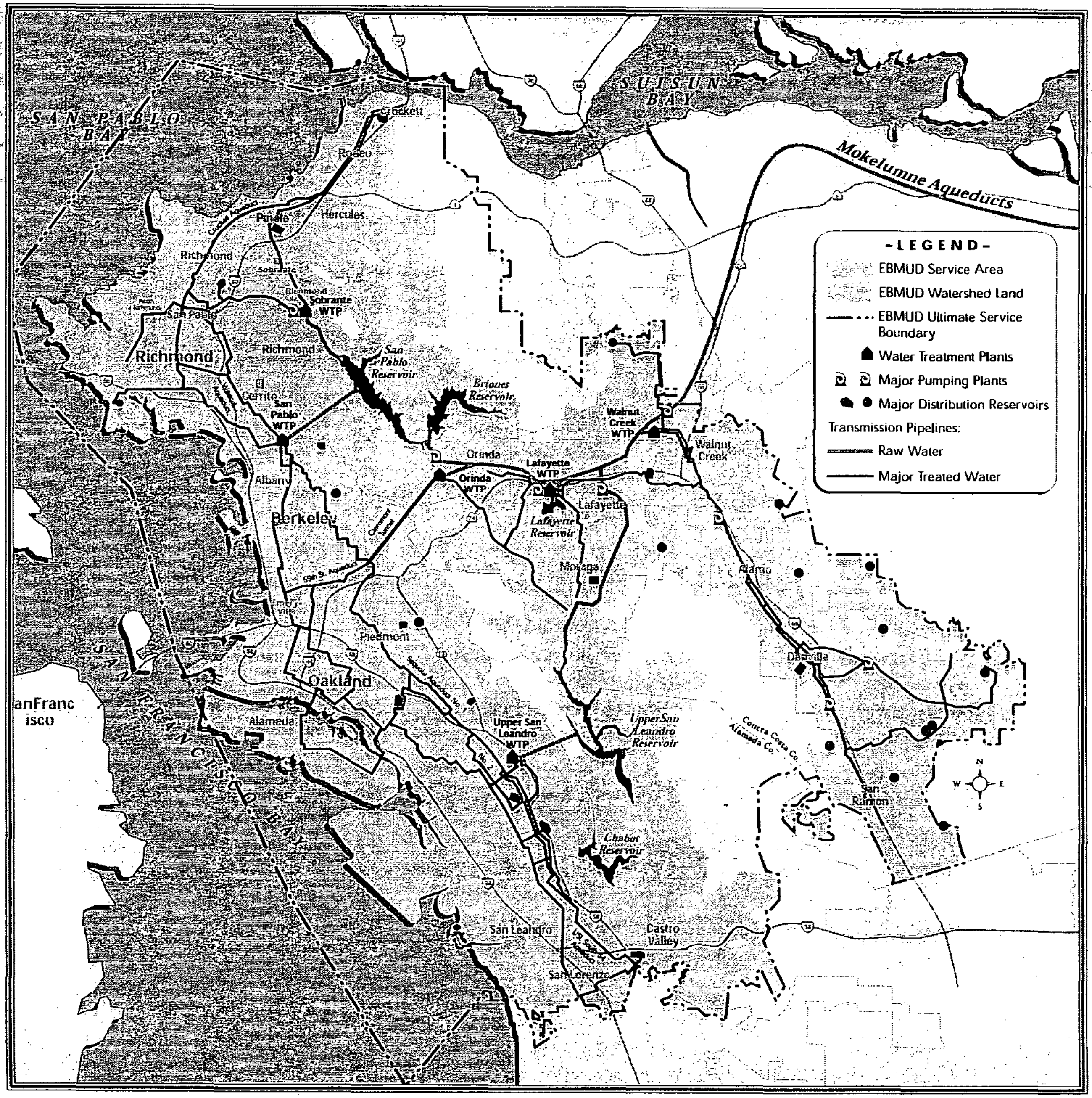


Mokelumne River water is collected in Pardee Reservoir in the Sierra foothills for East Bay communities. Pardee Dam is on the left; the spillway is on the right.

EBMUD is a publicly owned utility formed under the Municipal Utility District Act passed by the California Legislature in 1921. The Act permits formation of multipurpose government agencies to provide public services on a regional basis. In accordance with the Act's provisions, voters in the East San Francisco Bay Area created EBMUD in 1923 to provide water service. The MUD Act was amended in 1941 to enable formation of special districts. In 1944, voters in six East Bay cities elected to form EBMUD's Special District No. 1 to treat wastewater released into the Bay. Wastewater treatment for those cities began in 1951 and was expanded 20 years later to include Kensington, El Cerrito and a part of Richmond.

EBMUD has a seven-member Board of Directors publicly elected from wards within the District's service area. The Board of Directors and management believe the District has a public responsibility to preserve the region's resources and set industry standards for the way water and wastewater utilities conduct themselves. EBMUD is a customer-oriented and environmentally sensitive public agency, firmly committed to serving people and the environment.

The Water System



The Water System

EBMUD's water system serves 20 incorporated cities and 15 unincorporated communities.

The cities are Alameda, Albany, Berkeley, Danville, El Cerrito, Emeryville, part of Hayward, Hercules, Lafayette, Moraga, Oakland, Orinda, Piedmont, Pinole, part of Pleasant Hill, Richmond, San Leandro, San Pablo, San Ramon, and part of Walnut Creek.

The unincorporated communities are Alamo, Ashland, Blackhawk, Castro Valley, Cherryland, Crockett, Diablo, El Sobrante, Fairview, Kensington, North Richmond, Oleum, Rodeo, San Lorenzo and Selby.

SOURCES OF WATER SUPPLY

Mokelumne River–Virtually all of the water used by EBMUD comes from the 577-square-mile protected watershed of the Mokelumne River, which collects the melted snows of Alpine, Amador and Calaveras counties. The watershed (land that drains into a body of water or a river system) is located on the west slope of the Sierra Nevada and is generally contained within national forest, EBMUD-owned lands or other undeveloped lands virtually unaffected by human activity. EBMUD has water rights for up to 325 million gallons (997 acre feet) daily from the Mokelumne River.

Local runoff–In normal years, District reservoirs in the East Bay receive an additional 30,000 acre feet of water from local watershed runoff. Much of it is stored in the East Bay reservoirs for system use. In dry years, evaporation and other reservoir losses can total more than the runoff. There is no firm yield from local watersheds.

American River–In 1970, EBMUD contracted with the U.S. Bureau of Reclamation for up to 134 million gallons (411 acre feet) daily of American River water from Folsom South Canal southeast of Sacramento. Intended as a supplemental supply for District needs into the next century and to offset deficiencies in drought years, the American River water entitlement has been tapped only once. Between September 1977 and January 1978, EBMUD took about 60 million gallons per day (25,000 acre feet total) from the Sacramento-San Joaquin River Delta, under an emergency agreement with the Bureau of Reclamation, to supplement supplies depleted by the drought of 1976 and 1977.

A lawsuit filed in 1972 by the Environmental Defense Fund (EDF) and others sought to prevent EBMUD from diverting American River water from Folsom South Canal. By appointment of the trial court, the State Water Resources Control Board (SWRCB) served as referee in the dispute. In June 1988, the SWRCB affirmed EBMUD's efficient management of existing water supplies and supported its proposed diversion of American River water.

In June 1989, an Alameda County Superior Court judge delivered a preliminary decision confirming EBMUD's right to divert American River water from Folsom-South Canal. The decision also set minimum flows in the river below Folsom Dam that must be met before EBMUD can take its supply. The judge's ruling on EDF v. EBMUD became final in June 1990.

WATER SUPPLY MANAGEMENT PROGRAM

To ensure adequate water supplies for future needs well into the twenty-first century, the District adopted a long-range Water Supply Management Program (WSMP) in October 1993.

A key component of the WSMP is a plan to store Mokelumne River water during wet years in underground aquifers for use in dry years to meet the needs of people and the river fishery. Additionally, the District continues to explore approaches for including the American River supplemental supply in the WSMP.

Other components of the program are expansion of water conservation efforts and water recycling projects.

PARDEE DAM AND RESERVOIR

Mokelumne River water is collected at Pardee Dam and Reservoir, 38 miles northeast of Stockton near the town of Jackson. The 28.65 megawatt Pardee Powerhouse at the base of the dam generates 110 million kilowatt hours of electrical energy annually for sale to Pacific Gas & Electric Company. That is enough to meet the energy needs of 28,650 people, or a community slightly larger than San Pablo.

Pardee Reservoir has 37 miles of shoreline, a water surface area of 2,257 acres, and a maximum capacity

The Water System

of 197,950 acre feet at spillway crest elevation. This equals a 10-month water supply for the District's service area at normal consumption rates. Pardee Reservoir is used principally for municipal water supply and for power generation.

Mokelumne Basin runoff in an average year is 741,000 acre feet, enough to fill Pardee Reservoir three-and-one-half times. In the driest winter of record, 1976-77, runoff was less than two-thirds of reservoir capacity. On March 25, 1977, the reservoir reached its lowest water level since it was first filled in 1930. Storage was only 47,000 acre feet—22.4 percent of capacity—and surface elevation was 112 feet below the spillway. In the wettest winter of record, 1982-83, runoff was sufficient to fill Pardee Reservoir 8.7 times.

CAMANCHE DAM AND RESERVOIR

Camanche Dam is located 10 miles downstream from Pardee Dam on the Mokelumne River. A 10.7-megawatt power plant at the base of the dam was placed in service in 1983. It generates 40 million kilowatt hours of electrical energy annually for sale to Pacific Gas & Electric Company.

Camanche Reservoir, working in tandem with Pardee Reservoir, stores water for irrigation and stream-flow regulation, providing flood control, water to meet the needs of downstream water rights holders, and water for fisheries and riparian habitat. (EBMUD takes its full allocation out of Pardee Reservoir.)

The reservoir has a surface area of 7,622 acres (about 12 square miles) and a 63-mile shoreline. Capacity at spillway crest elevation is 417,120 acre feet. During the 1988 drought year, Camanche became virtually dry, dropping to just 10,000 acre feet—two percent of capacity.

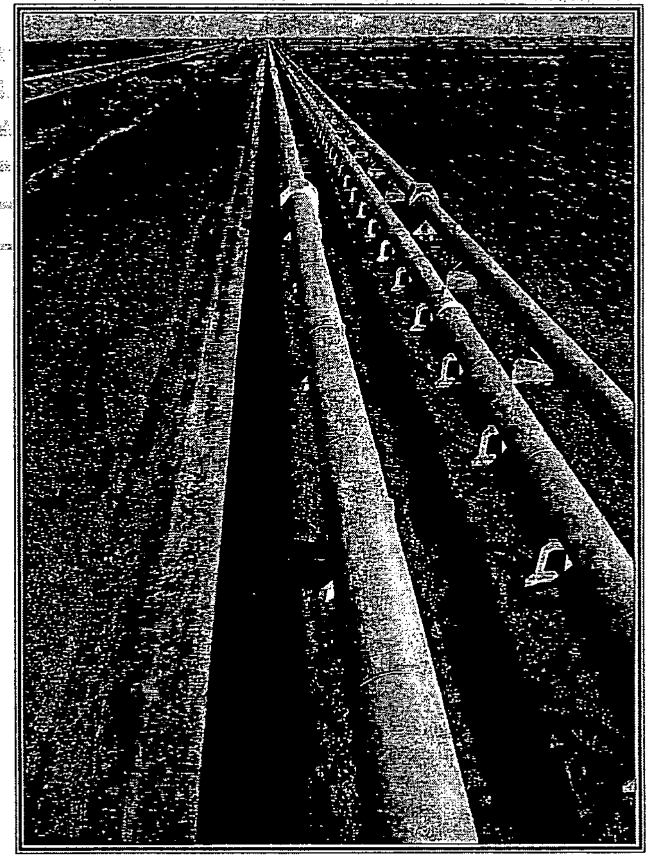
RAW WATER AQUEDUCTS AND TUNNELS

Raw (untreated) water from Pardee Reservoir is transported 91.5 miles to East Bay water treatment plants or terminal reservoirs through the Pardee Tunnel, the Mokelumne Aqueducts and the Lafayette Aqueducts. Water leaving Pardee takes 30 to 45 hours, flowing by gravity, to reach the Bay Area.

Mokelumne Aqueducts–Raw water from Pardee Reservoir moves through the Pardee Tunnel, an 8-foot-high horseshoe structure 2.2 miles long, to the three Mokelumne Aqueducts near Valley Springs in Calaveras County. The first Mokelumne Aqueduct is 5 feet, 5 inches in diameter, the second is 5 feet, 7 inches, and the third is 7 feet, 3 inches. All are steel pipelines extending 82.2 miles from the Pardee Tunnel to the east end of two Lafayette Aqueducts in Walnut Creek.

Lafayette and Briones Aqueducts–Lafayette Aqueduct No. 1 is a 9-foot circular concrete pipe and three tunnels that extend 7.1 miles from Walnut Creek to the Orinda Filter Plant. Lafayette Aqueduct No. 2 is a 9-foot concrete pipe with seven tunnels extending 7.3 miles to the Briones Diversion Works near Orinda. Here, the supply can be pumped (or diverted) through the 7-foot, 6-inch steel Briones Aqueduct into Briones Reservoir, discharged into San Pablo Reservoir, or diverted through the 7-foot, 6-inch steel Orinda Raw Water Line to Orinda Filter Plant.

Either or both Lafayette Aqueducts can be used to divert Mokelumne water from Pardee directly or indirectly to all of the District's water treatment plants.



The Mokelumne Aqueducts carry the high-quality Sierra water about 90 miles from Pardee Reservoir to the East Bay.

Tunnels–Untreated water from San Pablo and Upper San Leandro Reservoirs is delivered to filter plants through two horseshoe tunnels. San Pablo Tunnel is 5 feet in diameter and carries water 2.57 miles from the San Pablo Reservoir to the San Pablo Water Treatment Plant. Upper San Leandro Tunnel is 6 feet, 6 inches in diameter and carries water 1.35 miles from Upper San Leandro Reservoir to the Upper San Leandro Water Treatment Plant.

The Water System

RAW WATER PUMPING PLANTS

Walnut Creek No. 1 and No. 2 Pumping Plants, built in 1958, and Walnut Creek No. 3 Pumping Plant, built in 1976, increase the capacities of the Mokelumne Aqueducts. When operating, these three pumping plants increase the combined capacity of the aqueducts from 202 million gallons per day (MGD) to over 325 MGD.

The Moraga Pumping Plant and Aqueduct, placed in service in 1975, supply water from the Lafayette Aqueducts to Upper San Leandro Reservoir. The plant's four pumps have an aggregate 5,950 horsepower, with a combined delivery capacity of 105 MGD. The aqueduct is six miles of 5.5-foot, 5-foot and 4-foot steel and concrete pipe between Lafayette and the Upper San Leandro Reservoir near Moraga.

The Briones Pumping Plant and Aqueduct were placed in service in 1965 following completion of Briones Reservoir. Briones No. 2 Pumping Plant was constructed in 1980. These facilities supply Briones Reservoir with Mokelumne River water. The five pumps in the two Briones pumping plants have an aggregate 4,800 horsepower and can deliver up to 94 MGD.

The Chabot Pumping Plant and irrigation system were completed in 1991 to provide up to 2.2 million gallons per day of untreated water to two golf courses. Irrigating with raw water from Chabot Reservoir greatly reduces the golf courses' use of treated drinking water.

EAST BAY TERMINAL RESERVOIRS

Water not immediately put through water treatment plants and distributed is stored in five East Bay terminal reservoirs. Their combined maximum capacity is 155,150 acre feet of untreated water, a four-to-six-month supply.

San Pablo is the northernmost of the five reservoirs. East of San Pablo Reservoir is Briones, EBMUD's newest and largest local reservoir. Lafayette Reservoir is located in the City of Lafayette, and to the south are Upper San Leandro Reservoir and Chabot Reservoir.

RAW WATER PUMPING PLANTS *million gallons a day

Mokelumne Aqueduct	Pumps and Horsepower	Gravity Flow MGD*	Pumped Flow
No. 1	three 2000	41	67
No. 2	three 2500	54	87
No. 3	four 3500	107	172
Total		202	326

PARDEE AND CAMANCHE DAMS

	Pardee	Camanche
Completed	1929	1964
Crest length	1,337'	2,640'
Crest above stream bed	345'	171'
Crest above sea level	580'	263'
Spillway crest above sea level	567.6'	235.5'
Width at base	239'	750'
Width at crest	16'	34.5'
Volume cubic yards	617,000	11.1 million (including 4-mile dike)
Dam type	Concrete Gravity	Zoned Earth with impervious core

DAMS FOR EAST BAY RESERVOIRS

	Briones	Chabot	Lafayette	San Pablo	Upper San Leandro
Completed	1964	1875	1928	1919	1926
Crest Length	2,450'	450'	1,200'	1,250'	1,400'
Crest Above Stream Bed	270'	142'	132'	171'	182'
Crest Above Sea Level	588'	250'	466'	329'	477'
Spillway Above Sea Level	576'	227'	449'	314'	460'
Base Width	1,850'	1,300'	1,050'	1,376'	1,170'
Crest Width	50'	30'	200'	137'	30'
Volume Cubic Yards	11,776,000	662,000	1,763,000	3,600,000	3,041,000
Dam Type	Rolled Zone Earthfill	Earth-fill	Earth-fill	Hydraulic Earth-fill	Hydraulic Earth-fill

EAST BAY RESERVOIRS

	Briones	Chabot	Lafayette	San Pablo	Upper San Leandro
Capacity, acre ft.	60,510	10,350	4,250	38,600	41,440
Capacity, billion gallons	19.3	3.37	1.38	12.58	13.91
Water Surface acres	725	340	126	834	771
Shoreline miles	14	9	3	14	25
Watershed sq. miles (including land not owned by EBMUD)	9	41	1	32	30

Water Quality

EBMUD drinking water has always met or surpassed federal and state water quality regulations.

It is District policy to provide the highest quality water possible to all customers. The most important factor in water quality is its source: the purer the source, the safer the water. EBMUD water requires only minimal treatment to meet health standards. Because it comes from a remote, protected watershed, the raw water is not subjected to pesticides, agricultural or urban runoff, municipal sewage discharges or industrial toxics. EBMUD uses no groundwater.

EBMUD went to the Sierra Nevada for its Mokelumne River source in the 1920s, an era when infectious disease in water supplies was the principal health concern. Today's knowledge about contaminants and the public's renewed concern with safe water supplies reaffirm the wisdom of that decision. In 1925, four drinking water contaminants were regulated by the U.S. government. The list grew slightly to six by 1946, 14 by 1962, 22 by 1976, and soared to 84 by 1992. Today, monitoring is required for more than 100 contaminants, but only 19 were detected in EBMUD drinking water in 1999.

EBMUD drinking water is sampled and tested continually from all parts of the water system to ensure that it meets or surpasses all primary (health-related) and secondary (aesthetic) regulatory standards established by the U.S. Environmental Protection Agency and the California Department of Health Services. Chemical and physical tests are performed in laboratories at EBMUD water treatment plants every two hours and analyses are performed daily in the EBMUD Environmental Laboratory (see page 15).

Annually, the laboratory spends about $3 million on drinking-water quality alone. Test results on EBMUD drinking water consistently show that regulated constituents of drinking water either are not detected at all, or they are present in amounts far below limits permitted by state and federal drinking-water standards.

TREATMENT PLANTS — *million gallons per day

	Walnut Creek	Orinda	Upper SL	San Pablo
Capacity	80 MGD*	175 MGD	83 MGD	60 MGD
	Lafayette		Sobrante	
	42 MGD		60 MGD	

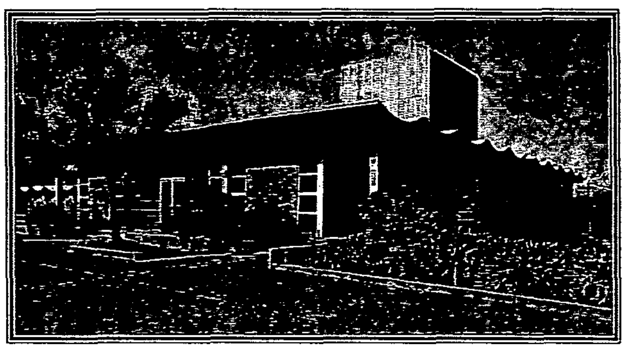
Water Quality

TREATMENT PLANTS

Six water treatment plants in the EBMUD system are capable of filtering and processing more than 505 million gallons of water daily. The water treatment plants are Upper San Leandro in Oakland, San Pablo in Kensington (inactive), Sobrante in El Sobrante, and plants located in and named for Orinda, Lafayette and Walnut Creek.

Orinda Water Treatment Plant has the largest output, with a capacity of 175 MGD. This plant serves all or parts of Alameda, Albany, Berkeley, El Cerrito, Emeryville, Moraga, Oakland, Orinda, Piedmont, Richmond and San Leandro. The other plants supply water in varying amounts to the balance of the EBMUD service area.

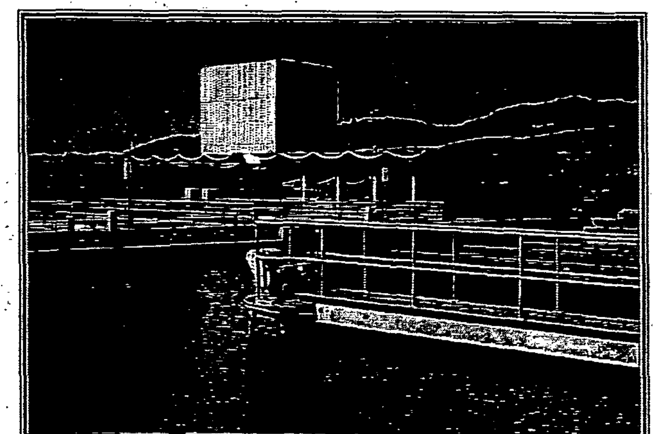
Every drop of water delivered to customers is filtered through sand anthracite or carbon. All six water treatment plants individually provide fluoridation.



The Sobrante Water Treatment Plant in El Sobrante treats water from San Pablo Reservoir in the East Bay.

TREATMENT PROCESSES

Raw water contains such impurities as sediment, bacteria and algae and other microorganisms. These are removed by full, conventional treatment–consisting of six basic steps–at the Upper San Leandro, San Pablo and Sobrante water treatment plants. Upper San Leandro and Sobrante conduct an additional step, ozonation. These plants treat water from the East Bay terminal reservoirs. Orinda, Lafayette and Walnut Creek water treatment plants use only coagulation, direct filtration and disinfection, because their water comes from the Mokelumne Aqueducts and needs only limited treatment.



Aeration, which has a fountain-like appearance, increases oxygen in the water and releases gases that cause unpleasant tastes and odors. Heavy particles settle to the bottom as the water flows very slowly through a sedimentation basin.

Water Quality

THE SIX TREATMENT STEPS ARE:

Aeration–Water entering the plant is sprayed into the air through nozzles, producing a fountain-like effect. Breaking the water into small drops creates a proper oxygen balance, releasing trapped gases that can cause objectionable tastes and odors.

Coagulation–Dirt and organic material (turbidity) are removed in the next four steps. First, EBMUD adds coagulants to the water in large mixing basins. The coagulants neutralize particles, allowing them to join together.

Flocculation–After coagulants are added, the water is gently mixed to cause sediment particles to combine and grow large enough to settle.

Sedimentation–The water flows into quiet sedimentation basins where the particles settle to the bottom. This step removes about 85 percent of the suspended foreign matter in the water. Water for the next step is collected from the top of the sedimentation basins.

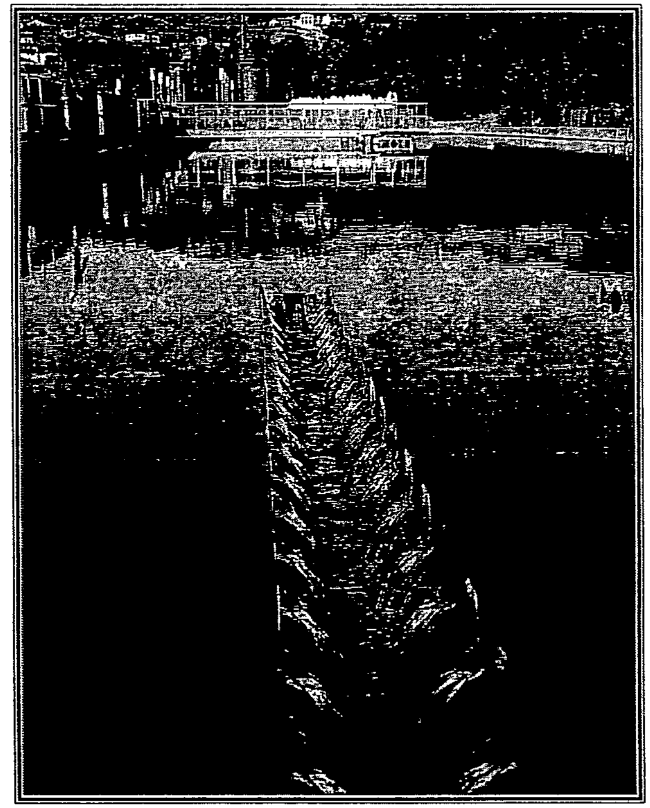
Ozonation–At Sobrante and Upper San Leandro water treatment plants, ozone is used for disinfection, taste and odor control, and reduction of trihalomethanes (THMs, a chemical compound formed by natural organics in water when they come into contact with chlorine).

Filtration–Any remaining particles are trapped and removed during filtration. The almost clear water from the sedimentation basins flows into deep, concrete-walled boxes. At the bottom are filter beds made up of layers of coal, sand, gravel and rocks. Impure particles are trapped in the coal and sand as the now-clean water flows down through the rest of the bed to a collecting system.

Disinfection–The addition of chloramine kills any pathogenic microscopic life, such as bacteria or viruses, still in the water.

Granular activated carbon is used in the filters at Sobrante and Upper San Leandro filter plants for taste-and-odor control.

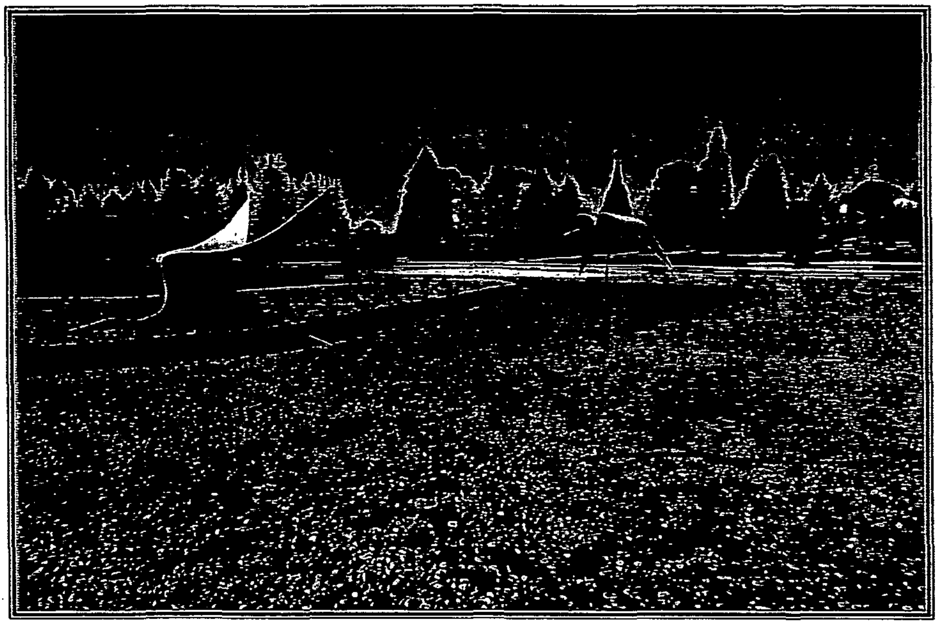
In addition to treatment and fluoridation, EBMUD adds calcium hydroxide (lime) or sodium hydroxide to the water at the source or at a water treatment plant to control corrosion. Using lime to achieve a slightly alkaline chemical balance prevents the water from corroding District distribution pipes and consumers' plumbing. This keeps substances like lead from leaking out of plumbing and into the drinking water.



Almost clear water from the top of the sedimentation basin flows down into filter beds. Filtration removes any remaining particles in the water.

Water Distribution

Treated-water reservoirs and tanks are designed to blend with surrounding neighborhoods or open spaces.



Treated water goes to customers through miles of pipes and distribution reservoirs and tanks. Shown clockwise from the upper left are the Summit Reservoir in Berkeley (capacity 37 million gallons), the twin Castenada Reservoirs in San Ramon Valley (capacity 12 million gallons each), and the Estates Reservoir in Oakland (capacity 17.6 million).

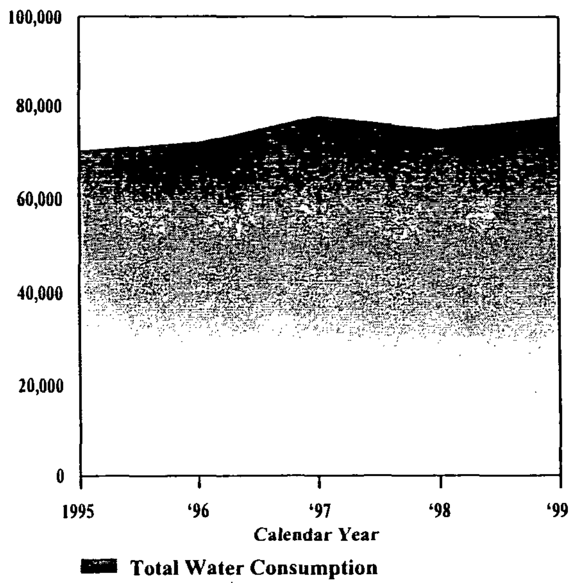
Treated water is carried 3.41 miles through the Claremont Tunnel, a 9-foot-diameter horseshoe bore, from the Orinda Filter Plant to three distribution aqueducts.

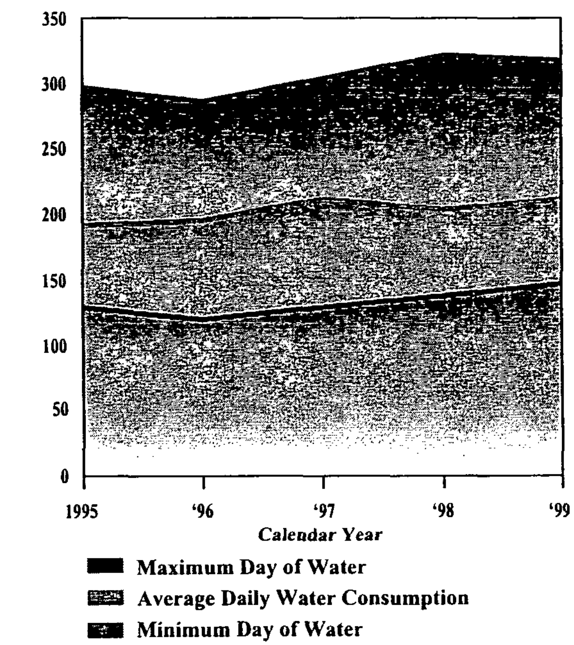
The water distribution network includes 3,944 miles of pipe, 126 pumping plants and 165 neighborhood reservoirs (tanks storing treated drinking water), having an operating capacity of 870 million gallons.

EBMUD's service area is divided into 122 pressure zones, ranging in elevation from sea level to 1,450 feet. About 60 percent of treated water is distributed to customers by gravity flow.

Water Consumption

While population and metered services have increased more than 10% since the mid-'70s, customers use less water today than in 1976—the first year of a historic two-year drought.





WATER CONSUMPTION BY ACCOUNT CATEGORY, 1994

Type of Account	Number of Metered Accounts	% of Total Metered Consumption
Residential	338,887	92.6
Commercial	22,979	6.3
Industrial	1,441	0.4
Public authority	2,451	0.7
Total	365,758	100.0%

The District had 365,758 active metered service connections (as of December 31, 1999), serving more than 1.2 million people. Of that population, approximately 756,000 live in Alameda County and about 418,000 live in Contra Costa County.

In calendar year 1992—a drought year—average daily gross consumption was 178 million gallons.

In 1999, average daily gross consumption was 210.8 million gallons. Per capita daily water use in 1999 averaged 150 gallons.

The highest annual gross water consumption of record was in 1976, with average daily consumption of 222 million gallons. When water rationing was in effect during the drought year of 1977, average daily gross consumption dropped 39 percent, to 135 million gallons, the lowest since 1958.

The one-day consumption record was set on July 14, 1972, at 377 million gallons. On January 1, 1978, consumption reached the lowest one-day level since 1961, at 94 million gallons.

When the District began supplying water in 1928, service area population was approximately 460,000 and daily water use was 60 gallons per person. By 1940 it was 78 gallons, and 161 gallons in 1960. By 1970 the population was more than 1.1 million and daily water use per capita was 189 gallons. The drought of 1976 and 1977 caused daily water use to fall, and in 1980 it was 155 gallons per person. Water use had not reached its 1976 level when drought returned in 1988, even though metered services had increased by 10 percent, and the service area population was nearly 1.2 million.

Water Conservation

EBMUD's pioneering Water Conservation Master Plan will help meet long-term water supply needs.

EBMUD encourages customers to help assure an adequate water supply tomorrow by using water efficiently today.

In 1994, EBMUD developed and began using the nation's first Water Conservation Master Plan to help meet long-term water supply needs. The master plan is a blueprint for conservation programs intended to achieve water savings of 33 MGD in the year 2020. This is nearly enough water to meet the needs of a city the size of Oakland, or to meet the combined needs of Walnut Creek, Pleasant Hill, Alamo, Danville and San Ramon.

A key component of the District's Water Supply Management Program, the Water Conservation Master Plan will guide efforts to educate and motivate EBMUD customers to use water more wisely. To achieve long-term water savings districtwide, the water conservation staff continues expanding community and customer outreach through workshops, residential and commercial water audits, incentives and rebates, newsletters, and community events and exhibits.

As a free community service, water conservation staff advises customers about "water wise" landscaping and efficient irrigation methods. EBMUD also helps develop demonstration gardens that use low-water landscapes and plant material, and drip irrigation. These and other valuable tips are found in EBMUD's popular book, *Water Conserving Plants and Landscapes for the Bay Area,* now in its third edition.

Always available free to EBMUD customers are water audits, posters, brochures and conservation devices that reduce water use.

For more than 25 years, EBMUD has provided the award-winning Project WATER (Water Awareness Through Education and Research) program free to schools in the EBMUD service area. Creative instructional and supplemental materials–designed for varying grade levels–are easily integrated into school curricula. Service-learning opportunities on our East Bay watershed lands with District Ranger-Naturalists are available for school classes. Tours of water treatment plants, the Water Conservation Center, and the wastewater treatment plant are available for class field trips.

EBMUD monitors its own operations to conserve water and to prevent water losses. The District saves about 1.3 MGD through an electronic leak-detection program, and about 9 MGD are saved by reclaiming the wash-water at District water treatment plants and at the wastewater treatment plant. In dry years, EBMUD saves water by shutting down power generation at Pardee Powerhouse and limiting power generation at Camanche Powerhouse to minimums necessary to meet obligations to downstream water-rights holders.

In 1977, the second year of California's historic drought, EBMUD adopted mandatory conservation measures that reduced water use by 39 percent.

The winter of 1986-87 was one of the driest in EBMUD's history. Precipitation in the winter of 1987-88 was even worse, making it the second driest winter on record. During the 1987-1993 drought,

Watershed Land

An EBMUD customer enjoys her lush, low-water-using landscape.

the District set water-use-reduction goals annually, ranging from 12 percent to 25 percent. Our customers cut water use by 25 percent in 1991, exceeding that year's goal of a 15 percent reduction from the use in 1986.

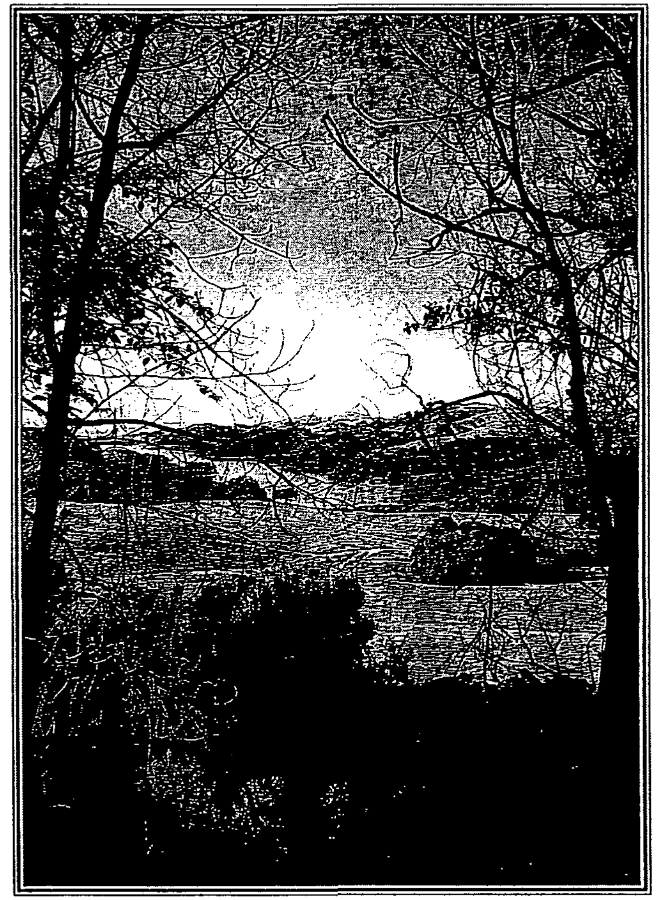
The drought program included a rate structure designed to reward low water use, an expanded water conservation program and water-use restrictions. Although the drought ended in spring 1993, EBMUD's customers have continued to reduce water use by about 15 percent during the hot summer months.

EBMUD owns 54,605 acres of watershed land in the East Bay and in the Mokelumne Basin, including 12,765 surface acres of water in the reservoirs. Environmentally sound management of this land protects the water's high quality and increases water production. Use of pesticides and other chemicals on the watersheds is avoided. Erosion is carefully monitored and controlled to minimize silt entering the reservoirs.

District policies allow land uses compatible with the primary watershed purpose of protecting the water supply, with emphasis on preserving open space. These activities are guided by EBMUD's Mission Statement, adopted by the Board of Directors in 1992:

To manage the natural resources with which the District is entrusted, to provide reliable, high quality water and wastewater services to the people of the East Bay, and to preserve and protect the environment for future generations.

The East Bay Watershed Master Plan adopted in 1996 followed four years of extensive studies of 25,300 acres of EBMUD lands, 2,700 surface acres of water in local reservoirs, and land uses occurring within a half mile of EBMUD watershed property.



San Pablo Reservoir and the other East Bay reservoirs are surrounded by 25,000 acres of watershed land owned and carefully managed by EBMUD to protect water quality.

EBMUD offers recreational opportunities compatible with protection of the water and land.

RESERVOIR RECREATION

Recreation is offered at five reservoirs (Briones and Upper San Leandro are closed to recreation). Four of the five—Pardee, Lafayette, San Pablo and Chabot reservoirs—store drinking water, so water-contact activities are not allowed. At Camanche, a flood control and irrigation reservoir, swimming, water skiing, wind surfing and wading are permitted. Pardee Reservoir opened to public recreation in 1958. Lafayette, Chabot and Camanche were opened in 1966, and San Pablo in 1973.

Lafayette Reservoir is a year-round, day-use area for fishing, boating and picnicking. Rowboats and pedal boats are available to rent. Canoes, kayaks and small private sailboats are allowed, but no gasoline motors are permitted. Group picnicking facilities and a three-mile-loop trail are available.

Chabot Reservoir is open all year with facilities for boat and bank fishing, canoeing, picnicking and hiking. It is operated by the East Bay Regional Park District under a 50-year contract expiring in 2014.

San Pablo Reservoir is open daily from mid-February to mid-November. Activities operated by private concession include fishing, picnicking, boating and hiking. A large play area for children, group picnic areas and rental boats with motors are available. Effective January 1, 2000, high-emission (two-cycle) boat engines were banned from this reservoir. As of January 1, 2002, no engines discharging gasoline into water will be allowed here.

Camanche Reservoir is open all year and includes cottages and campgrounds on the north and south shores. Swimming, wind surfing and water skiing are allowed, along with boating, picnicking, and camping, made available by a private concessionaire.

Pardee Reservoir is open daily from mid-February to mid-November. Facilities operated by concession include a marina, boat rentals and launch ramp, swimming pools and a campground.

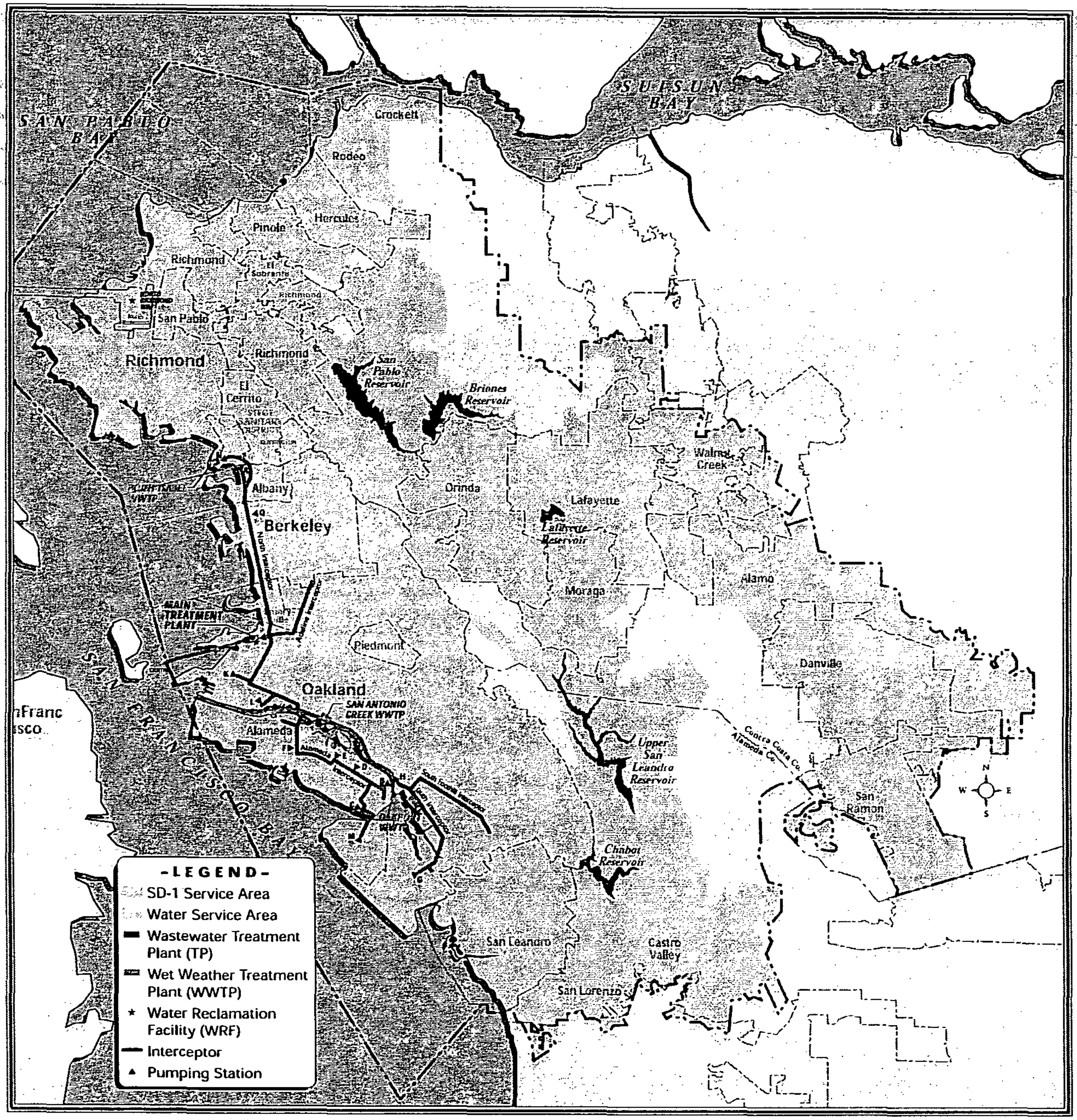
TRAILS

In 1974, a 60-mile system of trails was opened for hiking and horseback riding through the District's undeveloped East Bay watershed. Now, 83 miles of trail go through the Mokelumne and East Bay watersheds. The trails around Lafayette Reservoir, Lake Chabot and within the San Pablo Reservoir Recreation Area are available to everyone. Use of EBMUD's "back country" and Mokelumne trails requires valid permits, available for a small fee. An EBMUD Trail Map is provided free to permit holders.

OTHER RECREATION

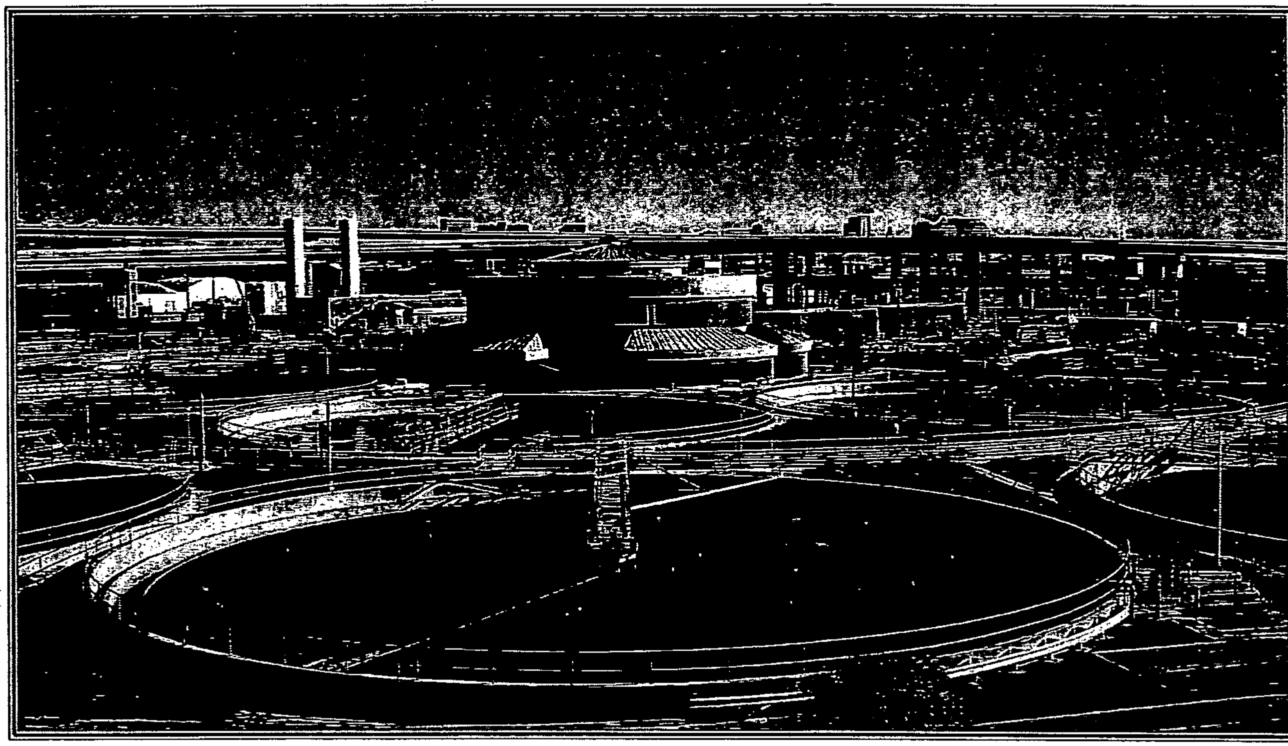
The Mokelumne Day Use Area offers hiking and picnicking. The Camanche Hills Hunting Preserve is a facility for hunting upland game birds.

The Wastewater System



The Wastewater System

Advanced technology and state-of-the-art scientific analysis aid EBMUD's conscientious efforts to protect San Francisco Bay.



These are the final settling tanks, or clarifiers–part of the secondary wastewater treatment process.

Special District No. 1, a separate district within EBMUD governed by the same Board of Directors, was established in 1944 and is administered by the District's Wastewater Department.

Domestic, commercial and industrial wastewater is treated for the cities of Alameda, Albany, Berkeley, Emeryville, Oakland and Piedmont, and for the Stege Sanitary District, which includes El Cerrito, Kensington and part of Richmond. Each of these communities operates sewer collection systems that discharge into one of five EBMUD intercepting sewers.

Design Criteria for Wastewater Treatment Plant

	Season	
1.Flows	Dry	Wet
a. Average Influent Flow, MGD	120	N/A
b. Peak Hourly Influent Flow, MGD	168	415
c. Maximum Flow to Primary Treatment, MGD	168	415
d. Maximum Flow to Storage Basin	N/A	95
e. Maximum Flow to Secondary Treatment, MGD	168	168

The interceptors are 29 miles of reinforced concrete pipes ranging from 12 inches to 9 feet in diameter. They collect wastewater from approximately 1,400 miles of sewers owned and operated by the communities. Fourteen pumping stations, ranging in capacity from 1.5 to 60 million gallons a day (MGD), lift wastewater throughout the interceptors as it travels to the Wastewater Treatment Plant.

WASTEWATER TREATMENT

Wastewater collected by the interceptors flows to the District's Wastewater Treatment Plant, in Oakland near the entrance of the San Francisco-Oakland Bay Bridge. The plant provides secondary treatment for a maximum flow of 168 MGD. Primary treatment can be provided for up to a peak of 415 MGD. The average annual flow is approximately 80 MGD.

Primary treatment removes floating material, oils and greases, sand and silt and organic solids heavy enough to settle in water. **Secondary treatment** biologically removes most of the suspended and dissolved organic and chemical impurities that would rob lifegiving oxygen from the waters of the Bay if allowed to decompose naturally.

The treatment steps are pre-chlorination (for odor control), screening (to remove large objects), grit removal, primary sedimentation, secondary treatment using high-purity, oxygen-activated sludge, final clarification, sludge digestion, dewatering and composting. The treated effluent is then disinfected,

The Wastewater System

dechlorinated and discharged one mile off the East Bay shore through a deep-water outfall into San Francisco Bay.

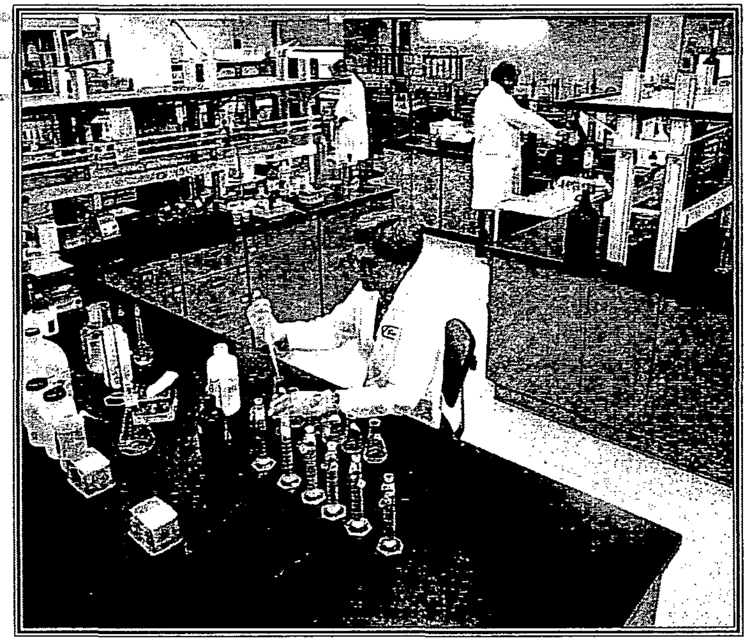
LABORATORY SERVICES

The Wastewater Department manages the EBMUD Environmental Laboratory, which operates 10 hours a day, 365 days a year to keep constant tabs on water quality for the drinking-water and wastewater systems.

In the mid-1990s, the District expanded the laboratory to 30,000 square feet in a two-year, $12-million construction project. The laboratory is certified by the California Department of Health Services Environmental Laboratory Accreditation Program for water, wastewater and hazardous waste analysis to use USEPA-approved standard methods for analyzing air, water, wastewater, soils, sludge, receiving water, sediments, biosolids and materials.

The Environmental Laboratory meets the District's needs for all regulatory monitoring, process monitoring and special studies, including monitoring for potential contaminants in drinking water, from the source water to the consumer tap.

Quality Assurance and Quality Control Programs (QA/QC) permeate every aspect of the laboratory's daily operations. Five work sections comprise the laboratory: Organic Chemistry, Inorganic Chemistry, Biology, Metals, and Client and Analytical Support.



Organic Chemistry–The laboratory's Organic Chemistry Section performs all aspects of instrumental analyses for organic chemistry using gas chromatrography-mass spectrometers and gas chromatography to identify some 300 organic compounds. A high-performance liquid chromatograph tests for non-volatile organics, and the latest in gel permeation clean-up extraction technology is used to prepare air, water and solid samples for analysis.

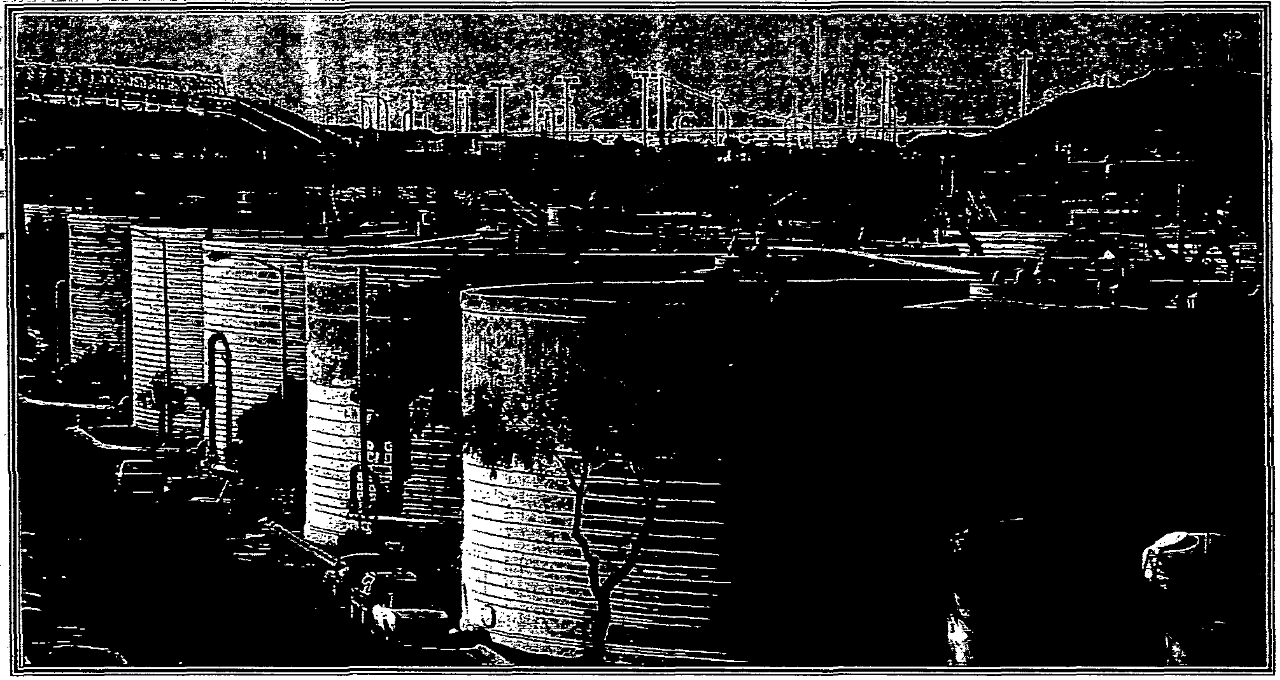
Inorganic Chemistry–This section performs chromatigraphic, spectrophometric, potentiometric and physical analyses. Most of the section's workload supports water and wastewater process control operations and regulatory compliance monitoring.

Metals–The Metals Section performs metals analyses using U. S. Environmental Protection Agency-approved analytical methods for water and wastewater. Using state-of-the-art instrumental procedures, the staff can simultaneously analyze up to 75 elements with extremely low detection limits. Most heavy metals can be accurately measured in the range of parts or sub-parts per billion.

Client and Analytical Support–This section manages all client projects; collects, receives and preserves samples; tracks progress and provides QA/QC support; and reports data. This staff group also manages procurement, shipping, receiving and storage of inventory; preparation of glassware and sampling kits; and laboratory services contracts.

EBMUD's Laboratory Services Division has received many awards over the years. These include the Outstanding Service Award and many Laboratory Analyst of the Year awards from the California Water Pollution Control Association.

The Wastewater System



Digesters–the large, circular tanks–break down organic materials, producing a heavy humus ideal for use on agricultural lands.

BAY PROTECTION

Wet Weather Program–Deteriorated community sewer pipes and improper storm drain connections allowed rainwater to enter local sewer systems during the heaviest storms, causing overflows at more than 175 locations. In 1979 EBMUD entered into a joint powers agreement with the communities in its service area to develop a regional solution. An East Bay Infiltration/Inflow Study produced reports for each community and recommended an overall 20-year program of sewer rehabilitation and construction of new sewer capacity in each city. The study reports were also the basis for obtaining grant funding.

In 1986, the joint powers agreement was amended to carry out the East Bay Infiltration/Inflow Correction Program, for which EBMUD is the lead agency. The communities have expended almost $100 million on their highest priority improvements. They are proceeding with the long-range program to correct the sewer system.

As EBMUD's contribution to the regional solution, the Wastewater Department is continuing a program of improving and expanding facilities to provide adequate treatment capacity for the high wet-weather flows. The communities' sewer improvements will reduce the "peak" regional wastewater flows from 1.1 billion gallons per day to 775 MGD. The District's treatment capacity will increase from 290 MGD to 775 MGD.

EBMUD's Wet Weather Program involved design and construction of more than $250 million in improvements over 10 years, including four new treatment plants, two storage basins, 7.5 miles of new interceptors and expansion of the main Wastewater Treatment Plant. The program is complete.

Construction of the 158-MGD Oakport Wet Weather Treatment Plant was completed in 1990. It accepts peak flows diverted from the District's South Interceptor to prevent untreated overflows.

Two projects totaling $100 million were completed in 1992 and increased the capacity of the main Wastewater Treatment Plant from 290 MGD to 415 MGD to accommodate peak flows. These projects included major modifications to the influent and effluent pumping stations, the solids-handling system, the chlorination facilities, the process control system, and an 11-million gallon storage basin to hold peak storm flows for later treatment.

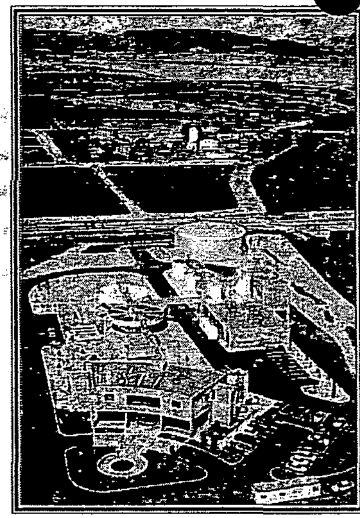
Construction was completed in 1992 on two major pipeline projects, the South Foothill and Adeline Street Interceptors. These "joint-benefit" relief sewers serve the District and the cities of Oakland, Berkeley and Emeryville, providing greater hydraulic capacity to eliminate wet-weather overflows.

In 1993, the 100-MGD Point Isabel Wet Weather Treatment Plant was completed. It accepts peak flows from the District's North Interceptor. The 28-MGD North Interceptor Wet Weather Facility was completed in 1994, and diverts flows from the main Wastewater Treatment Plant to the Point Isabel plant.

Two projects were completed in 1997. San Antonio Creek Wet Weather Treatment Plant accepts peak flows from the South Interceptor. The Pump Station C Storage Basin accepts peak flows from the Alameda interceptor.

A Pump Station B upgrade, completed in fall 1999, increased the capacity of the Alameda Interceptor.

The Wastewater System



EBMUD's North Richmond Water Reclamation Plant (foreground), which provides tertiary treatment to secondary treated wastewater from the West County Wastewater District (background), sends the water to Chevron Refinery for industrial use.

Wastewater Source Control–Source Control means requiring customers–the source–to remove such toxics as heavy metals and organic pollutants by carrying out management practices, process controls and/or pretreatment before discharging their wastes into the sewer system. The District's wastewater service area includes more than 20,000 commercial and industrial accounts. In 1972, EBMUD began a local source control program requiring pretreatment of wastes by certain categories of industrial customers. The Wastewater Source Control Program reduced by 91 percent the amount of heavy metals discharged into sewers, and EBMUD's treatment plant reduces the remaining heavy metals another 75 percent. These two steps together have reduced by 98 percent the quantity of heavy metals discharged into the Bay since 1977.

In 1988, source control efforts expanded into pollution prevention/waste minimization activities by educating commercial customers about how to reduce not only heavy metals, but volatile organics as well. Preventing pollution also eliminates or minimizes many costs for industrial and commercial customers by avoiding permit fees, disposal charges, consultant expenses and the need to buy more chemicals.

In 1989, 1993 and 1997, EBMUD's Pretreatment Program received the National Pretreatment Excellence Award for large programs from the U.S. Environmental Protection Agency. EBMUD is the only large agency to win the award more than once. In 1990, the District's air emissions monitoring program/inventory gained national recognition by receiving an award for research and development from the American Academy of Environmental Engineers.

CONSERVATION OF RESOURCES

Wastewater Reclamation–The Water Reclamation Program develops projects to reduce demands on potable water supplies. The program includes eight operating projects.

Since 1977, the Wastewater Department has reused up to 4 million gallons daily of treated wastewater for equipment washdown, lawn irrigation and cooling. In 1984, EBMUD began its first golf course irrigation project using reclaimed water. A second was added in 1988, and three more in 1991. These five projects save more than 300 million gallons of potable water annually.

Two projects began operating in 1995 to provide irrigation water for freeway landscaping along I-580 and cooling water for use at the Chevron Refinery in Richmond. EBMUD's current water reclamation program saves nearly 16 MGD of high-quality drinking water, or about 5.8 billion gallons annually.

In 1991, EBMUD completed a draft Water Reclamation Master Plan which identified by priority potential water recycling projects within the District's service area. This master plan was incorporated in the Water Supply Management Program (see page 2) adopted in October 1993. The WSMP includes saving an additional 8 MGD of drinking water through wastewater reclamation projects by the year 2020. This would boost EBMUD's Water Recycling Program to nearly 23 MGD, or about 9 billion gallons annually.

Biosolids Management–The solid, stabilized organic materials removed from wastewater are called biosolids. In the 1980s, EBMUD's award-winning compost program recycled about 20 percent of the biosolids generated during wastewater treatment.

The District initiated a Solids Management Implementation Plan in 1993 to deal with solids produced during water and wastewater operations. The plan concluded that regional composting, land application, landfill disposal and heat treatment were top-rated management options.

In 1994, EBMUD began applying biosolids to agricultural lands. Composting was discontinued in 1995 because land application was found to be more cost effective. Today, 100 percent of the biosolids produced go to beneficial uses.

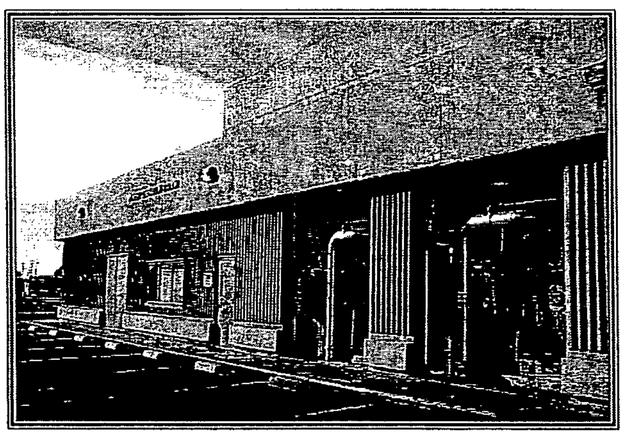
In summer, the land application is on Solano County farmland growing crops not intended for human consumption. In winter, biosolids provide an alternate cover for sanitary landfill. This work is accomplished through a private contractor at substantial savings to EBMUD, compared with the cost of the District's previous practice of landfill disposal and local composting.

Energy Recovery–Another wastewater treatment byproduct is methane gas produced by the sludge digestion process. EBMUD put into service in the spring of 1985 a 4.2 megawatt power generation plant which recovers about 85 percent of the available energy from methane gas. It also generates 60 percent of the electrical power needed to operate the Wastewater Treatment Plant.

Historical Highlights

Municipal Utility District Act adopted by State	1921
Election authorizing formation of Utility District	May 8, 1923
East Bay Municipal Utility District organized	May 22,1923
$39 million in general obligation bonds approved for construction of original Mokelumne System	Nov. 4, 1924
$26 million in general obligation bonds approved for purchase of the East Bay Water Company	Nov. 1, 1927
Properties of East Bay Water Company acquired	Dec. 8, 1928
Mokelumne water first reached local distribution system serving 440,000 people in a 92.6-square-mile area with 40 MGD through 1,381 miles of mains	June 23,1929
Municipal Utility District Act of 1921 amended to enable formation of Special Districts	1941
Election authorizing formation of Special District One (SD1)	Nov. 7, 1944
$12 million in general obligation bonds approved to finance construction of second Mokelumne Aqueduct	Nov. 5, 1946
$23.5 million in general obligation bonds approved for construction of water pollution control system (SD 1)	Nov. 5, 1946
Construction began for primary wastewater treatment facilities	1948
Second Mokelumne Aqueduct completed	April 27,1949
Wastewater treatment system placed in operation; initially served 593,000 people in 70 square miles, with a sewage flow of 55 MGD	Nov. 15, 1951
$252 million in general obligation bonds approved for water development project of East Bay Area	June 3, 1958
Third Mokelumne Aqueduct completed	May 14, 1963
Camanche Dam completed	March 6,1964
Briones Dam completed	Aug. 28, 1964
Walnut Creek Filter Plant dedicated, marking completion of the major elements of the water development project	April 19, 1967
Stege Sanitary District annexed to SD I	Aug. 11, 1970
Land Use Master Plan adopted	Oct. 13, 1970
$60 million in general obligation bonds approved for water pollution control project to add secondary treatment facilities	Nov. 3, 1970
Contract signed with U. S. Bureau of Reclamation for 150,000 acre feet per year of American River water to be taken from Folsom South Canal	December 1970
Water Management Plan adopted	Oct. 10, 1972
Groundbreaking ceremony for $73-million secondary wastewater treatment facilities	June 20, 1973
Construction began on secondary wastewater treatment facilities	Feb. 1974
Citizens voted to fluoridate the water supply	Nov. 5, 1974
Fluoridation began at the filter plants	August 1976
Driest year of record since construction of Pardee Dam	Winter 1976-77
Construction completed on expanded primary wastewater treatment facilities	January 1977
Water Shortage Emergency declared because of drought	Feb. 2, 1977
Water rationing in effect	Feb. 8, 1977 through Feb. 1, 1978
Wastewater Treatment secondary process facilities began operation	June 1977
Emergency Middle River Pumping Plant in service because of water shortage	Sept. 1977 through Jan. 1978
Upper San Leandro Dam modification completed	Sept. 1977
Inflow to Pardee Reservoir lowest of record	October 1977
Secondary wastewater treatment facilities placed in full operation	October 1978
Camanche Reservoir filled to capacity and spilled for the first time since its construction	June 6, 1979
The East Bay Infiltration/Inflow Study began	Sept. 1980
San Pablo Dam modification completed	Oct. 1980
Chabot Reservoir Spillway modification completed	May 1981
$25 million in Wastewater Revenue Bonds authorized	Sept. 1981

$20 million in Water System Revenue Bonds authorized	Oct. 1981
Wettest year of record since construction of Pardee Dam; 100-year storms hit Wastewater Department's service area	Winter 1982-83
Composting of digested sludge (solid byproduct of wastewater treatment) and marketing of soil amendment"CompGro" began	May 1983
Highest total storage of record in local reservoirs	March 4, 1983
Pardee Power Plant Third Unit completed and in service	June 1983
Camanche Power Plant completed and in service	August 1983
Highest of record annual power generation at Pardee and Camanche powerhouses	1984
Water Supply Availability and Deficiency Policy adopted	May 1985
Dedication of the Wastewater Department's Power Generation Station, which uses methane gas to produce energy	July 1985
Urban Water Management Plan adopted	Nov. 1985
East Bay Infiltration/Inflow Correction Program Began	January 1986
$600 million in Water System Revenue Bonds authorized	June 1986
San Ramon Valley Near-Term Improvement Projects totaling $67 million completed	Sept. 1986

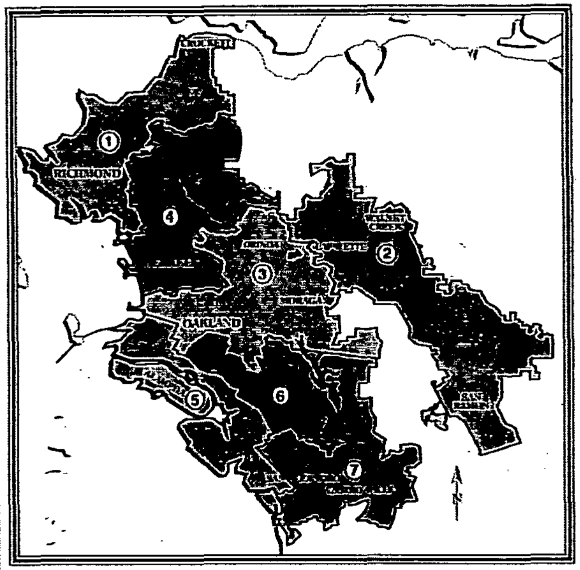


The Power Generation Station recovers most of the available energy from methane gas to produce electrical power needed for wastewater treatment.

Policy Adopted on Interruptible Sales of Surplus Water	Oct. 1986
Wastewater Department began the Wet Weather Capital Improvement Program	January 1987
Wet Weather Program's National Pollution Discharge Elimination System permit issued	March 1987
$200 million in Wastewater System Revenue Bonds authorized	Oct. 1987
Water and Wastewater Tax Exempt Commercial Paper Program authorized	Oct. 1987
Water Shortage Emergency declared because of drought	March 22, 1988
OP/NET computerized system began controlling Distribution system	Dec. 1988
Water Supply Management Program adopted	May 9, 1989
Water Shortage Emergency declared over	Sept. 12, 1989
Loma Prieta earthquake damaged EBMUD water and wastewater systems	Oct. 17, 1989
Firestorm in the Oakland-Berkeley hills cut off 2,400 water services and destroyed more than 3,300 homes	Oct. 20, 1991
Six-year Drought Conservation Program ended	April 1, 1993
Updated Water Supply Management Program adopted	Oct. 26 1993
Seismic Improvement Program adopted to strengthen the water system over 10 years at a cost of $189 million	Nov. 22, 1994
EBMUD's North Richmond Water Reclamation Plant began operation to provide reclaimed wastewater to the Chevron Refinery for industrial cooling	June 1995
East Bay Watershed Master Plan adopted	March 12, 1996
The highest Mokelumne flows in EBMUD history spilled over Pardee Dam	Jan. 2, 1997
Action plan adopted to reduce MTBE and other gasoline components in EBMUD water	Jan. 13, 1998
EBMUD converted from chlorine to chloramine as the water distribution system disinfectant	Feb. 23-April 27, 1998
Wet Weather Progarm completed	Oct. 1999

About The District Organization

BOARD OF DIRECTORS BY WARD



Board Member	Ward	Board Member	Ward
Lesa R. McIntosh	1	David Richardson	4
John A. Coleman	2	Danny W. Wan	5
		William B. Patterson	6
Katy Foulkes	3	Frank Mellon	7

Board meetings are open to the public and held on the second and fourth Tuesdays of each month at 1:15 p.m. in the EBMUD Board Room, second floor, 375 Eleventh Street, Oakland, California.

ADMINISTRATIVE PROFILE

The District has 1,916 permanent, full-time employees under the administrative direction of an appointed General Manager and management staff. Most employees are represented by the American Federation of State, County and Municipal Employees, Locals 444 and 2019; the International Federation of Professional and Technical Engineers, Local 21; and the International Union of Operating Engineers, Local 39. A voluntary Affirmative Action Policy was adopted by the Board of Directors in 1975 and reaffirmed in 1981. In 1984, the Board adopted a Minority Business and Women Enterprise Policy to formalize its established practice of increasing the amount of District business contracted with minority- and female-owned businesses and professional services. In 1998, the Board replaced this program and policy with the Contract Equity Policy and Program. The Board adopted in 1988 a policy to increase minority employment in the workforces of District contractors. In 1991, the Board adopted a policy preventing sexual harassment in the workplace.

FINANCIAL PROFILE

EBMUD's revenues come from a variety of sources, including sales of water and hydroelectric power, meter service charges, sewage treatment charges, a wet-weather facilities charge, and a small amount from property taxes.

The 1999-00 fiscal year budget of $454.8 million for the water system included $237.4 million in capital improvements. The wastewater system budget of $95.1 million included $35.8 million in capital improvements.

DISTRICT OFFICES

Administration Center

375 Eleventh Street, Oakland, CA 94607-4240
Phone: (510) 835-3000 (24 hours)

Mailing Address:
P. O. Box 24055, Oakland, CA 93623-1055

Business Offices

Location	Address	Zip Code	Telephone
Oakland	375 Eleventh St.	94607	(510) 287-1380
Richmond	1030 Nevin Ave.	94801	(510) 232-5051
San Leandro	1595 Washington Ave.	94577	(510) 483-3540

Water Conservation Offices

Oakland	375 Eleventh St.	94607	(510) 287-0590
Oakland	2130 Adeline Street	94607	(510) 287-0590

Water Conservation Center

San Leandro	1595 Washington Ave.	94577	(510) 483-3540

ALL ABOUT EBMUD
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Ida McClendon, Editor-Writer
Richard Leon, Designer

The District's new Administration Center in downtown Oakland replaced several old and crowded offices inefficiently dispersed through the East Bay. In 1991, more than 680 employees moved into the nine-story structure where customers are offered the full variety of EBMUD services in a central and easily accessible location.

STATE OF CALIFORNIA—RESOURCES AGENCY

EDMUND G. BROWN JR., GOVERNOR

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD—
CENTRAL VALLEY REGION
3201 S STREET
SACRAMENTO, CALIFORNIA 95816
PHONE: (916) 445-0270

DRAFT

INVENTORY AND ASSESSMENT OF WATER QUALITY PROBLEMS RELATED TO ABANDONED AND INACTIVE MINES IN THE CENTRAL VALLEY REGION OF CALIFORNIA

by

Stein M. Buer, Stanley R. Phillippe
and Thomas R. Pinkos - Staff Engineers

Citation Date:
1979
(per Pinkos, 2/13/01)

TABLE 1. INVENTORY OF PROBLEM MINES

Watershed	Mine Name	County	CDMG Map No.	USGS Map	Latitude	Longitude	Commodity Mined	Type of Operation	Receiving Stream
American River, SF	Alhambra Shumway	El Dorado	5A-733	Georgetown	38 49.54'	120 47.37'	Gold	Undergrnd	Mosquito Trail Glch—Rock Crk—SF American R
Bear River	Dairy Farm	Placer	5A-633	Cmp Far W	39 1.51'	121 17.25'	Copper	Undergrnd	Camp Far West Reservoir
	Lava Cap-Banner	Nevada	5A-571	Chicago Pk	39 13.64'	120 58.19'	Gold	Undergrnd	L.Clipper Crk—Greenhorn Crk—Rollins Res—Bear R
Butte Creek	Cherokee	Butte	5A-278	Cherokee	39 38.20'	121 37.70'	Gold	Hyd Placr	Sawmill Ravine—Dry Creek—Butte Crk
	Mineral Slide	Butte	(none)	Paradise	39 47.14'	121 37.63'	Gold	Undergrnd	L.Butte Crk—Butte Crk
Cache Creek	Abbott	Lake	5A-645	Wilbur Spg	39 1.23'	122 26.63'	Mercury	Undergrnd	Harley Glch—Cache Crk
	Manzanita	Colusa	5A-644	Wilbur Spg	39 2.30'	122 25.82'	Mercury	Undergrnd	Sulfur Crk—Bear Crk—Cache Crk
	Reid	Yolo	5A-656	Knoxville	38 51.88'	122 22.20'	Mercury	Undergrnd	Davis Crk—Cache Crk
	Sulfur Bank	Lake	5A-650	Clr Lk Hi	38 59.90'	122 40.35'	Merc,Sul	Open Pit	Clear Lake—Cache Crk
Cosumnes River	Copper Hill	Amador	5B-044	Latrobe	38 30.13'	120 58.00'	Copper	Undergrnd	Cosumnes River
Feather River	China Gulch	Plumas	(none)	Greenvlle	40 12.74'	120 45.17'	Copper	Undergrnd	Lights Crk—Wolf Crk—NF Feather R
	Engel	Plumas	5A-076A	Greenvlle	40 12.20'	120 46.41'	Cop,Silv	Undergrnd	Lights Crk—Wolf Crk—NF Feather R
	Iron Dyke	Plumas	5A-080	Greenvlle	40 3.90'	120 50.60'	Cu,Ag,Au	Undergrnd	Taylor Crk—Indian Crk—Wolf Crk—NF Feather R
	Walker	Plumas	5A-159	Mt Inglls	39 58.70'	120 39.80'	Copper	Undergrnd	L.Grizzly Crk—Indian Crk—Wolf Crk—NF Feather R
Fresno Slough	New Idria	San Benito	5D-045	Idria	36 24.85'	120 40.39'	Mercury	OPit&Undg	San Carlos Crk—Silver Crk—Panoche Crk
Mokelumne River	Argonaut	Amador	5B-105	Jackson	38 21.77'	120 47.10'	Gold	Undergrnd	Jackson Crk—Dry Crk—Mokelumne R
	Newton	Amador	5B-089	Ione	38 20.45'	120 53.20'	Copper	Undergrnd	Copper Crk—Sutter Crk—Dry Crk—Mokelumne R
	Penn	Calaveras	5B-223	Vlly Spg	38 13.97'	120 52.50'	Copper	OPit&Undg	Mokelumne River (Camanche Res)
Putah Creek	Aetna	Napa	5A-785	Aetna Spg	38 39.43'	122 29.51'	Mercury	Surf&Undg	Swartz Crk—Pope Crk—Putah Crk—Lake Berryessa
	Anderson	Lake	5A-652	Whisp Pne	38 46.35'	122 42.40'	Mercury	Undergrnd	Anderson Crk—Bear Canyon Crk—Putah Crk—Lk. Berry.
	Big Injun	Lake	5A-650A	Whisp Pne	38 45.85'	122 42.40'	Mercury	Surf&OPit	Bear Canyon Crk—Putah Crk—Lake Berryessa
	Corona	Napa	5A-790	Detert Spg	38 40.21'	122 32.47'	Mercury	Undergrnd	James Crk—Pope Crk—Putah Crk—Lake Berryessa
	Great Western	Lake	5A-795	Mt St Hel	38 42.87'	122 38.44'	Mercury	OPit&Undg	Hoodoo Crk—Dry Crk—Putah Crk—Lake Berryessa
	Knoxville	Napa	5A-659	Knoxville	38 49.61'	122 20.34'	Mercury	OPit&Undg	Knoxville Crk—Eticuera Crk—Lake Berryessa
	Oat Hill	Napa	5A-789	Detert Spg	38 40.50'	122 21.65'	Mercury	Surface	James Crk—Pope Crk—Putah Crk—Lake Berryessa
Sacramento River	Afterthought	Shasta	5A-019	Millville	40 44.10'	122 4.10'	Cu,Ag,Au	Undergrnd	L.Cow Crk—Sacramento R
	Balaklala	Shasta	5A-033	Shasta Dam	40 43.59'	122 29.79'	Cu,Zn,Ag	Undergrnd	West Squaw Crk—Shasta Lake
	Bully Hill	Shasta	5A-017	Bllbkka Mt	40 47.80'	122 12.20'	Cu,Zn,Pb	Undg&Surf	First Crk, Town Crk—Shasta Lake
	Golinsky	Shasta	5A-014	Lamoine	40 45.84'	122 27.40'	Cu,Zn,Au	Undergrnd	L.Backbone Crk—Shasta Lake
	Greenhorn	Shasta	5A-055	Frnch Glch	40 39.75'	122 41.65'	Cu,Au,Ag	Undergrnd	Willow Crk—Clear Crk—Whiskeytown Lake
	Iron Mountain	Shasta	5A-041	Frnch Glch	40 40.39'	122 31.47'	Cu,Zn,Au	Undg&Surf	Spring Crk—Keswick Res (Sacramento R)
	Keystone	Shasta	5A-037	Frnch Glch	40 43.10'	122 30.32'	Cu,Au,Ag	Undergrnd	West Squaw Crk—Shasta Lake
	Mammoth	Shasta	5A-013	Lamoine	40 45.84'	122 27.40'	Cu,Zn,Au	Undergrnd	L.Backbone Crk—Shasta Lake
	Shasta King	Shasta	5A-035	Shasta Dam	40 43.80'	122 29.80'	Cu,Au,Ag	Undergrnd	West Squaw Crk—Shasta Lake
an Joaquin Delta	Mount Diablo	Contra Costa	(none)	Antioch So	37 53.87'	121 52.54'	Mercury	Undergrnd	Marsh Crk—Marsh Crk Res—San Joaquin Delta
tanislaus River	Empire	Calaveras	5C-072	Copperopls	37 58.60'	120 38.30'	Copper	OPit&Undg	Copper Crk—Black Crk—Tulloch Res (Stanislaus R)
	Keystone	Calaveras	5C-073	Copperopls	37 59.20'	120 38.90'	Copper	Undergrnd	Penny Crk—Sawmill Crk—Black Crk—Tulloch Res
uba River	Kenton	Sierra	5A-357	Alleghany	39 27.31'	120 51.52'	Gold	Undergrnd	Kanaka Crk—M Yuba R
	Malakoff Diggings	Nevada	5A-345	Pike,NBlmf	39 22.20'	120 55.00'	Gold	Surf Hydr	Humbug Crk—SF Yuba R
	Plumbago	Sierra	5A-384	Alleghany	39 27.17'	120 48.74'	Gold	Undergrnd	Buckeye Ravine—M Yuba R
	Sixteen to One	Sierra	5A-367	Alleghany	39 27.92'	120 50.53'	Gold	Undergrnd	Kanaka Crk—M Yuba R

PENN MINE

Penn Mine is located along the Mokelumne River between Pardee and Camanche Reservoirs. Downstream pollution as a result of drainage from the Penn Mine is succintly explained in CDFG Environmental Services Branch Administrative Report No. 78-1 by Finlayson and Rectenwald, which may be found in the mine file labeled "Penn Mine".

Water quality problems due to Penn Mine have been abated by diversion works and containment facilities constructed in 1978 (see also Case File #166 - Penn Mine). If these measures suffice to eliminate further downstream pollution due to the mine, a rank of LOW will be warranted, or perhaps a non-rank, i.e., elimination from the list. However, should the measures prove inadequate, a HIGH rank is justified, particularly if downstream fishkills are a direct result of the mine discharge.

Data to date are summarized below. No data sufficient to judge the effectiveness of the abatement measures are yet available. Therefore, Penn Mine will be <u>tentatively</u> ranked on the basis of its impact on the stream <u>without</u> effective abatement measures.

		cfs		μg/l				mg/l
Station	Date	Q	pH	As	Cu	Pb	Zn	Fe
Upstream from mine discharge, below Pardee Reservoir	2/10,11/58 [1]	650	6.9	0	10	0	10	.13
	10/6/77 [3]		7.28	-	<10	-	250	--
	4/11/78 [4]		--	-	--	-	<10	--
	5/9/78 [4]		--	-	--	-	<10	--
Mine Run Creek, near confluence with Mokelumne River	2/10,11/58 [1]	1.4	2.7	10	59,000	310	1,640,000	178
Shoreline near Penn drainage Mokelumne River	5/5/77 [2]		--	-	30	-	120	.09
Downstream from mine discharge above Camanche Reservoir	2/10,11/58 [1]	680	3.4	0	3,800	0	37,600	1.3
	10/6/77 [3]		6.96	-	40	-	1,120	--
	4/11/78 [4]			-	--	-	50-960	--
	5/9/78 [4]						10-30	

Mokelumne River water is soft (total hardness ≃ 18 mg/l as $CaCO_3$)

1/ Gordone, CDFG unpublished data, 1960, in Finlayson and Rectenwald, CDFG ESB Admin. Rep. 78-1 (Oct. 78)

2/ Memorandum, CVRWQCB, S. Phillippe to J. Del Conte (June 27, 1977)

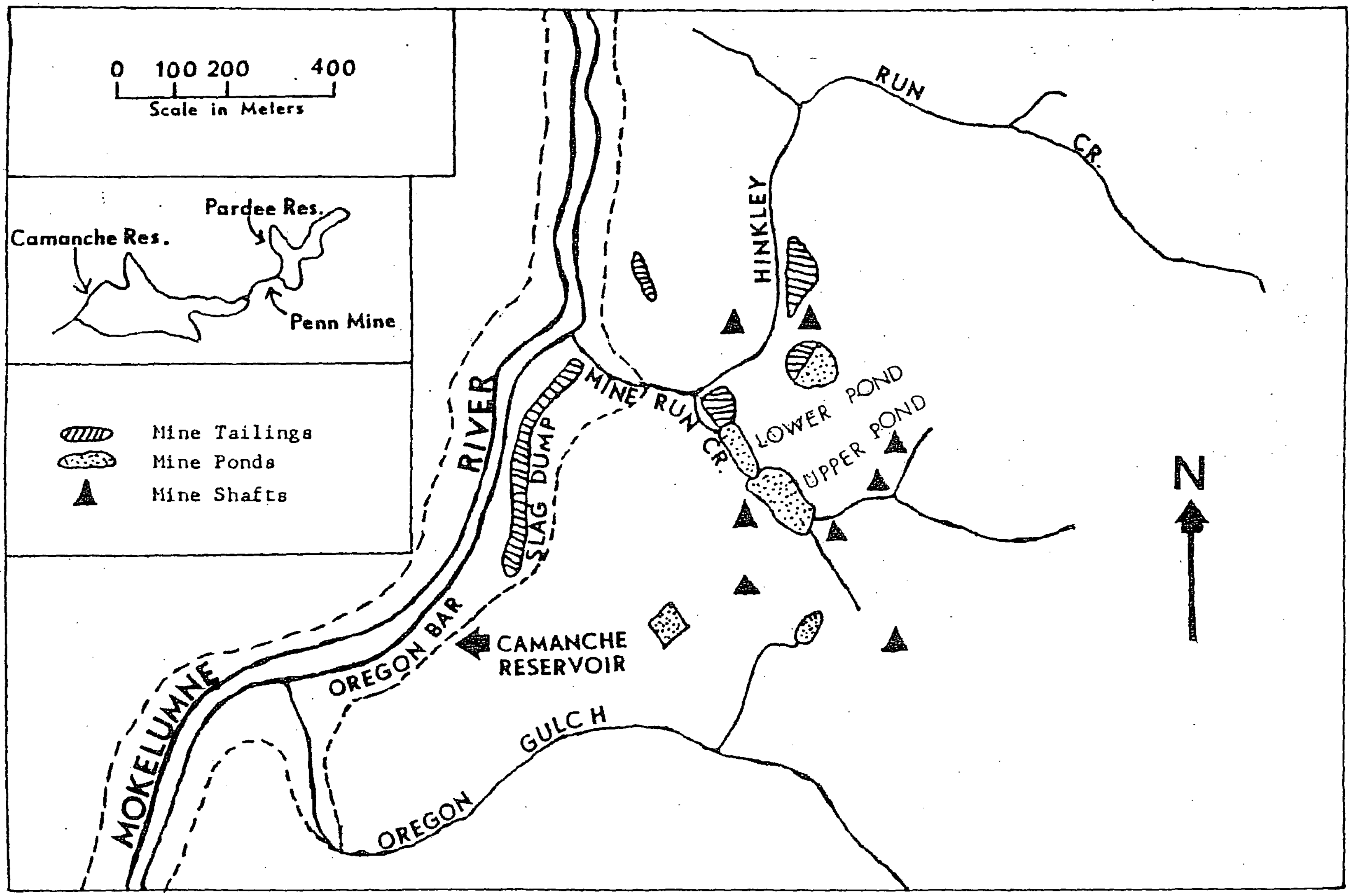
3/ Memorandum, re: Kill of Steelhead Trout at Mokelumne River Hatchery Beginning October 6, 1977, CDFG, R. Hanson to B. Lassen (Oct. 19, 1977)

4/ Memorandum re: Analysis of Water Samples for Zinc, Camanche Lake, CDFG (May 1 and 22, 1978)

Using the 1958 data for the Mokelumne River downstream from the mine, and above Camanche Reservoir, ac and hm equal 3, and fe = 1, resulting in ℂ = 26; since streamflow is greater than 5cfs, Rc = H. Using more current data, the high zinc levels result in hm = 3, producing ℂ = 15, and again, with the high Q in the river, Rc = H.

Using the 1958 data for Mine Run Creek, which discharges to the Mokelumne, hm = ac = fe = 3, resulting in ℂ = 30, and with Q = 1.4, Rc = H.

Therefore, based on chemical analysis of either the Mokelumne River or Mine Run Creek, <u>without</u> effective abatement measures, the rank of Penn Mine is <u>HIGH</u>.



The Penn Mine Watershed, Mokelumne River Basin, California.

The Resources Agency
Department of Fish and Game
Streamflow Requirements Program

Lower Mokelumne River Fisheries Management Plan

November, 1991

Douglas P. Wheeler
Secretary for Resources
The Resources Agency

Pete Wilson
Governor
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Lower Mokelumne River
Fisheries Management Plan 1/

Prepared by

The Resources Agency
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Abstract

Data collected during 1986-1987 were evaluated relative to the habitat requirements of the fish and wildlife resources of the lower Mokelumne River, San Joaquin County, California. This evaluation is in response to water developments and diversions that have reduced flows and increased water temperatures below Camanche Dam. This habitat once sustained significant populations of chinook salmon and steelhead trout.

Instream flows and temperatures providing necessary habitat requirements are identified.

1/ Investigation funded by the Streamflow Requirements Program, The Resources Agency, Department of Fish and Game, November, 1991.

2/ Field data collection by EBASCO Services Incorporated, (formally The Envirosphere Company) Sacramento, California.

characterized by higher water velocities in broad, higher gradient river channels with cobble-gravel substrates. Depths range from about 1 to 6 ft, depending on flow. The riffle habitat type is predominantly found in the first 6 to 7 mi below Camanche Dam (to RM 53.6).

Another habitat type is slow run-pool habitat. It is characterized by slow water velocities (<2.0 ft/s in mid-channel) in a narrower, low gradient river channel, with sand or mud substrates and water depths generally ranging from 2 to 15 ft. This run-pool habitat often has large amounts of woody debris in the channel from riparian vegetation. The woody debris collects on mid-channel bars and near eroding slopes on river bends creating loose log jams that sometimes span the width of the channel. The dispersed deadfall and accumulations of fallen trees also create some of the most usable cover areas for fish.

The run-pool habitat type dominates the 30 mi of the lower Mokelumne River below Elliott Road. Lodi Lake's pool habitat creates current velocities approaching zero. Below Woodbridge Dam there are short sections of river with increased gradient creating short riffles (2-25 ft long), however, the majority of habitat is the low gradient slow run-pool habitat with riparian debris accumulations in the channel. This slow run-pool habitat below Woodbridge Dam may become very shallow during low flow periods and cause problems for migrating adult and juvenile salmon. Scour holes associated with wood debris accumulations provide the only refuge of deeper water during these periods.

Historical Factors Influencing the Fishery

The fishery of the lower Mokelumne River has been adversely impacted since the early 1900's due to fish kills by pollution from winery and mine wastes, fish losses at unscreened diversions, and loss of habitat and physical obstruction due to dams.

Pollution

Winery wastes were disposed of directly into the Mokelumne River between 1933 and 1950 near Lodi during the fall months of grape harvest and processing. These wastes caused pollution blocks that prevented fish migration and fish kills occurred frequently (DFG 1959).

Between 1948 and 1959, a cannery near Thornton was a source of intermittent pollution from tomato cannery wastes. Fish kills occurred, however, it is doubtful that this created a serious block to salmon runs (DFG 1959).

Wastes from mining for copper, zinc, lead, gold, and silver have been a continual source of pollution since discovery of copper in 1861 at the Penn Mine 3 mi downstream of the present location of

Pardee Dam. During operation of the Penn Mine, water and mud were continually pumped from the mine shafts. This water and mud plus the leaching of piled mine tailings were the initial source of toxic concentrations of copper and zinc in the lower Mokelumne River. Since 1956 when the mine was abandoned, the leaching of surface stored ore deposits and mine tailings, and erosion and leaching of exposed subterranean deposits of copper and zinc continues to be a major source of toxicity (Finlayson and Rectenwald 1978).

Historically, unimpaired high flows in the Mokelumne River diluted most of the toxic materials from the Penn Mine and minimized the impacts. However, the construction of Pardee Dam (1928) reduced the dilution of Penn Mine wastes and runoff, and later, the completion of Camanche Dam (1963) created a heavy metal sink with the creation of Camanche Reservoir.

Woodbridge Diversion Canal

This large, diversion ditch has been in operation since 1910. The canal has a capacity of about 400 ft^3/s. From 1910 to 1967, the canal operated without a fish screen resulting in significant fish losses. Since installation of a screen in 1968 by DFG, salmonid losses to this diversion are minimal but losses do occur during downstream passage through Lodi Lake.

Physical Obstruction from Dams

The major obstacles to migration of chinook salmon and steelhead trout were Woodbridge Dam (1910), Pardee Dam (1928), and more recently Camanche Dam (1963).

Woodbridge Dam contained no fish ladder until 1925. Passage over the dam during this time period depended upon flows in the river and the length of the irrigation season (DFG 1959). When the dam was lowered at the end of the irrigation season, salmon and steelhead had a much better opportunity to pass over this barrier. The fish ladder, between 1925 and 1948, continued to block salmon and steelhead runs due to poor design. Since 1955, the reconstructed fish ladder proves to be adequate only when flows over Woodbridge Dam allow fish access to the ladder.

American shad and striped bass are restricted by Woodbridge Dam during their upstream spawning migration due to their reluctance to utilize fish ladders in general.

Completion of Pardee Dam in 1928 eliminated summer holding and spawning habitat for fall- and spring-run chinook salmon and steelhead trout. Completion of Camanche Dam in 1963 further reduced the habitat for these species.

Power peaking operations associated with hydroelectric power generation at Pardee Dam and later at Camanche Dam further prevented Mokelumne River chinook salmon and steelhead from realizing their potential. The power peaking operations created widely fluctuating flows resulting in interruption of adult passage and spawning activities, and losses due to stranding or exposure of eggs and fry.

Existing Fisheries Resources

A total of 27 species of resident and anadromous fishes are known to occur in the lower Mokelumne River (Table 2). Four anadromous fishes of management interest are present in the lower Mokelumne River: fall-run chinook salmon, steelhead trout, American shad, and striped bass. Various impacts of man on the aquatic habitat and the natural variation of environmental conditions in the lower Mokelumne River have resulted in constantly changing population densities of these species.

Chinook Salmon

Fall-run chinook salmon are the largest and most important anadromous fish in the lower Mokelumne River. Because of their size and food quality, they are highly prized by both commercial and sport fisherman. The San Joaquin River system, including the Mokelumne River, has historically been an important spawning area for this species.

Prior to the completion of Camanche Dam in 1964, salmon spawned primarily between Clements and the canyon about 3 mi below Pardee Dam, with a few fish spawning upstream in the canyon below Pardee Dam and downstream between Clements and Lockeford (DFG 1959). An undetermined number of salmon spawned in the river above Pardee Dam prior to its construction. DFG (1959) determined the Mokelumne River downstream of Pardee Reservoir was capable of sustaining an annual run of 15,000 adult chinook salmon and 2,000 adult steelhead trout and under conditions of satisfactory water quality and flow, existing spawning beds could easily accommodate 60,000 chinook salmon. As mitigation for the loss of spawning habitat between Camanche Dam and Pardee Dam, a hatchery installation capable of handling 10,000 adult chinook salmon and 2,000 steelhead trout was recommended. The river below the hatchery could be expected to handle 5,000 chinook salmon while the hatchery would handle the entire run of steelhead trout. On January 3, 1961, the DFG and EBMUD signed an agreement as mitigation for the Camanche Dam project that provided for the Mokelumne River Fish Hatchery (MRFH) with full capacity to produce 100,000 yearling steelhead trout and to process 15,000,000 chinook salmon eggs per year. Since completion, the MRFH has received an average of only 490 adults (range 0-1,782) and 28 adult steelhead trout (0-215) over the period 1964-1988 (Estey 1988). Total chinook salmon run sizes in the Mokelumne River varied over the period of record (1940-1990) from 100 to 15,900 fish (Table 3).

Presently, the majority of salmon spawning takes place over the 5 mi between Camanche Dam and Mackville Road with 95% of the suitable habitat within 3.5 mi of Camanche Dam (Taylor 1974a, 1974b). During and following the spawning season of 1986, spawning salmon were observed 1 to 2 mi downstream of Mackville Road, indicating that available spawning habitat extend to 7 mi below Camanche Dam.

The salmon run for the 19-year period (1940 to 1942, 1945, and 1948 to 1963) prior to the impoundment of Camanche Reservoir averaged 3,300 spawners and for the 27-year post-impoundment period (1964 to 1990) averaged 3,200 spawners.

TABLE 2. Common and scientific names of fishes occurring in the lower Mokelumne River, California.*,+

Common name	Scientific name
Chinook salmon	Oncorhynchus tshawytscha
Rainbow trout (resident and anadromous)	Oncorhynchus mykiss**
American shad	Alosa sapidissima
Striped bass	Morone saxatilis
Largemouth bass	Micropterus salmoides
Smallmouth bass	Micropterus dolomieui
Black crappie	Pomoxis nigromaculatus
Green sunfish	Lepomis cyanellus
Bluegill	Lepomis macrochirus
White catfish	Ictalurus catus
Channel catfish	Ictalurus punctatus
Black bullhead	Ictalurus melas
Brown bullhead	Ictalurus nebulosus
Pacific lamprey	Lampetra tridentata
Pond smelt	Hypomesus olidus
Sacramento sucker	Catostomus occidentalis
Sculpin	Cottus sp.
White sturgeon	Acipenser transmontanus
Green sturgeon	Acipenser medirostris
Warmouth bass	Lepomis gulosus
Carp	Cyprinus carpio
Sacramento blackfish	Orthodon microlepidotus
Hitch	Lavinia exilicauda
Splittail	Pogonichthys macrolepidotus
Goldfish	Carassius auratus
Threadfin shad	Dorosoma petenense
Tule perch	Hysterocarpus traski

*From: DFG (1959) and Turner and Kelley (1966).
+Common and scientific names from Special Pup. No. 12, American Fisheries Society (1980).
**Taxonomic change according to Kendall (1988).

areas near the Camanche Dam. Further, low dissolved oxygen levels, but not lethal, increase the hazard to aquatic life from sulfides (EPA 1986).

Dissolved oxygen concentration levels at or near saturation, with temporary reductions no lower than 5.0 ppm, are recommended for incubating egg survival of anadromous salmonids (Reiser and Bjornn 1979; Eddy 1972). Oxygen levels below saturation may increase development time, induce premature hatching, or increase the incidence of growth anomalies and lower fry survival.

pH

Acidic water conditions resulted from winery and cannery effluent discharges in the river from 1935 to 1957. These problems mostly affected the lower river areas where the industries developed. With strict water quality guidelines enacted specific to winery and cannery discharges, low pH problems in the lower river have been controlled since 1957.

The values of pH recorded during 1986 through 1989 range from 5.42 to 8.5 (Appendix D). The low pH (acidic) reading below Camanche Dam on October 1, 1987 and October 15, 1989 resulted from anoxic water releases from the bottom of Camanche Reservoir and the associated hydrogen sulfide gases. Low pH renders a greater proportion of sulfides in the form of toxic hydrogen sulfide (EPA 1986).

The pH levels recorded during 1987 and 1989 probably did not adversely affect salmon (although the concurrent anoxic conditions did cause fish kills). The Environmental Protection Agency (EPA) indicates the favorable pH range for fish is generally from 6.5 to 9.0 (EPA 1986) while the water quality objectives for inland surface waters established in the Basin Plan by the RWQCB is 6.5-8.5 (RWQCB 1975).

Turbidity

High turbidity caused by high silt loads, can cause avoidance reactions by adult salmon, and can stop their migration in extreme cases (Cordone and Kelley 1961; Bell 1986). Turbidities associated with high levels of suspended solids can also harm fish via the abrasion and clogging of gill membranes and reduced feeding activity (Reiser and Bjornn 1979). Increased turbidity can be associated with fine sediment deposits in large quantities which are known to reduce juvenile rearing area in pools and riffles and adversely affect food supplies, and egg or alevin survival by reducing interstitial spaces in the substrates (Bjornn et al. 1977; Cordone and Kelley 1961; Tebo 1957, 1974; Chapman 1962).

Water samples collected between Camanche Dam and I-5 in May and June, 1987, range from 2.3 to 18.0 NTU (Appendix D). Turbidity was greater near the Sacramento-San Joaquin Delta. DFG turbidity data (in JTUs) at the Mokelumne River Fish Installation range from 1.2 to 5.7 JTU over August 1986 to July 1987. The 1986-87 turbidity data for the lower Mokelumne River do not indicate problems for migrating adult salmon, incubating eggs, or juveniles. High turbidity was present during the fish kill in 1989 with 1.0-10.0 in visibility reported near Camanche Dam by Nelson et al. (1989) on October 13 and 17.0 NTU's in the MRFH by Miyamoto (1989) on October 4, but its contribution to the fish losses was not determined.

Specific Conductance

Conductivity measurements were taken at various locations along the lower Mokelumne River for water quality background data and in association with electrofisher sampling at population sample sites (Appendix D). Values ranged from 29 to 49 umhos. Problems with these levels were not identified.

Heavy Metals

Heavy metal pollution in the lower Mokelumne River has killed adult and juvenile chinook salmon in the past (Finlayson and Rectenwald 1978). Copper and zinc from Penn Mine, below Pardee Dam, were identified as the main metals causing the fish kills in the lower river. Recently, hazardous levels of cadmium has been determined to be present in discharges from Penn Mine as well and from the lower Mokelumne River at the base of Camanche Dam (RWQCB 1989, 1991) (Appendix D). Historically, unimpaired high flows in the Mokelumne River diluted most of the toxic materials from the Penn Mine and minimized the impact. However, the construction of Pardee Dam reduced the dilution of Penn Mine wastes and runoff, and the later completion of Camanche Dam created a heavy metal sink (Finlayson and Rectenwald 1978). These higher concentrations of heavy metals lead to fish kills and have contributed to the decline of the Mokelumne River chinook salmon and steelhead trout populations (DFG 1959; Finlayson and Rectenwald 1978). Also, metal-laden mine water was pumped directly into the Mokelumne River in some years, or leaked into the river from broken pipelines, causing fish kills (DFG 1956). Problems with toxic discharges from the Penn Mine continued through the 1960's and early 1970's (Finlayson and Rectenwald 1978).

In 1972, the RWQCB revised discharge requirements for Penn Mine, requiring a closed water system to prevent discharge to the Mokelumne River. Surface impoundments at the Penn Mine site hold acid-mine drainage fluids containing high concentrations of numerous metals from the mine dumps, (including hazardous concentrations of Cd, Cu, and Zn), and very high concentrations of sulfate (RWQCB 1989). Although the 1972 discharge requirements issued to the Penn Mine owners envisioned a closed system precluding release of heavy metals into Camanche Reservoir, the requirements have never been complied with and discharges do occur

(SWRCB 1988). In February, March, and April of 1986, uncontrolled discharges from Penn Mine surface impoundments ranging from 100-1,293 gpm of hazardous levels of copper and zinc entered Camanche Reservoir. Acutely toxic effects at the MRFH were avoided because releases from Pardee during this period ranged as high as 20,000 ft^3/s and afforded dilution to mitigate toxic effects as the metals mixed with Camanche Reservoir water and flowed out of Camanche Reservoir at rates up to 5,000 ft^3/s. Sampling of Camanche Reservoir water by the RWQCB in March found levels of copper and zinc above EPA's water quality criteria for the protection of aquatic life. Following this, concentrations of metals toxic to aquatic life were discharged into the MRFH during the fish kill of 1989 (RWQCB 1989) possibly a result of the resuspension of reservoir sediments during turnover conditions that result in the mobilization of metals (E.V.S. Consultants 1989).

Other Constituents

High concentrations of hydrogen sulfide (H_2S) have been associated with fish kills in the lower Mokelumne River below Camanche Dam during 1987, 1988, and 1989 (DFG 1990; Miyamoto 1989; Horne 1989; RWQCB 1989). Sulfates from the Penn Mine are a likely source of the sulfate reduced in the Camanche Reservoir sediments to produce hydrogen sulfide. A hypolimnetic buildup of hydrogen sulfide is subsequently released to the river and the MRFH. Hydrogen sulfide is toxic to fish and aquatic macroinvertebrates at low concentrations (Cole 1979; EPA 1976, 1986).

Early destratification of Camanche Reservoir was the most likely indirect cause of the serious fish kills in 1987, 1988, and 1989 (Horne 1989; Miyamoto 1989). Successive years of drought conditions and changes in EBMUD's management of Camanche Reservoir resulted in early October surface elevations of Camanche Reservoir dropping below the normal fall elevation of 217 ft: 179 ft in 1987, 126 ft in 1988, and 186 ft in 1989. These unprecedented low reservoir levels and early depletion of the cold water hypolimnion through bottom releases to downstream users created destratification of the reservoir and subsequent mixing of the hypolimnion resulting in low dissolved oxygen, and high levels of turbidity, temperature, heavy metals, and hydrogen sulfide.

A wide range of sensitivities to hydrogen sulfide exists between various species and life stage of fishes. The toxicity of hydrogen sulfide to fish and aquatic macroinvertebrates has been well documented. The degree of hazard exhibited by sulfide to aquatic animal life is dependent on the temperature, pH, and dissolved oxygen (EPA 1986). At lower pH values a greater proportion is in the form of toxic hydrogen sulfide. In the winter when the pH is neutral or below or when dissolved oxygen levels are low but not lethal to fish, the hazard from sulfides is exacerbated. Acute toxicities to generally range from 0.008 to 0.15 mg/l. Chronic toxicities to fish generally range from 0.0007 to 0.01 mg/l.

However, increased duration of exposure of aquatic organisms to hydrogen sulfide results in decreased hydrogen sulfide concentrations causing an effect (EPA 1976, 1986; Smith et al. 1976a; Smith et al. 1976b; Oseid and Smith 1974).

An evaluation by Nelson et al. (1989) was made of the losses of juvenile steelhead that occurred at the Mokelumne River Fish Hatchery and in the river from September 28 to October 20, 1989. Hydrogen sulfide concentrations in the hatchery water ranged from 0.05 to 0.07 mg/l (Appendix D). This is within the lower range of acutely toxic concentrations and exceeds EPA (1986) recommended ambient water quality criteria (2 ug/l H_2S) for maintenance and protection of aquatic resources. Losses were also observed in the in-situ test site in the river adjacent to the hatchery. Losses of wild fish in the river were also observed during this study. The hydrogen sulfide concentrations during the in-situ test were in excess of 0.01 mg/l (Appendix D). Thus, the hydrogen sulfide concentrations in the river also exceeded the EPA recommended level of 2 ug/l.

Conclusions

Dissolved oxygen levels lethal to salmonids frequently occur. Low levels (but not necessarily lethal) also occur frequently that may delay the adult chinook salmon and steelhead spawning migration, increase egg development time and increase mortality, induce premature hatching, increase the incidence of growth anomalies and lower fry survival, and increase the adverse impacts of toxic constituents such as heavy metals and hydrogen sulfide.

High turbidity levels have been documented. Its presence is usually associated with other factors (sediment deposition, low dissolved oxygen, and high concentrations of heavy metals and hydrogen sulfide) which are at toxic or lethal levels to fresh water aquatic life.

Heavy metals and hydrogen sulfide in concentrations toxic to aquatic life have either caused or have been associated with fish kills in the lower Mokelumne River and the MRFH. Resuspension of reservoir sediments during turnover conditions could result in the mobilization of metals at levels that could be toxic to fish in the reservoir and downstream in the MRFH and the river. It seems certain that discharges of toxic materials will continue to stress the aquatic resources of the lower Mokelumne River in copper, zinc, and cadmium deposits along the river bottom both within and below Camanche Reservoir.

The following water quality parameters are to be achieved in all receiving waters below Camanche Dam and water delivered to the MRFH:

1) Dissolved oxygen should not be less than 7.0 mg/l.

2) The pH shall not exceed the range 6.5-8.5.

3) There should be no heavy metal or other constituent which cause chronic or acute toxicity to any life stage of aquatic life. Heavy metal and other constituents should not exceed those recommended by the EPA (1986) for maintenance of fresh water aquatic life. Ambient water concentrations for copper, cadmium, and zinc shall not exceed those objectives developed by the DFG for the Upper Sacramento River. The DFG used an application factor of 0.1 x K_{LC50} (where: K_{LC50} = 96-hr LC50 developed from DFG studies) together with the hardness relationship of the EPA to develop the following:

Hardness (mg/l)	Copper (ug/l)	Cadmium (ug/l)	Zinc (ug/l)
20	3	0.10	9
30	5	0.16	13
40	7	0.22	16
50	8	0.22	19
60	10	0.36	22
70	11	0.43	25
80	13	0.50	28
90	14	0.57	31
100	16	0.65	34

4) The Mokelumne River shall be free of changes in turbidity that cause nuisance of adversely affect beneficial uses. Increases in turbidity attributable to controllable water quality factors shall not exceed those designated by the RWQCB Basin Plan (1975).

5) Spawning habitat for salmonids shall be maintained through conditions that prevent sedimentation and gravel cementation.

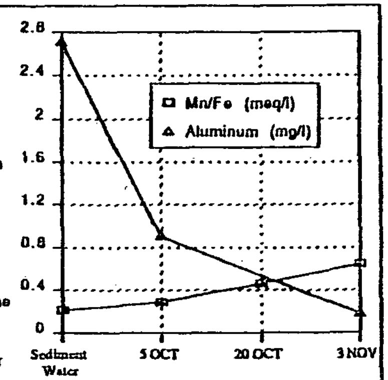
TABLE D-4: Preliminary report on the analytical results of water and sediment samples taken during 1989 in the MRFH, lower Mokelumne River, California. Source: RWQCB (1989).

	DISCHARGES FROM CAMANCHE RESERVOIR INTO MOKELUMNE FISH HATCHERY			SEDIMENTS DISCHARGED INTO HATCHERY DURING FISH KILL EPISODE (SEPT-OCT 89') Total Concentrations	Interstitial Water Extracted From Sediments	PENN MINE LOWER SURFACE IMPOUNDMENT FLUIDS (EBMUD Mine Run Dam)
Date Sampled	5 Oct. 89'	20 Oct. 89'	3 Nov. 89'	3 Nov. 89'	3 Nov. 89' (3)	13 June 89'
Sample ID	CM HTCH 5 OCT	CM HTCH 20 OCT	CM HTCH MN ATR	CM HTCH SED (2)	CM HTCH SED H2O	PM-MRD
	mg/l	mg/l	mg/l	mg/kg	mg/l	mg/l
Aluminum	0.9	sample received acidified (see note 1 below)	0.18	39000	2.7	327
Antimony				<260		0.06
Arsenic						
Barium	0.04		0.03	390	1.7	
Beryllium				<5.6		0.034
Cadmium				6.3	0.01	1
Calcium	5	5.2	4.5	3600	45	383
Chromium				43		0.07
Cobalt				24		0.71
Copper				97	0.05	85
Iron (Total)	1.4	1	0.4	48000	128.5	98
Lead				<5	0.008	
Lithium						0.39
Magnesium	1.4	1.5	1.25	4800	11.7	502
Manganese	0.6	0.68	0.38	3400	39.5	31
Molybdenum				<5.2		0.03
Nickel				<26		0.57
Potassium	1	0.47	0.66	4200	20.6	
Selenium						
Silver				<5.2		
Sodium	2.8	2.4	2.5	<2600	5.8	55
Titanium				130	0.15	0.022
Vanadium				77		0.05
Zinc	0.025		0.03	670	0.10	326
Bicarbonate	25.59	0.00	23.17		792.00	0.00
Carbonate	0.01	0.00	0.01		0.49	0.00
Chloride	1	22	1.5		5	
Nitrate	3.1					
Sulfate	2.3	[illegible]	2.1			6780
Silica	4.5	Sample suspect acidified w/sulfuric acid (although reported nitric acid preservation).	4.1			
Boron	0.04		<.02		0.06	1.7
TDS	49		41		1049	9230
EC	68		51		1375	5960
pH	7		6.7		7.1	3
Ionic Strength	0.00102		0.00072		0.022	0.28
Moisture %				93		
Total Sulfur				* 280 mg/l per 22 Dec. phone message		

Percent Soluble Fraction of Sediment Sample (Soluble/Total) x 100	
Aluminum	0.007
Barium	0.436
Cadmium	0.159
Calcium	1.250
Copper	0.052
Iron (Total)	0.268
Magnesium	0.244
Manganese	1.162
Potassium	0.490
Titanium	0.115
Zinc	0.027

	Sediment Water	HATCHERY 5 OCT.	HATCHERY 20 OCT	HATCHERY 3 NOV	Penn Mine MRD
Ca/Mg (meq/l)	2.332	2.166	2.102	2.183	0.463
Cu/Zn (meq/l)	0.286				0.268
Mn/Fe (meq/l)	0.208	0.290	0.461	0.644	0.214

Iron and manganese are redox sensitive elements, Fe more so than Mn. Assuming that initial conditions (when the lake bottom was first disturbed) are represented by interstitial sediment water values, the increasing Mn/Fe values over time represent an aqueous geochemical system recovering from a reducing environment. The aluminum value for 20 Oct. is interpolated. Al has a minimum solubility of about 7 μg/l in near neutral waters.



In acidic waters it is not uncommon to find Al in concentrations of hundreds of mg/l (as in the Penn Mine leachates). The decrease observed over time probably indicates both precipitation reactions and settling of suspended colloidal matter.

The above table reflects the mean average of analyzed values when analyses were conducted by more than one lab.

1) sample 'CM HTCH 20 OCT' was originally collected by DFG staff on that date and later obtained by RWQCB staff from DFG lab for further testing (the results listed in this table). The sample bottle was listed as h[illegible] been preserved with nitric acid, however these initial results suggest that a sulfuric acid was present. Th[illegible]re the reported sulfate results may not represent actual water concentrations.

2) Valu[illegible]mple 'CM HTCH SED' represent the dry weight of the total concentrations of the sediment.

3) The [illegible]al water from the sediments was extracted by centifuge on 7 and 8 November.

SRD, 22 Dec. 1989

METALS LAB QC REPORT, February 1991

All values in mg/l

TABLE 1 Page 1 of 2

Summary of analyses

	CD-7										CD			
Sample #	S1-A		S1-B				S2-A		S2-B		24-11-90		90-20	
Lab	S. F. Lab	Anlab	S. F. Lab	Anlab	Twinning	APPL	S. F. Lab	Anlab	S. F. Lab	Anlab	S. F. Lab	Anlab	S. F. Lab	Anlab
Aluminum	0.105	0.09	0.155	0.08	0.08	0.1	0.200	0.100	0.52	0.1	0.23	<.05	0.08	<.05
Cadmium	0.023	0.002	0.0138	0.012	0.054	0.04	0.092	0.220	0.0124	0.074	<.001	<.0001	0.048	0.074
Copper	0.014	0.01	0.04	0.022	0.029	0.02	0.027	0.020	0.033	0.03	0.0014	0.002	0.0124	0.008
Zinc	0.048	0.03	0.103	0.087	0.12	0.08	0.082	0.130	0.114	0.13	0.024	0.009	0.088	0.037
Lead	<0.001		<0.001				<0.001		<0.001		<0.001		0.0016	<0.001
Calcium											4.8	4.2	6.4	4.3
Iron											0.19	0.2	0.588	0.5
Magnesium											3.9	1.3	4.9	1.3
Manganese											0.077	0.08	0.622	0.6
Potassium											0.75	1.1	0.82	1.2
Sodium											3.1	3	2.66	2.1
Silica											2.1		3.7	
Sulfate											5.8			
Chloride											1.5			
Alkalinity(T)											21			
pH											7.2			
EC											60			
TDS											54			
Hardness											28	16	36	16
Date Collected	21 Nov. 90		21 Nov. 90				21 Nov. 90		21 Nov. 90		24 Nov. 90		21 Nov. 90	

SPIKE INFORMATION

	S1-A	S1-B	S2-A	S2-B	24-11-90	90-20
Aluminum	0.100	0.100	0.100	0.100	none	none
Cadmium	0.010	0.020	0.010	0.020	none	none
Copper	0.010	0.030	0.010	0.030	none	none
Zinc	0.030	0.090	0.030	0.090	none	none
Matrix Water	D.I. H2O	D.I. H2O	'90-20'	'90-20'	'24-11-90'	'90-20'

all values in milligrams per liter (mg/l)

ANALYTICAL METHODS reported used by individual labs

	S. F. Lab	Anlab	Twinning	APPL
Aluminum	202.2	QA/QC data not provided; Analytic method information was not provided	202.2	202.2
Cadmium	213.2		213.2	213.2
Copper	220.2		220.2	220.2
Lead	239.2			
Zinc	289.1		289.2	289.2
Calcium	215.2			
Iron	236.1			
Magnesium	242.1			
Manganese	243.1			
Potassium	258.1			
Sodium	273.1			

	S. F. Lab
Silica	370.1
Sulfate	375.2
Chloride	325.3
Alk.(Tot)	310.1
pH	150.1
EC	120.1
TDS	160.1
Hardness	130.1

Toxicity information

EPA 4 day average
Cd, Cu, Pb, and Zn are hardness based.
Aluminum is pH based.

Hardness:	(28)	(16)	(36)	(16)
Al Toxicity (mg/l)	0.0870	0.0870	0.0870	0.0870
Cu Toxicity (mg/l)	0.0040	0.0025	0.0050	0.0025
Cd Toxicity (mg/l)	0.0004	0.0003	0.0005	0.0003
Pb Toxicity (mg/l)	0.0006	0.0003	0.0009	0.0003
Zn Toxicity (mg/l)	0.0361	0.0225	0.0447	0.0225

S.C.B., 11 April 1991

DRAFT Post Restoration Final Effectiveness Report

Penn Mine Environmental Restoration Project

September 2000

Prepared for
East Bay Municipal Utility District and Regional Water Quality Control Board - Central Valley Region

Project No. 144069.09.00
September 2000

CH2MHILL

Oakland, California

Copper. Copper was not detected above the reporting limit (2.08 to 3.54 µg/L) in the upstream sample during the reporting year. In the downstream sample, copper was only detected once: in the sample collected in February at a concentration of 3.54 µg/L.

Zinc. In the upstream sample, zinc concentration ranged from < 2.08 to 9.29 µg/L, with an average of 3.77 µg/L. In the downstream sample, zinc concentrations ranged from 2.12 to 20.7 µg/L, with an average of 7.48 µg/L. In seven of the twelve sampling events, zinc concentrations were higher in the downstream sample than in the upstream sample. The sampling events in which the zinc concentrations were higher in the upstream sample than in the downstream sample, or very close in the two samples, were during months with light or no precipitation.

pH. The pH values of upstream and downstream samples were very similar throughout the year. In the upstream samples, pH ranged from 7.0 to 7.6, with an average of 7.2. In the downstream sample, pH ranged from 7.1 to 7.8, with an average of 7.3.

Sulfate. Sulfate concentrations in upstream and downstream samples were similar throughout most of the year. In the upstream sample, sulfate concentrations ranged from 1.2 to 2.7 mg/L, averaging 1.8 mg/L. Sulfate concentrations in the downstream sample ranged from 1.4 to 3.6 mg/L, with an average of 2.1 mg/L. The biggest differences between upstream and downstream sample concentrations (with downstream being higher) were seen in January and February, the months of highest precipitation.

Calcium. In the upstream sample, calcium concentrations ranged from 3,170 to 4, 910 µg/L, with an average of 3,971 µg/L. In the downstream sample, calcium concentrations ranged from 3,310 to 4,900 µg/L, with an average of 3,937 µg/L. The greatest difference between upstream and downstream calcium concentrations was seen in January and March, when the upstream sample calcium concentration was higher than the downstream concentration by 440 and 240 µg/L , respectively.

Magnesium. In the upstream sample, magnesium concentrations ranged from 920 to 2,040 µg/L, with an average of 1,370 µg/L. In the downstream sample, magnesium concentrations ranged from 1,030 to 1,720 µg/L, with an average of 1,365 µg/L.

5.3 Surface Water

The first post-restoration surface water samples were collected in November 8, 1999 following the first significant rainfall event, and were collected monthly thereafter through August 2000. Surface water samples were collected from the established sampling locations described in Table 1 (when there was flow) and from seeps observed in Hinckley Run. The samples were analyzed for the parameters listed in Table 2a by EBMUD's laboratory. Surface water sample results are discussed below, focusing on pH, copper, zinc, magnesium, calcium, and sulfate, the primary indicators of mine site impacts. Table 11 summarizes the annual surface water results for these parameters.

Calcium concentrations ranged from 24,900 to 324,000 µg/L and magnesium ranged from 17,900 to 156,000 µg/L.

The concentrations of copper, zinc, sulfate, calcium, and magnesium were significantly higher at PRSW-5 than in the upstream samples from PRSW-3 and –4.

5.3.5 Outflow to Camanche Reservoir (PRSW-6)

PRSW-6 is located just below the confluence of Mine Run and Hinckley Run Creeks. The flow from PRSW-6 discharges to Camanche Reservoir. Samples were collected from PRSW-6 from November 1999 through August 2000.

The copper concentrations ranged from 15.6 to 4,790 µg/L. The lowest concentration was detected in August. The highest concentrations were detected in March and May when the seep in Hinckley run was flowing and the pH was below about 6.5. The copper concentration remained below about 1,000 µg/L over an approximately 590-fold range of flow rates, as illustrated in Figure 12. Excluding two copper data points during a time when the pH at PRSW-6 was below about 6.5, there is an approximately linear relationship between hydraulic flow rate and copper mass load from the site (Figure 13). The combination of consistent copper concentrations over a large flow range, and copper mass load proportional to flow is consistent with the immobilization of copper as a carbonate or basic carbonate compound forming on the limestone surfaces. The dependence of copper concentration on pH is illustrated in Figure 14, which shows the site-wide relationship between pH and the dissolved copper concentration.

Zinc concentrations ranged from 1,880 to 116,000 µg/L. There is an inverse relationship between flow and zinc concentration in PRSW-6, as shown in Figure 15. The zinc mass load rose rapidly at low flow rates, and tapered off approximately asymptotically at high flows, as shown in Figure 16. This behavior is consistent with zinc (possibly sphalerite) oxidizing at a relatively constant rate throughout the site, and showing weak dependence on the hydraulic rate of discharge from the site.

Sulfate ranged from 210 to 3,400 mg/L. The highest concentration was detected in December when the lowest flow was recorded. The lowest concentration corresponds to the highest flow in February. The pH range was 4 to 7.4. The low of 4 corresponds to the low pH in PRSW-2 (downstream Hinckley Run) when the seep, PRSS-3, was flowing. At PRSW-6 the sulfate concentration was inversely proportional to the flow rate and, similar to zinc, the mass load leveled off at higher flows (Figures 17 and 18).

Calcium ranged from 41,000 to 704,000 µg/L. An inverse relationship between calcium concentration and flow is seen in the data. Magnesium ranged from 20,600 to 264,000 µg/L. Although less consistent than for calcium, there is an inverse relationship between flow and magnesium concentration in PRSW-6.

5.3.6 Runoff From Former Shoreline Pile Area (PRSW-7)

PRSW-7 is located on the slope below the former shoreline pile. Samples were collected from PRSW-7 in January, February, and April 2000.

7.0 Estimated Copper and Zinc Loadings to Camanche Reservoir

Copper and zinc loadings to Camanche Reservoir were estimated from surface water and groundwater data collected during the post-restoration period to date. Cumulative estimated site surface water runoff and copper and zinc concentrations for the period from the first significant rainfall event following completion of site restoration (November 1999) to the end of August 2000 were used to estimate the mass loads of copper and zinc from surface water to Camanche Reservoir. The copper and zinc loads from groundwater discharging to Camanche Reservoir were estimated using the volume calculated for ARD-impacted subsurface discharge to Camanche Reservoir (Q_5 in Table 13), and the average copper and zinc concentrations from groundwater monitoring wells located downgradient of the site discharge, PRGW-9, -10, -11, and –12.

The copper and zinc loads from surface water discharge were estimated using data from the post-restoration monitoring period to date: November 8, 1999 to August 31, 2000 (298 days). The loads from groundwater discharge were estimated using data representing the period from October 27, 1999, the first rainfall event of the season, to August 31, 2000 (310 days).

The estimated copper mass load from site surface water for this 298-day period, based on data from monitoring station PRSW-6, was 200.4 pounds (lbs). The zinc mass load was estimated at 1,762 lbs. Copper and zinc mass loads entering the site during the same period, from data at monitoring stations PRSW-1, -3, and -4, were 10.2 and 23.78 lbs., respectively. The net mass loads from surface water attributed to the site (after deducting the incoming upland contribution) were, therefore, 190.2 of lbs. copper and 1,738 lbs. of zinc.

The estimated copper mass load from the discharge of ARD-impacted groundwater to Camanche Reservoir is 0.06 lb., and the zinc load 1.57 lbs.

The estimated combined net surface water and groundwater loads for the monitoring period are 190.3 lbs. of copper and 1,740 lbs. of zinc.

To compare these loads that were based on 298- to 310-day periods to annual loads estimated for the pre-restoration condition, they were converted to annual loads estimates. The surface water mass load contribution was adjusted for an annual period by assuming flows and concentrations observed at the site in the dry period (June – August) for an additional 67 days. The resulting loads were added to that estimated for the 298-day period. The groundwater mass load contribution was adjusted for an annual period by assuming the same average concentrations and the same discharge rate used for the 310-day period estimate for the additional 55 day period. The resulting loads were added to the groundwater loads estimated for the 310-day period. Resulting annual load estimates were: 190.4 lbs. of copper and 1,907 lbs. of zinc. These estimated annual copper and zinc loadings are much lower than the estimated pre-restoration annual averages for copper of 19,372 to 23,122 lbs. per year and for zinc of 35,875 to 43,035 lbs. per year (CH2M HILL, February 1999). Consequently, in the first year following

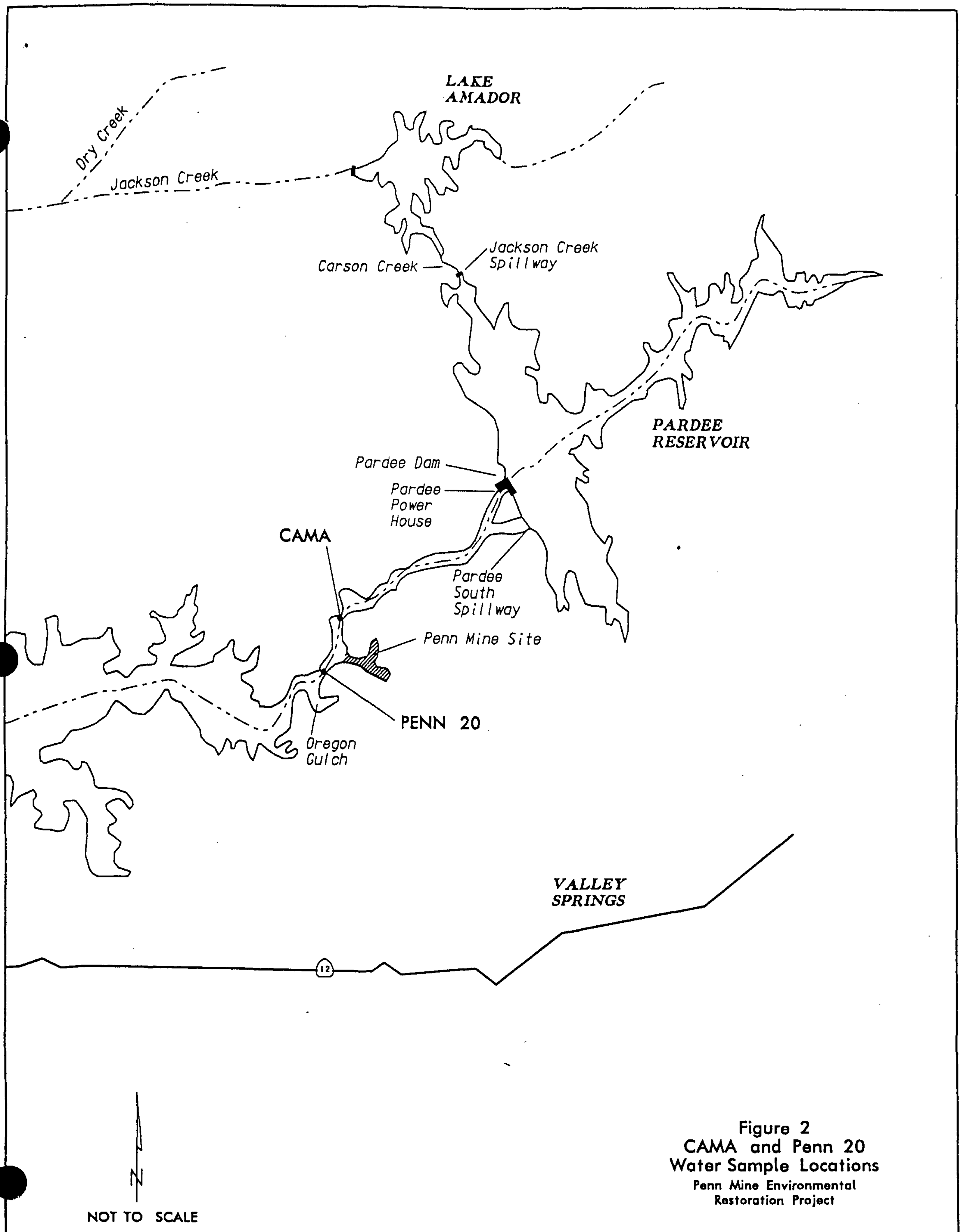


Figure 2
CAMA and Penn 20
Water Sample Locations
Penn Mine Environmental
Restoration Project

CH2MHILL

Full copy kept in Gene Davis's "2002 303(d) List - Solicitation" File - R33-d

Post-Restoration Final Effectiveness Monitoring Report

Penn Mine Environmental Restoration Project

Prepared for

East Bay Municipal Utility District and Regional Water Quality Control Board - Central Valley Region

Project No. 144069.09.09

December 2000

CH2MHILL

Oakland, California

Final Report

Penn Mine Environmental Restoration Project

Prepared for

East Bay Municipal Utility District and Regional Water Quality Control Board - Central Valley Region

Project No. [illegible]

December 2000

CH2MHILL

Oakland, California

Executive Summary

This document is the Closure Report for the Penn Mine Environmental Restoration Project. It was prepared in compliance with the United States Environmental Protection Agency (EPA) Findings of Violation and Order for Compliance, Docket No. IX 309-FY97-20 (309 Order) and the State Water Resources Control Board Resolution No. 97- "Adoption of Findings and the Mitigation Monitoring Plan Required by the California Environmental Quality Act (CEQA) for Approval of the Remediation Plan under Water Code Section 13398 et. seq., for the Penn Mine Site Long-Term Solution Project" (SB1108 Remediation Plan).

The 309 Order and SB1108 Remediation Plan required the East Bay Municipal Utility District (EBMUD) to implement Alternative 5A of the Draft Environmental Impact Report for the Penn Mine Site Long-Term Solution Project (EIR) (Golder, 1996). The goal of Alternative 5A was to restore the Penn Mine site to "pre-mining" conditions through the removal of mine waste material, disposal of the waste in an onsite landfill, and restoration of the natural drainage channels on the site.

Site Description and Background

The Penn Mine site is located in the Sierra Foothills near the town of Campo Seco in Calaveras County, California. The site occupies approximately 22 acres near the southeastern shore of the Mokelumne River and Camanche Reservoir. The site is located in the copper-zinc belt of the western foothills of the Sierra Nevada range. The site is one of several underground mines located along the foothills mineralized belt.

Penn Mine opened in 1861 and operated intermittently until 1953. Through underground mining, ore was extracted from steeply dipping, tubular copper and zinc sulfide ore bodies. In 1887, the mine was acquired by the New Penn Mine Company who operated the mine continuously until 1919. The Mine was operated intermittently after that time until 1943. It operated again just after the close of World War II at the direction of the U.S. government. It ceased operating in 1953. New Penn Mines, Inc. remains the owner of the property; however, the corporation currently has no known assets and its principals are either deceased or insolvent.

The primary environmental concern associated with the Penn Mine site is the generation of ARD that is generated when sulfide minerals, such as pyrite, present in the waste material and in the ore body are oxidized. The products of oxidation have adversely affected water quality in Camanche Reservoir due to the discharge of low pH water containing copper and zinc at concentrations greater than estimated pre-mining concentrations.

In the winter of 1978/1979, the Regional Water Quality Control Board–Central Valley Region (RWQCB) and EBMUD implemented a series of site improvements to mitigate acid rock drainage (ARD) discharge to Camanche Reservoir, surface water diversions to reduce surface water flow through the site, surface water impoundments in Mine Run and

Hinckley Run Creeks, and Mine Run Dam at the confluence of the two creeks to reduce the discharge of ARD-contaminated water to Camanche Reservoir.

In 1993, EPA issued a Finding of Violation and Order for Compliance to EBMUD pursuant to Sections 308 and 309 of the CWA for the discharge of ARD from the site. The order required that EBMUD undertake emergency response measures to reduce inflow into Mine Run Dam Reservoir (MRDR) and mitigate impacts of further releases from MRDR to Camanche Reservoir. Subsequently modifications to the Order required treatment of surface water before discharging to Camanche Reservoir, evaluation of site conditions and pollution control alternatives (i.e., conduct EIR), and implementation of the Penn Mine Long-Term Solution Project (EIR Alternative 5A).

The goal of the Penn Mine Environmental Restoration Project, as described in the EIR, was to provide long-term water quality protection at the Penn Mine site through the excavation and removal of all waste materials and their disposal in a landfill constructed onsite. All impoundments, including Mine Run Dam, are removed to allow runoff from Mine Run Creek and Hinckley Run Creek to discharge directly to Camanche Reservoir, and the site is restored in a manner to enhance vegetation and wildlife habitat. The Mine Run and Hinckley Run diversions are removed and natural surface water flow through the stream channels is restored.

Site Restoration

As required by the EPA 309 Order, a Project Advisory Committee (PAC) was established for the purpose of reviewing progress implementing the project and achieving water quality objectives. PAC members included representatives of EBMUD, the RWQCB, the State Water Resources Control Board (SWRCB), the EPA, the U. S. Geological Survey, and the Committee to Save the Mokelumne River. The PAC met quarterly throughout the duration of the project.

Site restoration was carried out in two stages, design and construction, followed by the post-restoration stage. Stage 1 included collecting additional site information, developing a Water Quality Management Plan, preparing the preliminary landfill, obtaining construction permits, and building access roads and lay-down areas. Stage 2 included constructing the onsite landfill, removing waste materials, evaluating additional mitigation measures, sealing Mine Shaft/Adit 4, grading and revegetating the site, restoring the stream channels, and removing surface water diversions. The post-restoration stage involves ongoing water quality monitoring and inspection and maintenance of the restoration elements.

Landfill

The landfill was designed and constructed in accordance with CCR Title 27. As a design/build project, the design was prepared and submitted in phases for review by EBMUD, the RWQCB, and the PAC. The final landfill CQA report was submitted for approval to the SWRCB.

Waste Rock Removal

The project called for approximately 300,000 to 332,000 cubic yards of waste material to be excavated from Mine Run Creek, Hinckley Run Creek, Mine Run Dam, and the Shoreline Waste Pile. The waste materials included all mine waste, mill tailings, sludges, mixed fills and soils, and alluvium beneath the impoundments. During Stage 1 of the project, the limits of waste excavation were further refined from the conceptual limits laid out in the EIR and a Waste Excavation Plan was prepared. The Waste Excavation Plan was the guide used during excavation of the mine waste.

Water Quality Monitoring

Water quality monitoring was conducted throughout the restoration project as required by the 309 Order and as described in the EIR. Data collected was and continues to be used to evaluate the effectiveness of the restoration effort. The key technical element of the water quality program was development of a site water budget. The water budget was used to estimate the total loads of copper and zinc from the various sources on the site, i.e., groundwater, surface water, and seeps. This information was used to identify the primary sources of metals discharging from the site so that mitigation efforts could be focused on these areas.

Evaluation of Additional Mitigation Measures

Three additional ARD mitigation measures were evaluated as potential BMPs during Stage 2 of the project: groundwater extraction and treatment, hydrocleaning exposed residual soils, and the use of geochemical amendments. Groundwater extraction and treatment was not determined to be a BMP because groundwater discharge contributes less than 1 percent of the total site load of copper and zinc to Camanche Reservoir. Hydrocleaning using hydroflushing or spray irrigation techniques were determined to not be BMPs because the metal load to Camanche Reservoir is associated with residual acidity in pore water rather than residual mine waste, and pore water, being held by surface tension, would require more than 1,900 years to displace the residual acidity held therein. The evaluation of the addition of geochemical amendments resulted in the recommendation to use a combination of dicalcium silicate, phosphate rock, and magnesium hydroxide at the site. These amendments have the effect of neutralizing residual acidity in the bedrock, immobilizing copper and mitigating the oxidation of pyrite.

Shaft 4 Area Seal

The EIR called for plugging Shaft 4 to reduce the discharge of acidic water from the mine workings to the ground surface in Hinckley Run. The condition of the Shaft 4 area was assessed after the overlying waste rock was removed. Based on the findings, re-plugging the opening to Adit 4 and sealing the bottom of the Hinckley Run channel near the adit were recommended to control discharge of ARD and groundwater into Hinckley Run. The adit seal and channel seal were constructed during Stage 2. In addition to implementing groundwater control in the Shaft and Adit 4 area, areas of reactive rock in Hinckley Run and Mine Run were sealed.

Rough and Final Grading and Restoration

After waste rock was removed, the site was graded, soil amendments were added, topsoil was placed, streambeds and wetlands were restored, slopes were hydroseeded, and diversion channels were removed. The site restoration design was based on criteria that were developed before waste excavation and refined based on data collected after waste excavation was completed and baseline conditions assessed.

Restoration occurred in two stages: rough grading, including the placement of soil amendments; and final grading and streambed restoration.

During rough grading, the site was contoured to promote surface water runoff into Mine Run and Hinckley Run channels, and soil amendments were applied to areas where reactive bedrock is exposed to neutralize runoff and minimize metal loading to the reservoir.

The stream channels at the site were designed and constructed to convey both low-flows and flows from storm-water runoff associated with a 100-year recurrence event, while maintaining a natural stream environment.

Following the stream channel restoration, disturbed areas were hydroseeded to provide erosion control during the first rainy season after project construction. Herbaceous plant cover established by hydroseeding also provides limited wildlife habitat. A combination of non-native and native species was used.

The stockpond (wetland) site is located on Hinckley Run, adjacent to the southeast side of the landfill, at the northern end of the Penn Mine site. To mitigate the impact of landfill construction and access road widening, the seasonal wetland habitat at the stockpond site was restored.

Post-Restoration Operation and Maintenance

During the post-restoration phase of the project, the Penn Mine site will be operated and maintained in accordance with the Operation and Maintenance Plan. O&M activities will be performed on a routine and emergency basis to monitor and maintain the restoration activities implemented. O&M activities will include routine and emergency inspections, surface water and groundwater quality monitoring, and routine and emergency maintenance.

Compliance

By implementing Alternative 5A of the EIR for the Penn Mine Long-Term Solution Project to the satisfaction of the SWRCB and the EPA, EBMUD and the RWQCB have satisfied the requirements of the EPA 309 order and the SB1108 Remediation Plan. Implementation continues into the post-restoration period as the site restoration elements are inspected and maintained and water quality and the effectiveness of the restoration are monitored.

1.2 Site Location and Geologic Setting

The site is located in the Sierra Foothills near the town of Campo Seco in Calaveras County, California, as shown in Figure 1-1. It is located in Section 4, Township 4 North, Range 10 East, Mount Diablo Base and Meridian. The site occupies approximately 22 acres near the southeastern shore of the Mokelumne River and Camanche Reservoir.

The Penn Mine site is located in the copper-zinc belt of the western foothills of the Sierra Nevada range. The site is one of several underground mines located along the foothills mineralized belt. The topography of the Penn Mine area is generally steep with rock outcrops. The principal topographic/geomorphic features in the area of the Penn Mine are the narrow north-northwest trending ridges and valleys and the Mokelumne River/Camanche Reservoir. The Mokelumne River generally transects the north-northwest trending ridges and valleys at right angles, creating steep-walled canyons.

1.3 Mine Site Description

1.3.1 Site Geology and Mine Workings

The bedrock geology at the Penn Mine site consists almost entirely of Gopher Ridge Volcanics, with associated thin sills of igneous intrusives. The bedrock is unconformably overlain by Tertiary conglomerates and surficial mine waste materials. The bedrock has undergone a regional greenschist-facies metamorphism and is weakly to intensely foliated. The foliation trends about N30°W and dips steeply to the northeast, with occasional northwest dips.

The Penn Mine deposit is a massive sulfide ore body of sphalerite-chalcopyrite in sericitized and silicified quartz porphyry and meta-felsite. The ore bodies occur as steeply pitching lenses along bedding or foliation planes. Two primary copper-zinc, massive sulfide, ore-bodies were mined at the site. The first was mined to approximately 700 feet below the ground surface (bgs). The larger ore-body was mined to 3,000 feet bgs with over 10 miles of drifts. The underground mine workings extend under Camanche Reservoir to the north and Oregon Gulch to the south.

The ore bodies were roughly tubular in shape and dipped steeply toward the northeast. The ore bodies occur primarily within the zones of sericite and quartz sericite schist, which are exclusively within the greenschist-grade metavolcanic rocks. The ore was composed of pyrite, chalcopyrite, and sphalerite, with secondary bornite, chalcocite, coellite, tetrahedrite, galena, barite, and calcite.

The surficial geology of the Penn Mine site was mapped by Davy in 1992, before the removal of the waste rock materials. At that time, much of the surficial material within Mine Run Creek and Hinckley Run Creek contained or was affected by sulfide-bearing mine waste. Previous earth moving operations had mixed reactive mine waste material with native soil in some areas, particularly near the former impoundments. The surficial geology was mapped again during site restoration efforts after waste excavation had been completed (see Section 4.5.2).

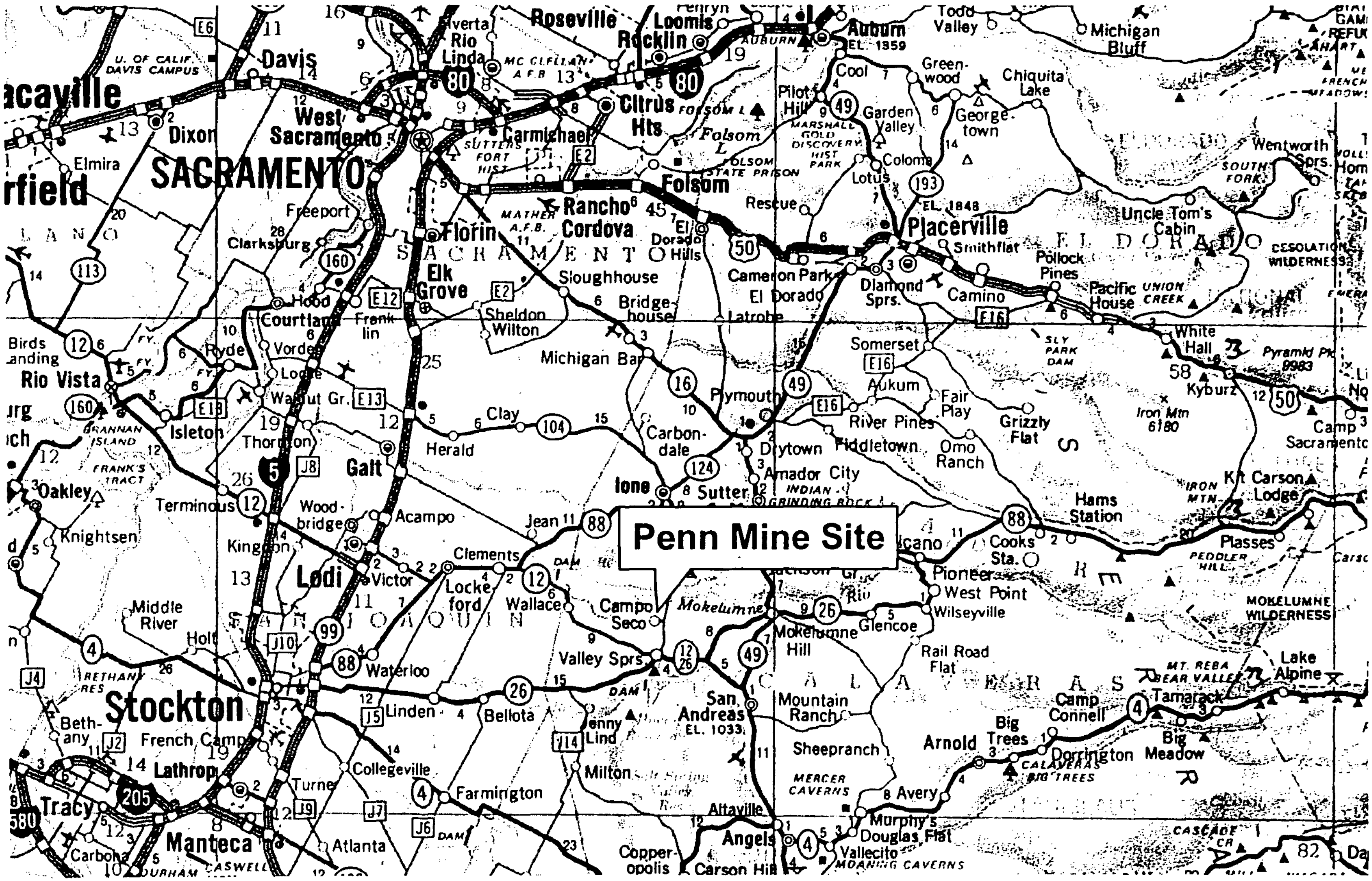


Figure 1-1
Site Location
Penn Mine Environmental Restoration Project

1.3.2 Description of Environmental Concern

The primary environmental concern associated with the Penn Mine site is the generation of acid rock drainage (ARD). ARD is generated when sulfide minerals, such as pyrite, present in the waste material and in the ore body are oxidized. Oxidation occurs when water from streams or precipitation and oxygen react with the sulfide in the rock. The oxidation process releases acid (H_2SO_4-), dissolved metals (such as copper, zinc and iron), sulfate, and heat.

The initial oxidation of pyrite sets into motion a self-generating chain of events. The products of oxidation (heat, acid, and dissolved iron) accelerate the continued oxidation of pyrite. The dissolved iron also promotes the oxidation of other sulfide minerals and results in the release of heavy metals. Galvanic reactions resulting from the presence of dissimilar metals species in electrolyte (sulfuric acid) promote the dissolution of metal sulfide minerals. Finally, the acid released by the oxidation of pyrite keeps iron and other dissolved metals in solution. The result is the continued generation of site runoff with low pH and high concentrations of dissolved metals.

The products of oxidation have historically adversely affected water quality in Camanche Reservoir due to the discharge of low pH water containing copper and zinc at concentrations greater than estimated pre-mining concentrations.

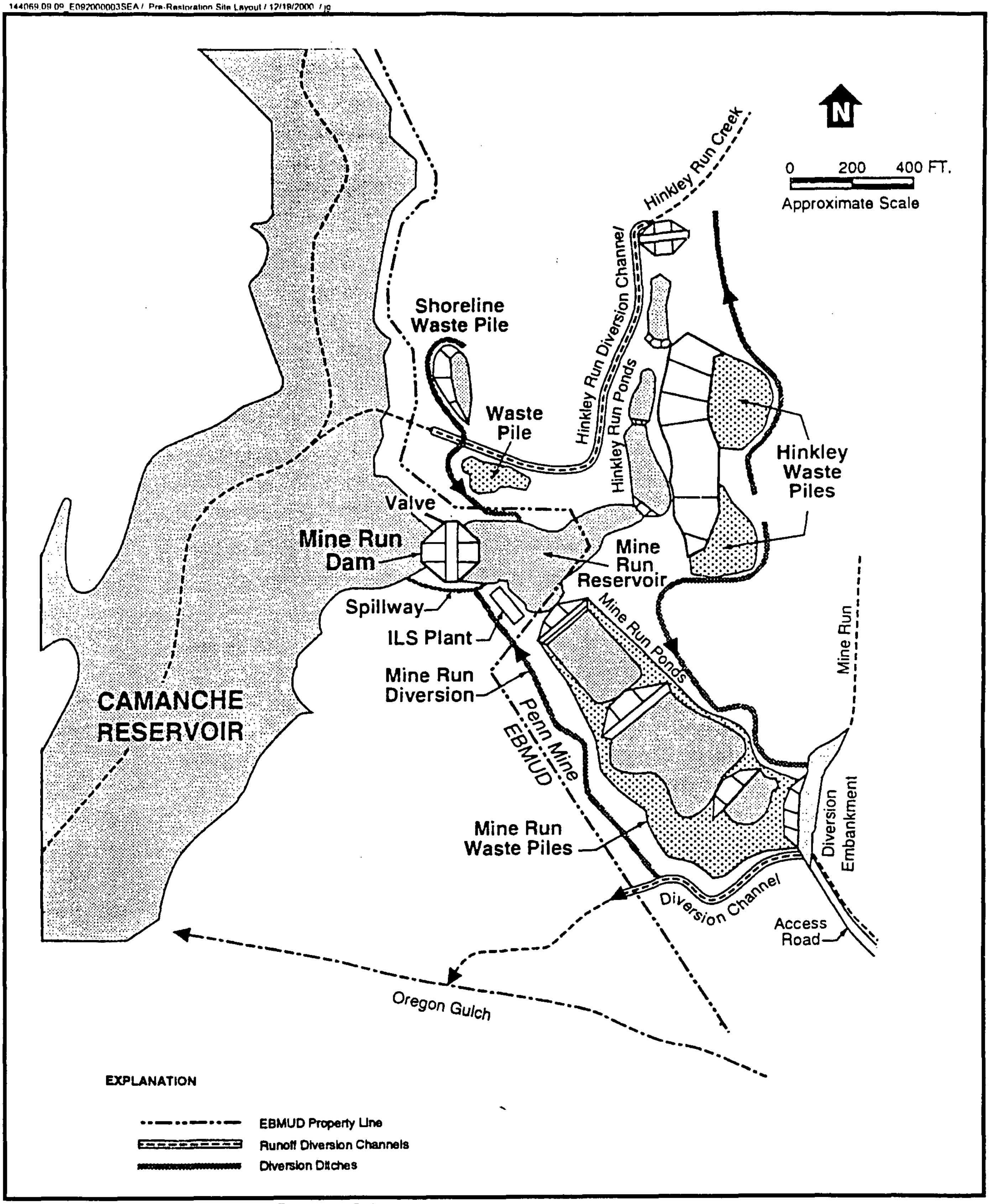
1.3.3 Site Condition Prior to Environmental Restoration

The features of the Penn Mine site prior to the restoration project are described in detail in the EIR (Golder, 1996). A photograph of the Penn Mine site prior to restoration is show in Figure 1-2. A schematic detailing specific pre-restoration site features is included in Figure 1-3. These features are briefly described below.

Waste material derived from mining and processing were placed in a steep angle of repose along two major drainages at the site, Mine Run and Hinckley Run. These drainages are tributaries to the Mokelumne River and Camanche Reservoir. Mine waste covered about 26 acres within Hinckley and Mine Run and a small area known as the shoreline pile. The mine waste was graded to form a series of seven ponds, three each in Hinckley and Mine Run and one pond at the confluence of Hinckley and Mine Run known as Mine Run Dam Reservoir (MRDR). Water from precipitation onto the site collected in the ponds, which had a combined capacity of about 19 million gallons. The water, having flowed through mine waste, was of low pH and contained dissolved metals. Mine Run Dam was constructed at the downgradient end of MRDR to prevent the ponded water from entering Camanche Reservoir.

Surface water entering the site at the upstream ends of Hinckley and Mine Run was diverted to avoid contact with the mine waste and therefore limit the volume of ARD that was generated. Diverted water from Mine Run was impounded by Mine Run Diversion Dam. The water was then pumped to the next drainage to the south, Oregon Gulch. Diverted water from Hinckley Run flowed into a concrete-lined ditch constructed along Hinckley Run Road. This water discharged to Camanche Reservoir between Mine Run Dam and the Shoreline Pile. Runoff from the Shoreline pile was collected in an earthen drainage ditch and directed back to MRDR.

144069.09.09_E092000003SEA / Pre-Restoration Site Layout / 12/18/2000 / jg



SOURCE: Draft EIR for The Penn Mine Site Long-Term Solution Project, Golder Associates, 1996.

FIGURE 1-3
Pre-Restoration Site Layout
PENN MINE ENVIRONMENTAL RESTORATION PROJECT

2.0 Background

2.1 Project History

Penn Mine opened in 1861 and operated intermittently until 1953. Through underground mining, ore was extracted from steeply dipping, tubular copper and zinc sulfide ore bodies. In 1887, the mine was acquired by the New Penn Mine Company who operated the mine continuously until 1919. The Mine was operated intermittently after that time until 1943. It operated again just after the close of World War II at the direction of the U.S. government. It ceased operating in 1953. New Penn Mines, Inc. remains the owner of the property; however, the corporation currently has no known assets and its principals are either deceased or insolvent.

At various periods, ore removed from the mine workings was direct smelted, concentrated onsite through flotation and smelted, or shipped directly offsite to concentrators or smelters. Waste rock excavated during mining was brought to the surface and disposed of on the ground in steeply inclined piles resting at the angle of repose. The mine dewatering operations and reactive mine waste rock ultimately resulted in the generation of ARD, which discharged directly to the Mokelumne River degrading water quality.

In 1963, EBMUD constructed Camanche Dam and created Camanche Reservoir. ARD from the Penn Mine site continued to affect water quality in the reservoir. In the winter of 1978-1979, the RWQCB, the California Department of Fish and Game, and EBMUD agreed to a series of site improvements to mitigate ARD discharge to Camanche Reservoir. Site improvements implemented included construction of:

- Surface water diversions to divert water normally running onto the site from contacting mine waste
- Surface water impoundments in Hinckley Run Creek and Mine Run Creek to store accumulated ARD and increase evaporation of water from the site
- Mine Run Dam at the confluence of the two creeks to keep ARD from discharging to Camanche Reservoir
- A pump and pipe system to control water levels in the ponds and facilitate evaporation by recirculating ARD from MRDR to the upper impoundments in Mine Run Creek

Mine Run Dam and most of MRDR were located on property acquired by EBMUD in the early 1960s as a result of the construction of Camanche Reservoir. The ponds retained the ARD and kept it from discharging to Camanche Reservoir; however, during periods of heavy rainfall MRDR would rise and overflow.

In the mid 1980s, investigations by RWQCB staff indicated that the impoundments constructed at the Penn Mine constituted "toxic Pits," as defined by the Toxic Pits Cleanup Act of 1984 (TPCA). On April 27, 1990, the RWQCB granted EBMUD an exemption waiving waste discharge requirements under the Porter Cologne Water Quality Control Act for

MRDR. The resolution (No. 90-128) also exempted MRDR from the requirements of TPCA. The exemption was appealed by the Committee to Save the Mokelumne River (CSM) and the California Sportfishing Protection Alliance (CSPA) and upheld by the State Water Resources Control Board (SWRCB) in December 1991. In 1992, a lawsuit protesting the exemption was filed by the CSM and SCPA in California Superior Court. A separate action was also filed in Federal Court that sought to require EBMUD and the RWQCB to obtain an NPDES permit for discharges from Mine Run Dam. In 1993, the Federal Court ordered EBMUD and RWQCB to obtain an NPDES permit.

In 1993, the EPA also issued an order pursuant to Section 309 of the Clean Water Act from the U.S. Environmental Protection Agency (EPA). The order required that EBMUD undertake emergency response measures to reduce inflow into MRDR and mitigate impacts of further releases from MRDR. In response, EBMUD began batch treatment of water in MRDR. The batch method involved pumping lime slurry into the reservoir, and mixing by aeration to achieve a pH of 10 in the entire MRDR, prior to discharge to Camanche Reservoir.

A subsequent modification to the 309 order, also issued in 1993, directed EBMUD to build and operate an In-Line System (ILS) to treat mine drainage water in MRDR. The ILS treatment consisted of pumping water from MRDR or an impoundment into a tank where lime and limestone were added to neutralize its acidity. In a second tank, a clarifying polymer was added. Solids were allowed to settle out in the final tanks before discharging to Camanche Reservoir. The treatment system sludge was placed in MRDR.

In 1994, the EPA modified the 309 order and required EBMUD to consider waste rock removal as an option to address the generation of ARD. In February 1995, SWRCB staff issued a draft NPDES permit for public comment. In August 1995, the parties involved in the State proceeding agreed to stay the litigation pending the identification of a long-term solution to the ARD problem at the Penn Mine site.

A fourth modification to the 309 order, issued in October 1995, directed EBMUD to evaluate site conditions and pollution control alternatives. Project alternatives for long-term pollution control were evaluated in a Draft EIR, issued by EBMUD and the RWQCB in May 1996. Subsequently, through a consensus process involving concerned regulatory agencies and stakeholder groups, Alternative 5A was selected for implementation at the site. The members of the consensus group included representatives of EBMUD, the RWQCB, the EPA, the SWRCB, the CSM, and the CSPA.

Five documents comprise the EIR:

- Executive Summary of the Draft Environmental Impact Report for The Penn Mine Site Long-Term Solution Project, May 1996
- Draft Environmental Impact Report for The Penn Mine Site Long-Term Solution Project, Volume I, May 1996
- Draft Environmental Impact Report for The Penn Mine Site Long-Term Solution Project, Volume II Description and Rationale for the Selection of the Preferred Alternative, September 1996

- Final Environmental Impact Report for The Penn Mine Site Long-Term Solution Project, Comment Response Document, February 1997
- Mitigation Monitoring Plan for the Penn Mine Site Long-Term Solution Project, February 1997

EBMUD and the RWQCB certified the EIR in documents dated January 1997 and February 1997, respectively.

In February 1997, the parties to the state court litigation entered into a Settlement Agreement that resolved that litigation and provided for implementation of the Penn Mine Long-Term Solution Project. The 309 order was modified in 1997 to require EBMUD to implement the Penn Mine Long-Term Solution Project.

In May 1997, EBMUD submitted a Remediation Plan to the SWRCB. The plan, prepared in accordance with the requirements of Senate Bill 1108 (SB 1108), outlined the restoration program outlined in the EIR. SB 1108 was enacted in October 1995 by the California Legislature to authorize public agencies to undertake activities, subject to approval by an oversight agency, to remediate the effects of discharges of mine waste on abandoned mine properties. For Penn Mine, the remediation agency is EBMUD and the RWQCB. The oversight agency is the SWRCB. The SWRCB approved the Remediation Plan for the Penn Mine site in June 1997.

Implementation of the Penn Mine Long-Term Solution Project began in 1997.

The chronology of Penn Mine activities is summarized in Table 2-1.

TABLE 2-1
Chronology of Penn Mine Activities

Year	Activity
1861	Discovery of ore body
1865	Smelter construction
1867	Activities cease due to decrease in copper price
1883	Mine reopened
1887	Property acquired by the Penn Mine Company
1899 to 1919	Continuous operation by the Penn Mine Company
1920 to 1942	Intermittent mine operation
1928	Construction of Pardee Dam
1937	First documented fish kill on Mokelumne River
1946 to 1953	Final operational period, fish kills associated with mine dewatering reported
1964	Completion of Camanche Reservoir and Mokelumne River Fish Hatchery
1978	Construction of Mine Run Dam and surface water impoundments
April 1990	RWQCB granted EBMUD exemption waiving WDRs and TPCA requirements

TABLE 2-1
Chronology of Penn Mine Activities

Year	Activity
1992	Committee to save the Mokelumne and California Sportfishing Protection Alliance file lawsuits in state and federal court protesting exemption of Penn Mine from TPCA and WDRs and requiring EBMUD and RWQCB to obtain an NPDES Permit for Mine Run Dam
March 1993	EPA Findings of Violation and 309 Order issued. Initiation of batch treatment in Mine Run Dam Reservoir
December 1993	EPA modified 309 Order requiring In-Line Treatment System (ILS)
June 1994	EPA modified 309 Order requiring EBMUD to consider removal of waste rock in evaluating long-term solutions to ARD
February 1995	Draft NPDES Permit issued for public comment by SWRCB
August 1995	Stay Agreement filed
October 1995	EPA modified 309 Order requiring evaluation of site conditions and pollution control alternatives
1995	EIR process initiated
1996	Draft EIR issued by EBMUD and RWQCB and Alternative 5A selected for implementation at the site
January/February 1997	EIR certified by EBMUD Board of Directors and RWQCB
February 1997	Settlement agreement–resolved litigation and provided for implementation of Alternative 5A
May 1997	EPA modified 309 Order requiring implementation of Penn Mine Long-Term Solution Project
June 1997	Remediation Plan for site under SB1108 approved by SWRCB
July 1997	Phase 1 Environmental Site Restoration
March 1998	Phase 2 Environmental Site Restoration
October 1999	Restoration complete; began post-restoration monitoring

Based on chronology provided in the Draft EIR for the Penn Mine Site Long-Term Solution Project (Golder Associates, 1996)

2.2 Regulatory Framework

2.2.1 The 309 Order

The Federal Water Pollution Control Act, as amended by the Water Quality Act of 1987, also known as the Clean Water Act (CWA), regulates discharges to the waters of the United States. The Act authorizes EPA to take federal enforcement actions under Section 308(a) and 309(a).

On March 15, 1993, the EPA issued a Finding of Violation and Order for Compliance to EBMUD pursuant to Sections 308 and 309 of the CWA for the discharge of ARD from the

3.5.3.2 Metal Loading Estimates

Copper and zinc loads entering and leaving the site were estimated during the design phase of the project for both pre- and post-restoration conditions. The estimated pre-restoration and post-restoration loads are summarized in Table 3-6. The predicted decrease in copper and zinc loading to Camanche Reservoir from the pre-restoration to the post-restoration condition is the result of waste rock removal and other mitigation measures implemented at the site.

TABLE 3-6
Estimated Metal Loads

Component	Flow Acre-feet/year	Copper Mass (lbs/yr)	Zinc Mass (lbs/yr)
Pre-Restoration			
Inflow from direct precipitation, Q1	106.56	0.00	0.00
Groundwater inflow from shallow bedrock, and Mine Shaft 4 seepage, Q2	43.50	1,583	4,514
Evapotranspiration, Q3	94.00	0.00	0.00
Surface water and shallow alluvial groundwater discharge to Camanche Reservoir, Q4	56.20	19,378	39,930
Groundwater discharge from shallow bedrock to Camanche Reservoir, Q5	0.12	4.89	71.76
Upland watershed inflow (surface water and shallow alluvial groundwater), Q6 (1)	0.00	0.00	0.00
Total estimated discharge to Camanche Reservoir (Q4 + Q5)	**56.32**	**19,383**	**40,002**
Post-Restoration			
Inflow from direct precipitation, Q1	106.56	0.00	0.00
Groundwater inflow from shallow bedrock, and Mine Shaft 4 seepage after plug installation, Q2	12.20	52.00	158.38
Evapotranspiration, Q3	83.07	0.00	0.00
Surface water and shallow alluvial groundwater discharge to Camanche Reservoir, Q4	186.30	117.30	348.30
Groundwater discharge from shallow bedrock to Camanche Reservoir, Q5	0.12	4.89	71.76
Upland watershed inflow (surface water and shallow alluvial groundwater), Q6	150.70	48.92	151.60
Total estimated discharge to Camanche Reservoir (Q4 + Q5)	**186.42**	**122.2**	**420.1**

Notes:
(1) Q6 is diverted around site in pre-restoration condition.

Inflow. Prior to site restoration, the entire inflow metal loading comes from groundwater inflow from shallow bedrock and Shaft 4 area seepage. The post-restoration condition includes the additional inflow loading from the upland watershed; however, the overall inflow loading decreases primarily because of the sealing of the Shaft 4 area.

The estimated inflow of copper and zinc onto the Penn Mite site is:

- Pre-restoration

Copper	1,583 lbs/year
Zinc	4,514 lbs/year

- Post-restoration

Copper	100.9 lbs/year
Zinc	310 lbs/year

Outflow. Estimated pre-restoration outflows of copper and zinc to Camanche reservoir assume the absence of the ILS plant. Predicted post-restoration mass loads of copper and zinc to Camanche Reservoir assume that enough time has passed for the site to stabilize, i.e., residual acidity in pore water at the site has been displaced by incoming water and acid generation has been surpressed by use of soil amendments. The estimated outflow of copper and zinc to Camanche Reservoir via discharges of surface water, shallow alluvial groundwater, and groundwater in shallow bedrock is:

- Pre-restoration

Copper	19,383 lbs/year
Zinc	40,002 lbs/year

- Post-restoration

Copper	122.2 lbs/year
Zinc	420.1 lbs/year

A detailed discussion of the water budget and mass loading estimates is provided in the Second Interim Effectiveness Monitoring Report (CH2M HILL, July 1999). Actual post-restoration monitoring results and load estimates are included in the post-restoration monitoring reports and the Final Effectiveness Monitoring Report.

3.5.4 Monitoring System Construction

Water quality monitoring at the site involves surface water and groundwater sample collection and analysis and surface water flow measurements. Surface water samples are collected and flow is monitored at a series of weirs that have been constructed in Mine Run Creek and Hinckley Run Creek. Surface water samples are also collected at significant seeps and springs and downgradient of the former Shoreline Pile. Groundwater samples are collected from a network of monitoring wells, some previously existing at the site and some installed during the restoration project. Figure 3-1 shows the locations of the post-restoration surface water and groundwater monitoring system components.

3.5.4.1 Surface Water Monitoring

A series of flumes and weirs were constructed at the Penn Mine site to facilitate flow and water quality monitoring:

RECEIVED
SACRAMENTO
CVRWQCB

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Camanche Res
Mok River-
Al, Cu, Zn

V O L U M E   T H R E E

Draft Environmental Impact Statement/Report

Updated Water Supply Management Program

WSMP

EBMUD

TECHNICAL APPENDICES B1-B2

V O L U M E   T H R E E

Draft Environmental Impact Statement/Report

Updated Water Supply Management Program

Prepared for
East Bay Municipal Utility District
375 11th Street
Oakland, California 94607

Prepared by
BioSystems Analysis, Inc.
3152 Paradise Drive, Building 39
Tiburon, California 94920

LOWER MOKELUMNE RIVER MANAGEMENT PLAN

Prepared for:

EDAW, Inc.
753 Davis Street
San Francisco, CA 94111

Prepared by:

BioSystems Analysis, Inc.
3152 Paradise Drive
Tiburon, CA 94920
(415) 435-0399
(415) 435-0893

September 1992
J720/13

Table 1.1. ***Documented fish losses on the Mokelumne River between 1937 and 1989.***

YEAR	LOCATION	FISH	NUMBER	ASSOCIATED CONDITIONS	REFERENCES
1937	Downstream from Lodi wineries	Salmon	NA	Low oxygen from winery waste	CDFG 1937
1937	Penn Mine to Delta	All	All	Heavy metals	Shaw and Towers 1937
1939	Downstream from Lodi wineries	Salmon	>100	Heavy metals	Hatton 1940
1943-1945	Penn Mine to Delta	All	All	Heavy metals	Paul 1952; EBMUD 1990
1948	Downstream from Thornton Cannery	NA	NA	Low oxygen from cannery waste	CVRWPCB 1952; EBMUD 1990
1957	20 km downstream from the Penn Mine	Steelhead	NA	Heavy metals	Dunham 1961; Finlayson and Rectenwald 1978
1958	20 km downstream from the Penn Mine	Sculpins, suckers, lampreys	NA	Heavy metals	Dunham 1961; Finlayson and Rectenwald 1978
1958	15 km downstream from the Penn Mine	Steelhead, suckers, lampreys	NA	Heavy metals	Dunham 1961; Finlayson and Rectenwald 1978
1959	Camanche Bridge	Salmon, steelhead sculpins, bullhead, lamprey, suckers	NA	Heavy metals	Dunham 1961; Finlayson and Rectenwald 1978
1959	15 km downstream from the Penn Mine	Salmon, steelhead, sculpins, suckers	NA	Heavy metals	Dunham 1961; Finlayson and Rectenwald 1978
1959	Camanche Bridge	Salmon, sculpin	NA	Heavy metals	Dunham 1961; Finlayson and Rectenwald 1978
1959	Camanche Bridge	Salmon	NA	Heavy metals	Dunham 1961; Finlayson and Rectenwald 1978
1960	Lancha Plana	Steelhead, suckers	NA	Heavy metals	Dunham 1961; Finlayson and Rectenwald 1978
1960	Lancha Plana	Salmon adults	95%	Heavy metals	Menchen 1961
1961	Lancha Plana	Salmon fry	99%	Heavy metals	Menchen 1961
1967	MRFH	Salmon fry Steelhead	1,900 17,600	Heavy metals	Jewett 1971; Finlayson and Rectenwald 1978
1973	MRFH	Steelhead	46,200	Heavy metals	Jewett 1974; Finlayson and Rectenwald 1978
1977	MRFH	Steelhead Salmon fry	28,373 >100,000	Heavy metals and hydrogen sulfide	Jewett 1980

Table 1.1. Documented fish losses on the Mokelumne River between 1937 and 1989 (cont.).

YEAR	LOCATION	FISH	NUMBER	ASSOCIATED CONDITIONS	REFERENCES
1987	MRFH	Steelhead	109,000	Hydrogen sulfide and elevated temperature	Estey 1989; Horne 1989; EBMUD 1990
1988	MRFH	Steelhead Salmon	>45,000 28,000	Hydrogen sulfide and low oxygen	Estey 1990; EBMUD 1990
1989	MRFH	Steelhead	153,000	Hydrogen sulfide	Miyamoto 1989; EBMUD 1990

and fry being monitored (Menchen 1961). Although water samples were not taken continuously throughout the experiment, copper and zinc concentrations were as high as 14 times the lethal level (Menchen 1961).

Even after Penn Mine had been closed for more than 10 years, heavy metals from the mine continued to cause fish losses. Rain flooded the settling ponds at Penn Mine several times, and large water releases were made from Pardee Dam which transported metal-laden sediments downstream. These events resulted in the loss of fish at the MRFH in 1967, 1973, and 1977 (Finlayson and Rectenwald 1978).

At the time, it was thought that since "the decline of the king salmon and steelhead resources . . . are primarily the result of copper and zinc toxicity from Penn Mine," re-establishment of these populations would occur when this problem was eliminated (Finlayson and Rectenwald 1978). In 1979, EBMUD, the SWRCB, and CDFG combined resources and constructed a dam below the settling ponds to contain drainage and reduce the amount of heavy metals discharged into Camanche Reservoir. Since construction of this dam, the annual surface flow from Penn Mine drainage into the Mokelumne River via Mine Run Creek has decreased by over 90 percent (SWRCB 1991).

1.3.2 Industrial Development

Wineries around Woodbridge Dam began discharging organic waste into the Lower Mokelumne River in about 1933. Organic waste harms aquatic life because it depletes oxygen as it decomposes. By 1935, 1,862,000 liters of winery waste a day were being dumped into the river (San Joaquin County Health District [SJCHD] 1935). In 1937, dissolved oxygen levels in the river fell below that needed to support fish life; this resulted in fish losses below the winery outfalls and a blockage of upstream migration (CDFG 1937). In 1939, low levels of dissolved oxygen again resulted in the loss of several hundred salmon and blocked upstream migration (Hatton 1940). As a result, the State Public Health Department enforced the pollution laws and, within two weeks, oxygen levels increased and the upstream migration began (CDFG 1956).

Most of the wineries were closed between 1940 and 1943. Dissolved oxygen levels in the river returned to normal and large salmon migrations resumed. The wineries again began releasing effluent directly into the river in 1943 and by 1945 the salmon runs had virtually disappeared (CDFG 1956).

Canneries also discharged organic waste into the river. In 1948, discharge from Thornton Cannery in Thornton reduced dissolved oxygen levels in the river to almost zero. Oxygen depletion resulted in fish losses downstream from the cannery and blocked upstream migration. The cannery was ordered to cease discharge immediately or face legal action by the state. From 1948 through 1952, low dissolved oxygen levels were periodically measured during the canning season. However, salmon stocks were unaffected since the canning season was usually over by the middle of October (CDFG 1956). By 1952, both winery and cannery discharges were being treated to comply with state regulations and fish life was no longer threatened (CVRWQCB 1952).

1.3.3 Dams

Construction of dams along the Mokelumne River has hindered salmon migration since at least 1891 when a dam was constructed near the present site of Woodbridge Dam near Lodi, 57 kilometers upstream from the river mouth. The dam failed in 1895 and was replaced with a wooden dam in 1901. In 1910, the wooden dam was replaced by Woodbridge Dam, a 50-meter wide flashboard dam that is in place from April through October during the irrigation season. The dam had no fish ladder until 1925. Each fall after the irrigation season (usually October or November), the flashboards are removed, and the 2,000 acre-foot impoundment (Lake Lodi) is drained. During March or April of each spring, the boards are placed in the dam frame, Lake Lodi fills, and the water is diverted into the WID Canal intake.

Construction of Woodbridge Dam blocked access to all salmon and steelhead spawning habitat during the irrigation season from 1910 until 1925 when a fish ladder was built. This structure would have had a major impact on spring-run salmon since they migrate upstream between March and May. The fish ladder, constructed in 1925, was small and there was little, if any, flow through the ladder during the fall (Clark 1929). This inadequate fish ladder was replaced 23 years later in 1948 with a more effective structure. The new ladder washed out during a flood in 1950 when flows were over 25,000 cubic feet per second (cfs), the highest ever recorded on the Mokelumne River (USGS 1989).

A new fish ladder was built over Woodbridge Dam in 1955 and the CDFG stated that with the new ladder salmon stocks should return to historical levels (Lodi-News Sentinel, 17 November 1955). Today, there are two fishways for chinook salmon at Woodbridge Dam: one for passage when the lake is drained and one for passage when the lake is full. An additional Denil fishway was installed in 1972 to aid steelhead trout passage. Although numerous improvements to the present system have been suggested, there is no documentation that the present configuration of the dam or its fishways block salmon and steelhead migration.

In 1928, Pardee Dam was constructed upstream from Woodbridge Dam approximately 117 river kilometers upstream from the river mouth. This concrete dam is 105 meters high and stores 209,950 acre-feet of water. Pardee Reservoir has 59 kilometers of shoreline and a maximum surface area of 913 hectares. Flow releases from Pardee Dam provide for incidental electric power generation. The Pardee Power Plant has a maximum capacity of 27 megawatts.

Spring-run chinook salmon were eliminated from the Mokelumne River prior to 1929 (Clark, 1929), and the lack of a fish ladder at Woodbridge Dam, construction of Pardee and Camanche dams, mining operations, overfishing, poaching, and unscreened diversions all affected the fall-run chinook salmon and steelhead trout populations.

In 1962, construction began on Camanche Dam located 16 kilometers below Pardee Dam, and 103 kilometers upstream from the mouth of the Mokelumne River. The 72 meter high dam, completed in 1964, was built for flood control and stream-flow regulation and storage. Camanche Reservoir can hold 430,880 acre-feet of water and, at maximum capacity, has a surface area of 18,833 hectares. The reservoir has 101 kilometers of shoreline and a maximum depth of 41 meters. The construction of Camanche Dam inundated 80 percent of the remaining fall-run salmon spawning habitat as well as most of the steelhead trout habitat on the Mokelumne River (CDFG 1955; Fry and Petrovich 1970). The remaining spawning habitat now extends for about 11 kilometers downstream from the base of Camanche Dam to below Mackville Road Bridge.

1.3.4 Flow Modifications

The Mokelumne River watershed drains a region of the central Sierra Nevada from the Sierra crest to the foothills in central California. River flows on the lower river are recorded at gaging stations maintained by the United States Geological Service (USGS) at Mokelumne Hill, below Camanche Dam, and below Woodbridge Dam. EBMUD also generates an estimate of unimpaired flow called "true natural flow" (TNF) into Pardee Reservoir. This estimate is based on measured riverflow but is corrected for the upstream project operations of Pacific Gas and Electric Company (PG&E) and other water users. This estimate does not account for downstream storage and diversion and is intended as an estimate of historical flow conditions prior to the construction of any water storage and diversion facilities.

From 1928 to 1988, mean monthly TNF estimates peaked in May at approximately 3,200 cfs and fell to 100 cfs in September and October (Figure 1-4). High flows from March to July are caused by spring snow melt runoff. Average unimpaired runoff in the Lower Mokelumne River is over 1,000 cfs.

Pardee and Camanche reservoirs have a combined storage capacity of over 641,000 acre-feet of water. This is equivalent to almost 90 percent of the mean annual runoff of the entire Mokelumne River Watershed Basin.

The purpose of the Pardee project was to store the high spring flows and divert a portion of them out of the basin to the East Bay. As a result of the Pardee project, river flows from July through November were increased over historical unimpaired river flows. The operation of Camanche Dam (beginning in 1964) resulted in further reductions in spring flows and a slight additional increase in summer and fall flows below Camanche Dam (Figure 1-4). These hydrologic modifications improved naturally existing habitat for the fall-run salmon and winter-run steelhead populations. Historically, unimpaired flow estimates and measured flows (at Camanche and Woodbridge dams) have differed considerably within and between years because of differences in water availability (precipitation, snowmelt, and release schedules). The historic variability in monthly flow was analyzed using exceedance analysis (Figure 1-5). Low flow was defined to occur during the 10 percent of the period of record when monthly flows were the lowest. Because low flow is exceeded 90 percent of the time, it is also referred to as the 90 percent exceedance flow. Normal flow is exceeded

EBMUD

EAST BAY MUNICIPAL UTILITY DISTRICT
REGULATORY COMPLIANCE OFFICE
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TELEPHONE NO. (510) 287-1507
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FACSIMILE TRANSMITTAL

FAX TO: Michelle Wood

COMPANY: CRWQCB

FAX NO.: 916. ~~255.0752~~ 255-~~3016~~ 3015

FROM: ALEX COATE

DATE: 8/2/01

SUBJECT: WQ Data for Lower Mokelumne, Camanche & Rich Gulch request

No. of Pages: 6 **(including transmittal)**

MESSAGE:

Attached are e-mail messages and 3 pages of data.

W:\rco\RCORCDOCS\Faxcover.doc

Coate, Alexander

From: Coate, Alexander
Sent: Thursday, August 02, 2001 10:36 AM
To: 'Michelle Wood'
Subject: RE: Water Quality Data for Lower Mok River, Camanche Reservoir and Rich Gulch

Michelle -

The District has no additional data for Rich Gulch other than what we collected when Gwin Mine was opened for exploration a couple of years ago. We understand that the CVRWQCB believes there is not enough data to support listing at this time. We will evaluate the cost/benefit of collecting quarterly samples for the next two years to support future listing.

For the lower Mokelumne, I could not find any low MDL copper data (<1.0 ug/l) for Pardee or Camanche Reservoirs. We do have low MDL dissolved copper data for two stations below Camanche Dam. These stations are located 100 feet above the Camanche Power House discharge and 500 feet below the discharge. 47 sample results at each of these two locations are provided in the attached excel spreadsheet. This low MDL data is being collected and submitted as a part of the Power House NPDES permit monthly reports with the intent to determine if the Power House discharge impacts the river relative to the ultra low hardness based aquatic toxicity criteria.

As we discussed, a search of our laboratory database contains lots of data for various constituents in Pardee and Camanche Reservoirs and in the Mokelumne River. Because the data were collected for drinking water purposes, many of the MDLs are higher than aquatic toxicity criteria. The data is the result of many studies and monitorng programs that were created to answer specific questions. Unfortunately I don't know those questions or the unique site conditions or sample collection criteria. It would take a lot of effort to review all the data and determine what data is suitable for comparison with aquatic toxicity criteria. The District would prefer not to undertake this effort without a clear objective.

I have also located the CDFG Lower Mokelumne River Management Plan and will make a copy and send to you next week. Hope this helps and don't hesitate to call if you have questions. - Alex

Alexander R. Coate
Manager of Regulatory Compliance
East Bay Municipal Utility District
Ph# 510-287-1663
FAX# 510-287-1330
Email: acoate@ebmud.com

-----Original Message-----
From: Michelle Wood [mailto:WoodM@rb5s.swrcb.ca.gov]
Sent: Tuesday, July 31, 2001 9:48 AM
To: acoate@ebmud.com
Cc: Bill Brattain; Patrick Morris
Subject: Water Quality Data for Lower Mok River, Camanche Reservoir and Rich Gulch

Alex,
As we discussed this morning, I am working with Joe Karkoski and other TMDL staff to review water quality information submitted by the public to help update the Clean Water Act 303(d) List. I developed the questions listed below as I reviewed your letter to Joe Karkoski dated April 23, 2001. Some of these questions we've briefly reviewed already. I sincerely appreciate your efforts in helping us to obtain additional information!

Michelle

Michelle L. Wood
Environmental Specialist III, Mercury TMDL Unit

California Regional Water Quality Control Board
Central Valley Region, Sacramento
tel: 916.255.0750 fax: 916.255.0752
e-mail: woodm@rb5s.swrcb.ca.gov

1. Rich Gulch/Gwin Mine. Is arsenic from Rich Gulch a long-term concern for EBMUD? That is, do you have data that indicate elevated levels of arsenic occur in Rich Gulch during years before or after the January 1997 storm events?

2. Camanche Reservoir data upstream and downstream of Penn Mine.
(a) Table 7 in CH2MHill's December 2000 report indicated that the method detection limit (MDL) for dissolved copper had been 2.08 µg/l for the samples collected from September 1999 through February 2000. However, the MDL was 3.12 µg/l for the samples collected from March through August 2000. Because the hardness is very low, the copper toxicity criteria are lower than the MDL of 3.12 µg/l. For water with hardness values of 15 to 20 µg/l, the maximum CTR criterion has a range of 2.2 to 2.9 µg/l, and the chronic CTR criterion has a range of 1.8 to 2.3 µg/l. Can CH2MHill change the sampling/analytical method to one that can have a method detection limit of 1 µg/l for dissolved copper so that Regional Board can determine compliance with the toxicity criteria? (Note, Bill Brattain of the Sac River Chap 15 Unit is also looking into this question.)

(b) It may well be that upstream water has dissolved copper concentrations slightly higher than the toxicity criteria. Greg Vaughn (NPDES Unit) thought there was "pre-project" (e.g., early 1990's) upstream data obtained with a low MDL (1 µg/l) that showed that, because of the very low hardness, upstream water may also exceed toxicity criterion for copper. Is this data set available?

3. Lower Mokelumne River Downstream of Camanche Reservoir. I have available two data sets to help me to address comments from public entities other than EBMUD. (1) EBMUD 1989-1992 aluminum, cadmium, copper, iron, and zinc concentration data (total and dissolved forms) for three sampling sites that apply to the lower Mokelumne River. [CamC samples the discharge from Camanche Dam to the Mokelumne River, CamD samples the Camanche Reservoir lower outlet to the Mokelumne River, and station VAPK samples the Mokelumne River at Van Assen Park downstream of Camanche Dam.] (2) EBMUD 1993-97 dissolved oxygen data set for Station #11 sent to the Regional Board as part of the 1998 303(d) List Update solicitation for information. (This data set also includes some temperature and turbidity information.)

(a) Aluminum & Cadmium: (1) Has EBMUD collected additional aluminum and cadmium (and hardness) data for the lower Mokelumne River? (2) Are the sampling frequencies and method detection limits adequate to determine compliance with the relevant water quality standards?

(b) Copper & Zinc: The EBMUD data were generated in or before 1992; therefore, the data are outdated because substantial remediation activities have taken place since 1992. (1) Are more recent Cu, Zn, and hardness data available for the LMR downstream of Camanche Reservoir (but upstream of the legal Delta boundary)? (2) Are recent Cu and Zn concentrations below the hardness-adjusted CTR criteria? (3) Was the sampling frequency adequate to determine compliance (e.g., samples collected during wet and dry seasons and during wet and drought water years)?

(c) Temperature: Are more recent (December 1998-present) temperature data available for Station #11?

(d) Turbidity: Is there a turbidity data set available for Station #11 (or comparable location)?

4. Do you have a spare copy of the CDFG Lower Mokelumne River Fisheries Management Plan?

Received: 8/ 2/01 3:48PM; 15102871330 -> RWQCB REGION 5 SACRAMENTO ; Page 4
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Low-level Dissolved Copper Results in Mokelumne River
Samples from upstream and downstream of Camanche Dam Powerhouse

Sample ID	Collect date	Type	Site	Locator	Parameter	Qual	Value	Units	MDL	Method ref
L48690-3	4-Aug-97	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		0.98	ug/L	0.8	EPA 220.2: FILTER
L50020-3	4-Sep-97	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		1.3	ug/L	0.8	EPA 220.2: FILTER
L51405-3	9-Oct-97	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		1	ug/L	0.8	EPA 220.2: FILTER
L52671-3	10-Nov-97	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		1.2	ug/L	0.8	EPA 220.2: FILTER
L53704-3	4-Dec-97	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		1.9	ug/L	0.8	EPA 220.2: FILTER
L54909-3	7-Jan-98	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		2.9	ug/L	0.8	EPA 220.2: FILTER
L54909-3	7-Jan-98	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		2.9	ug/L	0.8	EPA 220.2: FILTER
L56199-3	10-Feb-98	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		1	ug/L	0.8	EPA 220.2: FILTER
L57038-3	5-Mar-98	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		1.2	ug/L	0.8	EPA 220.2: FILTER
L58434-3	2-Apr-98	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		3.4	ug/L	0.8	EPA 220.2: FILTER
L60019-3	8-May-98	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		0.95	ug/L	0.8	EPA 220.2: FILTER
L60960-3	9-Jun-98	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		1.6	ug/L	0.8	EPA 220.2: FILTER
L62239-4	8-Jul-98	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		0.8	ug/L	0.8	EPA 220.2: FILTER
L63685-3	5-Aug-98	GRAB	WW CAMANCHE PH	MS DOWN	COPPER	B	0.8	ug/L	0.8	SM(18)3113B: FILTER
L65378-3	21-Sep-98	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		2.6	ug/L	0.8	SM(18)3113B: FILTER
L66346-3	7-Oct-98	GRAB	WW CAMANCHE PH	MS DOWN	COPPER	B	9.1	ug/L	0.8	SM(18)3113B: FILTER
L68656-3	2-Dec-98	GRAB	WW CAMANCHE PH	MS DOWN	COPPER	B	2.1	ug/L	0.8	SM(18)3113B: FILTER
L69929-3	6-Jan-99	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		2.1	ug/L	0.8	SM(18)3113B: FILTER
L71014-3	3-Feb-99	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		1.2	ug/L	0.8	SM(18)3113B: FILTER
L71655-3	3-Mar-99	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		0.82	ug/L	0.8	SM(18)3113B: FILTER
L72405-3	8-Apr-99	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		1.3	ug/L	0.8	SM(18)3113B: FILTER
L73061-3	5-May-99	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		1.4	ug/L	0.8	SM(18)3113B: FILTER
L73685-3	3-Jun-99	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		0.89	ug/L	0.8	SM(18)3113B: FILTER
L74536-3	7-Jul-99	GRAB	WW CAMANCHE PH	MS DOWN	COPPER	B	1	ug/L	0.3	SM(18)3113B: FILTER
L75221-3	4-Aug-99	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		0.82	ug/L	0.3	SM(18)3113B: FILTER
L75891-3	1-Sep-99	GRAB	WW CAMANCHE PH	MS DOWN	COPPER	U	0.3	ug/L	0.3	SM(18)3113B: FILTER
L76726-3	6-Oct-99	GRAB	WW CAMANCHE PH	MS DOWN	COPPER	B	0.73	ug/L	0.3	SM(18)3113B: FILTER
L77395-3	3-Nov-99	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		1	ug/L	0.3	SM(18)3113B: FILTER
L77972-3	1-Dec-99	GRAB	WW CAMANCHE PH	MS DOWN	COPPER	B	4.2	ug/L	0.3	SM(18)3113B: FILTER
L78707-3	5-Jan-00	GRAB	WW CAMANCHE PH	MS DOWN	COPPER	B	1.1	ug/L	0.3	SM(18)3113B: FILTER
L79412-3	2-Feb-00	GRAB	WW CAMANCHE PH	MS DOWN	COPPER	U	0.3	ug/L	0.3	SM(18)3113B: FILTER
L80086-3	1-Mar-00	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		14	ug/L	0.3	SM(18)3113B: FILTER
L81032-3	12-Apr-00	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		0.9	ug/L	0.3	SM(18)3113B: FILTER
L81526-3	3-May-00	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		1.1	ug/L	0.3	SM(18)3113B: FILTER

B = analyte detected in method blank
U = undetected at MDL

Low-level Dissolved Copper Results in Mokelumne River
Samples from upstream and downstream of Camanche Dam Powerhouse

Sample ID	Collect date	Type	Site	Locator	Parameter	Qual	Value	Units	MDL	Method ref
L82253-3	7-Jun-00	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		2.3	ug/L	0.3	SM(18)3113B: FILTER
L82881-3	5-Jul-00	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		0.77	ug/L	0.3	SM(18)3113B: FILTER
L83512-3	2-Aug-00	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		2.6	ug/L	0.3	SM(18)3113B: FILTER
L84318-3	6-Sep-00	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		1.5	ug/L	0.3	SM(18)3113B: FILTER
L84969-1	4-Oct-00	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		2	ug/L	0.3	SM(18)3113B: FILTER
L85657-1	1-Nov-00	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		0.72	ug/L	0.3	SM(18)3113B: FILTER
L86391-1	6-Dec-00	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		0.8	ug/L	0.3	SM(18)3113B: FILTER
L86922-1	3-Jan-01	GRAB	WW CAMANCHE PH	MS DOWN	COPPER	B	1.7	ug/L	0.3	SM(18)3113B: FILTER
L87678-1	7-Feb-01	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		0.57	ug/L	0.3	SM(18)3113B: FILTER
L88502-2	14-Mar-01	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		0.77	ug/L	0.3	SM(18)3113B: FILTER
L88982-3	4-Apr-01	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		0.54	ug/L	0.3	SM(18)3113B: FILTER
L89594-2	2-May-01	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		2.5	ug/L	0.3	SM(18)3113B: FILTER
L90361-2	6-Jun-01	GRAB	WW CAMANCHE PH	MS DOWN	COPPER		0.58	ug/L	0.3	SM(18)3113B: FILTER
L48690-2	4-Aug-97	GRAB	WW CAMANCHE PH	MS UP	COPPER		1.7	ug/L	0.8	EPA 220.2: FILTER
L50020-2	4-Sep-97	GRAB	WW CAMANCHE PH	MS UP	COPPER		2.9	ug/L	0.8	EPA 220.2: FILTER
L51405-2	9-Oct-97	GRAB	WW CAMANCHE PH	MS UP	COPPER		1.4	ug/L	0.8	EPA 220.2: FILTER
L52671-2	10-Nov-97	GRAB	WW CAMANCHE PH	MS UP	COPPER		1.2	ug/L	0.8	EPA 220.2: FILTER
L53704-2	4-Dec-97	GRAB	WW CAMANCHE PH	MS UP	COPPER		1.9	ug/L	0.8	EPA 220.2: FILTER
L54909-2	7-Jan-98	GRAB	WW CAMANCHE PH	MS UP	COPPER		1.3	ug/L	0.8	EPA 220.2: FILTER
L54909-2	7-Jan-98	GRAB	WW CAMANCHE PH	MS UP	COPPER		1.3	ug/L	0.8	EPA 220.2: FILTER
L56199-2	10-Feb-98	GRAB	WW CAMANCHE PH	MS UP	COPPER		1.3	ug/L	0.8	EPA 220.2: FILTER
L57038-1	5-Mar-98	GRAB	WW CAMANCHE PH	MS UP	COPPER		1.8	ug/L	0.8	EPA 220.2: FILTER
L58434-2	2-Apr-98	GRAB	WW CAMANCHE PH	MS UP	COPPER		0.87	ug/L	0.8	EPA 220.2: FILTER
L60019-2	8-May-98	GRAB	WW CAMANCHE PH	MS UP	COPPER		0.91	ug/L	0.8	EPA 220.2: FILTER
L60960-2	9-Jun-98	GRAB	WW CAMANCHE PH	MS UP	COPPER	U	0.8	ug/L	0.8	EPA 220.2: FILTER
L62239-3	8-Jul-98	GRAB	WW CAMANCHE PH	MS UP	COPPER		1.7	ug/L	0.8	EPA 220.2: FILTER
L63685-2	5-Aug-98	GRAB	WW CAMANCHE PH	MS UP	COPPER	U	0.8	ug/L	0.8	SM(18)3113B: FILTER
L65378-2	21-Sep-98	GRAB	WW CAMANCHE PH	MS UP	COPPER		2.8	ug/L	0.8	SM(18)3113B: FILTER
L66346-2	7-Oct-98	GRAB	WW CAMANCHE PH	MS UP	COPPER	B	6.2	ug/L	0.8	SM(18)3113B: FILTER
L68656-2	2-Dec-98	GRAB	WW CAMANCHE PH	MS UP	COPPER	B	7.8	ug/L	0.8	SM(18)3113B: FILTER
L69929-2	6-Jan-99	GRAB	WW CAMANCHE PH	MS UP	COPPER		4.2	ug/L	0.8	SM(18)3113B: FILTER

B = analyte detected in method b[illegible]k
U = undetected at [illegible]

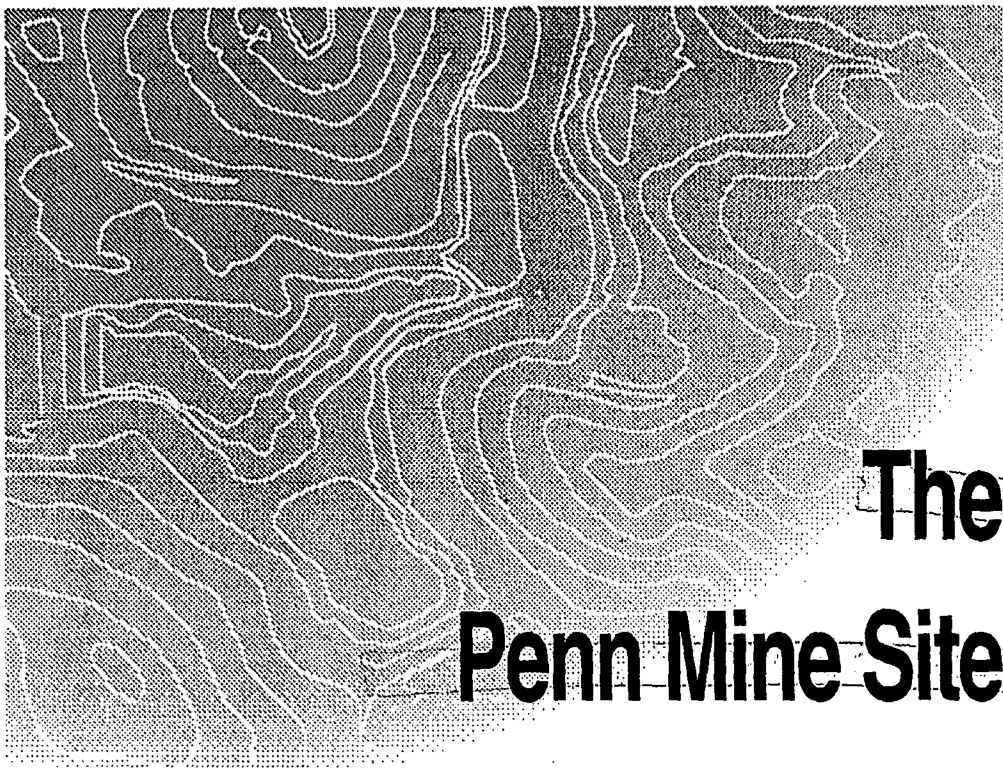
Low-level Dissolved Copper Results in Mokelumne River

Samples from upstream and downstream of Camanche Dam Powerhouse

Sample ID	Collect date	Type	Site	Locator	Parameter	Qual	Value	Units	MDL	Method ref
L71014-2	3-Feb-99	GRAB	WW CAMANCHE PH	MS UP	COPPER		4.5	ug/L	0.8	SM(18)3113B: FILTER
L71655-2	3-Mar-99	GRAB	WW CAMANCHE PH	MS UP	COPPER		1.4	ug/L	0.8	SM(18)3113B: FILTER
L72405-2	8-Apr-99	GRAB	WW CAMANCHE PH	MS UP	COPPER	U	0.8	ug/L	0.8	SM(18)3113B: FILTER
L73061-2	5-May-99	GRAB	WW CAMANCHE PH	MS UP	COPPER		1.5	ug/L	0.8	SM(18)3113B: FILTER
L73685-2	3-Jun-99	GRAB	WW CAMANCHE PH	MS UP	COPPER		1.5	ug/L	0.8	SM(18)3113B: FILTER
L74536-2	7-Jul-99	GRAB	WW CAMANCHE PH	MS UP	COPPER	B	3.9	ug/L	0.3	SM(18)3113B: FILTER
L75221-2	4-Aug-99	GRAB	WW CAMANCHE PH	MS UP	COPPER		0.62	ug/L	0.3	SM(18)3113B: FILTER
L75891-2	1-Sep-99	GRAB	WW CAMANCHE PH	MS UP	COPPER		0.63	ug/L	0.3	SM(18)3113B: FILTER
L76726-2	6-Oct-99	GRAB	WW CAMANCHE PH	MS UP	COPPER	B	1.8	ug/L	0.3	SM(18)3113B: FILTER
L77395-2	3-Nov-99	GRAB	WW CAMANCHE PH	MS UP	COPPER		5.8	ug/L	0.3	SM(18)3113B: FILTER
L77972-2	1-Dec-99	GRAB	WW CAMANCHE PH	MS UP	COPPER	B	1.3	ug/L	0.3	SM(18)3113B: FILTER
L78707-2	5-Jan-00	GRAB	WW CAMANCHE PH	MS UP	COPPER	B	0.91	ug/L	0.3	SM(18)3113B: FILTER
L79412-2	2-Feb-00	GRAB	WW CAMANCHE PH	MS UP	COPPER	U	0.3	ug/L	0.3	SM(18)3113B: FILTER
L80086-2	1-Mar-00	GRAB	WW CAMANCHE PH	MS UP	COPPER		1.3	ug/L	0.3	SM(18)3113B: FILTER
L81032-2	12-Apr-00	GRAB	WW CAMANCHE PH	MS UP	COPPER		0.82	ug/L	0.3	SM(18)3113B: FILTER
L81526-2	3-May-00	GRAB	WW CAMANCHE PH	MS UP	COPPER		1.3	ug/L	0.3	SM(18)3113B: FILTER
L82253-2	7-Jun-00	GRAB	WW CAMANCHE PH	MS UP	COPPER		1.8	ug/L	0.3	SM(18)3113B: FILTER
L82881-2	5-Jul-00	GRAB	WW CAMANCHE PH	MS UP	COPPER		1.7	ug/L	0.3	SM(18)3113B: FILTER
L83512-2	2-Aug-00	GRAB	WW CAMANCHE PH	MS UP	COPPER	U	0.3	ug/L	0.3	SM(18)3113B: FILTER
L84318-2	6-Sep-00	GRAB	WW CAMANCHE PH	MS UP	COPPER		1.2	ug/L	0.3	SM(18)3113B: FILTER
L84969-2	4-Oct-00	GRAB	WW CAMANCHE PH	MS UP	COPPER		0.98	ug/L	0.3	SM(18)3113B: FILTER
L85657-2	1-Nov-00	GRAB	WW CAMANCHE PH	MS UP	COPPER		1.2	ug/L	0.3	SM(18)3113B: FILTER
L86391-2	6-Dec-00	GRAB	WW CAMANCHE PH	MS UP	COPPER		5	ug/L	0.3	SM(18)3113B: FILTER
L86922-3	3-Jan-01	GRAB	WW CAMANCHE PH	MS UP	COPPER	B	4.3	ug/L	0.3	SM(18)3113B: FILTER
L87678-2	7-Feb-01	GRAB	WW CAMANCHE PH	MS UP	COPPER		0.83	ug/L	0.3	SM(18)3113B: FILTER
L88502-3	14-Mar-01	GRAB	WW CAMANCHE PH	MS UP	COPPER		0.66	ug/L	0.3	SM(18)3113B: FILTER
L88982-2	4-Apr-01	GRAB	WW CAMANCHE PH	MS UP	COPPER		0.59	ug/L	0.3	SM(18)3113B: FILTER
L89594-1	2-May-01	GRAB	WW CAMANCHE PH	MS UP	COPPER		1.3	ug/L	0.3	SM(18)3113B: FILTER
L90361-1	6-Jun-01	GRAB	WW CAMANCHE PH	MS UP	COPPER		1.4	ug/L	0.3	SM(18)3113B: FILTER

B = analyte detected in method blank
U = undetected at MDL

Draft Environmental Impact Report for



The Penn Mine Site Long-Term Solution Project

May 1996
SCH EIR No. 95103036

Prepared for:
East Bay Municipal Utility District
Central Valley Regional Water Quality Control Board

4. DESCRIPTION OF THE ELEMENTS OF THE PENN MINE PHYSICAL SYSTEM

4.1 Overview of Site Conditions

4.1.1 Operational History

The Penn Mine is located on the south bank of the Mokelumne River or Camanche Reservoir in Central California (Figure 4-1). The mine was opened in 1861 to extract, through underground mining, steeply dipping, tabular copper and zinc sulfide ore bodies, and was operated intermittently until 1953 (Davy, 1992). Table 4-1 summarizes the chronology of activities at the Penn Mine site. The mine is owned and was operated by New Penn Mines, Inc., a corporation currently with no known assets and deceased or insolvent principals (RWQCB, 1995). The United States government actively ensured that mining occurred during World War II at the Penn Mine (RWQCB, 1995).

Underground workings at the Penn Mine were developed from a system of eight shafts. At various periods, ore removed from the workings was direct smelted, concentrated on site through flotation, smelted, and shipped directly offsite to concentrators or smelters. Waste rock excavated during mining was brought up to the surface and placed in angle of repose dumps. The reactive mine waste rock ultimately resulted in the generation of acid rock drainage (ARD), which flowed to the Mokelumne River prior to 1978 and resulted in fish losses (Table 4-1).

In order to mitigate ARD discharge to the Mokelumne River, the Central Valley Regional Water Quality Control Board (RWQCB), with the California Department of Fish and Game and the East Bay Municipal Utility District (EBMUD), instituted a series of site improvements in the winter of 1978-1979. The site improvements included: surface water diversions; surface water impoundments in Hinkley Run Creek and Mine Run Creek; Mine Run Dam (MRD) at the confluence of the two creeks; and a pump and pipe system to the upper impoundments in Mine Run Creek. In 1993, EBMUD built an In-Line System (ILS) to treat mine drainage water in Mine Run Dam Reservoir (MRDR).

The ARD mitigation measures instituted at the Penn Mine site resulted in significant decreases in the amount of contaminants leaving the site (Figure 4-2) (Howard, 1991; RWQCB, 1995). An estimated average of 64,000 pounds of copper per year were discharged with storm water runoff from the Penn

Mine site during the 1950's through 1970's (RWQCB, 1995). The site improvements instituted in 1978-1979 reduced copper discharged to the Mokelumne River to an average of 12,500 pounds of copper per year (RWQCB, 1995). Finally, the development of the ILS in 1993 resulted in an average yearly discharge in treated effluent of 13 pounds of copper to the Mokelumne River (RWQCB, 1995). These estimates do not include discharges via groundwater. Sections 4.3.4 and 4.5 of this Draft EIR describe updated estimates of the water balance and metal loading for the site.

Site features at the Penn Mine site are indicated on Plate 1 and Photographs 4-1 through 4-5. Plate 1 shows the locations of mine shafts and adits, buildings, etc., including prominent waste piles (WP1 to WP5 and MT1) and site improvements (i.e., MRD, MRDR, impoundments, diversions, etc.). Photographs 4-1 through 4-5 include aerial and surface views of the Penn Mine site and show some of the features identified above. Photograph 4-1 is an aerial overview of the Penn Mine site looking eastward, with Camanche Reservoir located in the lower right foreground. Aerial views up and down Mine Run and Hinkley Run Creeks are included in Photographs 4-2 and 4-3, respectively. Photographs 4-4 and 4-5 include views of some of the more prominent waste piles, as well as mine structures and site improvements.

4.1.2 Previous Penn Mine Studies

Various economic, geologic, and environmental aspects of the Penn Mine site have been investigated in the past. Significant studies performed and their primary focus are summarized below:

- Heyl and others (1948) - California Division of Mines and Geology evaluation of the economic geology, metal output, and potential exploration targets.
- Wisser (1961) - Evaluation of the interconnection of the mine workings and Camanche Reservoir.
- Bechtel (1964) - Evaluation of the potential degradation of Camanche Reservoir and the Mokelumne River due to Penn Mine wastes.
- James Montgomery (1988) - Review of existing site features and recommendations for site improvements.
- Peterson (1985 and 1988) - U.S. Geological Survey investigation of geology, geochemistry, and development of updated geologic map.
- Bond (1988) - Toxic Pits Cleanup Act technical investigation, including collection of pond water, evaluation of geochemistry, and proposal of biocide treatment of waste.

- Model calibration was completed by comparing observed water volumes in all the ponds with predicted water volumes based on measured and estimated inflows and outflows (see Table 4-11 and Figure 4-14).
- Wet years exceed the total pond storage capacity (see 1992 vs. 1993 storage - the model predicted that approximately 13 acre-ft. of water would be discharged to prevent overtopping of the Mine Run Dam for 1993, while no discharge in 1992 was required).
- Direct precipitation on the Penn Mine disturbed area accounted for 20-25% of the total inflow predicted in the ponds.
- Upgradient run-on accounted for approximately 10% of the total inflow.
- Groundwater inflow accounted for 60% to 70% of the total inflow.
- Outflows are highly variable depending on the season, with evaporation ranging from 50% to 95% of the total outflow.
- The model indicates that approximately 56% of the rain water falling outside the ponds but within the local drainage flows into the ponds either as runoff or groundwater inflow. The remaining 44% is lost to evaporation, evapotranspiration, bedrock, or unsaturated storage.

The water balance model has been calibrated with an approximate range of groundwater seepage rates under Mine Run Dam of 0.2 to 1 gpm. Using the assumptions for the area of discharge and gradient reported by Hamlin and Alpers (1995), this corresponds to a hydraulic conductivity of 0.7 to 3.5 ft./day.

As described in the previous section, these predicted hydraulic conductivity values are two and three orders of magnitude greater than the median hydraulic conductivity (0.1 ft./day) estimated by Hamlin and Alpers (1995) for the metavolcanics, but are similar to the conductivities and flow rates estimated based on the range of data modeled. The actual seepage losses out of Mine Run Dam are likely in the range of those predicted by the water balance.

4.4 Water Quality

Penn Mine water quality has been discussed in a number of previous studies (Bechtel, 1964; Dunham, 1961; Finlayson et al., 1978; Rectenwald, 1977; Bond, 1988, Brown and Caldwell, 1991; Davy, 1992 and 1993). Surface and groundwater quality has been affected by the placement of mining wastes in and around the Mine Run and Hinkley Run drainages, and by periodic discharges from Shaft No. 3. Various measures to control discharge of site water have been implemented to reduce offsite water quality impacts. These efforts have resulted in changes of the on-site water quality over time; however, the overall effect has been to reduce offsite water quality impacts. This section presents summaries of the historic water quality for alluvial and bedrock groundwaters, surface water run-on, and pond water quality. The surface water discussion is subdivided on the basis of geographic location and includes description of Camanche Reservoir, tributaries to Camanche Reservoir, and the Penn Mine.

4.4.1 Camanche Reservoir

Feb. 1996 to May 1993

Camanche Reservoir surface water quality data has been collected by EBMUD at several locations. The data evaluated for this study has been collected since February 1993, which was the start up period for the existing water treatment plant at MRDR, and has been collected during months in which the Penn Mine treatment and/or diversion systems have been operated. Therefore, these data represent the existing reservoir conditions, which reflect the active water treatment at the site. The data are primarily from winter and spring months, so seasonal variations in concentrations have not been assessed. Water quality data has been collected at the surface of the reservoir and at various depths below the surface. Camanche sampling points relevant to this study include the following locations:

- Approximately 0.5 miles upstream of Penn Mine MRDR discharge;
- At the point of Penn Mine MRDR discharge;
- Approximately 0.8 miles downstream of the Penn Mine MRDR discharge;
- Approximately 2.0 miles downstream of the Penn Mine MRDR discharge; and,
- At the Camanche Reservoir dam.

These sampling locations are shown on Figures 4-15 and 4-16. Table 4-12 presents the temperature, pH, and dissolved oxygen data. Review of the pH and dissolved oxygen data indicates that Camanche Reservoir has a near neutral pH and is well oxygenated. The pH values show very little variation from upstream of the discharge point of MRDR to the Camanche Dam.

The dissolved oxygen values ranged from 7.94 mg/l at 11°C to 12.2 mg/l at 7.71°C. The minimum and maximum values of dissolved oxygen produced saturation ratios of 76 and 102 percent, respectively. The oxygen saturation ratios were calculated using the temperature versus dissolved oxygen table provided in Linsley and Franzini (1979). No effect from the Penn Mine on pH or dissolved oxygen values is discernible from these data, when active water treatment was initiated.

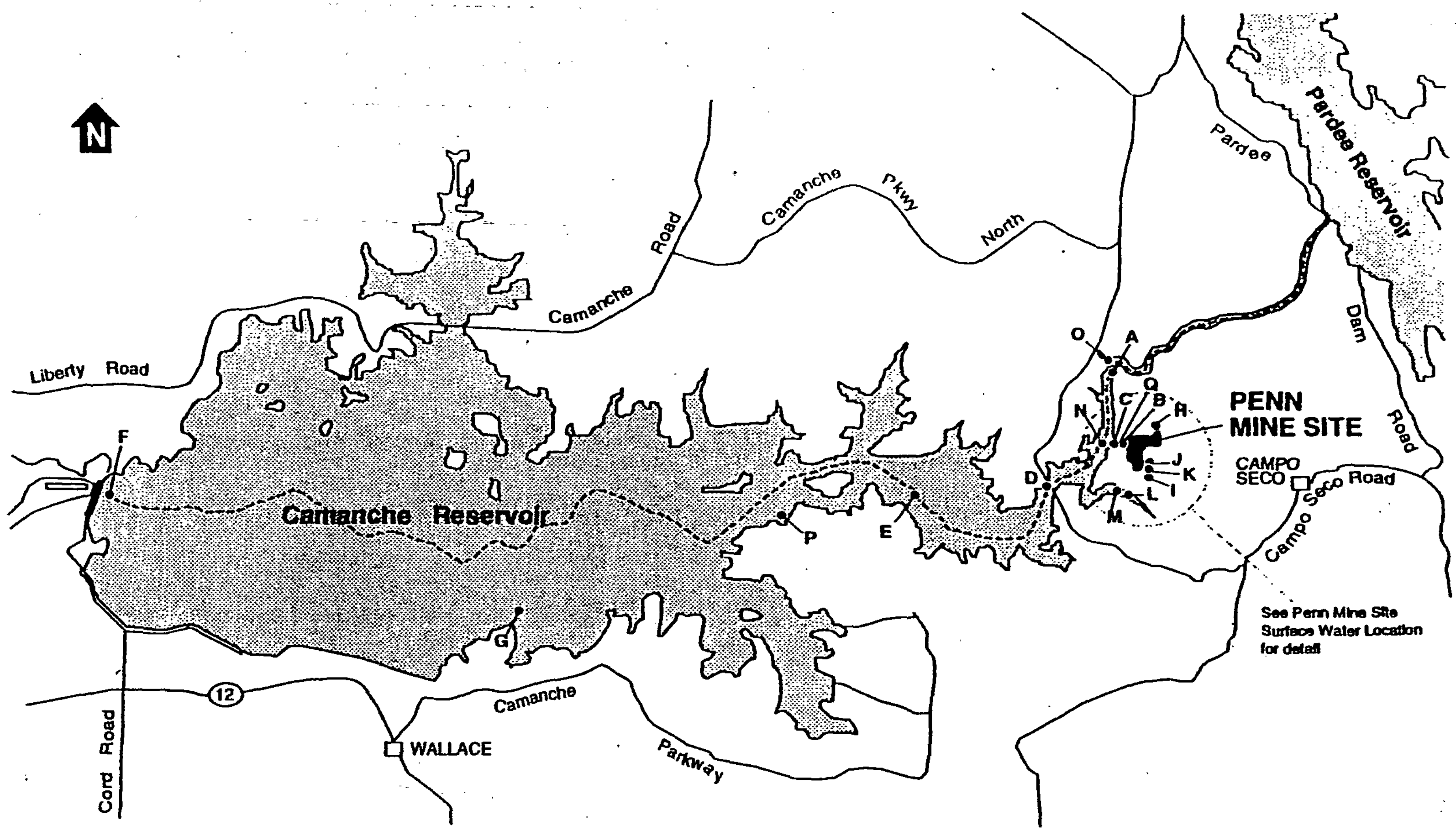
The Camanche Reservoir analytical data for metals, hardness and total suspended solids (TSS) are presented in Table 4-13. Metal analyses include both total recoverable and dissolved results. Hardness and TSS values were consistent between the sample points upstream of the MRDR and the sample points downstream of MRDR. Similarly, no systematic spatial variability is apparent for metal concentrations which display similar ranges throughout the sampling points for the Camanche Reservoir. The metals routinely detected in the reservoir include aluminum, barium, iron, copper and zinc. Aluminum is detected in almost all samples at concentrations ranging from less than 0.02 to greater than 3 mg/l. Since early 1994, when analytical methods were revised to provide lower detection limits than the previous years samples, copper and zinc have been detected in most samples. Concentrations measured have ranged from 0.002 mg/l to 0.14 mg/l for copper, with most samples less than 0.01 mg/l, and from 0.004 mg/l to 0.18 mg/l for zinc, with most samples less than 0.02 mg/l. Barium and iron are also consistently detected at concentrations ranging from 0.01 mg/l to 0.14 mg/l for barium and 0.05 mg/l to greater then 2 mg/l for iron. Metals analyzed and which have been rarely or never detected include arsenic, cadmium, chromium, mercury, lead, nickel, selenium, silver, and titanium. Most detected metal concentrations were near detection limits and showed no increases below the MRDR discharge point. However, occasional high concentration spikes are present.

During the period of sample collection and evaluation (February 1993 - present), no impacts to Camanche Reservoir water quality were noted. These data indicated the following:

- pH is near neutral and has little fluctuation with depth;
- Dissolved oxygen content is quite high and shows little fluctuation with depth;
- Hardness and TSS are very low;
- Metals concentrations were generally just above detection levels or not detected. Aluminum, iron, barium, copper and zinc are consistently detected.

4.4.2 Tributaries to Camanche Reservoir

Several tributaries to the Camanche Reservoir were evaluated as part of this study due to their proximity to the Penn Mine, including:



EXPLANATION

- • *Surface Water Sampling Location*
- A Camanche Res. 0.5 miles upstream of Penn Mine (CAMA01)
- B Mine Run Dam @ weir
- C Camanche Res. at mouth of slag tunnel
- D Camanche Res. 0.8 miles downstream of Penn Mine (CAMB01)
- E Camanche Res. 2 miles downstream of Penn Mine (CALP01)
- F Camanche Res. 10 miles downstream of Penn Mine (CAMD)
- G Camanche Res. influent into South Shore water supply
- H Hinkley Creek at stock pond
- I Mine Run Creek - 100 yards upstream on south fork
- J Mine Run Creek - 100 yards upstream on north fork
- K Mine Run Diversion - Ponded water (PENN 12)
- L Oregon Gulch - 250 yards upstream of confl w/ trib
- M Oregon Gulch - 250 yards downstream of confl w/ trib
- N Camanche Res. 100 ft. downstream of Penn Mine
- O Mirror Creek
- P South Shore Filter Plant (CASSIN, CASSEF)
- Q Point of discharge of MRDR (PENN 15)

FIGURE **4-15**

CAMANCHE RESERVOIR AND PENN MINE SURFACE WATER SAMPLING LOCATIONS

PENN MINE PROJECT

DWG ID 953-7073\SurfaceWater DATE 1/96 DRAWN bayani

Golder Associates

4.6 Description of Surficial and Waste Materials

Surficial and acid-generating waste materials have been disposed of over an area of approximately 24 acres in the Hinkley Run and Mine Run Creek drainages at the Penn Mine site. Davy (1992) divided these materials into 10 mappable units, which are summarized in Table 4-2. The surface distribution of these 10 mappable units is shown in Plate 3.

The analytical techniques used to evaluate the soil samples are described in detail in Davy (1992). The analyses included: particle size using the hydrometer method; standard inorganic procedures for common ions and metals; and methods developed specifically for the unique geochemistry of ARD. Table 4-24 lists the geochemical characteristics of the soil samples and pond sediment samples collected from the Penn Mine. Table 4-25 summarizes the statistics for the Davy (1992) soil samples.

The following sections describe the physical and geochemical characteristics of the acid-generating waste materials observed at the Penn Mine and are primarily taken from Davy (1992).

4.6.1 Physical Characteristics

4.6.1.1 Mine Waste

Mine waste is the most significant waste material identified at the Penn Mine site. Dumps of mine waste were formed as rock containing non-economic grades of metal was transported to the surface and unloaded. Since the waste rock had no economic value, transport costs were generally minimized and it was placed as close to the shaft as possible. The slopes of the mine waste dumps generally attain the angle of repose of the material (about 40% for broken rock).

The mine waste material generally consists of angular rock fragments up to 2 inches in diameter, with some 12 inch diameter material, in a matrix of silty fine sand. The presence of significant iron oxide content commonly weakly cements the waste material. Mine waste is commonly yellow to yellow-brown (10YR 8/6 to 7.5YR 5/8). Many rock fragments apparently contain disseminated sulfides, but it is not readily apparent due to weathering. White mineral salts are observed to develop on weathering fragments upon drying.

Reactive mineralization in the mine waste material at the Penn Mine is dominated by the presence of pyrite (FeS_2) disseminated in schist and quartzite. Locally, pyrite occurs as fracture- fill material in schist and quartzite veins or as amorphous masses (Boring B-2 @ 14.5 ft., Plate 3). Amorphous pyrite

4.6.1.7 Native Soil and Fill

Native soil is observed to surround the entire Penn Mine area (Plate 3), while areas of native fill are generally associated with diversion ditches and roadways. Native soil generally consists of mostly fine grained silty sand with a little coarse grained material. The soil is generally strong brown in color (7.5 YR 4/6 to 7.5 YR 5/8) and locally reddish brown. Varying amounts of rock fragments are observed within native soil. Angular rock fragments are derived from local bedrock outcrops; soils near outcrops may contain large amounts of rock fragments greater than 4 inches in diameter. Rounded to subrounded, mostly quartz gravel is also observed. The gravel is up to 3 inches in diameter, but mostly less than 1 inch in diameter. Gravel generally comprises about 10-20% of native soil; locally, it may contain more at higher elevations; near the Tertiary gravel deposits from which they were derived. Areas where native soils are mapped may contain bedrock outcrops of small extent.

Native fill consists of native soil which has been disturbed during site grading operations. The soil material characteristics are therefore very similar to those described above for native soil. Bedrock is commonly exposed on cut slopes associated with the grading operations. The native fill is considered to contain little to no mine waste material.

4.6.2 Analytical Results

4.6.2.1 Soil and Waste Chemistry

A total of 49 soil samples (including 4 duplicates) and 7 pond sediment samples (including 1 duplicate) from the Penn Mine were analyzed by Davy (1992). The observations presented below largely summarize the Davy (1992) findings. The analytical results for these soil samples and pond sediment samples are presented in Table 4-24. Summaries of the statistical data for soil samples within each of the 10 defined surficial material types is presented in Table 4-25. Prior to calculating the statistics, duplicate values were averaged, providing a total of 45 analyses (Davy, 1992). Statistics presented include: average concentration; number of analyte detections; and coefficient of variation (standard deviation/average). The coefficient of variation (CV) is a unitless measure of the variability of an analyte. As a general rule, the CV for both metals and environmental data tends to be between 1.0 and 2.0. Data with a CV less than 1.0 is relatively homogeneous while data with a CV exceeding 2.0 is considered highly variable.

Discussions of the concentrations observed for selected analytes for the soil samples are presented in the following paragraphs. Pond sediment chemistry is addressed separately at the end of this section.

Comparisons to regulatory standards, including EPA RCRA standards and California Action Metals Total Threshold Limit Concentrations (TTLC) are described below. Since the metals detected (with the exception of lead [TTLC = 1000 mg/kg]) are highly soluble in acid solutions, concentration values less than the TTLC values do not necessarily indicate acceptable (non-hazardous) concentrations.

Copper (Cu)

Copper was detected in all samples submitted for analysis (Table 4-24). Average copper concentrations by soil type are in the range of 70 to 1,800 mg/kg (0.007% to 0.18%)(Table 4-25). These values are well below the average copper grade of the ore (2% to 5%), indicating minimal dissemination of copper within the wall rock and accurate ore/waste determinations during mining (Davy, 1992).

The largest average concentrations of copper are found within the waste dumps, while the lowest concentration (72 mg/kg) was detected in the mill tailings (Table 4-25). The low tailings concentration indicates that the milling process used was reasonably efficient.

Soil and bedrock underlying observed waste materials (up to 5 feet below the contact with waste) contain copper concentrations of about 100 to 250 mg/kg (Tables 4-24 and 4-25). These copper concentrations may be the result of the vertical migration of acid rock drainage.

Since copper concentrations vary by over an order of magnitude between the different soil types, the overall coefficient of variation is relatively large (1.54) (Table 4-25). Within individual units, copper concentrations are less variable, with a coefficient of variation in the range of 0.5 to 1.42.

Iron (Fe)

Iron was detected in all samples submitted for analysis and significant concentrations were found in all soil types (Table 4-24). Average iron values ranged from 2.1 to 5.7% (Table 4-25). As described in Section 4.2.1, pyrite is disseminated throughout the wall rock of the ore body; thus, pyrite is common in nearly all the waste rock and fill derived from the waste.

Significant iron levels are present in the samples acquired from the alluvium and bedrock underlying the waste; however, the forms of sulfur analyses indicate that this iron is associated with sulfate generated from ARD reactions in the overlying waste or non-reactive sulfur compounds (Table 4-24) (Davy, 1992). Thus although iron is present, ARD generation in the native non-mineralized materials underlying the waste is probably not significant.

The similar concentrations of iron found in all soil types is reflected in the coefficient of variation which is equal to 0.40 (Table 4-25).

Gold (Au)

Gold was detected (at a detection limit of 0.5 to 1.0 mg/kg) in only 3 of the 45 samples analyzed (Table 4-24). The three samples containing detectable levels of gold were from waste material. The average gold content of these 3 samples (2.9 mg/kg [0.085 Troy oz/ton]), is consistent with the reported average gold grade of the ore (0.07 oz/ton; Heyl and others, 1948). Based on these results, it is concluded that gold values in excess of the detection limit (i.e. 0.5 to 1.0 mg/kg) are not common in the waste material.

Zinc (Zn)

Zinc was detected in all 45 soil samples, with average concentrations ranging between 87 and 5,000 mg/kg (Tables 4-24 and 4-25). The largest concentrations were detected in the mine waste, mixed fill, and mill tailings sampled in Mine Run Creek; this may suggest that the southern ore body contained larger or more disseminated zinc values.

A wide range of zinc concentrations are observed between the various material types. Within each material type, however, the values are relatively homogeneous, as demonstrated by low coefficients of variation (generally less than one) (Table 4-25).

Silver (Ag)

Silver was detected at concentrations exceeding the 0.5 mg/kg detection limit in 28 of the 45 samples (Table 4-24). The average silver concentration ranges from below the detection limit (alluvium below waste) to 35.5 mg/kg in Waste Pile WP5. The overall average silver concentration is 8.8 mg/kg (0.26 Troy oz/ton) (Davy, 1992).

The variability of silver concentrations across the site is not extremely large, despite the large number of non-detect values, since the coefficient of variation is 1.38 (Table 4-25).

Lead (Pb)

Lead was detected in all 45 samples with average concentrations ranging between 21 and 1,160 mg/kg over the 10 material types (Tables 4-24 and 4-25). The lowest concentrations were detected in alluvium underlying waste material. This finding is consistent with the low mobility of lead sulfide (galena) in solutions with a pH greater than 2 (Davy, 1992); even if lead is solubilized from galena in the mine waste, it is apt to re-precipitate nearby under the observed pH conditions.

Arsenic (As)

Arsenic was detected in all 45 samples at an average concentration of 110 mg/kg, with average concentrations ranging between 12 and 345 mg/kg over the 10 material types (Tables 4-24 and 4-25).

The variability of arsenic concentrations across the site is not large. The coefficient of variability is below 1 for 9 of the materials tested and averages about 1 for the 10 material types.

Cadmium (Cd)

Cadmium was detected in all 45 samples at an average concentration of 15 mg/kg with average concentrations ranging from 8 to 38 mg/kg over the 10 material types (Tables 4-24 and 4-25). Cadmium concentrations are relatively homogeneous over all material types, as reflected by the low coefficient of variation (0.57) (Table 4-25). Apparently, cadmium was widely disseminated at relatively low levels in the wall rock surrounding the ore body, most likely substituting for Zn in sphalerite.

Mercury (Hg)

Mercury was detected in all 45 samples (Table 4-24) at an average concentration of 1.5 mg/kg with average concentrations ranging from 0.5 to 5.7 mg/kg over the 10 material types (Table 4-25).

pH

Methods for calculating pH values for solids were described in Davy (1992). Average pH values for solids range from 2.0 to 3.6 (Tables 4-24 and 4-25). A pH value below 4.0 indicates that the solid material contains readily available acidity due to prior acid generation (BC AMD Task Force, 1990);

values were believed to be artifacts of the analytical procedure (Davy, 1992). Brief inspection of the information on Tables 4-24, 4-26 and 4-27 indicates a fairly good correlation between the Newmont values of sulfide content and the peroxide method acid potential, which suggests that the most indicative values in Table 4-24 are the acid potential values (Davy, 1992). These values indicate that all samples have a net acid generating capacity, with the exception of sample B18-3. In addition, all samples resulted in immediate acidic pH values when water was added in a 1:1 mixture.

The samples with the largest acid generating capacity include:

Sample ID	Acid Potential
B2-1	15.0
B14-1	13.0
B14-3	13.0
T5SC	17.0

Most of the higher values are from mine waste material. Higher metal concentrations (particularly Zn and Cu) are also typically associated with samples with the largest sulfur and acid potential values. The potential acid values shown above can be used to directly calculate the required amount of lime that would be necessary to neutralize the waste materials.

4.6.2.2 Pond Sediment Chemistry

The results of the analyses of the single pond sediment samples collected from each of the 7 surface water impoundments are shown in Table 4-24. The pond sediment concentrations for the various analytes are very similar to those determined for the pond water from each of the impoundments (Davy, 1992).

Copper concentrations in the pond sediments are highest in pond MRC1 (1,800 mg/kg) and lowest in pond MRC2 (100 mg/kg). Iron concentrations vary from 92,000 mg/kg in pond HRC1 to 8,700 mg/kg in pond MRC2. Gold was detected only in ponds MRC1 and MRC2 (1.1 and 2.5 mg/kg, respectively). Pond MRC1 contained by far the highest concentration of zinc (2,900 mg/kg), while pond HRC3 contained the lowest concentration (170 mg/kg). Silver concentrations vary from 2.2 to 21 mg/kg throughout the 7 impoundments. Lead concentrations are most elevated in pond MRC1 (1,200 mg/kg) and the lowest in pond MRDR (290 mg/kg). Arsenic concentrations vary from 42 to

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Attorneys for U.S. Fish and Wildlife Service

BEFORE THE STATE WATER RESOURCES CONTROL

In the Matter of the Water Rights Hearing for the Lower Mokelumne River

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CLOSING STATEMENT
U.S. FISH AND WILDLIFE SERVICE

EXISTING CONDITIONS

The U.S. Fish and Wildlife Service (Service) participated in this hearing to assist the State Water Resources Control Board (Board) in determining terms and conditions for an order to protect public trust resources in the lower Mokelumne River. The Service's testimony reflected agency concerns about fish and wildlife habitat and populations existing from Pardee Reservoir downstream to the Sacramento-San Joaquin Delta. While we are concerned about fish and wildlife resources throughout the Mokelumne River Basin, for purposes of this hearing our highest priority is to protect and restore the remaining 63 miles of

anadromous fish habitat below Camanche Dam, [illegible]
riparian vegetation of the river corridor.

We testified that the habitat is degraded and that anadromous fish populations have declined to extremely low levels, so low that consideration is being given to listing these fish populations as threatened or endangered. During the course of the hearing, the Service listened to testimony by East Bay Municipal Utility District (EBMUD) suggesting that pre-Camanche and post-Camanche adult salmon escapement numbers are essentially the same. However, cross-examination of EBMUD by the California Sportfishing Protection Alliance regarding the escapement data past Woodbridge Dam clearly points out the likelihood that pre-Camanche escapement numbers were greatly underestimated, and that post-Camanche escapement numbers are much lower than pre-Camanche escapement numbers.

Although there are few accurate records of the quality of the fishery habitat under pre-Camanche conditions, clearly, the severely reduced flows dedicated to fishery purposes have greatly impaired reproduction. For example, only 13,000 acre-feet are provided for fish flows during dry and above normal/wet years and 5,400 acre-feet during critical dry years. Also, the erratic nature of flows, resulting from peaking power and flood control releases, has had an adverse impact on adult migration, spawning, incubation and fry life stages. Even without precise historic information, it is reasonable to assume that the numerous impoundments throughout the watershed have caused an increase in average annual water temperatures to the detriment of the anadromous fishery. Testimony by several parties confirmed that Camanche Reservoir, because of its large surface area and shallow depth, acts as a heat sink, warming the waters that flow into it.

In addition, Camanche Dam has intercepted recruitment of suitably sized spawning gravels from upstream sources, thus reducing salmon spawning habitat to a relatively short section of river, i.e., approximately 6.5 miles below Camanche Dam. It is well documented that below dams like Camanche, spawning habitat gradually declines over time. Without periodic replenishment of suitably sized gravels, the habitat value of the spawning beds declines in quality and quantity. The absence of properly timed flushing flows below Camanche Dam to cleanse the gravels of fine sediments also has reduced their suitability as spawning and incubation habitat.

Fish and Wildlife Service fishery biologist Gary Taylor testified that the lower river's riparian vegetation is diminishing over time. He noted that during Service site visits, he observed numerous areas in the riverine corridor devoid of vegetation along with a consistent absence of tree and shrub regeneration. A dense canopy of tall trees and overhanging undergrowth is needed to provide shade and cover along the main river channel and side channels. Such vegetation is important for both fish and wildlife survival, and as trees and shrubs die and fall into the river, they add to instream cover. As described in the California Department of Fish and Game (DFG)

Lower Mokelumne River Fisheries Management Plan, riparian vegetation also produces food which becomes available to a variety of fish species. We heard no testimony that refutes this account of diminishing riparian vegetation along the river.

The volume and timing of flows in the Mokelumne River greatly affect vegetation in the riparian corridor. Flows of sufficient volume are needed seasonally to fill the backwater channels, flush stagnant waters, and recruit nutrient-laden fine sediments that promote plant growth. Therefore, the Board should also consider the flow needs of the riparian corridor in setting terms and conditions.

Fish and Wildlife Service biologist Judy Sefchick testified that the management of Camanche Reservoir elevations and Pardee inflows have not consistently provided water of suitable quality to the Mokelumne River Fish Facility (MRFF) and the lower Mokelumne River fishery. Using EBMUD's own studies and monitoring results she documented occurrences of low dissolved oxygen, elevated hydrogen sulfide, and elevated heavy metal levels at critical times of the year for fisheries and other aquatic resources. Her findings substantiate the need for immediate action to restore water quality in Camanche Reservoir, the MRFF, and the lower Mokelumne River.

In repeated testimony at the hearing, low dissolved oxygen levels were cited as one of the major contributors to MRFF fish kills in 1987, 1988, and 1989. Ms. Sefchick recognized the efforts made by EBMUD to provide at least 7 ppm dissolved oxygen to the lower Mokelumne River. However, she indicated that in order to adequately maintain all life cycle stages of salmonids, dissolved oxygen levels in the lower Mokelumne River must be greater than 8 ppm. This is consistent with the U. S. Environmental Protection Agency Quality Criteria for Water 1986 (USFWS Exhibit No. 6) for the maintenance and protection of aquatic resources.

While Russell Bowen of EBMUD suggested that heavy metals are not a problem in the lower Mokelumne River system, he and other EBMUD witnesses admitted during cross-examination that Camanche Reservoir releases regularly exceed EPA criteria for the maintenance and protection of aquatic resources. Ms. Sefchick testified that dissolved metal concentrations available to aquatic organisms have exceeded the EPA criteria of 0.0031 ppm copper and 0.0248 ppm zinc as recently as 1989, as shown in the Camanche Reservoir Water Quality Studies Final Report prepared by Brown and Caldwell (EBMUD Exhibit 33 A-13, pages 19-23). In addition, in her rebuttal testimony, Ms. Sefchick testified that the water quality data provided by EBMUD in Exhibit 83 shows exceedences of the EPA metals criteria as recently as October 20, 1992.

During rebuttal, Ms. Sefchick testified that the data provided in EBMUD Exhibit 83 shows that levels of copper and zinc repeatedly exceeded EPA criteria (EPA 1986) throughout EBMUD's water quality monitoring program. At CAMC, a sampling station for discharge to the river below Camanche Dam (map in EBMUD

Exhibit 33 Appendix A-5) (Enclosure 1), 26-53 percent of the sampling dates between 1989 and 1992 showed exceedences of the EPA criteria for copper or zinc, or both. Ms. Sefchick also pointed out that in 1987 no data was collected to determine metal concentrations, and in 1988, only total concentrations of metals were measured (dissolved metal concentrations are needed to assess concentrations that are bioavailable to fishery and aquatic resources).

Ms. Sefchick further testified during rebuttal that EBMUD Exhibit 83 shows that for many months of the year, fish in the lower river are exposed to levels of heavy metals that exceed healthful conditions. At sampling stations CAMC and CAMD, exceedences occurred in 9 months of the year in 1989, in 6 of the 8 months sampled in 1990, in 7 of the 11 months sampled in 1991, and in 6 of the 11 months sampled in 1992.

Ms. Sefchick also stated during rebuttal that the data in EBMUD Exhibit 83 show that the frequency of monitoring has been highly variable for the three sampling stations most indicative of water quality conditions in the lower Mokelumne River. Sometimes EBMUD monitored weekly, sometimes once a month, and on occasion, several times a day. Sometimes no monitoring was done for months or even years. She pointed out that for a period of over 2 years (June 1989 to August 1991) sampling station VAPK, the only sampling station in the lower Mokelumne River, was not monitored at all to determine metal concentrations. Only seven samples were taken to determine metal concentrations at sampling site VAPK for the period of May 1988 through July 1991 (EBMUD Exhibit 83). She testified that in order to gain an accurate and complete account of Mokelumne River water quality conditions and their effects on fishes, and to fully assess the impact of EBMUD's operations on the MRFF and the lower Mokelumne River, a more intense strategy that includes a greater number of sampling sites and more frequent sampling of the lower River is needed. Bioassay testing for chronic effects; and monitoring of the river to observe changes in fish health, behavior, or fish mortality is also needed.

During the Service's cross examination of EBMUD, EBMUD indicated that no deleterious effects of metals have been observed in Mokelumne River fishes. However, they acknowledged that no testing has been done to determine the effects of elevated metal concentrations on fish. The Service testified that avoidance reactions, reduced swimming speeds, and delayed migration are all behavioral changes of fish that could result from exposure to water containing elevated metal concentrations. Monitoring the behavior and health of chinook salmon and other anadromous fish is especially important since they must navigate hundreds of miles of river and ocean to complete their life cycle. However, the necessary testing to determine the sublethal effects of the elevated metal concentrations on these fish has not been undertaken.

The acute bioassay done by EVS Consultants (EBMUD Exhibit A33 A-13) demonstrates that metal concentrations in Camanche

Reservoir sediments could be toxic to fish. The study report states on page 49 that, "The bioassay tests established that resuspension of the sediments from the river and reservoir can lead to toxic solutions."

In response to a February 18, 1993 request from Robert C. Helwick, Esq., of EBMUD, the Service provided general technical assistance concerning EBMUD's development of a lower Mokelumne River water quality monitoring plan (Enclosure 2). The Service provided framework guidelines for a water quality monitoring plan that would provide reliable data indicative of water quality conditions in Pardee and Camanche Reservoirs, the Mokelumne River Fish Facility, and the lower Mokelumne River. The Service recommended that EBMUD prepare a water quality monitoring plan, incorporating the Service's guidelines, for review by the Service and other appropriate parties. To our knowledge EBMUD has not responded to the Service's recommendation.

DFG AND EBMUD PLAN COMPARISON

Both the DFG and EBMUD prepared comprehensive plans for maintaining and restoring fish and wildlife public trust resources. The Service evaluated the DFG's Lower Mokelumne River Fisheries Management Plan (DFG Plan - DFG Exhibit 22), and EBMUD's Lower Mokelumne River Management Plan (EBMUD Exhibit 32), with regard to their goals and likelihood of success. We found some areas of agreement in terms of flow amounts, timing of releases, fluctuation control, temperature criteria, and non-flow related measures. However, there are many areas of disagreement which are of great importance. These include (1) definition of water years for water availability and associated flow management, (2) water temperature criteria and measurement points, (3) management measures during low flow years, (4) Pardee and Camanche Reservoir operation to maximize coldwater storage, (5) water quality criteria implementation, and (6) instream flows.

Gary Taylor testified that the DFG Plan is superior to the EBMUD Plan for protecting and restoring fish and wildlife public trust resources in the lower Mokelumne River. After reviewing the hearing submittals and listening to testimony, the Service remains convinced that this is true. The minimum instream flows recommended in the EBMUD plan, as displayed in EBMUD Exhibit No. 25, Table 4, are far below those needed to restore the salmon and steelhead resources. Reducing flows following the spawning period and continuing lower flows through the spring rearing period is not a suitable management scheme. Spawning-level flows should be continued into the early and late spring period to ensure that habitat is available for steelhead spawning and for juvenile salmon and steelhead rearing. Increased levels of flow are needed in the late spring to encourage downstream emigration and to improve passage to the San Francisco Bay/Sacramento-San Joaquin Delta (Delta).

Another serious deficiency in the EBMUD Plan is the reliance on trapping emigrating juveniles and smolts and trucking them farther downriver to the Delta in many years. This type of management action should only be employed under extreme conditions on rare occasions. Frequent reliance on this type of management, in lieu of implementing operational improvements to provide adequate flows and to meet water temperature criteria, is unacceptable. Reliance on trapping and trucking in approximately 50 percent of the water years would likely result in much greater straying of adults to other systems, lengthen the period for restoration of the Mokelumne River strain of fall-run chinook salmon, and cause unnecessary handling mortalities. Also, the extremely low flows coincident with the trapping and trucking scheme would adversely impact the entire ecosystem of the Mokelumne River downstream of Woodbridge Dam.

In contrast to the EBMUD Plan, the DFG Plan would provide higher spawning level flows throughout the spring period, and further increase flows in the late spring to ensure successful emigration of juveniles and smolts. The DFG Plan does not rely on trapping and trucking during dry and critically dry years but instead focuses on a more condensed life cycle for fall-run chinook salmon that avoids the negative aspects of trapping and trucking. The Service generally agrees with most of the elements in the DFG Plan, as Gary Taylor testified. However, Mr. Taylor informed the Board that the Service was conducting an independent analysis of instream flow needs for use in commenting on the Federal Energy Regulatory Commission's (FERC) Environmental Impact Statement for the Lower Mokelumne River Project, FERC No.

2916. The Service provided comments on FERC's draft Environmental Impact Statement for the Lower Mokelumne River Project on March 2, 1993. The comments include recommended instream flow schedules for the lower Mokelumne River. We have attached a copy of those comments for the Board's consideration (Enclosure 3).[1]

The Board should note the similarity of the Service's recommended flows to those of the DFG Plan. It is the Service's position that either of the instream flow schedules is superior to those proposed by EBMUD for the protection of fish and wildlife resources.

Water Availability

The DFG Plan proposes a more useful and practiced formula than the LMRMP for measuring water availability. By applying the formula in the DFG Plan, for example, unimpaired inflow into Pardee Reservoir provides a clear measure of water availability for allocation. In contrast, EBMUD's proposal allows for more manipulation of water between storage reservoirs and complicates comprehension of water availability within each water year.

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[1] Please be aware that page 11 of the March 2 letter was a duplicate of page 10 ("Minimum Flows... Normal and above Water years"), thus flows for dry and critical water years were omitted. On May 14, 1993, a letter was sent to the FERC explaining the omission and providing the correct dry/critical years schedule (Enclosure 4).

River Corridor Management

The DFG Plan strives to maintain and improve the entire 63 miles of river corridor below Camanche Dam for anadromous fish by setting flow and temperature criteria suitable for all life stages of salmon and steelhead. In contrast, the EBMUD plan dismisses the lower two-thirds of the river below Woodbridge Dam for all low flow years (50% occurrence) and resorts to trapping and trucking outmigrant fish (EBMUD-Exhibit 25, page 24). Testimony from the DFG and EBMUD emphasized the need to re-establish lower Mokelumne River stock because it would have the greatest likelihood of returning to spawn in the Mokelumne, instead of straying into some other San Joaquin River tributary or up the Sacramento River. No testimony at the hearing disputed that trapping and trucking increases mortality, resulting from handling, and leads to increased straying. The EBMUD plan, by employing this management practice in half the years, is decidedly inferior to the DFG Plan.

Water Temperature Criteria

In his testimony, Gary Taylor stated that he agrees with most of the water temperature criteria recommended in the DFG Plan. He remains convinced, however, that water temperature criteria should not be based on water availability, i.e., dry and critical year designations. Instead, criteria should be based on the biological needs of the target species, for example, fall-run chinook salmon and steelhead.

There are substantial data indicating that temperatures exceeding 16 degrees Celsius for an extended period during the juvenile life stage can result in growth stress, increased susceptibility to disease, and otherwise reduce survival. Page 66 of the DFG Plan cites some of the references (Rich 1987 and Reiser and Bjornn 1979) that support setting 15.6 degrees Celsius as the upper threshold for the juvenile life stage.

Temperature criteria should be set for measurement points that coincide with management plan goals and should be achievable in most years. This is another shortcoming of the EBMUD Plan. Instead of seeking alternative means to meet the water temperature needs of the species, the EBMUD Plan abandons temperature criteria for a reach of the river (downstream of Woodbridge Dam) that is essential for salmon and steelhead survival.

Russell Bowen testified that EBMUD had investigated several alternative means to provide colder, better oxygenated water for the river and the MRFF. However, EBMUD dismissed the Pardee Reservoir direct diversion option (described on page 4-10 of EBMUD-Exhibit 33, Appendix A-5), which, in the Service's view, is a viable option that would enable the DFG Plan temperature criteria to be met. This same concept was proposed as a solution to the water temperature and water quality problems associated with Camanche Reservoir by Dr. Chapman testifying on behalf of the California Sport Fishing and Protection Alliance (CSPA-Exhibit 16, page 16). The Service believes there are feasible measures, such as a Pardee Reservoir direct diversion and a Camanche Reservoir multilevel intake structure, that can be taken to meet the DFG Plan water temperature criteria.

Woodbridge Dam/Lodi Lake Fish Passage

In his testimony, Gary Taylor identified many concerns about the adverse impacts of the Woodbridge Dam/Lodi Lake facilities on anadromous fish passage. He pointed out many deficiencies in the designs of the Woodbridge Canal fish screening facility and in the facilities at the dam to pass fish upstream and downstream. Mr. Taylor also testified that he believes Lodi Lake itself is an impediment to the safe and timely downstream migration of salmon and juvenile steelhead. Through their own independent investigation, EBMUD consultants identified many of the same deficiencies in the Woodbridge Canal fish screens and fish passage facilities. These deficiencies are pointed out in EBMUD-Exhibit 32, Appendix G. Dan Odenweller of the DFG testified that the fish screens do not meet current specifications and that modifications are warranted.

Although Woodbridge Irrigation District provided testimony and cross examination to emphasize that they were not responsible for any fish problems because (1) the DFG designed and constructed all the fish screening and passage facilities, and (2) there is a lack of conclusive evidence that the screening and passage facilities or the lake are causing significant mortality, we stand by our assessment and conclusions. We remain convinced that the Lodi Lake complex, including the dam and diversion, is a serious impediment to timely anadromous fish migration and contributes to the low productivity of Mokelumne River anadromous fish populations.

Water Quality

The DFG Plan focuses on criteria implementation to insure the maintenance of suitable water quality in the MRFF, Camanche Reservoir, and the lower Mokelumne River. In contrast, the EBMUD Plan does not propose implementation of criteria and focuses on technical-fix solutions for water quality problems. The Service believes that the DFG Plan would better provide for the protection and restoration of fishery and other aquatic resources until additional studies can be conducted of Camanche Reservoir, the MRFF, and the lower Mokelumne River. During cross-examination by the Service, EBMUD acknowledged that the Speece Cone (EBMUD's primary physical solution to improve water quality to the MRFF and the lower Mokelumne River) is highly experimental. Although benefits from the Speece Cone could result, the technology is unproven and should not be relied upon as the sole means to improve water quality.

The Board should be aware that in its October 1992 report titled: "Camanche Hypolimnetic Oxygenation Demonstration Project", EBMUD stated the Speece Cone would be constructed and in operation by June 1, 1993. Following a recent site visit, DFG staff informed the Service that no evidence of construction activity of the Speece Cone is evident at this time.

The potassium permanganate system that is currently being used at the MRFF to treat elevated levels of hydrogen sulfide has been proposed by EBMUD as the primary back-up system if the Speece Cone fails. Judy Sefchick testified during cross-examination that the potassium permanganate system has many drawbacks. Besides adding chemicals to the river, the system is unreliable. The system's flow meters and sniffers have never worked properly, as is indicated in EBMUD Exhibit 33 A-34.

Ms. Sefchick testified that the factor most responsible for the convergence of water quality problems such as low dissolved oxygen, elevated levels of hydrogen sulfide, and elevated levels of heavy metals appears to be the depletion of the Camanche Reservoir hypolimnion. The DFG Plan includes a more reliable way to provide good quality water by requiring that a minimum pool level be set in addition to minimum releases from Pardee Reservoir. The EBMUD proposes a minimum hypolimnion level in Camanche Reservoir to prevent early destratification; however, it also proposes that releases from Pardee, used to maintain the hypolimnion, be halted if Pardee storage falls below a certain level. Allowing EBMUD unfettered flexibility in the management of Pardee releases and Camanche Reservoir levels could result in inappropriate management of the reservoir, especially in dry years, that could further harm populations of chinook salmon and steelhead trout. Both the DFG Plan and the Service support the adoption of a reservoir management plan that specifies a minimum pool that, with proper management of Pardee releases, will insure maintenance of an adequate hypolimnion in all water years. Although we agree that a minimum pool level must be maintained in order to preserve the Camanche Reservoir hypolimnion, we believe that further studies should be completed and limnological models developed to determine the optimum level under various water year conditions.

During the rebuttal testimony of Judy Sefchick, it became clear that the data in EBMUD Exhibit 83 provide additional support for the Service's recommendations that: (1) a more intensive and structured monitoring program for recording metals data and other water quality data be established, which includes several sampling sites in the lower Mokelumne River, (2) additional studies be done to assess chronic metal toxicity in lower Mokelumne River fish, and (3) interim metals criteria be set and met until site-specific criteria for the Mokelumne River can be developed.

RECOMMENDATIONS

The Service recognize that not all of the measures needed to accomplish full protection and restoration of the lower Mokelumne River fish and wildlife public trust resources are within the jurisdiction of the Board. We also recognize that not all needed measures within the jurisdiction of the Board are immediately implementable. Therefore we present our recommendations under the headings of interim and long-term measures. Accordingly, the Fish and Wildlife recommends that:

INTERIM MEASURES

1. The instream flows developed by the Service for above normal, dry and critical water years, to be measured at Highway 99 and Woodbridge Dam, be implemented, along with followup monitoring to determine their effectiveness in attaining habitat and population maintenance and restoration goals.

2. The mean daily water temperature criteria specified on page xv of the DFG Plan be adopted, except that water temperature from April 1 through May 31 not exceed 15.6 degrees Celsius above the confluence of the Cosumnes River.

3. The short-term daily streamflow fluctuation and streamflow reduction measures described on page xvi of the DFG Plan be implemented.

4. The area below Camanche Dam be managed in low-flow years as described in the DFG Plan, but with the flow schedule recommended by the Service. Trapping and trucking fish during low flow years should not be considered as a management practice only in the rarest of emergencies.

5. A comprehensive bio-engineering study of the entire Lodi Lake complex be conducted to determine how it impacts upstream adult passage and downstream fry and juvenile passage.

6. A phased program be implemented that incorporates such non-flow measures, as increased law enforcement to halt poaching,

phased restoration of spawning gravels, elimination of gravel mining operations within the stream channel, state-of-the-art screening on all fish pumps along the river, and a riparian vegetation management plan.

7. Water quality criteria be adopted for Camanche Reservoir, the MRFF, and the lower Mokelumne River. The following interim water quality criteria should be imposed for the Lower Mokelumne River until site-specific studies can be conducted:

(1) > 8 ppm dissolved oxygen (EPA 1986)[2]

(2) < 0.002 ppm hydrogen sulfide (EPA 1986)

(3) 6.5 - 9.0 pH (EPA 1986)

(4) Criteria for copper, cadmium, and zinc as recommended in the DFG's 1991 Management Plan -

$\leq$ 0.003 ppm copper

$\leq$ 0.009 ppm zinc

$\leq$ 0.0001 ppm cadmium

---

[2] These criteria apply to the lower Mokelumne River only; 7.0 ppm dissolved oxygen is acceptable in Camanche and Pardee Reservoirs.
In her testimony, Judy Sefchick indicated that the Service supports adoption of the criteria developed by the DFG for Central Valley streams for cadmium, copper, and zinc until site-specific criteria for the lower Mokelumne River can be developed. This position is consistent with that of the EPA which supports each State developing water quality criteria that are appropriate for species, like chinook salmon, that are most sensitive to water quality conditions. Although precise heavy metals criteria for the lower Mokelumne River need to be determined, we believe that the criteria developed by the DFG for the upper Sacramento River should be used until site-specific studies can be done.

(5) other metals criteria as recommended by the EPA (1986) for the protection of aquatic resources.

Camanche Reservoir is a sink for heavy metals and has potentially toxic levels of heavy metals in its bottom sediments that may be resuspended under certain conditions. EBMUD, through its own studies (as shown in EBMUD Exhibit 33 A-1 and EBMUD Exhibit 33 A-13), has identified the same potential problems with heavy metal toxicity to aquatic organisms that the Service has recognized. The Camanche Reservoir Water Quality Studies Final Report (EBMUD Exhibit 33 A-13) states on page 51, "Resuspension of reservoir sediments during turnover conditions and the resulting release of metals as dissolved species, should be carefully monitored. During these turnover periods, levels of dissolved metals may contribute to the stress on fish in the reservoir and MRFF."

LONG TERM MEASURES

1. Instream flow requirements be revised after monitoring the effects of the Service's recommended regime for no less than a 10-year period that includes at least one representative example of each type water year as defined by the DFG Plan.

2. The water temperature regime described under the interim measure recommendations be continued unless a preponderance of study data or added project features justify further modifications.

criteria be continued, unless study data or added features justify modifications.

4. The area below Camanche Dam be managed in low-flow years as under the interim recommendations.

5. Modifications to the configuration and operation of the Woodbridge Dam/Lodi Lake fish passage facilities be made following completion of the interim bio-engineering study.

6. The phase-in of non-flow measures be continued based on ongoing monitoring and study results.

7. Water quality criteria be adjusted to reflect the results of site-specific studies of the lower Mokelumne River, and implement a reservoir management plan that, with the proper management of Camanche Reservoir elevations and Pardee releases, will insure the maintenance of an adequate hypolimnion in Camanche Reservoir to provide water for the MRFF and the lower Mokelumne River that meets the water quality criteria.

Respectfully submitted,

John W. Burke III
Regional Solicitor

May 17, 1993
Date

By: Lynn Cox
Assistant Regional Solicitor

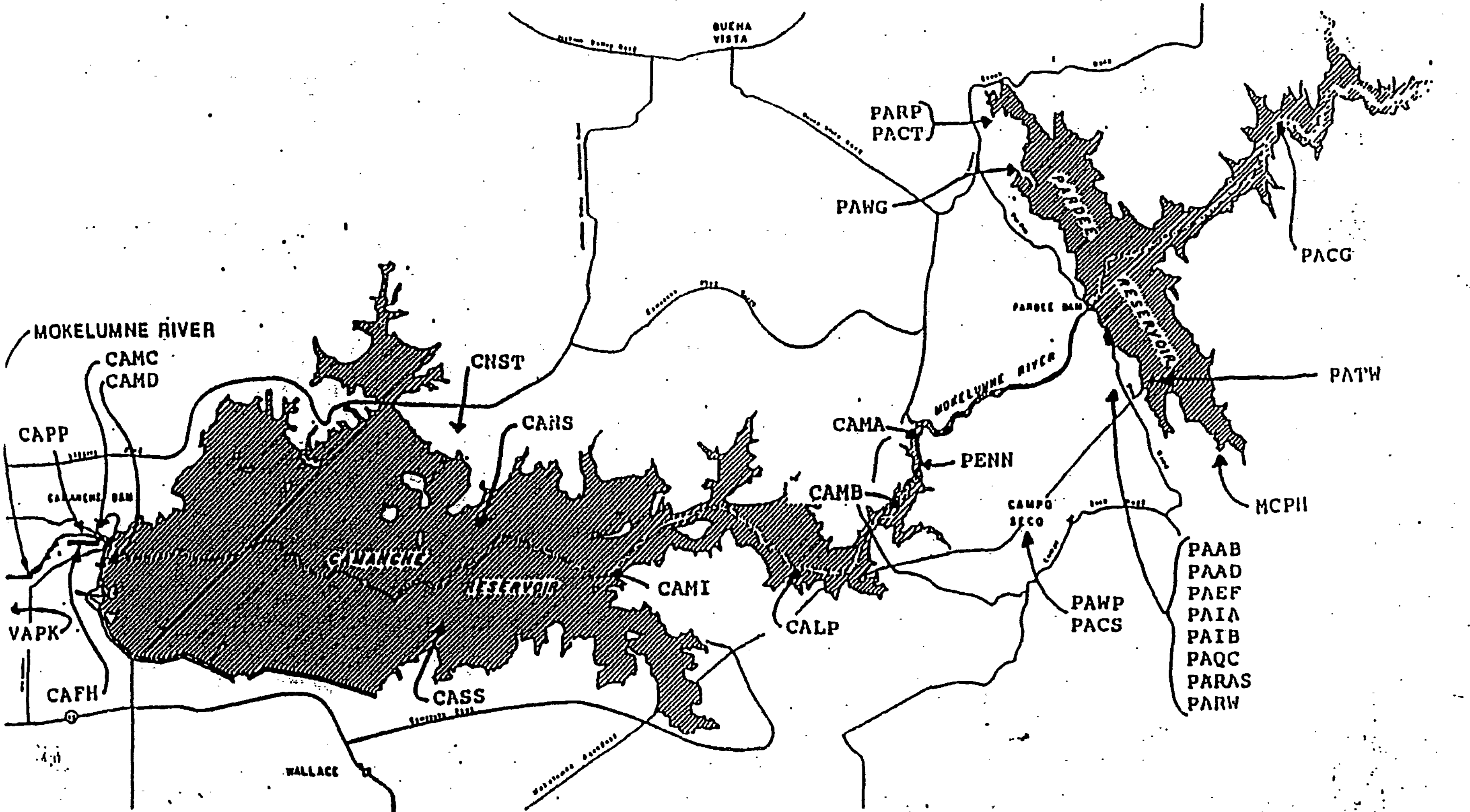

FIGURE 2-1
WATER QUALITY SAMPLING STATIONS FOR CAMANCHE AND PARDEE RESERVOIRS

Pursuant to Mr. Del Piero's request at the Mokelumne River Hearing in November 1992, additional water quality data concerning heavy metal concentrations was supplied by EBMUD. After reviewing this supplemental data, the USFWS made some general observations.

The data provided by EBMUD only included the 3 sampling stations most indicative of conditions in the lower Mokelumne River. Exhibit 83 has indicated that the 3 sampling stations were: CamC, which samples the discharge from Camanche Dam to the Mokelumne River; CamD, which samples the Camanche Reservoir lower outlet to the Mokelumne River; and station VAPK, which samples the Mokelumne River at Van Assen Park. According to the map in EBMUD Exhibit 33 Appendix A-5, CamD is the outlet within the Reservoir, whereas CamC samples the river side of the discharge and is therefore more indicative of Mokelumne River conditions.

Although EBMUD indicated in Exhibit 33 (page 4) that they began a water quality monitoring program in September 1987, after a fish kill at the MRFF to determine what was occurring in the releases from Camanche Reservoir to the hatchery and downstream, the data presented in Exhibit 83 show that heavy metal concentrations were not analyzed for at any of the 3 sampling sites until May 1988. In that month, heavy metals were monitored at sampling stations CamD and VAPK. EBMUD did not begin to monitor for heavy metal concentrations at CamC until September 1988.

The data contained in Exhibit 83 show that the frequency of monitoring has been highly variable for the 3 sampling stations most indicative of water quality conditions in the river. The data show that sometimes EBMUD monitored weekly, sometimes once a month, and on occasion, several times a day. Sometimes no monitoring was done for months or even years. For example, at the single sampling location in the lower river (VAPK), no monitoring at all was done to determine metal concentrations for a period of over 2 years (June 1989 to Augusst 1991). Only 7 samples were taken to determine metal concentrations for that site for the entire period between May 1988 through July 1991.

The sporadic nature of the sampling does not demonstrate an intensive water quality monitoring program which is necessary in order to obtain the information needed to fully assess the impact of EBMUD's operations on the MRFF and the lower Mokelumne River. Nor does the data provide an adequate database of baseline conditions in the river from which to draw a conclusion that heavy metals are no longer a problem.

After reviewing the data provided in EBMUD Exhibit 83, the USFWS had some concerns about the data as presented. On several occasions, the dissolved metal concentration exceeded its corresponding total metal concentration for both copper and zinc. Total metal concentrations represent the sum of such things as soluble complexed forms of the metal, the occluded forms of the metal in minerals, clays, and sorbed to particulate matter, as well as dissolved portions of the metal. The dissolved metal concentration should therefore only be a portion of the total metal concentration, and should not happened from 1989 to 1991 for copper and zinc.

The USFWS requested quality control and assurance data from EBMUD on December 28, 1992 in order to interpret the data in Exhibit 83 and understand these findings. We acknowledge and appreciate the additional information EBMUD provided to us however, no results were provided to explain the greater dissolved metal values. Since the USFWS found that the quality control and assurance information provided by EBMUD was not useful in interpreting the data in Exhibit 83, we have not included this information in our letter for your review. This information is available at our Sacramento office, however, if FERC wishes to review it in greater detail.

After reviewing the water hardness values supplied by EBMUD, we used hardness values of 20 at sampling stations CAMC and VAPK, and 25 at station CamD to assess the toxicity of copper and zinc. The data show that throughout EBMUD's monitoring program, there are elevated levels of copper and zinc and exceedences of the EPA (1986) criteria set for zinc and copper for the protection of aquatic resources. In the USFWS's examination of the data, zinc, copper, and cadmium were focused on.

In 1987, no data was collected to determine metal concentrations at any of the 3 sampling locations. In 1988, only total concentrations of metals, which are useless in evaluating the bioavailability of metals to fish, were measured. Dissolved metal concentrations, which are needed to assess the bioavailability to fishery and aquatic resources, were not measured.

In 1989, there were 11 sample dates in which exceedences of the EPA criteria for zinc occurred and 21 sample dates in which exceedences for copper occurred at CamC. Therefore, in 24 of the 67 sample dates, exceedences of the EPA criteria for copper, zinc, or both metals occurred. This represents 36% of the sampling dates. At CamD in 1989, 3 sample dates showed exceedences of the EPA criteria for zinc and 1 sample date showed exceedences for copper. At station VAPK, metal concentrations were given as total values in 1989, therefore exceedences could not be determined.

In 1990, even though fewer samples were taken at the sampling stations, 4 sample dates showed exceedences for zinc and 7 sample dates showed exceedences for copper at CamC. Nine of the 17 sample dates showed exceedences for copper, zinc, or both metals, which represented 53% of the data collected at CamC. At CamD in 1990, there was 1 exceedence of copper. No data was collected to determine metal concentrations at VAPK in 1990.

In 1991, 1 sample date showed an exceedence of zinc and 9 sample dates showed exceedences of copper at CamC. This represents 10 of the 26 samples or 38% of the sample dates that exceed the EPA (1986) criteria for copper, zinc, or both metals. One exceedence of zinc and 2 exceedences of copper occurred at CamD in 1991. There were no exceedences at VAPK, but only 5 samples were collected there in 1991.

As recently as October 20, 1992, an exceedence of the EPA criteria for copper occurred. Six exceedences of copper occurred at CamC in 1992, which represents 26% of the sample dates. No exceedences were found at CamD of VAPK in 1992.

Although the frequency of monitoring has been highly variable for the 3 sampling stations most indicative of water quality conditions in the lower Mokelumne River, the data show elevated levels of copper and zinc and repeated exceedences of the EPA (1986) criteria over the entire period of monitoring. These exceedences indicate a potential problem for fisheries and aquatic resources in the Mokelumne River.

The data show that fish in the lower river are exposed to levels of heavy metals that exceed healthful conditions for many months of the year. In 1989, exceedences occurred during 9 months of the year, in 1990, exceedences occurred in 6 of the 8 months sampled, in 1991, exceedences occurred in 7 of the 11 months sampled at CamC and CamD, and in 1992, exceedences occurred in 6 of the 11 months sampled as indicated by the data.

Even though the data show frequent violations of the water quality standards for metals, the effects of those exceedences on fish have not been studied. To date, there has not been any chronic toxicity testing to determine the effects of the metals on such things as fish behavior, migration, swimming speed, feeding, or egg incubation. The information and studies presented to date by EBMUD do not provide a basis for the conclusion that heavy metals are not a factor affecting the fishery or aquatic resources in the Mokelumne River.

Cow Creek -
Bacteria

B.1.14 Clover Creek, Fecal Coliform

Summary of Proposed Action

The California Regional Water Quality Control Board-Central Valley Region, Regional Board, recommends the addition of Clover Creek to California's Clean Water Act Section 303(d) list due to impairment by fecal coliform. Information available to the Regional Board on fecal coliform levels in Clover Creek indicates that water quality objectives are not being attained. A description for the basis for this determination is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Clover Creek	**Pollutants/Stressors**	Fecal Coliform
Hydrologic Unit	507.33	**Sources**	Human and/or livestock sources
Total Waterbody Size	27.5 miles	**TMDL Priority**	
Size Affected	10.5 miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	The lower 10.5 miles	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	40° 38' 46"	**Upstream Extent Longitude**	122° 01' 10"
Downstream Extent Latitude	40° 33' 17"	**Downstream Extent Longitude**	122° 11' 15"

Watershed Characteristics

Clover Creek is located in Shasta County and flows from the foothills of Mount Lassen southwest to the Sacramento River, east of Anderson. Clover Creek is part of the Cow Creek watershed. Land use within the Cow Creek watershed previously included use by indigenous peoples and historic mining, and currently includes ranches, timberlands, and towns (Montoya and Pan, 1992; Hannaford and North State Institute for Sustainable Communities, 2000).

Water Quality Objectives Not Attained

The numeric objective for bacteria is not being attained in Clover Creek. The bacteria objective in the Basin Plan states, in part, "In waters designated for contact recreation (REC-1), the fecal coliform concentration based on a minimum of not less than five samples for any 30-day period shall not exceed a geometric mean of 200/100 ml, nor shall more than ten percent of the total number of samples taken during any 30-day period exceed 400/100 ml (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/~rwqcb5/bsnplnab.pdf)." The bacteria objectives are presented in terms of Most Probable Number (MPN) per 100 milliliters (ml). The bacteria objectives were evaluated for Clover Creek by comparing fecal coliform concentrations measured in Clover Creek to Basin Plan objectives.

Evidence of Impairment

Water samples were collected from the lower reach of Clover Creek between June and October 1999. The average fecal coliform levels in the water samples were above 300 MPN/100ml. The fecal coliform levels exceeded the geometric mean Basin Plan criterion (200 MPN/100ml) for at least five months in 1999. Many of samples were also above the 30-day Basin Plan criterion (400 MPN/100 ml) (Hannaford and North State Institute for Sustainable Communities, 2000).

Extent of Impairment

Clover Creek flows for approximately 27.5 miles. The lower reach of Clover Creek, from 10.5 miles upstream of its confluence to its confluence with the main stem of Cow Creek, is impacted by fecal coliform.

Potential Sources

Hannaford and North State Institute for Sustainable Communities (2000) concluded that Clover Creek contained "at least the wildlife input" and potentially low levels of livestock and human inputs of bacteria. The levels contributed by these sources are considered to be the background levels for the area. Since the impaired Clover Creek site is not known to contain more wildlife than the other areas, the excess bacteria "probably originated from livestock or human sources," including septic systems and/or sewage lines leaching into the streams (Hannaford and North State Institute for Sustainable Communities, 2000).

B.1.36 Oak Run Creek, Fecal Coliform

Summary of Proposed Action

The California Regional Water Quality Control Board-Central Valley Region (Regional Board) recommends the addition of Oak Run Creek to California's Clean Water Act Section 303(d) list due to impairment by fecal coliform. Information available to the Regional Board on pathogens levels in Oak Run Creek indicates that water quality objectives are not being attained. A description for the basis for this determination is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Oak Run Creek	**Pollutants/Stressors**	Fecal Coliform
Hydrologic Unit	507.33	**Sources**	Human and/or livestock sources
Total Waterbody Size	23.5 miles	**TMDL Priority**	
Size Affected	4.5 miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	From 16.5 miles before the confluence to 12 miles from the confluence.	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	40° 41' 41"	**Upstream Extent Longitude**	122° 02' 21"
Downstream Extent Latitude	40° 39' 19"	**Downstream Extent Longitude**	122° 04' 23"

Watershed Characteristics

Oak Run Creek is located in Shasta County, and flows from the foothills of Mount Lassen southwest to the Sacramento River, east of Anderson. Oak Run Creek is part of the Cow Creek watershed. Land use within the Cow Creek watershed previously included use by indigenous peoples and historic mining, and currently includes ranches, timberlands, and towns (Montoya and Pan, 1992; Hannaford and North State Institute for Sustainable Communities, 2000).

Water Quality Objectives Not Attained

The numeric objective for bacteria is not being attained in Oak Run Creek. The bacteria objective in the Basin Plan states, in part, "In waters designated for contact recreation (REC-1), the fecal coliform concentration based on a minimum of not less than five samples for any 30-day period shall not exceed a geometric mean of 200/100 ml, nor shall more than ten percent of the total number of samples taken during any 30-day period exceed 400/100 ml (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/~rwqcb5/bsnplnab.pdf)." The bacteria objectives are presented in terms of Most Probable Number (MPN) per 100 milliliters (ml). The bacteria objectives were evaluated for Oak Run Creek by comparing fecal coliform concentrations measured in Oak Run Creek to Basin Plan objectives.

Evidence of Impairment

Water samples were collected from the middle reach of Oak Run Creek between June and October 1999. The average fecal coliform levels in the water samples collected from Oak Run Creek were approximately 400 MPN/100ml. The fecal coliform levels exceeded the geometric mean Basin Plan criterion (200 MPN/100ml) for at least five months in 1999. The maximum fecal coliform count ranged up to almost 1,800 MPN/100ml. Many of samples were also above the 30-day Basin Plan criterion (400 MPN/100 ml) (Hannaford and North State Institute for Sustainable Communities, 2000).

Extent of Impairment

Oak Run Creek flows for approximately 23.5 miles. The middle reach, approximately 4.5 miles long, is impacted by fecal coliform.

Potential Sources

Hannaford and North State Institute for Sustainable Communities (2000) concluded that Oak Run Creek contained "at least the wildlife input" and potentially low levels of livestock and human inputs of bacteria.

The levels contributed by these sources are considered to be the background levels for the area. Since the impaired Oak Run Creek site is not known to contain more wildlife than the other areas, the excess bacteria "probably originated from livestock or human sources," including septic systems and/or sewage lines leaching into the streams (Hannaford and North State Institute for Sustainable Communities, 2000).

B.1.37 Orestimba Creek, Azinphos-methyl

Summary of Proposed Action

The California Regional Water Quality Control Board-Central Valley Region (Regional Board) recommends the addition of Orestimba Creek to California's Clean Water Act Section 303(d) list due to impairment by azinphos-methyl. Information available to the Regional Board on azinphos-methyl concentrations in Orestimba Creek indicates that water quality objectives are not being attained. The basis for this determination is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Orestimba Creek	**Pollutants/Stressors**	Azinphos-methyl
Hydrologic Unit	541.10	**Sources**	Agriculture
Total Waterbody Size	30 miles	**TMDL Priority**	
Size Affected	10 miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	The lower 10 miles, from the foothills to the SJR	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	37° 19' 31"	**Upstream Extent Longitude**	121° 06' 58"
Downstream Extent Latitude	37° 25' 17"	**Downstream Extent Longitude**	121° 00' 13"

Watershed Characteristics

Orestimba Creek is an ephemeral stream draining a portion of the west side of the San Joaquin Valley. Orestimba Creek flows result from stormwater runoff in the winter and irrigation return flow in the spring and summer. During the winter the creek can receive flow from Coastal Ranges as well as from the area that drains into the main canal of the Central California Irrigation District, depending on the intensity and duration of storms, thus increasing the drainage area to 125,102 acres.

Water Quality Objectives Not Attained

The narrative objectives for pesticides and toxicity are not being attained for azinphos-methyl in Orestimba Creek. The narrative objective for pesticides states, "No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses." The narrative toxicity objective in the Basin Plan states, in part, "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life." The narrative toxicity objective further states that "The Regional Water Board will also consider ... numerical criteria and guidelines for toxic substances developed by the State Water Board, the California Office of Environmental Health Hazard Assessment, the California Department of Health Services, the U.S. Food and Drug Administration, the National Academy of Sciences, the U.S. Environmental Protection Agency, and other appropriate organizations to evaluate compliance with this objective" (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/~rwqcb5/bsnplnab.pdf). The US Environmental Protection Agency (USEPA) has established an ambient water quality criterion for azinphos-methyl for the protection of freshwater aquatic life of 0.01 μg/L (USEPA, 1976).

Evidence of Impairment

Between 1992 and 1993, a total of 46 water samples collected from Orestimba Creek at River Road were analyzed for azinphos-methyl (Table 1). Between February 1992 and November 1993, two of the six samples analyzed (33%) contained azinphos-methyl concentrations at or above the USEPA criterion. The highest concentrations generally occurred between June and November; concentrations were also high in

B.1.48 South Cow Creek, Fecal Coliform

Summary of Proposed Action

The California Regional Water Quality Control Board-Central Valley Region, Regional Board, recommends the addition of South Cow Creek to California's Clean Water Act Section 303(d) list due to impairment by fecal coliform. Information available to the Regional Board on fecal coliform levels in South Cow Creek indicates that water quality objectives are not being attained. A description for the basis for this determination is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	South Cow Creek	**Pollutants/Stressors**	Fecal Coliform
Hydrologic Unit	507.33	**Sources**	Human and/or livestock sources
Total Waterbody Size	28.5 miles	**TMDL Priority**	
Size Affected	7 miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	From approximately 14 miles from the confluence to 7 miles before the confluence	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	40° 35' 21"	**Upstream Extent Longitude**	121° 55' 13"
Downstream Extent Latitude	40° 34' 55"	**Downstream Extent Longitude**	122° 00' 51"

Watershed Characteristics

South Cow Creek is located in Shasta County and flows from the foothills of Mount Lassen southwest to the Sacramento River, east of Anderson. South Cow Creek is part of the Cow Creek watershed. Land use within the Cow Creek watershed previously included use by indigenous peoples and historic mining, and currently includes ranches, timberlands, and towns (Montoya and Pan, 1992; Hannaford and North State Institute for Sustainable Communities, 2000).

Water Quality Objectives Not Attained

The numeric objective for bacteria is not being attained in South Cow Creek. The bacteria objective in the Basin Plan states, in part, "In waters designated for contact recreation (REC-1), the fecal coliform concentration based on a minimum of not less than five samples for any 30-day period shall not exceed a geometric mean of 200/100 ml, nor shall more than ten percent of the total number of samples taken during any 30-day period exceed 400/100 ml (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/~rwqcb5/bsnplnab.pdf)." The bacteria objectives are presented in terms of Most Probable Number (MPN) per 100 milliliters (ml). The bacteria objectives were evaluated for South Cow Creek by comparing fecal coliform concentrations measured in South Cow Creek to Basin Plan objectives.

Evidence of Impairment

Water samples were collected from the middle reach of South Cow Creek between June and October 1999. The average fecal coliform level in the water samples was approximately 800 MPN/100ml. The fecal coliform levels exceeded the geometric mean Basin Plan criterion (200 MPN/100ml) for at least five months in 1999. Many of samples were also above the 30-day Basin Plan criterion (400 MPN/100 ml) (Hannaford and North State Institute for Sustainable Communities, 2000).

Extent of Impairment

South Cow Creek flows for approximately 28.5. The middle reach, approximately 7 miles long, is impacted by fecal coliform.

Potential Sources

Hannaford and North State Institute for Sustainable Communities (2000) concluded that the South Cow Creek site contained "at least the wildlife input" and potentially low levels of livestock and human inputs of bacteria, which they considered to be the background level for the area outside the impaired area. Since the impaired South Cow Creek site is not known to contain more wildlife than the other areas of South Cow Creek, the excess bacteria "probably originated from livestock or human sources," including septic systems and/or sewage lines leaching into the streams (Hannaford and North State Institute for Sustainable Communities, 2000).

Final Report → www.delta. ~~delta~~ dfg .ca.gov/afrp/documents/cowcrk rpt.pdf

Preliminary Water Quality Assessment of Cow Creek Tributaries

Morgan J. Hannaford
and
North State Institute for
Sustainable Communities

Little Cow Crk
Oak Run Crk
Clover Crk
Old Cow Crk
S. Cow Crk
Main Stem Cow Crk

May 15, 2000

report submitted to

Patricia Parker
US Fish and Wildlife Service
10950 Tyler Road
Red Bluff, CA 96080

(+)

Temp - impaired
DO - ok
Turbidity - pot. impaired
Fecal coliform - impaired
pH - ok
(Info. Already placed in "Pot. 303(d) changes" file)

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OVERVIEW

Basin Geography

The Cow Creek watershed encompasses approximately 430 square miles and drains the base and foothills of Mt. Lassen in a southwest direction into the Sacramento River. The basin area is roughly bordered by Highway 299 to the north, Highway 44 to the south, and Highway 89 to the east. Cow Creek is a dendritic (tree like) stream system and can be divided into five main sub-basins (see relief map, Figure 1), including Little Cow Creek, Oak Run Creek, Clover Creek, Old Cow Creek and South Cow Creek.

According to area maps and historical naming convention the Main Stem of Cow Creek begins at the confluence of South Cow and Old Cow Creeks. From there it flows west for seven miles where it joins with Clover Creek, and then within one more mile joins with Oak Run Creek. The Main Stem of Cow Creek and Little Cow Creek converge further downstream, at the Highway 44 bridge crossing. The Main Stem of Cow Creek continues south for approximately 7.5 miles where it empties into the Sacramento River, 23 miles downstream of Shasta Dam and 4 miles east of the town of Anderson.

Little Cow Creek (also known as North Cow Creek) drains a 148 square mile basin. The headwaters (Cedar Creek, North Fork, and Mill Creek) originate at an elevation of roughly 5900 feet on the west slopes of Tolladay Peak, Snow Mtn. and Clover Mtn. Little Cow Creek flows for 36 miles southwesterly along Hwy 299 and then southerly along Deschutes Rd. before it joins with the Main Stem Cow Creek at Hwy 44.

Oak Run Creek, the smallest of the five main tributaries, drains a 42 square mile basin and originates at approximately 3200 feet elevation. Oak Run Creek flows 23.5 miles southwesterly, past the town of Oak Run and along Oak Run Road, to its confluence with the Main Stem of Cow Creek in Palo Cedro.

Clover Creek drains a 54 square mile basin and originates at approximately 5500 feet elevation on the south slope of Clover Mountain. Clover creek flows 27.5 miles from the headwaters to its confluence with the Main Stem of Cow Creek.

Old Cow Creek drains an 80 square mile basin and originates at 6500 feet elevation in the Latour Demonstration State Forest. Old Cow Creek flows 32 miles and conjoins with Hunt Creek, Glendenning Creek (east of Whitmore), Canyon Creek and Coal Gulch before its confluence with South Cow Creek three miles east of Millville.

South Cow Creek drains a 78 square mile basin and originates at 5800 feet elevation in the Latour Demonstration State Forest. South Cow Creek flows 28.5 miles to its confluence with Old Cow Creek near Hwy 44. Its larger tributary streams include Atkins Creek, Beal Creek, Hamp Creek, and Mill Creek.

Figure 1. Relief map of the Cow Creek Basin and its drainage network. Shading identifies elevation in 1000 foot increments. Note how the 2000 foot transition coincides with a dramatic change in stream gradient, see Figure 2.

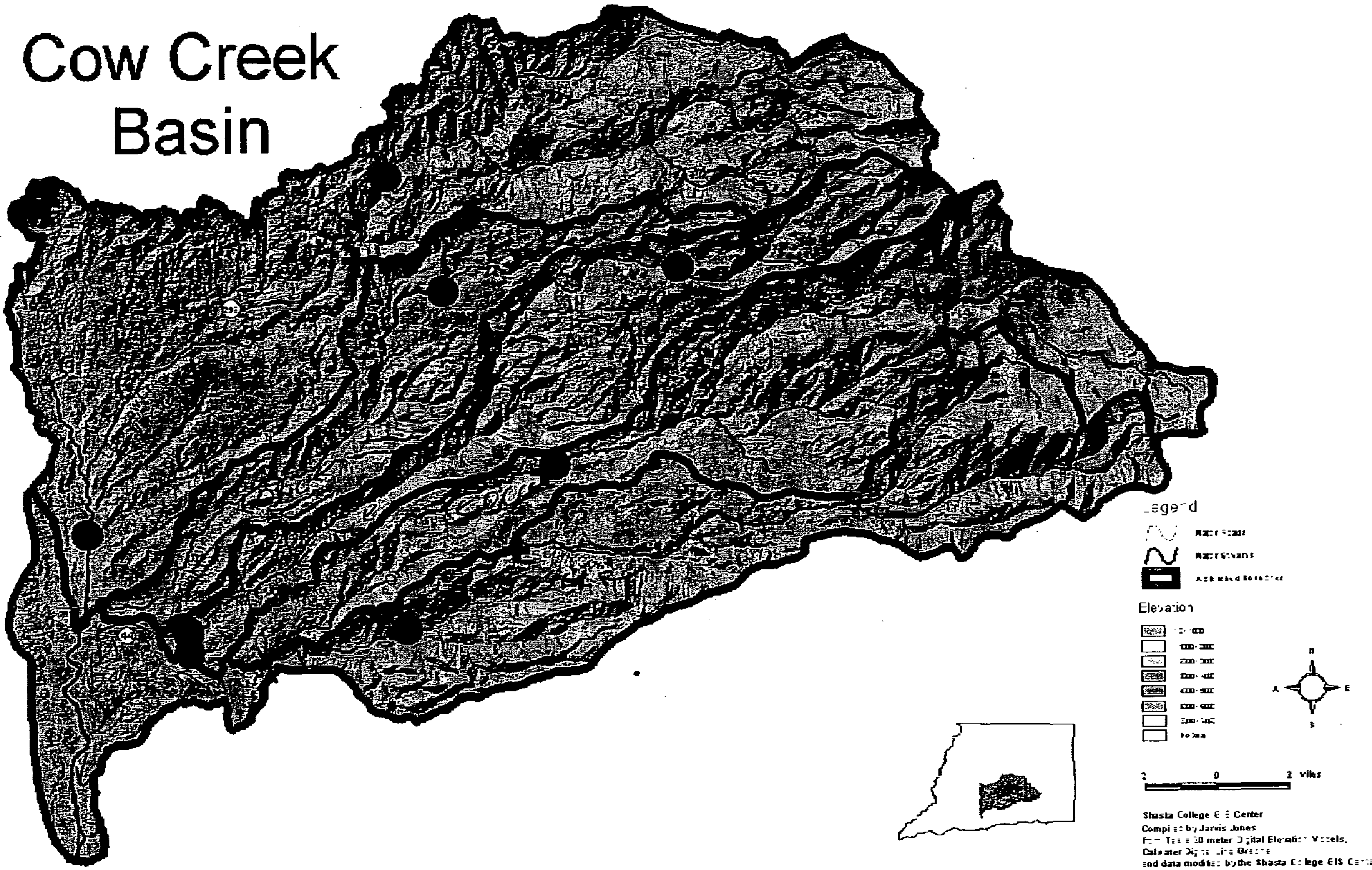

Cow Creek
Basin
Elevation

Table 1. Summary data for tributaries of the Cow Creek Basin.

Stream Name	**Basin Area (sq. mi.)**	**Stream Length (mi.)**
Little Cow Creek	148	36
Oak Run Creek	42	23.5 = 59.5
Clover Creek	54	27.5 = 87
Old Cow Creek	80	32.9 = 119.9
South Cow Creek	78	28.5 = 148.4
Main Stem Cow Creek	29	15 = 163.4
Total to Sacramento River	430	47.8

Basin Geologic History

Cow Creek and its tributaries carve into diverse layers of geologic features. The eastern high elevation reaches are the result of relatively recent volcanic activity, ranging from 12 million years ago to the present; the last eruption series occurred from 1915-1917 (Alt and Hyndman 1975). Encrusted lava rocks along with loose volcanic debris were deposited over more ancient (Cretaceous) marine sandstone and shale formations. Over time the Cow Creek tributaries have sliced through the blanket of volcanic deposits and eroded into the underlying sandstone and shale producing extensive alluvial deposits (Alt and Hyndman 1975). Gradient-transition points (i.e., head-cuts or knick-points) are evident in all 5 tributaries at approximately 1000 feet elevation, forming spectacular waterfalls. These erosional deposits are the source of rich, well-draining soils that support lush forests and more recent agricultural development.

Cultural History

The Cow Creek Basin has a rich cultural history. The region was used extensively by indigenous peoples, most recently the Yana tribes, up to the late 1880s (Allen 1979, 1984). European-American settlers, attracted by the gold extraction activities based in various parts of Shasta County, established the first community in the Millville area of Cow Creek in 1853. The mid-elevation reaches of South Cow Creek were settled as early as 1855 (SWRB 1965). By 1863 the settlement called Tamarack (now called Whitmore in honor of one of its founders) was established and steadily grew into a small trade center.

Land Use History

Irrigation in the Cow Creek basin began soon after its settlement and continues today with a complex series of diversions and lift-pumps in all tributaries. Stream diversions and pumps carry water to fields, pasturelands and residences in the upper and lower elevation areas. The lowland area primarily supports livestock ranches. Private and public timberlands dominate the eastern upland parts of the basin, above 2000 ft. Mining activity was limited to the northern portion of the basin, along Little Cow Creek, where the Afterthought Mine near Ingot (Hwy 299) was a source for gold and copper ore from 1862 to 1952 (Albers and Robertson 1961). Hydro-power plants were established on Old Cow Creek (Kilarc Reservoir and Powerplant) and South Cow Creek (Olsen Diversion) in the early 1900s to provide electricity for copper smelting, businesses and residents (Allen 1979).

WATER AND HABITAT QUALITY CONCERNS

Background

A primary goal of the Anadromous Fish Restoration Plan of the Central Valley Project Improvement Act [section 3406(b)(1)] is to double natural production of anadromous fish populations in Central Valley Rivers by 2002. Pursuant to this goal, the U.S. Fish and Wildlife Service (USFWS) and California Department of Fish and Game (CDFG) are examining opportunities to increase chinook salmon and steelhead populations throughout the northern Sacramento River valley. According to the California Department of Fish and Game the Cow Creek basin has the potential to support 5,000 to 10,000 fall-run chinook salmon, and a minimal number of steelhead. Although accurate counts are not available, it is believed that current populations are far below historic numbers (see appendix B). Water quality, physical habitat degradation and barriers to fish migration are major factors suspected of contributing to limited salmon populations in the Main Stem Cow Creek and its tributaries.

The Central Valley Regional Water Quality Control Board (CVRWQCB) is responsible for assuring that water quality is adequate for the protection of all beneficial uses, including water supplies, aquatic life and recreation. Past water quality data and reports from water users in the basin have raised concerns regarding deteriorating water quality for all of the above uses. Fecal coliform, from defective septic systems and livestock, threaten drinking water and recreational-contact users. In conjunction with warm summer water temperatures, heavy microbial oxygen demand could effect aquatic species by decreasing the available dissolved oxygen. Additionally, excessive soil erosion and bank failure in some tributaries is believed to contribute to increase stream turbidity.

The Western Shasta County Resource Conservation District's (WSRCD) mission is to work with willing landowners, government agencies and other organizations to facilitate the conservation or restoration of Shasta County's natural resources. With the successful formation of stakeholder-based watershed groups on Battle Creek and Clear Creek the WSRCD's primary interest was to incorporate landowner education and participation in all management decisions that effect the Cow Creek Basin.

Shasta College and the McConnell Foundation established the North State Institute for Sustainable Communities (NSISC) to conduct research on issues related to the sustainability of the Northern Sacramento River Watershed. This Preliminary Water Quality Assessment Project is intended to strengthen the linkage between State and Federal agencies, conservation groups, the community and education. The NSISC, as the grant recipient, coordinated activities and sub-contracted with Shasta College Biology Instructor, Morgan Hannaford Ph.D., to collect data, train students in water quality monitoring techniques and develop this report.

Barriers to Fish Migration

Both natural and man-made channel features limit anadromous fish access to Cow Creek tributaries. Habitat surveys conducted by California Department of Fish and Game identified a number of unscreened permanent (approximately 14) and temporary water diversions in the reaches of the Main Stem of Cow Creek that are accessible to salmon and steelhead (CDFG 1992). Water diversion normally extends from April through October, during which time juvenile salmon may still be present. The concern here is that water diversions may draw juvenile fish out of the stream channel and strand them in ditches or fields. Furthermore, some of the diversion structures may be potential barriers to adult fish migrating upstream to spawn.

Prominent natural barriers exist that restrict chinook salmon to the low elevation portions of the Cow Creek Basin. Each of the 5 main Cow Creek tributaries has a significant change in stream gradient (slope) accompanied by a waterfall at the transition point (Figure 2, see also Table 2). The waterfalls result from a head-cut (knick-point) as the tributaries erode through the sandstone deposits mentioned above. This natural stream channel evolution has probably occurred over millions of years. A geologic fault (rift) may also contribute to the sudden change in gradient in all the tributaries, all occurring at a similar elevation and distance from the Cow Creek outlet to the Sacramento River.

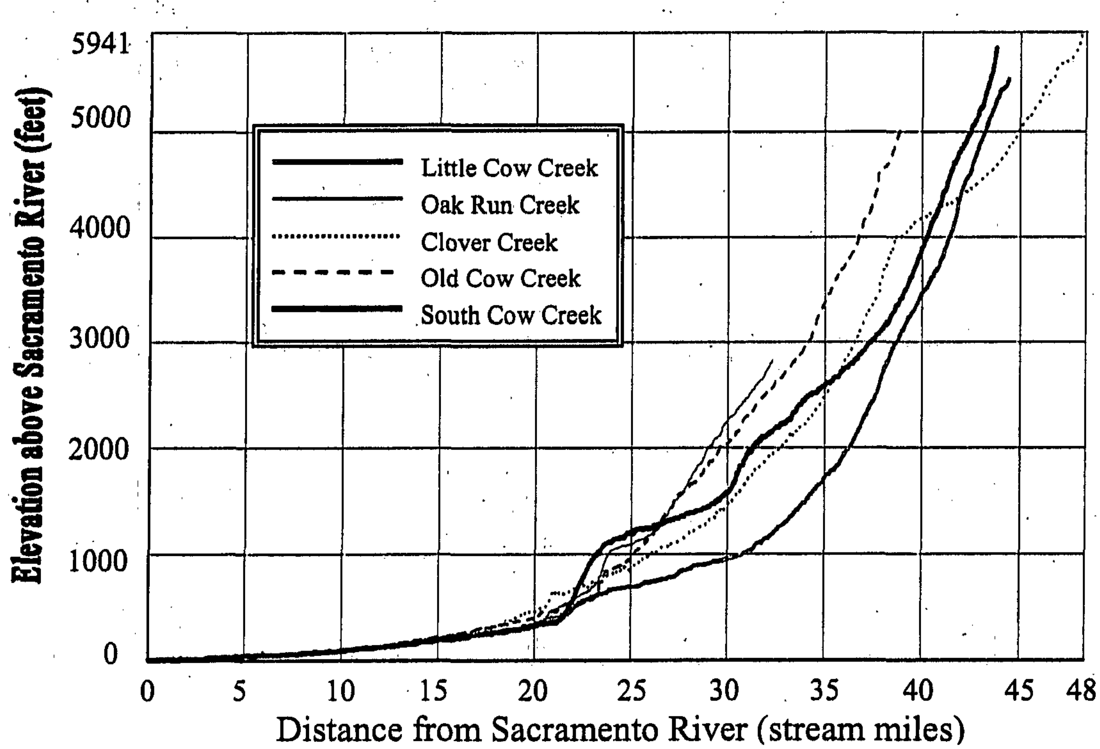


Figure 2. Stream gradient profile for Cow Creek tributaries. Elevation units can be adjusted to sea level by adding 372 feet. Prominent shifts in gradient occurring at 20-25 miles limit chinook salmon to the lower elevation reaches (i.e., below 1000 ft. above sea level).

Table 2. Summary of natural barriers to anadromous fish migration. Based on information from Colleen Harvey (CDFG; personal communication) and field observations.

Stream Name	Barrier Location	Description
Little Cow Creek	Diddy Wells Falls	15' bedrock falls - Partial barrier to upstream migrants during normal flows.
Oak Run Creek	Unknown waterfall	Report of bedrock falls downstream from the town of Oak Run.
Clover Creek	Clover Creek Falls	>100' bedrock falls - Impassable barrier to all upstream migrants.
Old Cow Creek	Whitmore Falls	>12' bedrock falls - Partial barrier to upstream migrants during normal flows.
South Cow Creek	Wagner Canyon	Boulder cascades - Steep gradient.

Water Quality Data Sources

The U.S. Geological Survey maintains a gauging station on the Main Stem of Cow Creek, near Palo Cedro (gage basin area of 425 square miles). This gauge has a 40 year continuous record (1950-current; station number 11374000). Additionally, flow records exist for Little Cow Creek (1957-1965; station number 11373300), Oak Run Creek (1957-1966; station number 11373200), Clover Creek (1957-1959; station number 11372700) and South Cow Creek (1956-1972; station number 11372200).

The Department of Water Resources (DWR) Northern District office in Red Bluff maintains a monitoring program on the Main Stem of Cow Creek, downstream of the Hwy 44 bridge. This data, usually collected quarterly (4 times per year), is the only comprehensive record of water quality for the lower elevation portion of the Cow Creek Basin (Table 3). Macroinvertebrate samples were collected periodically throughout the basin over the past 25 years.

Table 3. Water quality parameters measured by the Department of Water Resources. Sample dates range from 1/92 - 2/00. All parameters were not measured on all dates. An asterisk indicates parameters with peaks notably higher than background levels.

Parameter	
Metals	As, Cd, Cr, Cu, *Fe, Pb, Mn, Hg, Mo, Se, Zn
Nutrients	Total N, Nitrate, Nitrite, Ammonia, Total P, Orthophosphate, Ca, Mg, Na, K, SO_4, Cl, B
Physical	Hardness, *Temperature, Dissolved Oxygen, pH, Conductivity, Alkalinity, *Turbidity
Biological	Macroinvertebrates

Most chemical parameter measurements in Table 3 (above) were below measurable concentrations, or well within surface water background limits (RWQCB 1998). Iron concentrations were notably high on most sample dates (range: 0.1 - 0.88 mg/L); however, based on the lithography and mining history of the area this may be within the natural background level, or contributed mostly by the Little Cow Creek drainage (see mining effects on water quality below). Summer water temperatures and turbidity associated with spring runoff were identified as other physical factors that deserved further attention.

Monitoring Sites

All data collected during the course of this study were from repeat visits to 9 stream reaches (see Appendix A for approximate locations). Sampling sites were selected based on available landowner permission, public access easements, and proximity to passable roads (for ease of sampling access). The overall monitoring plan was designed to identify differences between the major tributaries and between the lower (<1000 feet) and middle (1000 - 2000 feet) elevation reaches within each tributary.

Sampling dates range from early June 1999 to April 2000. Summer sampling occurred weekly to biweekly, depending on the parameters being measured. Winter and spring sampling coincided with peak rainfall events and are thus sporadic. Specific monitoring methods are outlined below.

Temperature and Dissolved Oxygen

Temperature is a primary limiting factor for all aquatic biota (Allen, 1995). Excessive temperatures can induce high metabolic rates and oxygen-debt stress in fish and invertebrates. In addition to the temperature effect on oxygen demand, the physical capacity for water to hold oxygen decreases as water gets warmer (Wetzel, 1983). Thus, many aquatic species have specific temperature requirements to successfully complete their life cycles. Although different salmon species and even populations within a species are known to have varying temperature requirements, as a whole salmonids are considered stenotherms (i.e., tolerating a narrow range of temperatures). Table 4 outlines estimated temperature requirements for specific developmental stages of chinook salmon (Armour 1991). These temperatures are too warm to support steelhead trout.

Table 4. Preferred temperature ranges for chinook salmon. These are estimates based on field and laboratory studies. Actual site-specific values may vary.

Species/Life Stages	Temperature Range Requirements*
Chinook Salmon	
Adult migration	3.3-14.4°C (38-58°F)
Spawning	4.4-13.9°C (40-57°F)
Egg incubation / fry emergence	5.0-14.4°C (41-58°F)
Juvenile rearing	5.0-14.4°C (41-58°F)

Adapted from Armour 1991.

*0.1°C precision is an artifact of translating temperatures from Fahrenheit, as reported in the literature.

Water Termperature Monitoring

Temperature probes, programmed to record every 15 minutes, were deployed at each monitoring site in June 1999. The probes (Onset Optic Stowaway™ and Hobo™ temperature loggers) were anchored to the stream bottom in the channel flow and in the shade to prevent edge-warming effects (Stevens et al. 1975). All probes were calibrated to a laboratory-grade reference thermometer to within ±0.5°C. Records from the Main Stem of Cow Creek, downstream of all tributaries, are from the DWR.

Based on the temperature records for Cow Creek (continuous records from 1995-2000, and current field measurements) the water temperature in the Main Stem of Cow Creek exceeds preferred developmental thresholds for chinook salmon approximately 6 months each year (roughly May - October). Furthermore, maximum peak temperatures frequently exceed lethal thresholds (~25°C) for juvenile and adult fish in summer months (Figure 3). The upstream tributary input can account for the bulk of this warm water during the hot summer months (Figure 4a & 4b). Because the flow in the Main Stem of Cow Creek is dominated by Old Cow Creek and South Cow Creek throughout the summer, temperatures are actually mediated; upstream average and maximum temperature in Little Cow Creek and Oak Run Creek exceeded those of the Main Stem downstream (Figure 4a).

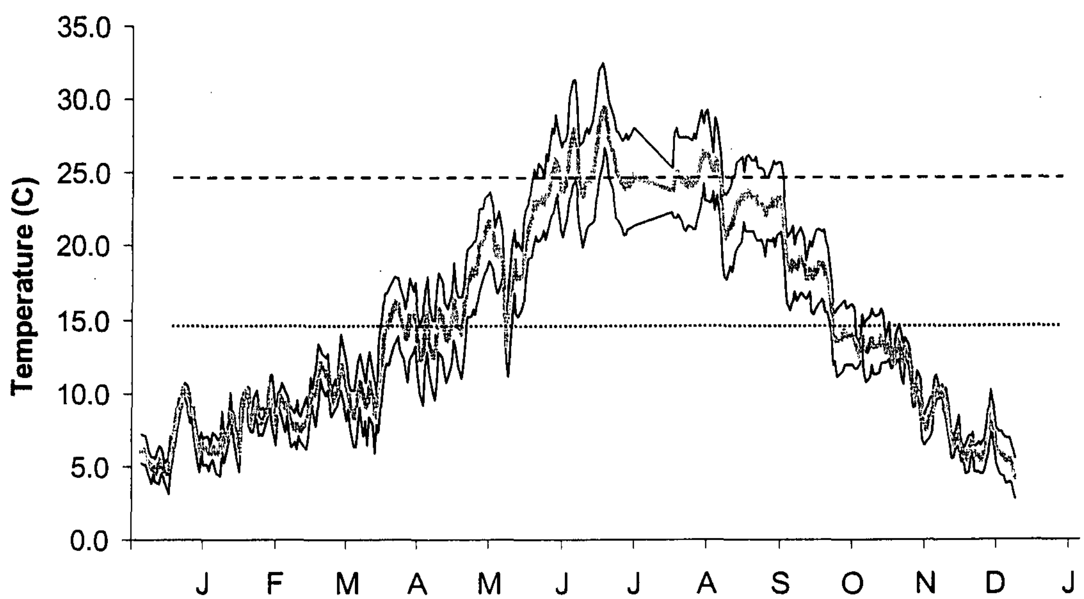
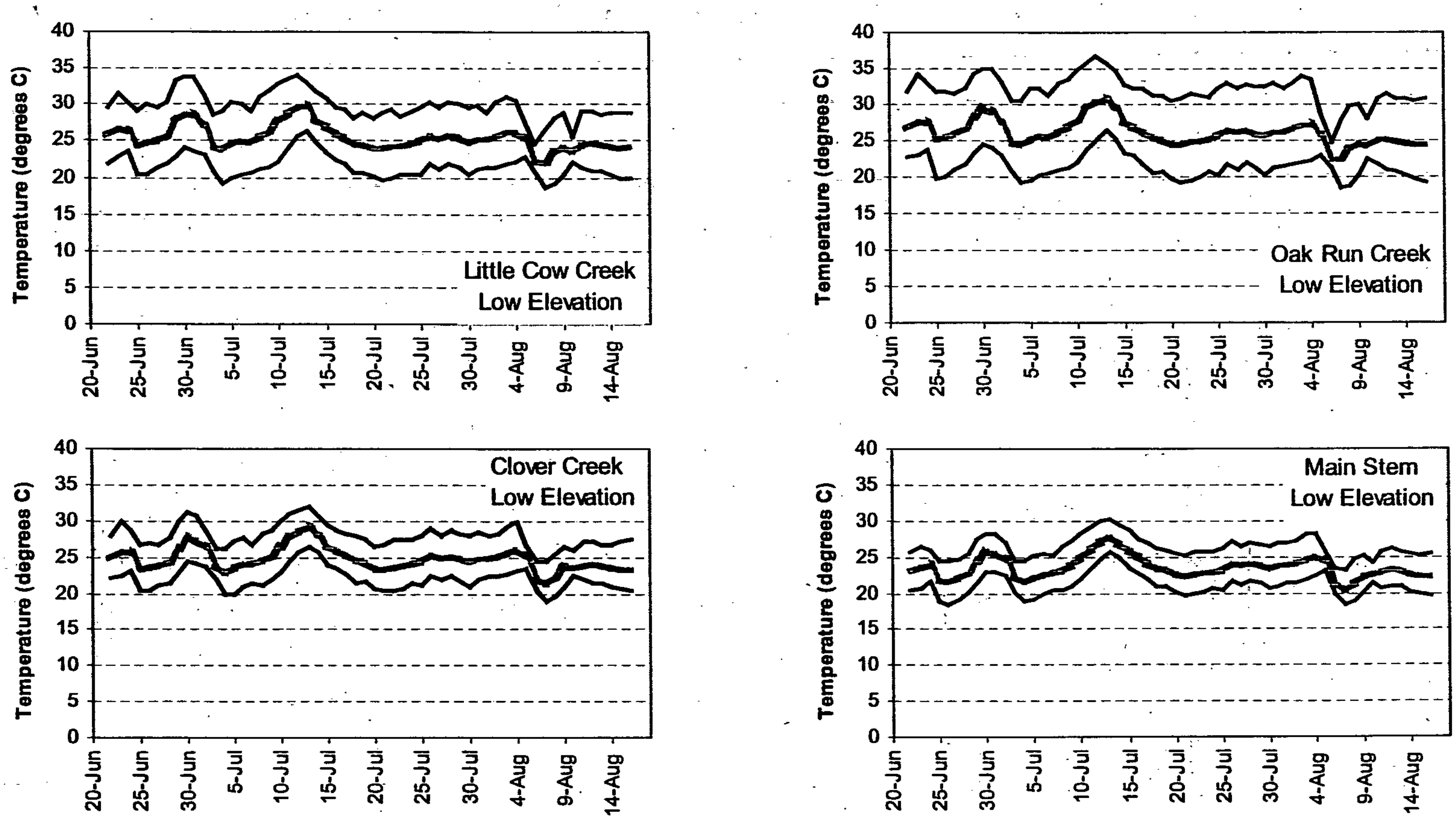


Figure 3. Daily range (maximum/minimum) and average water temperatures in 1999 for the Main Stem Cow Creek, near Palo Cedro. The dotted line is preferred developmental temperature, and the dashed line is lethal temperature thresholds for juvenile chinook salmon (based on published data, see text). Data for Jun 26 - Aug 9 are estimated because of sensor failure. Data source DWR.



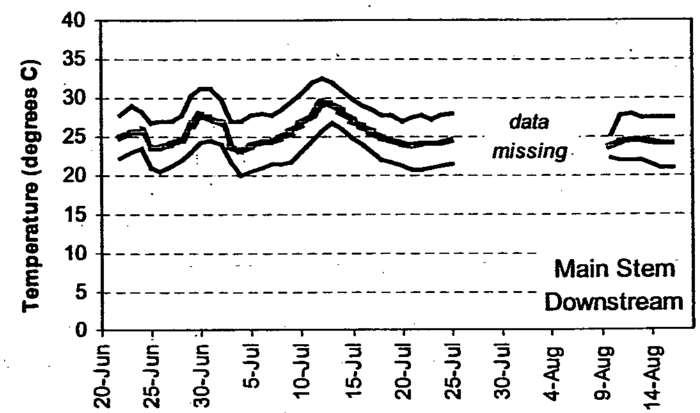


Figure 4a. Daily range (maximum/minimum) and average water temperatures in 1999 for the Cow Creek tributaries at low elevation (elev. < 1000 feet).

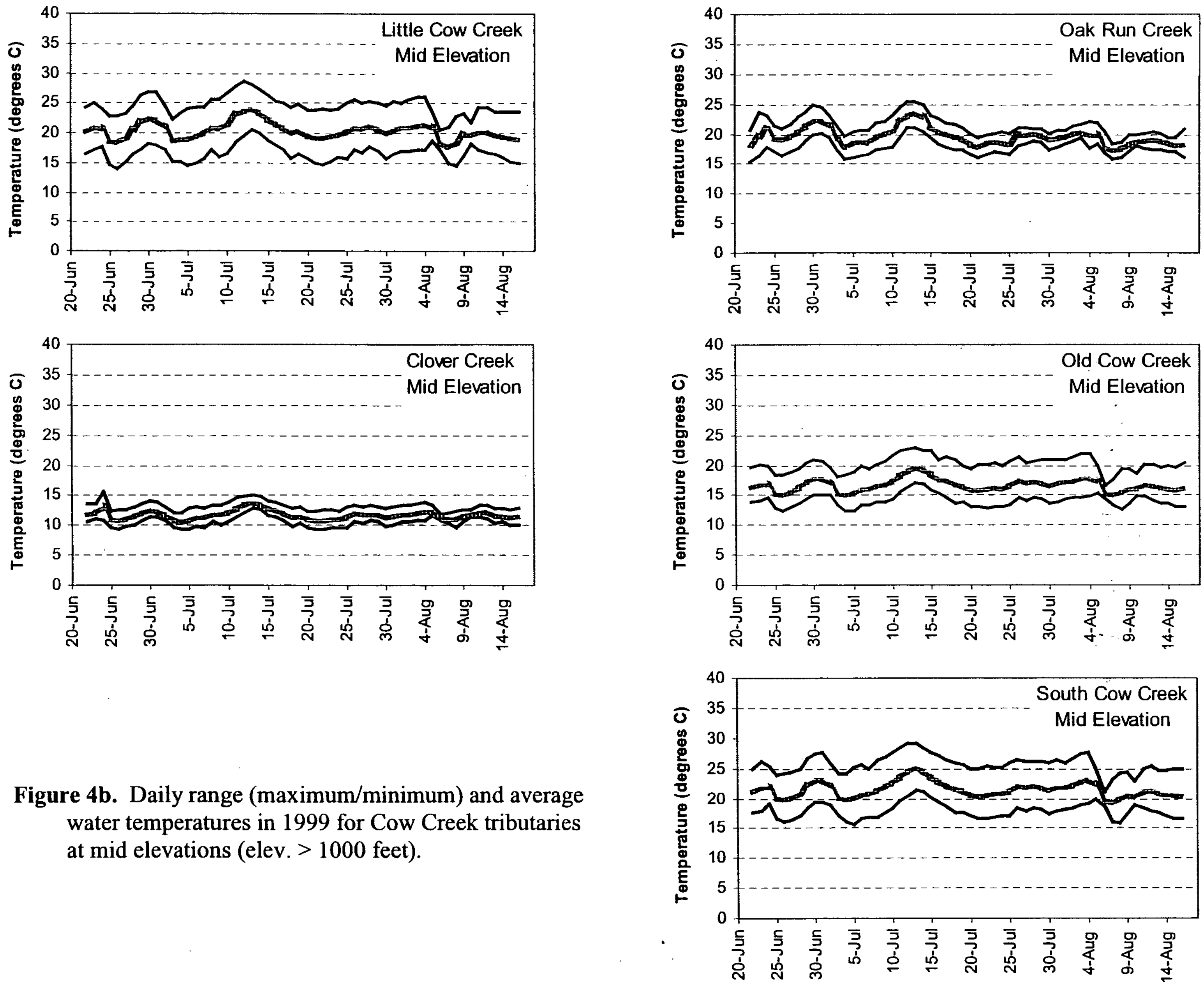


Figure 4b. Daily range (maximum/minimum) and average water temperatures in 1999 for Cow Creek tributaries at mid elevations (elev. > 1000 feet).

Within each tributary average and maximum temperatures recorded in mid elevation reaches were notably lower than downstream reaches (Figure 4b, see also Table 5). Downstream water temperature increases are a natural occurence and are expected in stream systems (Allen 1995), however the increase in temperatures can be exacerbated by a number of human induced factors. Degradation of riparian vegetation (i.e, reduced channel shading) and water diversion (i.e., decreased water volume) are specific factors that may apply to Cow Creek tributaries.

5° diff = Basin Plan criterion

Table 5. Differences in average and maximum daily summer temperatures from mid-elevation to low-elevation reaches in Cow Creek tributaries.

		Mid-Elev.	Low-Elev.	Difference
Little Cow Creek	Avg.	20.5 °C	25.5 °C	+5.0 °C
	Max	24.6 °C	29.9 °C	+5.3 °C
Oak Run Creek	Avg.	17.2 °C	26.2 °C	+9.0 °C
	Max	20.8 °C	32.1 °C	+11.3 °C
Clover Creek	Avg.	12.5 °C	24.8 °C	+12.3 °C
	Max	14.2 °C	28.0 °C	+13.8 °C
Old Cow Creek	Avg.	17.2 °C	23.6 °C	+5.4 °C*
	Max	20.8 °C	26.3 °C	+5.5 °C*
So. Cow Creek	Avg.	21.7 °C	--	+1.9 °C*
	Max	25.9 °C	--	+0.4 °C*

*indicates a comparison between Old Cow Cr. and So. Cow Cr. to their downstream confluence site.

Dissolved Oxygen

As mentioned above an increase in water temperature and associated increases in metabolic demand can reduce dissolved oxygen levels significantly. This effect is especially apparent when dissolved nutrients are supporting the growth of algae and microbes. The oxygen content in stream water comes from two primary sources: 1) oxygen gas dissolving into the water at the surface and during turbulent flows (e.g., riffles); and 2) oxygen production during photosynthesis by algae and macrophytes. The CVRWQCB guidelines state "...the monthly median of the mean daily dissolved oxygen (DO) concentration shall not fall below 85% of saturation..." EPA's water quality criteria states that DO concentrations should be at a minimum of 8.0 mg/L to protect early life stages of cold water aquatic life (i.e., anadromous fish). Existing data on DO levels in the Main Stem of Cow Creek were consistently at or near saturation (Figure 5). It should be noted that all samples were collected during the day, when stream DO concentrations peak. In the absence of light, aquatic algae respire and consume oxygen. Thus the lowest DO concentrations typically occur just before dawn.

Basin Plan –
Warm - 5.0
Cold/spawn - 7.0
EPA – cold & early life - 8.0

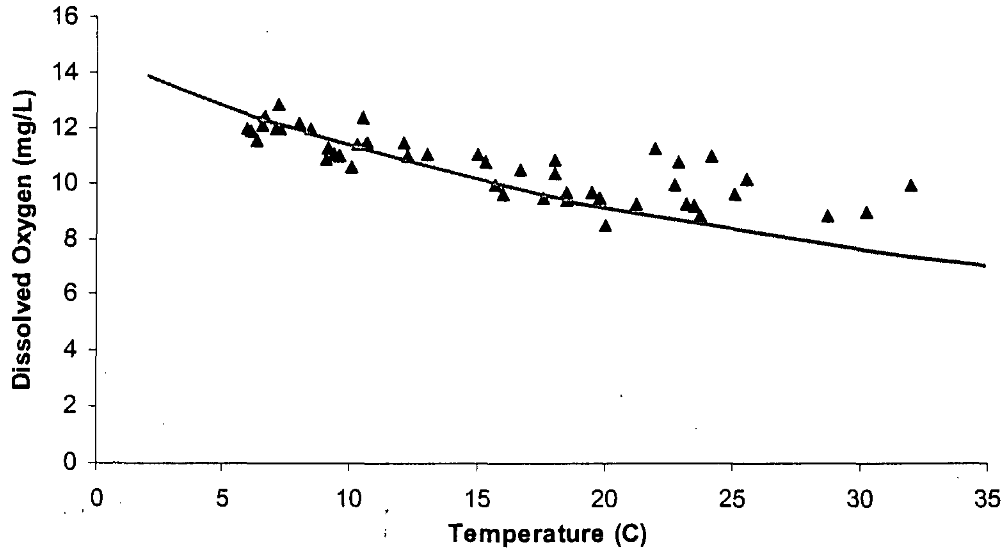


Figure 5. Relationship of dissolved oxygen and temperature measured from point samples on the Main Stem of Cow Creek, near Palo Cedro from 1992-2000. The line represents an approximate 100% oxygen saturation curve (after Wetzel 1983).

Data points at the extreme high end of the scale in Figure 5 may be the result of oxygen "super saturation" by stream turbulence or high daytime photosynthetic productivity. The latter can potentially cause diel oxygen "crashes" and subsequent fish mortality (Allen 1995).

Although chinook salmon adults and juveniles have access to the reaches that are under 1000 feet in elevation, much of this area has an unsuitable temperature range during the warm summer months of May - October (see Appendix A-1). In fact, salmon adults were observed migrating into the Main Stem of Cow Creek just after the first rainfall events in October. These rainfall events coincided with a sudden decrease in stream temperatures at all sites (field temperature measurements were less than 20°C following Oct. 1st). Reaches above 1000 feet, although observed to have significantly lower temperatures throughout the summer, are effectively blocked to most salmon adults and juveniles by the sharp gradient change caused by geologic features.

Turbidity

Turbidity is a measure of the suspended solids and visible particulates that give water a cloudy appearance. A turbidimeter directs a beam of light at a water sample and measures the amount of light scattered by suspended particles. This measurement is reported as Nephelometric Turbidity Units (NTUs). The main problem with turbidity analysis is that because samples can only be collected periodically (i.e., not on a continuous basis) so pulse events that are associated with intense storms, bank failure, channel changes or surface runoff are often missed. Thus, existing data can only be reported as a range.

1999 - 2000 Turbidity Measurements

Water samples from each site were measured for field turbidity during the low flow summer (1999) and several winter and spring (2000) storm flow events. Cow Creek and its tributaries generally fell within 3 categories during this study: 1) summer low flow turbidity was consistently less than 1 NTU; 2) after minor rain events turbidity ranged from 1 - 5 NTU; and 3) during spring storm events turbidity ranged from 5 - 20 NTU (Figure 6). No obvious differences were observed among the tributary streams in this study.

1⁻ to 20 NTU
→ no more than 20%

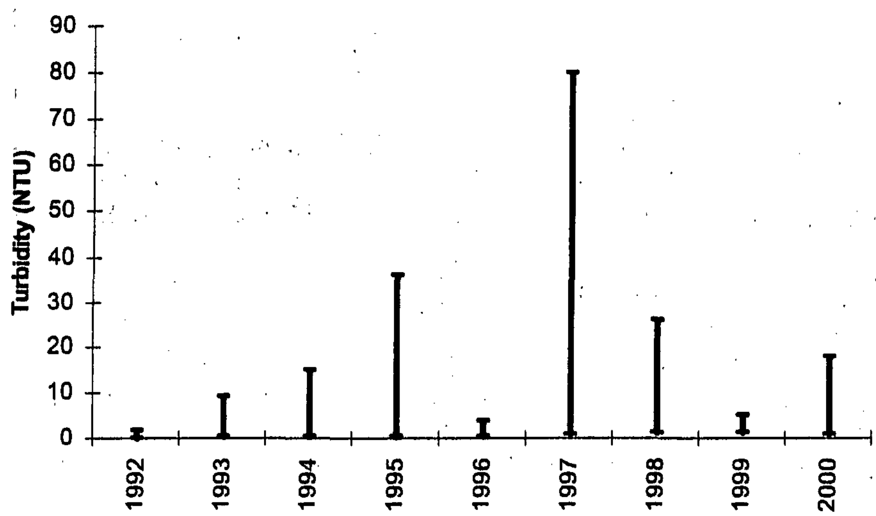


Figure 6. Range of turbidity measurements (Nephelometric Turbidity Units) collected from the Main Stem of Cow Creek, near Palo Cedro. Source: DWR and field data.

BASIN PLAN
geo mean - 200/100 mL
10% in 30d - 400/100 mL

Fecal Coliform

Coliform bacteria are a natural element of aquatic food chains. Along with aquatic fungi they constitute the micro-decomposers of aquatic systems (Allen 1995). Fecal coliform (i.e., *E. coli*) in surface and ground water are derived directly from solid wastes of mammals. Although fecal coliform are not considered to be pathogenic, their presence is generally accepted as an indicator of animal waste contamination that may harbor other harmful pathogens. Because of the potential health risks that are associated with animal feces contact, the RWQCB has clearly defined guidelines for fecal coliform levels in drinking water and recreational contact water (RWQCB 1998).

Measurement of coliform and fecal coliform is an estimate of the number of coliform cells in a 100ml water sample. This value is reported as the Most Probable Number (MPN) derived from the coliform testing procedure selected. The threshold for fecal coliform health risk in public drinking water is ≥1 MPN. The recreational contact use (e.g., swimming, fishing etc.) threshold is established as an average of ≥200 MPN calculated from 3 samples collected over a 30 day period; additionally, any one sample that contains 400 MPN or greater is not recommended for recreational contact use (RWQCB 1998).

Fecal Coliform Methods

The Colilert®-18 test from IDEXX Laboratories, Inc. is a simultaneous detector of total coliform and fecal coliform (*E. coli*) for marine and fresh waters. The measurement procedure allows for the calculation of 0 - 2419.2 MPN without dilution with sterile water. Samples are collected in sterile 100ml sample bottles in the field. In the laboratory an incubation reagent is added to each bottle and the sample is heat-sealed into an incubation-well pack (Quanti-Tray/2000®). The samples are then incubated at 35°C for 18 hours. The presence of total coliform is identified by the formation of a yellow metabolic product. Fecal coliform (*E. coli*) presence is identified by a fluorescent metabolic product, observed by illuminating with ultraviolet light.

The precision of this method was tested by collecting replicate samples at a single site (Main Stem of Cow Creek) and from a drinking water source (city of Redding tap water) as a control. All samples were processed simultaneously. The coefficient of variation (CV = standard deviation/mean) of the field samples was between 8 - 10% for representative low (25.4 MPN for fecal coliform) and high (1556.5 MPN for total coliform) measurements, respectively. All the drinking water control samples showed 0 MPN, indicating that false positives were not likely derived from the lab handling procedures.

Water samples for fecal coliform analysis were collected from June 25, 1999 through October 19, 1999. Water was collected in the mid-channel region by immersing the sterile sample bottle completely underwater, opening the container to flood the bottle and then resealing the sample under water. This was done to prevent surface water (which has been observed to contain higher coliform levels; R. Heinrichs personal communication) from entering the sample bottle. Sample bottles were placed on ice and incubated the same day they were collected.

Among the 9 sites sampled throughout this study, 3 sites had consistently high fecal coliform concentrations (Figure 7). Clover Creek in the low elevation reach, and South Cow Creek and Oak Run Creek in the middle elevation reaches had fecal coliform concentrations that exceeded recommended recreational contact standards. The other 6 sites were consistently low in fecal coliform concentration, well within the recreational contact standards.

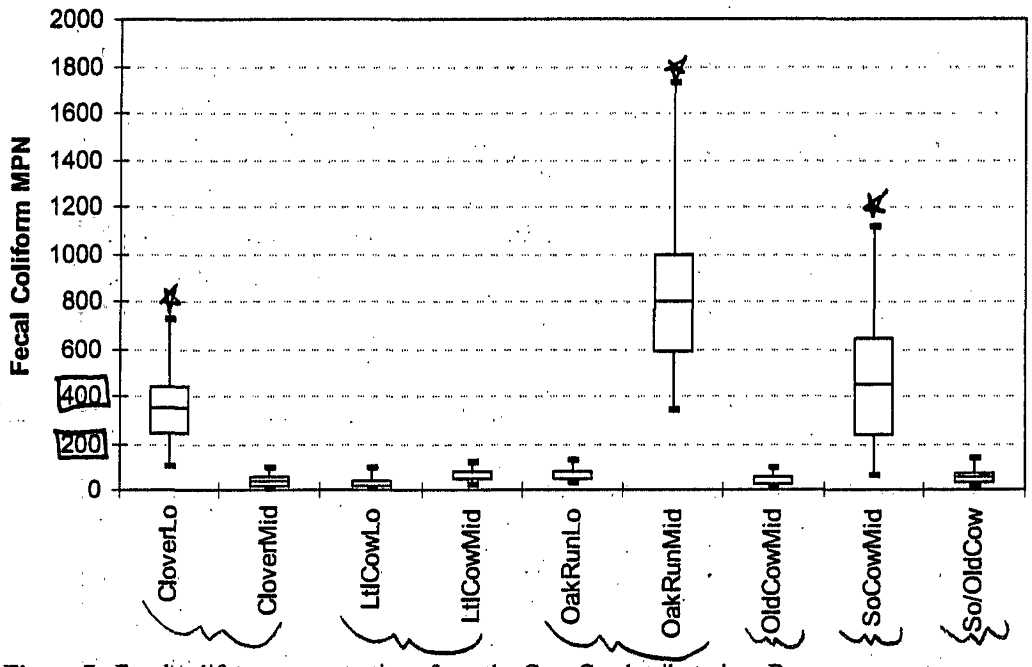


Figure 7. Fecal coliform concentrations from the Cow Creek tributaries. Boxes represent average (midline) and standard error (±1 SE). Bars represent the range (maximum and minimum) of measured values from a total of 6 samples collected from 6/25/99 to 10/19/99. 200 MPN and 400 MPN are the recreational use standards - see text for explanation. "Lo" and "Mid" refers to lower and middle elevation reaches.

The actual source of fecal coliform in Cow Creek is unknown. Possible sources include wildlife defecating near streams, livestock waste entering the streams, or human septic systems or sewage lines leeching into the streams. We can assume that the study sites with low coliform levels (less than 50 MPN in most cases) represent at least the wildlife input. Acknowledging that this represents a background level of fecal coliform, the high fecal coliform levels measured in this study probably originated from livestock or human sources.

Water Chemistry and Mine Drainage

Historical hard rock mining for metals is limited to Little Cow Creek, namely the Afterthought Mine near Ingot. The Afterthought Mine is the easternmost exposure of the "Shasta Crescent", a band of metal ore deposits that fed the Shasta County gold rush in the 1850s. The Afterthough Mine produced approximately 166,500 tons of ore from 1862 to 1952 (Albers and Robertson, 1961). The mine was worked primarily for copper, zinc, silver, and gold. An on-site smelter operated from 1901 to 1908; after which the ore was transported by cable car to a smelter near Keswick (powered by the Kilarc Power Plant on Old Cow Creek).

A summary of water quality assessments on the Afterthought Mine tailings and portal outflow (Gaggini and Croyle, 1994 and references cited therein) identified high levels of mercury, total zinc, lead, arsenic, and iron concentrations. Acid mine drainage is also a concern where readings as low as pH 2.6 have been taken from a creek that drains the tailings into Little Cow Creek. Water quality measurements downstream of the Afterthought Mine show that the mine drainage water is significantly diluted by Little Cow Creek. Dissolved iron concentrations ranged from 0.05mg/L downstream of the mine to 1.75mg/L at the mine portal. Acid mine drainage effects were also diluted by Little Cow Creek as reported acidity readings fall within a range of pH 6.2 to 8.1 downstream of the mine.

Acid waters were not identified as a water quality concern based on the results of this study (Figure 8). Measurements taken immediately downstream of the Afterthough Mine (pH 8.6) did not differ appreciably from pH measurements taken upstream of the mine at the Little Cow Creek middle elevation site. The lower elevation Little Cow Creek reach had a slightly lower pH range (i.e., more acidic) than the upstream sites, however this cannot be attributed to the mine drainage exclusively.

Basin Plan 20 MCL Range → 6.5-8.5

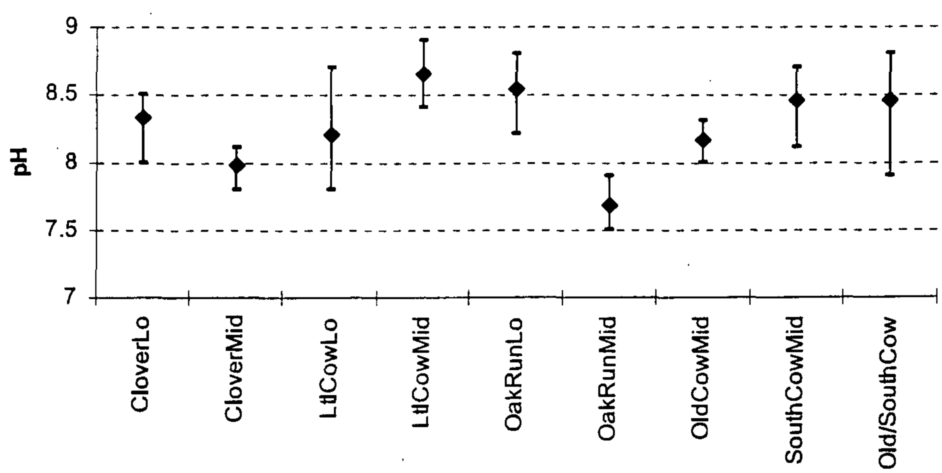


Figure 8. Range (maximum and minimum, bars) and average (diamonds) field pH measurements from the Cow Creek tributaries. Measurements were taken from 6/25/99 to 10/19/99.

Specific conductivity (i.e., an estimate of dissolved ions in water) measurements were within a natural background range (Figure 9). It is interesting to note the increase in conductivity from upstream to downstream sites. This increase in dissolved solids can most easily be explained by the underlying litholoy that changes from volcanic rock in mid elevation reaches to ancient marine (saline) deposits in the lower elevations.

Range → 700- 1000 µS/cm

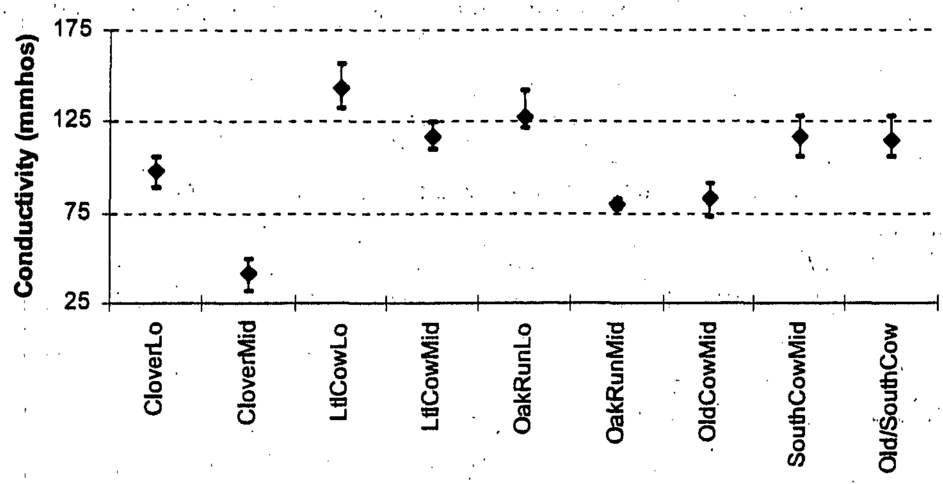


Figure 9. Range (maximum and minimum, bars) and average (diamonds) field conductivity measurements from the Cow Creek tributaries. Measurements were taken from 6/25/99 to 10/19/99.

SUMMARY AND RECOMMENDATIONS

The Cow Creek Basin currently supports extensive timber production, livestock production, recreational uses and wildlife habitat. The potential problems identified in this report need to be investigated further to identify specific solutions that support all beneficial uses.

Temperature

High summer temperatures are likely limiting chinook salmon juvenile rearing habitat. Although barriers to downstream juvenile migration were not specifically identified in this study, a survey of all lower elevation diversions needs to be documented to identify those that are accessible to migrating juveniles. A survey of this kind would benefit greatly from landowner cooperation through the developing Cow Creek group, and technical support for screen design by CDFG and USFW.

An estimate of lost riparian vegetation that may have functioned to buffer nutrients and sediment, shade the channel and provide instream cover in the lower elevation reaches needs to be completed to evaluate the potential benefits of riparian restoration.

Fecal Coliform

Tests that determine the source of fecal coliform bacteria (e.g., human vs. cattle *E. coli* strains) in surface water can be done to identify possible pollution reduction actions in Oak Run Creek, Clover Creek and South Cow Creek. Additionally, detailed surveys at these 3 reaches can identify specific sources. In the meantime, tests of biochemical oxygen demand (BOD) and diel field oxygen concentrations should be done to determine if this pollution is detrimental to aquatic life. Benthic macroinvertebrate communities, which are widely used as indicators of organic pollution stress in aquatic systems (Resh et. al. 1995), can be utilized in a field bioassay to evaluate the real effects of long term water quality problems.

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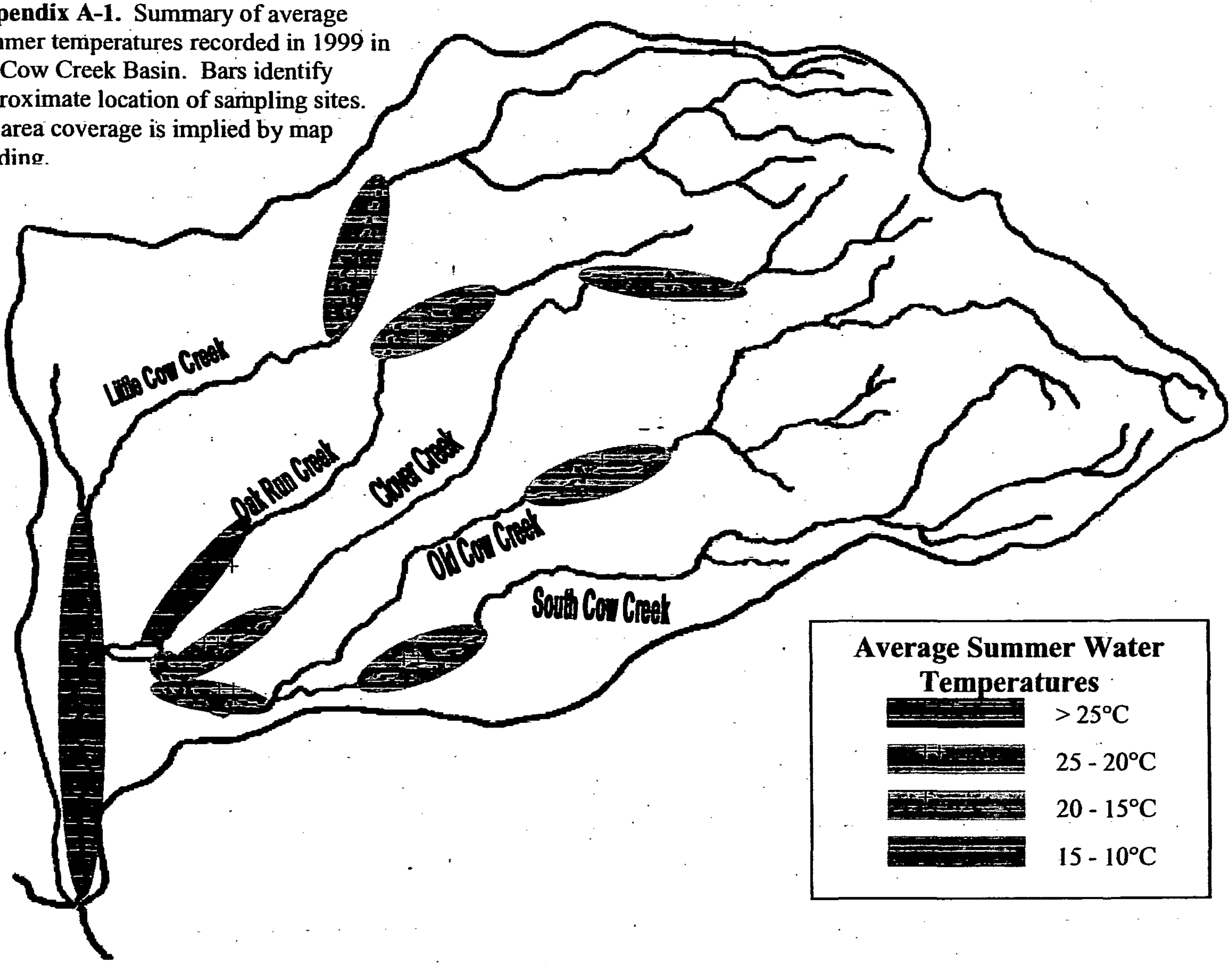
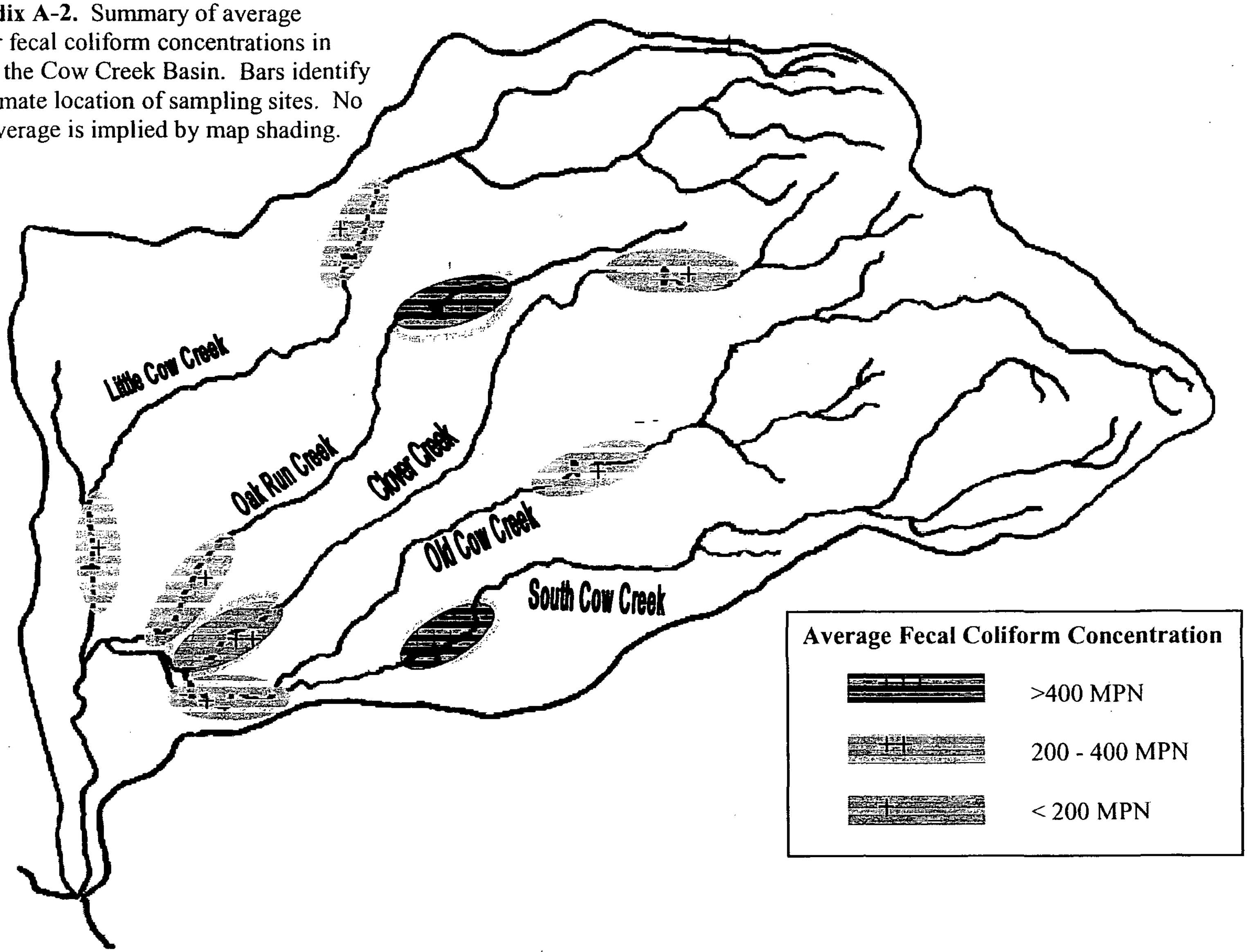
APPENDIX A
BASIN MAP SUMMARY OF DATA

Appendix A-1. Summary of average summer temperatures recorded in 1999 in the Cow Creek Basin. Bars identify approximate location of sampling sites. No area coverage is implied by map shading.



Appendix A-2. Summary of average summer fecal coliform concentrations in 1999 in the Cow Creek Basin. Bars identify approximate location of sampling sites. No area coverage is implied by map shading.



APPENDIX B
RECORD OF STAKEHOLDER MEETINGS

"COW CREEK WATERSHED" PUBLIC MEETING NOTICE

MEETING: January 26, 1999
TIME: 7:00 P.M. - 9:00 P.M.
LOCATION: ----------------------------

NOTE: This meeting will be repeated on February 25, 1999.

The Institute for Sustainable Communities is hosting a "Cow Creek Watershed Information Gathering Session". The purpose of this meeting is to identify resource concerns relating to the Cow Creek Watershed.

The Institute received a grant from the U.S. Fish & Wildlife Service to initiate a process of collaboration among landowners, resource agencies and educational institutions including; The Western Resource Conservation District, U.S. Fish & Wildlife Service, The California Department of Fish & Game, The Regional Water Quality Control Board and Shasta College - Center for Science Industry and Natural Resources.

The major objectives of this grant are to gather information regarding resource concerns relating to the watershed, identify landowner cooperators, initiate a data collection survey related to water quantity and quality and to assess the level of community acceptance for future projects. The predicted biological benefits of this project are to make some informed decisions based on existing conditions and future potential restoration activities of the streams.

Cow Creek Watershed landowners and others are encouraged to attend. Your input is important.

Institute for Sustainable Communities

☆ COW CREEK WATERSHED ☆

" Information Gathering Session"
January 26, 1999

~ A G E N D A ~

1. Introductions:
Francis Duchi, ISC Executive Director

2. Institute for Sustainable Communities:
Who are We?

3. Grant Overview:

4. Brief Agency Presentations:

- Jeff Souza ~ Western Shasta Resource Conservation District
- Tricia Parker ~ U.S. Fish & Wildlife Service
- Harry Rectenwald ~ Department of Fish & Game
- Carole Crowe ~ Regional Water Quality Control Board

5. Resource Identification:
Issues & Concerns ~

INSTITUTE FOR SUSTAINABLE COMMUNITIES

COW CREEK WATERSHED
Public Meeting Minutes
January 26, 1999

The Institute for Sustainable Communities held a APublic Information Gathering Session@ at the Junction School Gym in Palo Cedro on January 26, 1999 from 7:00 pm to approximately 9:30 pm. The purpose of the meeting was to identify issues and concerns about the Cow Creek Watershed. Landowners and others were encouraged to attend.

There were approximately 85+ landowners and others who attended.

Francis Duchi, Executive Director for *the Institute for Sustainable Communities* (ISC) started the meeting by giving a brief overview of ISC & its goals and purposes. He defined the $15,000 Grant & it objectives and explained how Shasta College students would be involved.

Jeff Souza, Project Manager for Western Shasta Resource Conservation District (WSRCD) gave an introduction about WSRCD and talked about Clear Creek & Battle Creek projects and explained how the Alocals@ (Cow Creek Watershed Landowners) could get involved & decide how things should be done in their local watersheds. He addressed the Clean Water Act, (205j) Grant & how there was an application for funds. The proposal was not approved. ISC submitted a proposal to US FWS with hopes to help jump-start the data collection process in Cow Creek and gather information that will contribute to the data needs of the assessment plan until the Clean Water Act Grant can be resubmitted.

Tricia Parker from U.S. Fish & Wildlife Service (US FWS) discussed her role as being part of US FWS & how she has worked with watershed groups for approximately 10 years. She also discussed the Anadromous Fish Restoration Act and how the groups can get started.

Harry Rectenwald from U.S. Fish & Game (USFG) discussed salmon & steel head and fish barriers. He showed pictures and handed out graphs indicating the salmon population in Cow Creek. He also addressed Water Rights and how important they are.

Carol Crowe, Central Valley Regional Water Quality Control Board (CVRWQCB) gave the background on WQCB and addressed the importance of water quality. She also addressed Point Source pollution, sediment, and stream temperatures.

The meeting was opened to participants for input regarding issues and concerns of the watershed and the data collection project.

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SUMMARY OF QUESTIONS FROM PALO CEDRO WATERSHED MEETING JANUARY 26, 1999

1) Questions regarding the data collection.

Need more information on the study design and statistical validity.
Why is Cow Creek so important?
What is being collected and why?
What are the time limitations related to access?
What agencies will be on landowners' property?
Is this baseline data that's being collected?
Has baseline data been collected?
Will it affect water rights?
What about liability on someone's property?
Is there a sunset clause?
Will this lead to more studies?
Will this be used in litigation?
There is a general concern about how the data is applied or misused, (i.e. affecting drainage from livestock, stream fencing, loss of land, and who pays?) and concerns about gaps in the project if there are gaps in the data.

What about wildlife and a written guarantee that we won't be regulated.

2) Questions about WSRCD, USFWS, and ISC.

Have we talked to other agencies such as the USGS?
Need more information about the WSRCD, and the ISC.
Does the USFWS already know what they want to do?
Why were government agencies only involved in putting the meeting together?
What does USDA have to do with this?

3) Questions about Water Rights?

Will this affect future water rights?
Doesn't Bella Vista Water District have water rights information?

4) Questions about funding?
Is the funding to fix problems or the landowners problems?

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5) Questions relating to landowner issues?
What are the negative impacts to landowners in Cow Creek or in other watersheds?
Fencing of cattle from streams?
Checking drainage from livestock operations?
What's the cost to landowner to help fish and water quality?
Possible loss of land, equity, restriction in land uses, who pays?
Will there be future restrictions to logging and livestock?
Landowners have a lot of information related to the overall watershed health, water quantity, and water quality. What are the implications of the Endangered Species Act?
There are no anadramous fish in my area! Landowners have been here a long time and there was plenty of water and fish.

6) Other comments and concerns.

There is a loss of land due to erosion and a need to prevent deterioration in water quality and wildlife habitat.
There are increasing conflicts between older and newer residents.
There is a need to control brush in the watershed as it relates to losing bridges.
There is a need for road improvements/paving.
Will this create another government agency and increase our taxes?
Would like information on the track record in other watersheds.
Cow Creek. is in the best shape this year, flows are at peak due to Fountain Fire.
Why are fish being killed at Coleman Fish Hatchery?
Bass and perch are eating salmon and trout.
What permission does BLM give for access?
Leaves in creek cause discoloration.
Not everyone on the creek is paranoid of the government.

★ Please attend ★

THE FIRST

COW CREEK WATERSHED

INFORMATION GATHERING SESSION

Thursday, February 25, 1999
7:00 - 9:00 p.m.

Held at:
Whitmore Elementary School
in the Gym

WE WANT TO HEAR FROM YOU!

✓Help us gather information about resource concerns and issues relating to Cow Creek Watershed.

✓Information will be presented about Cow Creek and its fisheries.

✓Agency representatives will be available to answer your questions.

✓Cow Creek Watershed Landowners & Others encouraged to attend.

For more information please contact:
INSTITUTE FOR SUSTAINABLE COMMUNITIES
@ 226-6238 or
email: fduchi@shastain.org

INSTITUTE FOR SUSTAINABLE COMMUNITIES

COW CREEK WATERSHED
Public Meeting Minutes
February 25, 1999

The second "Public Information Gathering Session" was held at the Whitmore Elementary School on February 25, 1999 at 7:00 p.m. Approximately 25 residents, landowners and interested participants attended.

Francis Duchi, Executive Director of the Institute of Sustainable Communities welcomed everyone, gave a brief overview of the Institute and its goal of identifying willing landowner participants to assist with the US Fish and Wildlife Service funded Data Collection Grant.

Agencies including the U.S. Fish and Wildlife Service, California Dept of Fish and Game, and the Regional Water Quality Control Board, working with the Western Resource Conservation District and Shasta Community College are interested in collecting additional data in the five main tributaries and main stem of Cow Creek. Data includes water temperature, sedimentation, water quantity, and fecal coliform.

A second goal of the meeting was to acquire information and concerns from landowners regarding the future formation of local watershed groups.

Harry Rectenwald, Fisheries Biologist explained the interest that California Fish and Game had regarding Cow Creek's salmon and steelhead numbers, the need for additional data collection, and the need for the development of cost-effective methods to improve spawning habitat. Mr. Rectenwald stressed the agency's efforts were to work collaboratively with landowners.

Carol Crowe representing the Central Valley Regional Water Quality Control Board explained her role in the project as wanting additional water quality samples in order to monitor fecal coliform and other water quality issues. Since the Board is responsible for assuring that water quality is adequate for the protection of all beneficial uses, past studies and reports from water users have raised some water quality concerns with regard to accelerated erosion and sediment discharge, elevated temperatures and fecal coliform.

Jeff Souza discussed the role of the Western Resource Conservation District, its work with watershed groups and funding available to support watershed restoration.

continued.

Discussion with landowners raised the following questions:

- How can data collected be compared if there is no previous data?
- The creeks have completely dried up in past years.
- We are concerned about government regulation of water rights and uses.
- Use good science in the data collection study.
- How long has it been since steelhead have disappeared? What is the cause?
- What kind of projects would be involved?
- How will turbidity be determined since it is variable? Dependent on drought and floods.
- - It is very complicated and expensive to show trends.
- Who defines the problem?
- What are solutions to temperature and bacteria problems other than restricting land use?
- All surface water, including springs, have coliform.
- What role does CVPIA and AFRP play in this?
- What guarantees are there that the landowner won't be held liable if fish are restored and listed?
- The program being presented is too narrow.
- If CalFed gives us dollars they may expect to take our water later.
- Need a better defined study plan.
- The Clean Water Act has the ability to shut down all ranching.
- How can we get better agency people?
- We have been lied to by government in the past.

Hank Pritchard, a representative of the Battle Creek Watershed, addressed the group as one who had similar concerns approximately two years ago. After getting involved he has lessened his fears of water loss and feels like progress has been made on Battle Creek. He has not lost any water or land. He encouragement the landowners to get involved.

Steve Fitch, Representative for Assemblymen Dickerson, and Glenn Hawes, Shasta County Supervisor and watershed landowner, also offered words of encouragement.

The meeting was adjourned at 9 p.m.

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COW CREEK WATERSHED INFORMATION

1. COW CREEK ISSUES AND CONCERNS:

The 425 square mile Cow Creek watershed is comprised of five major tributaries, North Cow, Oak Run, Clover, Old Cow, and South Cow creeks. Principal uses include water for ranch and other agricultural operations, habitat for fish and other aquatic life, and water for recreational uses, (swimming, rafting, wildlife viewing, etc.). Established land use activities are; Timber harvest, livestock grazing, hydro power production, and rural residential development in the lower watershed. The vision shared by most Cow Creek Watershed landowners and resource users would be to protect and preserve the agricultural/rural lifestyle, enhance fish and wildlife populations, and protect water quality for all beneficial uses.

The California Dept of Fish and Game and the U.S. Fish and Wildlife Service are looking for opportunities to increase salmon and steelhead populations throughout the Sacramento River and tributary streams. The agencies estimate that Cow Creek has the potential for 5,000 to 10,000 fall-run salmon and an undetermined number of steelhead. Though accurate counts are not available,(see attached) it is believed that current populations are below potential levels.

Habitat surveys conducted early this decade (1992), identified a number of permanent, (approximately 14) and temporary diversions in the reaches of Cow Creek that are accessible to salmon and steelhead. The diversions lacked fish screens giving rise to concerns of young fish being taken out of the stream along with the irrigation water. The diversion season normally extends April through October when there are still some young fish in the watershed. In addition, some of the irrigation diversion structures may be potential barriers to adult fish migrating upstream to spawn. Some reaches of the stream have banks that appear to have abnormal amounts of erosion and/or minimal vegetation coverage along the stream. Sediment arising from eroding banks could interfere with successful spawning of fish that lay their eggs in the stream gravel. Reduced shading of the stream where vegetation is abnormally sparse can increase the heat gain of the water as it travels downstream.

The California Regional Water Quality Control Board is responsible for assuring that water quality is adequate for the protection of all beneficial uses (i.e. water supplies, aquatic life, and recreational uses). Past studies and reports from water users have raised some water quality concerns with regard to accelerated erosion and sediment discharge, elevated water temperatures and fecal coliform bacteria concentrations.

The potential resource issues and concerns for Cow Creek are summarized as follows:

- Current Salmon and Steelhead populations which are below potential levels
- Accelerated erosion that causes property loss and impacts aquatic habitat
- Water quality levels that may not fully protect all beneficial uses
- Riparian and aquatic habitat conditions which may be below optimal levels

Other watershed issues could include fire management, illegal trespass, poaching, and the desire to maintain local control of watershed management.

2. EXISTING DATA BASE:

The existing information on Cow Creek watershed conditions is derived from the following studies and reports:

- 1992 DFG Cow Creek Stream Survey Report
- Habitat Restoration Actions to Double Natural Production of Anadromous Fish in the Central Valley of California - A working plan on Restoration Needs, Volume 3
- California Dept of Water Resources, Water Quality Monitoring data on Cow Creek Near Palo Cedro
- RWQCB Cow Creek Water Quality Survey, Summer 1996

The data search is still underway.

3. THE EXISTING GRANT AND PROPOSED MONITORING PROGRAM:

The Institute of Sustainable Communities, ISC, (a public non profit whose mission is to promote the development of Healthy Sustainable Communities through education, research, and public service), has received a $15,000 grant from the US Fish and Wildlife Service to summarize existing data and initiate additional data collection and monitoring on the lower reaches of each tributary and main branch of Cow Creek. Shasta College would like to link environmental education and water resource techniques training to real world situations. Money provided to Shasta College for a portion of this monitoring will pay for equipment, vehicle mileage, and hourly stipends for students interested in water resources issues in order to gain practical hands-on experience. The two main goals of the study are to:

- Compile and summarize past data on the Cow Creek Drainage in order to assess historical conditions.
- To supplement the current Department of Water Resources data from the Palo Cedro main branch station (see attached) with data from the lower reaches of each tributary. Data emphasis will initially be on turbidity, water temperatures, water quantity, and water quality. (Coliform counts)

4. LANDOWNER CONCERNS:

A great deal of concern regarding potential government regulation was evident at the Palo Cedro meeting on 1/26/99. Several of the questions related to the new data collection and monitoring effort. In response to those concerns, several conditions have been established for the proposed water quality survey:

1. <u>No regulatory agency personnel will collect the data.</u> The data will be collected by Shasta College students and staff.
2. <u>Data will not be collected in a regulatory fashion.</u> Certain procedures must be followed in order for data to be used for regulatory purposes. These procedures will not be followed for this survey.
3. <u>Landowners will have an opportunity to review the data prior to release.</u>

Appropriate hold harmless/permission forms will be developed and signed prior to any data collection.
In general, concern over regulated changes in land use from endangered species and water use issues is increasing. Many of the resource agencies have indicated that they would prefer to work with the local landowners to solve resource concerns through voluntary actions as opposed to regulatory measures. The local landowners know the land and its history better than anyone. For this reason it is critical that the landowners are involved in any efforts to restore, enhance, and manage the watershed.

There are many programs that are currently available for willing landowners to help fund projects to solve resource problems. It is premature to talk about what possible solutions might be used to restore salmon and steelhead populations. The water quality data collection and monitoring survey would be a first step to gather information about the watershed in order to arrive at some possible solutions that could be implemented on a voluntary basis. **High priority solutions would be those that benefit both the landowner and the resource while at the same time emphasizing those solutions that have little or no negative impacts to the landowner.**

5. WATERSHED PROGRAMS OBJECTIVES:

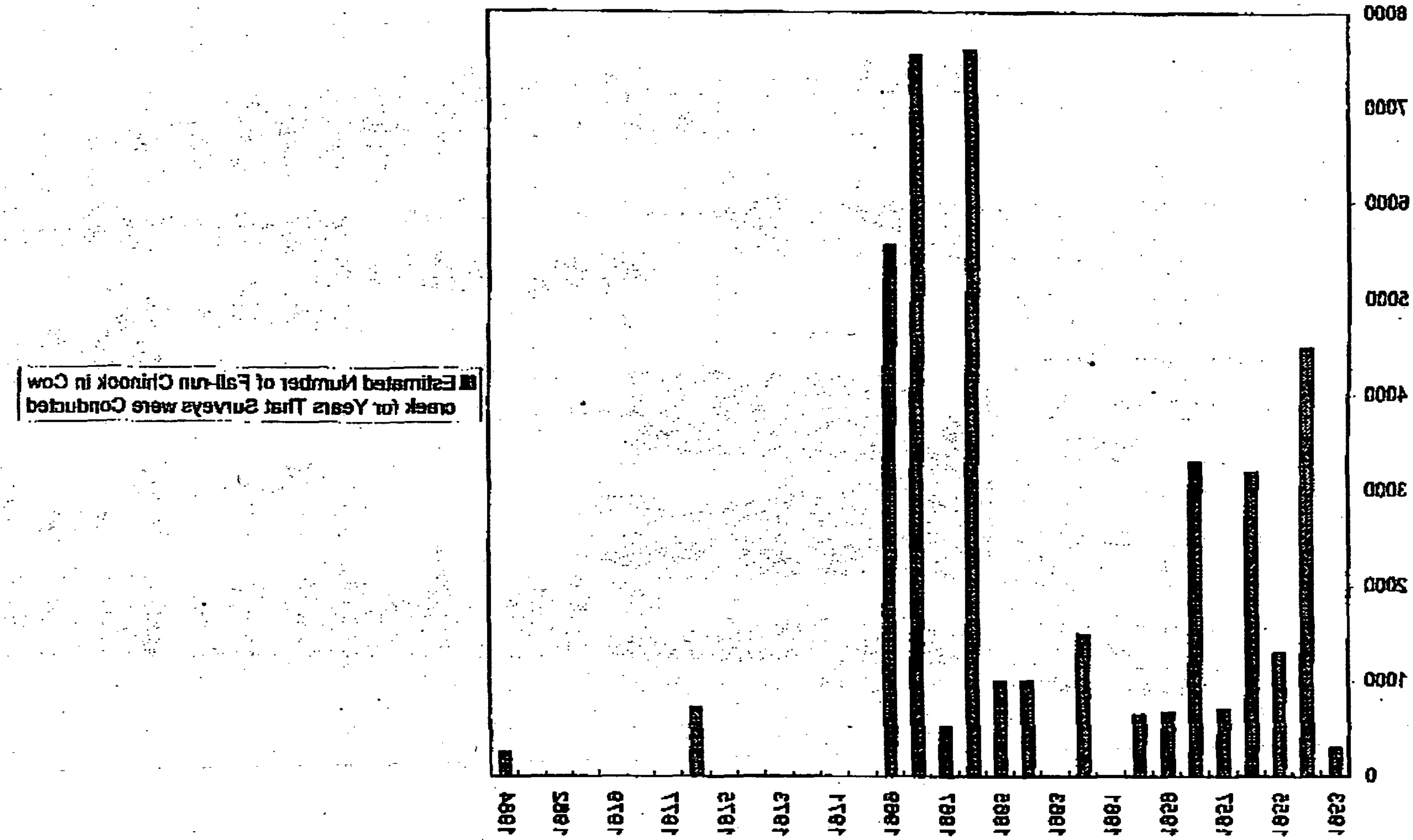
The short-term objectives of the ISC and resource agencies is to collect information to better understand and define the issues discussed in No. 1 above. In addition, throughout the Sacramento River basin, watershed management groups have formed to address local issues, (see attached map) Typically these local watershed programs are supported by public and private grants to assess watershed conditions, conduct education, implement projects and monitor long-term watershed trends. ISC and the agencies would support this type of a program for Cow Creek, however it is imperative that the motivation and leadership come from the watershed residents. As a possible next step, representatives of nearby local watershed programs could be invited to discuss their program experiences and accomplishments.

Table 2. Seasonal occurrence of selected life stages of anadromous salmonids in the Upper Sacramento River, California, based on Schafter (1980) and Vogel and Marine (1991).

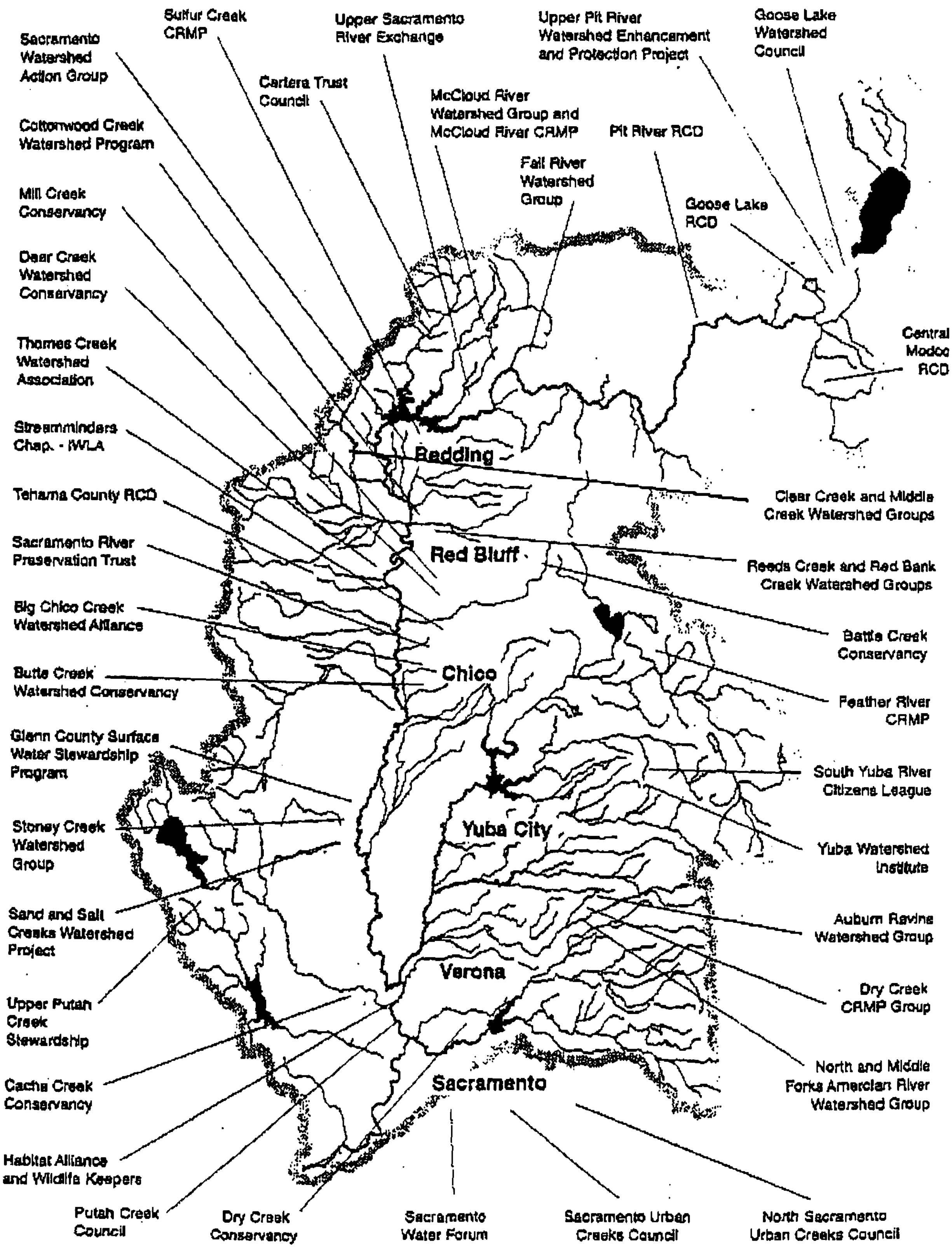
Life Stage	Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Adult Migration	Winter Chinook				X								
	Spring Chinook					X							
	Fall Chinook									X	X		
	Late-Fall Chinook	X											
	Steelhead												
Spawning	Winter Chinook												
	Spring Chinook									X			
	Fall Chinook											X	
	Late-Fall Chinook		X										
	Steelhead												
Juvenile Residence	Winter Chinook												
	Spring Chinook												
	Fall Chinook												
	Late-Fall Chinook												
	Steelhead												

X = Denotes approximate peak of life stage if a significant peak occurs.

Estimated Number of Fall-run Chinook in Cow creek for Years That Surveys were Conducted



Watershed Groups and Conservancies on the Sacramento River Watershed Program Distribution List



COW CREEK WATERSHED
~~ AGENDA ~~

TUESDAY, MAY 18, 1999 • 7:00 – 9:15 P.M.
MILLVILLE GRANGE HALL, PALO CEDRO, CA
22031 Old Highway 44 Drive

7:00 **INTRODUCTIONS:**
Francis Duchi, Executive Director of the Institute for Sustainable Communities will briefly review the purposes of the Cow Creek Watershed Data Collection and resident watershed interest project.

7:10 **CALIFORNIA COORDINATED RESOURCE MANAGEMENT AND PLANNING (CRMP):**
Bob Bailey, District Conservationist will present a 20-minute slide program on the following topic: The CRMP Watershed Process of Managing Areas with Multiple Use
Ownership.

7:30 **PANEL PRESENTATION:**
7:30 Diane Gaumer / Deer Creek Conservancy
7:40 Keri Burke / Mill Creek Conservancy
7:50 Irwin Fust, Shasta County Supervisor / Cow Creek
8:00 Al Carter / Landowner / Clear Creek
The above Watershed Representatives will review the organizational structure of their respective watershed groups and discuss why and how their group formed.

8:10 **AB-730:**
Steve Fitch, Legislative Assistant to Assemblyman Dickerson
Will discuss the Proposed scope for the AB-730 bill.
The California Watershed Management and rehabilitation Act.

8:20 ***Opportunity to address your questions to the above Presenters...***

8:40 **DATA COLLECTION PROJECT:**
Morgan Hannaford with Shasta College and Phil Warner with California Department of Fish and Game will review the Data Collection portion of the project.

8:55 **CLEAN WATER ACT FUNDING:**
Jeff Souza, Projects Manager of the Western Shasta Resource Conservation District will review potential future funding, and discuss how the group may wish to proceed.

9:15 **Adjourn**

Attachments: Cow Creek Watershed Information and Data Collection Project 1999

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COW CREEK WATERSHED

Public Meeting Minutes # 3

May 18, 1999

The third "Public Information-Gathering Session" was held at the Millville Grange Hall in Palo Cedro on March 18, 1999 at 7:00 p.m. Approximately 50 residents, landowners and interested participants attended.

Francis Duchi, Executive Director of the Institute of Sustainable Communities welcomed everyone, gave a brief overview of the Institute and its goal of identifying willing landowner participants to assist with the US Fish and Wildlife Service funded Data Collection Grant.

Francis introduced Bob Bailey of The Natural Resources Conservation Service, who gave a slide presentation on the California Coordinated Resource Management watershed process of managing areas with multiple use ownership. A copy of a handbook regarding the CRMP process was offered to those who might be interested.

Diane Gaumer with the Deer Creek Conservancy was introduced at 7:35 p.m. Diane gave a brief history regarding the formation of the Deer Creek Conservancy watershed group, which was started in 1994. Diane's presentation included a step-by-step description of all the issues involved in the planning and formation of the Conservancy, which included the positives, as well as the negatives, grant applications, funding sources, and the many agencies involved, as well as many individuals. Diane's presentation was very informative and well received by those present.

Keri Burke with the Mill Creek Conservancy was introduced at 8:00 p.m. This Conservancy encompasses 132 sq. miles from Lake Helen to Los Molinos. There are only 16 landowners owning a 100 acres or more and 65 smaller landowners, most of whom live in the rural, residential subdivision areas located at lower levels. Keri's presentation included many of the issues encountered in the planning and formation of the Mill Creek Conservancy, and some of the current projects they were working on.

Shasta County Supervisor Irwin Fust was scheduled to speak; however, he was not able to attend.

Al Carter gave a very positive talk regarding his involvement with local, as well as government agencies, as a landowner in the Clear Creek watershed. Al explained some of his problems as a landowner, i.e., under-grazing, over grazing, erosion, and star thistle. He then talked about many of the benefits he had received in becoming involved in cooperating with different environmental programs. He shared how these groups/agencies have given him assistance in introducing native grasses, which helped to choke out the star thistle and that he should rotate his grazing areas. Al encouraged those present to become involved in the formation of a watershed group.

At 8:25, Steve Fitch, Legislative Assistant to Assemblyman Dickerson, spoke about the Proposed Scope of the AB-730 Bill, The Watershed Management and Rehabilitation Act. Steve shared with landowners, the many Grants that were available and that there were numerous funding programs available north of Sacramento. He discussed the need for coordination and the long-term implications of continuing the local watershed groups.

Diane Gaumer stated that there were 29 Granting sources available, all of which have something to do with watershed groups. She asked Steve if Dickerson's office was working with local watershed/landowner groups so that they were not hindered in their endeavors. Steve answered with a "yes."

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At 8:35, Morgan Hannaford described the present Data Collection process, as well as the involvement of Shasta College students who would be collecting the data. Morgan encouraged interested landowners to contact him if they were interested in participating. The question was asked, "will we (landowners) be able to see a copy of the final report/findings of this project?" Morgan stated that this information would be available to the landowners.

At 8:55, Phil Warner of the California Department of Fish Game gave a talk regarding the Department of Fish and Game and their interest and willingness to work with landowners. Phil discussed some of the issues the DF&G were working on, regarding stream erosion and sedimentation, anadromous fish, etc. He stated that if anyone had an interest in fish screen diversions, they should contact him at the DF&G, Redding office.

At 9:10, Dennis Heiman with the Regional Water Quality Control Board filled in for Jeff Souza of the WSRCD. Dennis distributed a copy of the 205j Grant. The scope of this Grant is to conduct watershed assessment focusing on (1) potential for anadromous fish enhancement and (2) evaluation of any water quality problems. Dennis stated that if anyone had concerns or issues of what may or may not be included in the study, that they were to contact Jeff Souza at WSRCD. Dennis commented that the motivation of the WSRCD is to work with the landowners. He also pointed out that without the landowner's cooperation, many of these agencies would not be able to complete and carryout the projects of their offices.

Francis informed the group, that this project was funded through a $15,000 Grant received from the U.S. Fish and Wildlife Service and that the Institute of Sustainable Communities became involved in the Clear Creek Data Collection project in collaboration with Shasta College. The purpose of the three information-gathering meetings was to inform the landowners of the project and to find willing participants who would allow students on their land so that the data-collection could take place. Francis then informed the group that the WSRCD would be taking over the Institute's roll regarding the formation of a watershed work group. All landowners that are interested in any future endeavors and wish to be involved in the formation of a watershed group should contact Jeff Souza at the WSRCD.

Francis thanked the group for showing their continued interest by attending tonight's meeting.

The meeting was adjourned at 9:20 p.m.

/bjc

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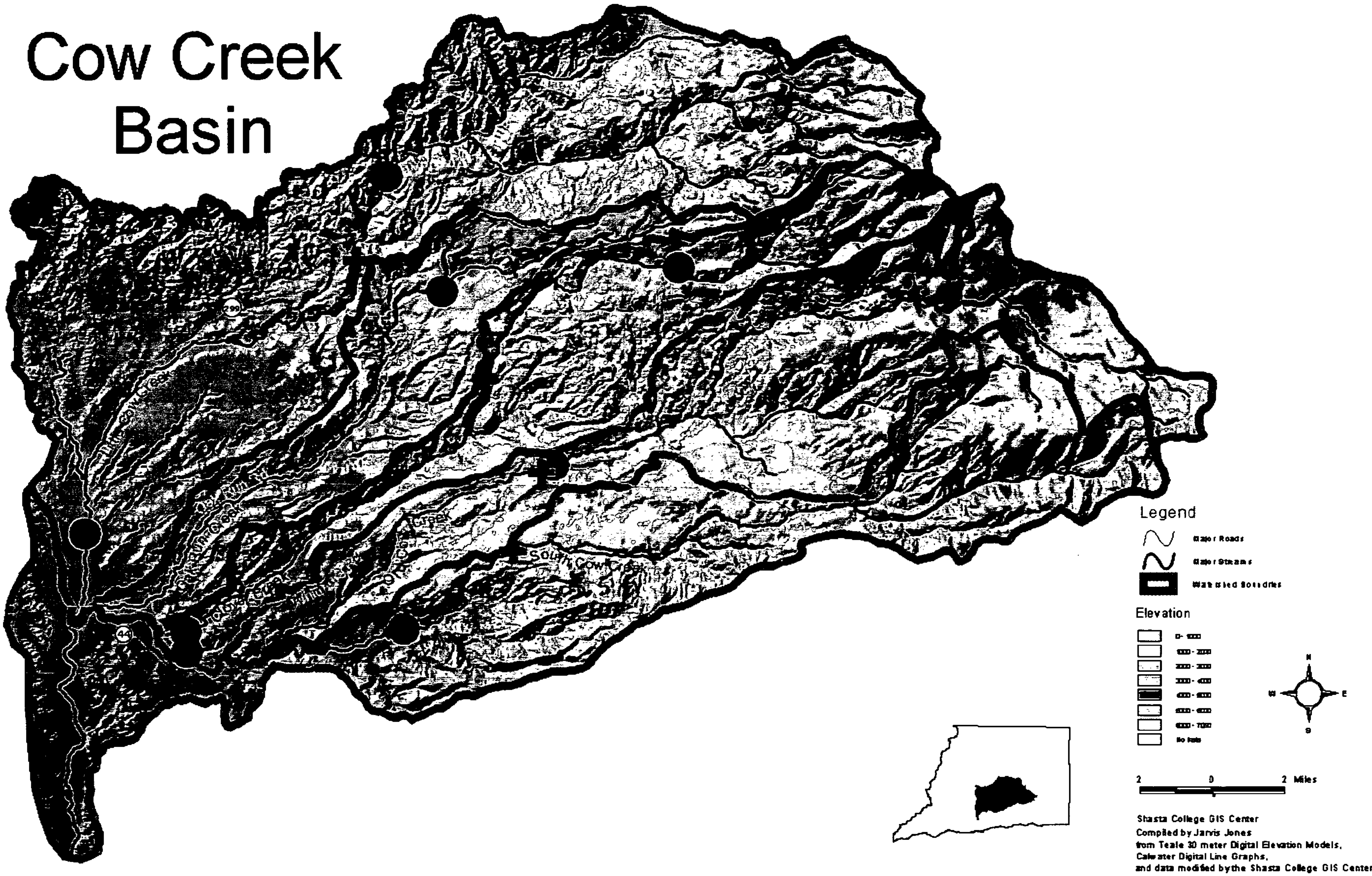
Cow Creek Basin



CBD-Past.

B.1.15 Colusa Basin Drain, Azinphos-methyl

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region, (Regional Board) recommends the addition of the Colusa Basin Drain (CBD) to California's Clean Water Act Section 303(d) list due to impairment by azinphos-methyl. Information available to the Regional Board on azinphos-methyl concentrations in the CBD indicates that water quality objectives are not being attained. The basis for this determination is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Colusa Basin Drain	**Pollutants/Stressors**	Azinphos-methyl
Hydrologic Unit	520.21	**Sources**	Agriculture
Total Waterbody Size	70 miles	**TMDL Priority**	
Size Affected	70 miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	The entire waterbody	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	39° 37' 31"	**Upstream Extent Longitude**	122° 04' 07"
Downstream Extent Latitude	38° 48' 06"	**Downstream Extent Longitude**	121° 43' 18"

Watershed Characteristics

The CBD flows for approximately 70 miles along the west side of the Sacramento River, from Colusa to the CBD's confluence with the Sacramento River at Knights Landing. The CBD receives runoff from hundreds of thousands of acres of agricultural fields during rain events and from irrigation return flow.

Water Quality Objectives Not Attained

The narrative objectives for pesticides and toxicity are not being attained for azinphos-methyl in the CBD. The narrative objective for pesticides states. "No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses." The narrative toxicity objective in the Basin Plan states, in part, "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life." The narrative toxicity objective further states that "The Regional Water Board will also consider ... numerical criteria and guidelines for toxic substances developed by the State Water Board, the California Office of Environmental Health Hazard Assessment, the California Department of Health Services, the U.S. Food and Drug Administration, the National Academy of Sciences, the U.S. Environmental Protection Agency, and other appropriate organizations to evaluate compliance with this objective" (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/~rwqcb5/bsnplnab.pdf). The US Environmental Protection Agency (USEPA) has established an ambient water quality criterion for azinphos-methyl for the protection of freshwater aquatic life of 0.01 µg/L (USEPA, 1976).

Evidence of Impairment

The CBD was sampled at Road 99E, near Knights Landing, at least once a month between November 1996 and April 1998. A total of 21 water samples were analyzed for azinphos-methyl (Table B-2). Six of the 21 samples (about 28%) contained azinphos-methyl concentrations at or above US Environmental Protection Agency instantaneous maximum water criterion of 0.01 ug/L (USEPA, 1976). The highest concentrations were generally detected between December and April, and during August and September. High levels of azinphos-methyl often co-occurred with high levels of diazinon.

Table B-2. Summary of Azinphos-methyl Concentrations in the Colusa Basin Drain

Data Source	Sample Years	Number of Sample Dates	Range of Azinphos -methyl Concentrations	Criterion[a]	Number of Sample Dates Equal to or Above Criterion	Percent Sample Dates Equal to or Above Criterion
Domagalski, 2000	1996	2	nd	0.01 µg/L	0	0%
Domagalski, 2000	1997	15	nd - 0.054 µg/L		6	40%
Domagalski, 2000	1998	4	nd - 0.006 µg/L		0	0%
Summary	1996-1998	21	nd - 0.05 µg/L		6	28%

[a] USEPA instantaneous maximum water criterion (USEPA, 1976)
nd = not detected

Extent of Impairment
Azinphos-methyl is used to control insects on almonds, walnuts and other crops grown throughout the region drained by the CBD. Therefore, it is likely that the entire length of the CBD is impaired by azinphos-methyl.

Potential Sources
The extensive agricultural areas drained by the CBD are the most likely sources of azinphos-methyl.

B.1.16 Colusa Basin Drain, Diazinon

Summary of Proposed Actions

The California Regional Water Quality Control Board, Central Valley Region (Regional Board) recommends the addition of the Colusa Basin Drain (CBD) to California's Clean Water Act Section 303(d) list due to impairment by diazinon. Information available to the Regional Board on diazinon concentrations in the Colusa Basin Drain (CBD) indicates that water quality objectives are not being attained. The basis for this recommendation is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Colusa Basin Drain	**Pollutants/Stressors**	Diazinon
Hydrologic Unit	520.21	**Sources**	Agriculture
Total Waterbody Size	70 miles	**TMDL Priority**	
Size Affected	70 miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	The entire Drain	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	39° 37' 31"	**Upstream Extent Longitude**	122° 04' 07"
Downstream Extent Latitude	38° 48' 06"	**Downstream Extent Longitude**	121° 43' 18"

Watershed Characteristics

The CBD flows for approximately 70 miles along the west side of the Sacramento River, from Colusa to CBD's confluence with the Sacramento River at Knights Landing. The CBD receives runoff from hundreds of thousands of acres of agricultural fields during rain events, and from irrigation return flow in the dry season.

Water Quality Objectives Not Attained

The narrative objectives for pesticides and toxicity are not being attained for diazinon in the CBD. The narrative objective for pesticides states "No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses." The narrative toxicity objective in the Basin Plan states, in part, "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life." The narrative toxicity objective further states that "The Regional Water Board will also consider … numerical criteria and guidelines for toxic substances developed by the State Water Board, the California Office of Environmental Health Hazard Assessment, the California Department of Health Services, the U.S. Food and Drug Administration, the National Academy of Sciences, the U.S. Environmental Protection Agency, and other appropriate organizations to evaluate compliance with this objective." (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/~rwqcb5/bsnplnab.pdf) The California Department of Fish and Game (CDFG) has established freshwater numeric acute (1-hour average) and chronic (4-day average) criteria for diazinon of 0.08 µg/L and 0.05 µg/L, respectively, for the protection of aquatic life (Siepmann and Finlayson, 2000).

Evidence of Impairment

Between 1994 and 1998, multiple studies analyzed a total of 56 ambient water samples collected from the CBD at Road 99E, near Knights Landing, for diazinon (Table B-2). Most samples were collected during the orchard dormant spray season. Overall, 18 of 56 samples (about 32%) contained diazinon concentrations at or above CDFG chronic water quality criterion of 0.05 µg/L and 11 of 56 (about 20%) samples exceeded CDFG acute water quality criterion of 0.08 µg/L.

Table B-2. Summary of Diazinon Concentrations in the Colusa Basin Drain

Data Source	Sample Years	Number of Sample Dates	Range of Diazinon Concentrations	Criteria[a]		Number of Sample Dates Equal to or Above Criteria	Percent of Sample Dates Equal to or Above Criteria
Holmes *et al*, 2000	1994	29	nd - 0.42 µg/L	Chronic	0.05 µg/L	8	28%
				Acute	0.08 µg/L	9	31%
Domagalski, 2000	1996	2	nd	Chronic	0.05 µg/L	0	0%
				Acute	0.08 µg/L	0	0%
Domagalski, 2000	1997	15	nd - 0.073 µg/L	Chronic	0.05 µg/L	0	0%
				Acute	0.08 µg/L	2	13%
Domagalski, 2000	1998	4	0.007 - 0.098 µg/L	Chronic	0.05 µg/L	0	0%
				Acute	0.08 µg/L	1	25%
Dileanis, *et al*, 2001	2000	6	nd - 0.038 µg/L	Chronic	0.05 µg/L	0	0%
				Acute	0.08 µg/L	0	0%
Summary	1994 - 2000	56	nd - 0.42 µg/L	Chronic	0.05 µg/L	8	14%
				Acute	0.08 µg/L	12	21%

[a] CDFG water quality criteria for the protection of aquatic life (Siepmann and Finlayson, 2000)
nd = not detected

Extent of Impairment
Diazinon is used to control insects on almonds, walnuts, stone fruits and other crops grown throughout the region drained by the CBD. Therefore, it is likely that the entire length of the CBD is impaired by diazinon.

Potential Sources
The extensive agricultural areas drained by the CBD are the most likely sources of diazinon.

B.1.17 Colusa Basin Drain, Molinate

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region (Regional Board) recommends the addition of the Colusa Basin Drain (CBD) to California's Clean Water Act Section 303(d) list due to impairment by molinate. Information available to the Regional Board on concentrations of molinate indicates that water quality objectives are not being attained. The basis for this recommendation is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Colusa Basin Drain	**Pollutants/Stressors**	Molinate
Hydrologic Unit	520.21	**Sources**	Agriculture
Total Waterbody Size	70 miles	**TMDL Priority**	
Size Affected	70 miles	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	The entire length of the Colusa Basin Drain	**TMDL End Date (Mo/Yr)**	
Upstream Extent Latitude	39° 37' 31"	**Upstream Extent Longitude**	122° 04' 07"
Downstream Extent Latitude	38° 48' 06"	**Downstream Extent Longitude**	121° 43' 18"

Watershed Characteristics

The Colusa Basin Drain (CBD) flows for approximately 70 miles along the west side of the Sacramento River, from close to the Sacramento River, at Colusa, to its confluence with the Sacramento River at Knights Landing. The CBD receives runoff from hundreds of thousands of acres of agricultural fields during rain events and from irrigation return flow.

Water Quality Objectives Not Attained

The narrative objective for pesticides and toxicity are not being attained for molinate in the CBD. The narrative objective for pesticides states, "No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses." The narrative objective for toxicity states, "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life." The narrative toxicity objective further states "The Regional Water Board will also consider...numerical criteria and guidelines for toxic substances developed by the State Water Board, the California Office of Environmental Health Hazard Assessment, the California Department of Health Services, the U.S. Food and Drug Administration, the National Academy of Sciences, the U.S. Environmental Protection Agency, and other appropriate organizations to evaluate compliance with this objective." (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/rwqcb5/bsnplnab.pdf). The California Department of Fish and Game (CDFG) molinate criterion to protect aquatic life is 13 µg/L (Harrington, 1990).

Evidence of Impairment

Between 1994 and 2000, multiple studies analyzed a total of 133 ambient water samples collected in the CBD for molinate. Samples were collected during the period of application of molinate to rice (generally May/June). Forty-two of 133 samples (about 32%) exceeded the CDFG aquatic life protection criterion for molinate of 13 µg/L. Table B-2 summarizes the available data.

Table B-2. Summary of Molinate Concentrations in the Colusa Basin Drain

Data Source	Sample Years	Number of Sample Dates	Range of Molinate Concentrations	Criterion[a]	Number of Sample Dates Equal to or Above Criterion	Percent of Sample Dates Equal to or Above Criterion
Holmes *et al*, 2000	1994	23	nd - 0.18 µg/L	13 µg/L	0	0%
Gorder and Lee, 1995	1995	21	nd – 32.9 µg/L	13 µg/L	8	38%
Domagalski, 2000; and Gorder *et al*, 1996	1996	23	nd – 43.68 µg/L	13 µg/L	11	48%
Domagalski, 2000; and CDPR, 1997	1997	21	nd – 29.0 µg/L	13 µg/L	8	38%
Domagalski, 2000; and Gorder and Newhart, 1998	1998	21	nd - 44.09 µg/L	13 µg/L	7	33%
Newhart and Bennett, 1999	1999	13	nd – 19.6 µg/L	13 µg/L	2	15%
Newhart *et al*, 2000	2000	11	nd - 22.0 µg/L	13 µg/L	6	33%
Summary	1994 - 2000	133	nd – 44.09 µg/L	13 µg/L	42	32%

[a] CDFG water quality criterion for the protection of aquatic life (Harrington, 1990)
nd = not detected

Extent of Impairment
Molinate is used to control aquatic weeds on rice grown throughout the region drained by the CBD. Therefore, it is likely that the entire length of the CBD is impaired by molinate.

Potential Sources
The extensive agricultural areas drained by the CBD are the most likely sources of molinate.

CBD - molinate

Information on Rice Pesticides Submitted to the California Regional Water Quality Control Board Central Valley Region

December 28, 1995

by

Nancy K. N. Gorder and J. Marshall Lee

California Environmental Protection Agency
Department of Pesticide Regulation
Environmental Monitoring and Pest Management Branch
Environmental Hazards Assessment Program
1020 N Street, Sacramento, California 95814-5624

Table 3. 1995 Pesticide Concentrations at the Colusa Basin Drain near Highway 20 in Colusa County (CBD5) in parts per billion (ppb). Samples collected by the Department of Pesticide Regulation unless noted otherwise.

	Molinate		Thiobencarb		Carbofuran		Methyl parathion		Malathion	
Laboratory	Primary	QC	Primary	QC	Primary	QC	Primary	QC	Primary	QC
Reporting limit	1.0	0.50	0.50	0.50	0.35	0.10	0.05	0.10	0.05	0.10
Date										
4/14	ND (ND)	ND	ND (ND)	ND	ND (ND)	ND	ND (ND)	ND	ND (ND)	ND
5/16	9.3	NS	ND	NS	0.70	NS	0.079	NS	1.033	NS
5/18	[8.2]	11.9	0.6	1.20	0.42	0.368	ND	ND	0.245	0.28
5/23	[15.4]	NS	[0.8]	NS	0.67	NS	0.0560	NS	ND	NS
5/25	25	32.9	0.7	0.870	ND	0.329	0.0675	ND	ND	ND
5/30	19	NS	1.2	NS	ND	NS	ND	NS	ND	NS
6/1	18	16.5	2.3	2.68	0.56	0.355	ND	ND	ND	ND
6/6	16.5 (11.8)	NS	1.3 (1.2)	NS	0.45 (0.44)	NS	ND (ND)	NS	ND (ND)	NS
6/8	17.8 (17.4)	18.4	3.5 (3.8)	3.7	0.34 (ND)	0.260	ND (ND)	ND	ND (ND)	ND
6/13	10.7 (10.7)	NS	1.7 (1.8)	NS	0.39 (0.35)	NS	ND (ND)	NS	ND (ND)	NS
6/15	13.9	13.3	0.8	0.872	ND	ND	ND	ND	ND	ND
6/20	10.4	NS	0.5	NS	ND	NS	ND	NS	ND	NS
6/22	8.5	10.1	0.5	0.758	0.40	ND	ND	ND	ND	ND
6/27	8.0	NS	1.8	NS	ND	NS	ND	NS	ND	NS
6/29	10	14.2	1.4	2.17	ND	0.314	ND	ND	ND	ND
7/3	8.5	NS	0.5	NS	ND	NS	ND	NS	ND	NS
7/6	5.1	5.23	0.6	0.682	ND	0.141	ND	ND	ND	ND
7/11	9.8	NS	ND	NS	ND	NS	ND	NS	ND	NS
7/13	3.2	3.19	ND	0.5	ND	0.124	ND	ND	ND	ND
7/18	3.3	NS	ND	NS	ND	NS	ND	NS	ND	NS
7/20	2.8	2.9	ND	ND	ND	0.178	ND	ND	ND	ND

Results in parentheses from samples collected by Klienfelder, Inc.
Results in brackets are the results of backup sample analyses

QC Quality Control
Blank Cells Results not yet reported

ND Not Detected
NS Not Sampled

Performance goals (ppb):

molinate	10	methyl parathion	0.13
thiobencarb	1.5	malathion	0.1
carbofuran	0.4		

PRELIMINARY DATA--
SUBJECT TO CHANGE

Table 4. 1995 Pesticide Concentrations at Butte Slough at Lower Pass Road in Sutter County in parts per billion (ppb). Samples collected by Klienfelder, Inc.

	Molinate	Thiobencarb	Carbofuran	Methyl parathion	Malathion
Date	Primary	Primary	Primary	Primary	Primary
4/14	ND	ND	ND	ND	ND
5/16	ND	ND	ND	ND	ND
5/23	[ND]	ND	ND	ND	ND
5/30	6.4	ND	0.57	ND	ND
6/1	7.4	ND	ND	0.187	ND
6/6	8.4	ND	0.37	ND	ND
6/8	6.1	ND	ND	ND	ND
6/13	3.4	ND	ND	ND	ND
6/15	3.9	1.1	ND	ND	ND
6/20	8.5	ND	0.37	ND	ND
6/22	6.3	1.3	ND	ND	ND
6/27	7.3	ND	ND	ND	0.639
6/29	7.0	ND	ND	ND	ND
7/3	6.2	ND	0.5	ND	ND
7/6	3.1	ND	ND	ND	ND
7/11	2.7	ND	ND	ND	ND
7/18	2.1	ND	ND	ND	ND

Results in brackets are the results of backup sample analyses.

Blank Cells Results not yet reported

ND Not Detected

Performance goals (ppb):

molinate	10
thiobencarb	1.5
carbofuran	0.4
methyl parathion	0.13
malathion	0.1

PRELIMINARY DATA--
SUBJECT TO CHANGE

CRD - molinate

Information on Rice Pesticides
Submitted to the
California Regional Water Quality Control Board
Central Valley Region

December 31, 1996

by

Nancy K. N. Gorder, J. Marshall Lee, and KayLynn Newhart

California Environmental Protection Agency
Department of Pesticide Regulation
Environmental Monitoring and Pest Management Branch
Environmental Hazards Assessment Program
1020 N Street, Sacramento, California 95814-5624

Table 3. 1996 Pesticide Concentrations at the Colusa Basin Drain near Highway 20 in Colusa County (CBD5) in parts per billion (ppb). Samples collected by Kleinfelder, Inc. under contract with the California Rice Industry Association.

	Molinate		Thiobencarb		Carbofuran		Methyl parathion		Malathion	
Laboratory type	Primary	QC	Primary	QC	Primary	QC	Primary	QC	Primary	QC
Reporting limit (ug/l)	**1.0**	**0.5**	**0.5**	**0.5**	**0.35**	**0.05**	**0.05**	**0.1**	**0.05**	**0.1**
Date										
4/1	ND	ND	ND	ND	ND	0.165[1]	ND	ND	ND	ND
4/23	ND	NA	ND	NA	ND	NA	ND	(ND)	0.990	(0.86)[3]
4/25	ND	ND	ND	ND	ND	0.162	ND	ND(ND)	0.856	0.846(0.907)[3]
4/30	ND	NA	ND	NA	(ND)	NA	ND	NA	ND	NA
5/2	ND	ND	ND	ND	1.10	0.938	ND	ND	ND	ND
5/7	1.11	NA	ND	NA	ND	NA	ND	NA	ND	NA
5/9	3.34	3.26	ND	ND	ND	0.388	ND	ND	ND	ND
5/14	12.23	NA	1.5	NA	0.61	NA	0.122	NA	0.594	NA
5/16	11.17	11.9	2.9	3.11	2.97	2.176	ND	ND	ND	ND
5/18[2]	30.0	NA	4.65	NA	1.91	NA	NA	NA	NA	NA
5/21	41.25	NA	5.0	NA	0.60	NA	0.07	NA	ND	NA
5/23	43.68	37.3	6.8	7.28	0.62	0.553	ND	ND	0.368	0.254
5/26[2]	38.9	NA	4.54	NA	0.546	NA	NA	NA	NA	NA
5/28	28.20	NA	7.7	NA	1.15	NA	0.059	ND	6.00	3.27

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Table 3. 1996 Pesticide Concentrations at the Colusa Basin Drain near Highway 20 in Colusa County (CBD5) in parts per billion (ppb). Samples collected by Kleinfelder, Inc. under contract with the California Rice Industry Association.

	Molinate		**Thiobencarb**		**Carbofuran**		**Methyl parathion**		**Malathion**	
Laboratory type	Primary	QC	Primary	QC	Primary	QC	Primary	QC	Primary	QC
Reporting limit (ug/l)	**1.0**	**0.5**	**0.5**	**0.5**	**0.35**	**0.05**	**0.05**	**0.1**	**0.05**	**0.1**
Date										
5/30	19.95	16.6	1.1	1.25	2.75	2.445	ND	ND	ND	ND
6/4	21.80	NA	3.0	NA	ND	NA	ND	NA	0.125	NA
6/6	19.80	17.2	5.9	5.95	ND	0.172	0.112	ND	0.684	0.611
6/11	17.10	(14.9)	16.2	(16.9)	ND	NA	ND	NA	ND	NA
6/13	27.60	24	3.7	3.45	ND	0.217	ND	ND	ND	ND
6/18	25.60	NA	3.9	NA	ND	NA	ND	NA	ND	NA
6/20	8.09	9.28	4.0	4.18	ND	0.218	ND	ND	ND	ND
6/25	2.89	NA	1.0	NA	ND	NA	ND	NA	ND	NA
6/27	2.75	3.83	1.3	1.45	0.41	0.335	ND	ND	0.06	ND

QC	Quality control
Blank cells	Results not yet reported
ND	Not detected
NA	Not analyzed
( )	Backup-split sample analyzed

PERFORMANCE GOALS (ppb):

molinate	10	methyl parathion	0.13
thiobencarb	1.5	malathion	0.1
carbofuran	0.4		

1 Confirmed by re-extraction and mass spectrometry.
2 All samples on these dates were collected by the Department of Pesticide Regulation and analyzed by the California Department of Food and and Agriculture analytical laboratory. Samples on these dates were collected as composite grab samples.
3 Reanalysis after calibration curve standards for malathion were recalculated.

PRELIMINARY DATA/SUBJECT TO CHANGE

Gorder & Lee, 1997. (CDPR) - ~~Butte Slough m~~ CBD - molinate

Department of Pesticide Regulation
Information on Rice Pesticides
Submitted to the Central Valley Regional Water Quality Control Board
December 23, 1997

Programs have been implemented by the Department of Pesticide Regulation (DPR) since 1983 to reduce discharges of the rice herbicides molinate (Ordram®) and thiobencarb (Bolero®and Abolish®) into surface waterways. In 1990, the objectives of these control efforts were clarified and expanded, following the adoption of amendments to the Central Valley Regional Water Quality Control Board's (Regional Board) Water Quality Control Plan (Basin Plan). This plan established performance goals for molinate and thiobencarb beginning in 1990, and for the insecticides carbofuran (Furadan®), methyl parathion, and malathion beginning in 1991. Regional Board staff are currently in the process of amending the pesticide section of the Basin Plan. This Basin Plan amendment will include defining numeric water quality objectives for the rice pesticides addressed in this program.

The following review describes the factors affecting quantities of molinate, thiobencarb, carbofuran, methyl parathion, and malathion discharged to agricultural drains and the Sacramento River and efforts to meet the performance goals in 1997. A summary of pertinent water quality monitoring efforts is provided. Programs implemented in 1997 helped control discharges of molinate, thiobencarb, carbofuran, methyl parathion, and malathion from rice fields to comply with the performance goals and the water quality objective for toxicity in the Basin Plan.

REVIEW OF 1997 PROGRAM

Discussion

A summary of the 1997 Rice Pesticides Program can be found in the following sections. Program requirements were implemented by county agricultural commissioners using restricted material permits. A description of the 1997 rice pesticide program requirements can be found in the guidelines provided to the county agricultural commissioners by the Director of DPR in a memorandum dated March 8, 1995 (see Appendix A). The 1995 permit conditions were determined appropriate for use in 1997. The commissioners also provided information to growers on the voluntary malathion program. Additional efforts were taken by DPR staff to continue improved communication about the seepage and drift problems to the rice industry. Aspects of the 1995-7 program that were different from the 1994 program are summarized in Appendix B.

PRELIMINARY DATA/SUBJECT TO CHANGE

Table 3. 1997 Pesticide Concentrations at the Colusa Basin Drain near Highway 20 in Colusa County (CBD5) in parts per billion (ppb).

	Molinate		Thiobencarb		Carbofuran		Methyl parathion	Malathion
Laboratory type	Primary	QC	Primary	QC	Primary	QC	Primary	Primary
Reporting limit (ug/l)	1.0	0.5	0.5	0.5	0.35	0.05	0.05	0.05
Date								
3/31	ND	ND	ND	ND	ND	ND	ND	ND
4/22	ND	ND	ND	ND	0.62	0.634	ND	ND
4/24	ND	ND	ND	ND	0.27	0.297	ND	ND
4/29	ND	0.523	0.7	0.732	0.37	0.349	ND	ND
5/01	1.55	1.85	ND	0.50	0.44	0.415	ND	ND
5/06	4.49	ND	1.9	0.917	0.43	0.369	ND	ND
5/08	7.31	7.35	1.4	1.32	0.42	0.360	ND	ND
5/13	15.87	NS	3.6	NS	ND	NS	0.107	ND
5/15	15.96	15.7	4.1	4.17	0.61	0.571	0.066	ND
5/20	24.65	NS	12.3	NS	ND	NS	ND	ND
5/22	25.67	29.0	6.0	6.96	0.42	0.408	ND	ND
5/27	13.07	NS	4.4	NS	ND	NS	ND	ND
5/29	14.88	11.9	3.3	2.95	ND	0.204	ND	ND

Samples collected by Kleinfelder, Inc. under contract with the California Rice Industry Association.

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Table 3, continued. 1997 Pesticide Concentrations at the Colusa Basin Drain near Highway 20 in Colusa County (CBD5) in parts per billion (ppb).

	Molinate		Thiobencarb		Carbofuran		Methyl parathion	Malathion
Laboratory type	Primary	QC	Primary	QC	Primary	QC	Primary	Primary
Reporting limit (ug/l)	1.0	0.5	0.5	0.5	0.35	0.05	0.05	0.05
Date								
6/3	11.16	NS	4.2	NS	ND	NS	ND	ND
6/5	9.41	9.51	2.6	2.58	ND	0.273	ND	ND
6/10	21.60	NS	2.0	NS	ND	NS	ND	ND
6/12	12.44	13.1	2.0	2.05	ND	0.154	ND	ND
6/17	3.10	NS	1.3	NS	ND	NS	ND	ND
6/19	3.05	4.13	1.5	1.51	ND	0.140	ND	ND
6/24	2.49	NS	1.3	NS	ND	NS	ND	ND
6/26	2.37	2.81	1.3	ND	ND	0.152	ND	ND

Key to designations on rice water monitoring table for CBD5:

QC	Quality control
Blank cells	Results not yet reported
ND	Not detected
NS	Not sampled

PERFORMANCE GOALS (ppb):

molinate	10	methyl parathion	0.13
thiobencarb	1.5	malathion	0.1
carbofuran	0.4		

CBD-molinate

Information on Rice Pesticides Submitted to the California Regional Water Quality Control Board Central Valley Region

December 31, 1998

by

Nancy K. N. Gorder and KayLynn Newhart

California Environmental Protection Agency
Department of Pesticide Regulation
Environmental Monitoring and Pest Management Branch
Environmental Hazards Assessment Program
830 K Street, Sacramento, California 95814-3510

PRELIMINARY DATA/SUBJECT TO CHANGE

Table 5. 1998 Pesticide Concentrations at the Colusa Basin Drain near Highway 20 in Colusa County (CBD5) in parts per billion (ppb).

	Molinate		Thiobencarb		Carbofuran		Methyl parathion	Malathion
Laboratory type	Primary	QC	Primary	QC	Primary	QC	Primary	Primary
Reporting limit (ug/l)	1.0	0.5	0.5	0.5	0.35	0.05	0.05	0.05
Date								
3/31	ND	ND	ND	ND	ND	0.87	ND	ND
5/05	ND	NS	ND	NS	ND	NS	ND	ND
5/07	ND	ND	ND	ND	ND	0.18	ND	ND
5/12	ND	NS	ND	NS	ND	NS	ND	ND
5/14	ND	0.93	ND	ND	0.38	0.36	ND	ND
5/19	3.91	NS	ND	NS	0.35	NS	ND	ND
5/21	1.23	2.19	ND	ND	0.69	0.68	ND	ND
5/26	12.39	NS	1.20	NS	ND	NS	ND	ND
5/28	13.76	9.86	1.80	1.53	0.38	0.38	ND	ND
6/02	44.09	NS	9.10	NS	0.40	NS	ND	ND
6/04	42.64	34.85	9.70	9.38	ND	0.22	ND	ND

Samples collected by Kleinfelder, Inc. under contract with the California Rice Industry Association.

Key to designations on rice water monitoring tables:

Blank cells	Results not yet reported
ND	Not detected
NS	Not sampled

PERFORMANCE GOALS (ppb):

molinate	10.0	methyl parathion	0.13
thiobencarb	1.5	malathion	0.10
carbofuran	0.4		

PRELIMINARY DATA/SUBJECT TO CHANGE

Table 5. 1998 Pesticide Concentrations at the Colusa Basin Drain near Highway 20 in Colusa County (CBD5) in parts per billion (ppb), con't.

	Molinate		Thiobencarb		Carbofuran		Methyl parathion	Malathion
Laboratory type	Primary	QC	Primary	QC	Primary	QC	Primary	Primary
Reporting limit (ug/l)	1.0	0.5	0.5	0.5	0.35	0.05	0.05	0.05
Date								
6/09	33.68	NS	6.40	NS	0.60	NS	ND	ND
6/11	19.83	18.95	6.60	5.70	0.40	0.36	ND	ND
6/16	33.87	NS	11.00	NS	ND	NS	0.13	ND
6/18	19.98	19.56	8.40	7.61	ND	0.17	ND	ND
6/23	9.41	NS	2.80	NS	ND	NS	ND	ND
6/25	7.58	8.20	2.00	1.80	0.53	0.50	ND	ND
6/30	5.53	NS	2.20	NS	ND	NS	ND	ND
7/02	4.16	3.10	1.80	1.55	1.35	1.35	ND	ND
7/07	3.86	NS	1.90	NS	0.39	NS	ND	ND
7/09	3.61	2.41	1.90	1.55	ND	0.29	ND	ND

Samples collected by Kleinfelder, Inc. under contract with the California Rice Industry Association.

Key to designations on rice water monitoring tables:

PERFORMANCE GOALS (ppb):

Blank cells	Results not yet reported				
ND	Not detected	molinate	10.0	methyl parathion	0.13
NS	Not sampled	thiobencarb	1.5	malathion	0.10
		carbofuran	0.4		

CBD - molinate

Information on Rice Pesticides Submitted to the California Regional Water Quality Control Board Central Valley Region

December 31, 1999

by

KayLynn Newhart and Kevin Bennett

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Department of Pesticide Regulation
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PRELIMINARY DATA/SUBJECT TO CHANGE

Table 3. 1999 Pesticide Concentrations at the Colusa Basin Drain near Highway 20 in Colusa County (CBD5) in parts per billion (ppb).

	Molinate		Thiobencarb		Carbofuran		Methyl parathion	Malathion
Laboratory type	Primary	QC	Primary	QC	Primary	QC	Primary	Primary
Reporting limit (ug/L)	1.0	0.5	0.5	0.5	0.35	0.20	0.05	0.05
Date								
4/13	ND	ND	ND	ND	ND	ND	ND	ND
4/27	NS	NS	NS	NS	ND	NA	ND	ND
4/29	NS	NS	NS	NS	ND	NA	ND	ND
5/4	NS	NS	NS	NS	0.65	NA	ND	ND
5/6	NS	NS	NS	NS	ND	NA	ND	ND
5/11	NS	NS	0.7	NA	3.6	NA	ND	ND
5/13	NS	NS	1.6	NA	0.63	NA	ND	ND
5/18	9.2	NA	4.2	NA	0.78	NA	ND	0.057
5/20	11.2	NA	3.7	NA	ND	NA	ND	0.289
5/25	11.9	NA	10.0	NA	ND	NA	ND	ND

Samples collected by Kleinfelder, Inc. under contract with the California Rice Research Board.

Key to designations on rice water monitoring table for CBD5 are shown at the end of the following page

PRELIMINARY DATA/SUBJECT TO CHANGE

Table 3 con't.,1999 Pesticide Concentrations at the Colusa Basin Drain near Highway 20 in Colusa County (CBD5) in parts per billion (ppb)

	Molinate		Thiobencarb		Carbofuran		Methyl parathion	Malathion
Laboratory type	Primary	QC	Primary	QC	Primary	QC	Primary	Primary
Reporting limit (ug/L)	1.0	0.5	0.5	0.5	0.35	0.20	0.05	0.05
Date								
5/27	18.6	18.4	10.9	12.7	ND	NA	ND	ND
6/1	ND	NA	6.3	NA	ND	NA	ND	ND
6/3	12.4	NA	4.8	NA	ND	NA	ND	ND
6/8	19.6	NA	10.9	NA	ND	NA	ND	ND
6/10	9.6	NA	3.5	NA	ND	NA	ND	ND
6/15	10.3	NA	2.0	5.0	ND	NA	ND	ND
6/17	7.8	NA	2.1	NA	ND	NA	ND	ND
6/22	10.3	NA	2.3	NA	ND	NA	NA	NA
6/24	7.8	NA	2.1	NA	ND	NA	NA	NA

Samples collected by Kleinfelder, Inc. under contract with the California Rice Research Board.

Key to designations on rice water monitoring table for CBD5:

QC	Quality control
Blank cells	Results not yet reported
ND	Not detected
NS	Not sampled
NA	Not analyzed

PERFORMANCE GOALS (ppb):

molinate	10	methyl parathion	0.13
thiobencarb	1.5	malathion	0.1
		carbofuran	0.4

CBD - molinate

Information on Rice Pesticides

Submitted to the California Regional Water Quality Control Board

December 31, 2000

By

KayLynn Newhart, DeeAn Jones, Sainey Ceesay

California Environmental Protection Agency
Department of Pesticide Regulation
Environmental Monitoring and Pest Management Branch
Environmental Hazards Assessment Program
830 K Street, Sacramento, California 95814-3510

Table 2. 2000 Pesticide Concentrations at the Colusa Basin Drain near Highway 20 in Colusa County (CBD5) in parts per billion (ppb).

	Molinate		Thiobencarb		Carbofuran		Methyl Parathion	Malathion
Sample Type	Primary	QC	Primary	QC	Primary	QC	Primary	Primary
Reporting limit (ppb)	1.0	0.5	0.5	0.5	0. 35	0.05	0.05	0.05
Date								
10-Apr	ND	ND	ND	ND	ND	ND	ND	ND
25-Apr	NS	NS	NS	NS	ND	NA	ND	ND
27-Apr	NS	NS	NS	NS	ND	NA	ND	ND
2-May	NS	NS	NS	NS	ND	NA	ND	ND
4-May	NS	NS	NS	NS	ND	NA	ND	ND
9-May	NS	NS	4.9	NA	ND	NA	ND	0.084
11-May	NS	NS	4.6	NA	ND	NA	ND	0.064
16-May	17.6	NA	6.7	NA	0.72	NA	ND	0.118
18-May	22.0	NA	10.7	NA	ND	NA	ND	0.369
23-May	18.7	NA	6.2	NA	ND	NA	ND	0.094
25-May	21.2	16.3	10.4	8.98	ND	.130	ND	0.459
30-May	19.1	NA	9.2	NA	ND	NA	ND	0.311
01-Jun	13.8	NA	6.1	NA	ND	NA	ND	0.145
06-Jun	7.73	NA	3.7	NA	ND	NA	ND	0.089
08-Jun	7.79	6.32	3.5	2.77	ND	ND	ND	ND
13-Jun	4.97	NA	2.3	NA	ND	NA	ND	ND
15-Jun	4.91	NA	3.1	NA	ND	NA	ND	ND
20-Jun	NS	NS	2.1	NA	ND	NA	NS	NS
22-Jun	NS	NS	1.7	NA	ND	NA	NS	NS

Samples collected by Kleinfelder, Inc. under contract with California Rice Research Board.
Key to designations for rice water monitoring table for CBD5:

QC	Quality Control	PERFORMANCE GOALS(ppb):			
ND	Not Detected	molinate	10.0	carbofuran	0.4
NS	Not Sampled	thiobencarb	1.5	malathion	0.1
NA	Not Analyzed	methyl parathion	0.13		

Don Pedro Lake –
Hg

B.1.20 Don Pedro Lake, Mercury

Summary of Proposed Action

The California Regional Water Quality Control Board, Central Valley Region (Regional Board) recommends the addition of Don Pedro Lake to California's Clean Water Act Section 303(d) list due to impairment by mercury. Information available to the Regional Board on mercury levels in fish tissue samples indicates that water quality objectives are not being attained in Don Pedro Lake. The description for the basis for this determination is given below.

Table B-1. 303(d) Listing/TMDL Information

Waterbody Name	Don Pedro Lake	**Pollutants/Stressors**	Mercury
Hydrologic Unit	536.32	**Sources**	Resource Extraction (abandoned mines)
Total Waterbody Size	12,960 acres	**TMDL Priority**	
Size Affected	12,960 acres	**TMDL Start Date (Mo/Yr)**	
Extent of Impairment	Entire reservoir	**TMDL End Date (Mo/Yr)**	

Watershed Characteristics

The New Don Pedro Dam creates Don Pedro Lake on the Tuolumne River in Tuolumne County, approximately 54 miles upstream from the Tuolumne River – San Joaquin River confluence (USGS, 1958-2000). The Don Pedro Dam was constructed in 1971 with a reservoir area of 12,960 acres; the Turlock Irrigation District operates the dam (CDWR, 1993). Numerous abandoned gold mines and other historic mine features are present in the watershed upstream of the Don Pedro Dam (OMR, 2000).

Water Quality Objectives Not Attained

The narrative objective for toxicity is not being attained for mercury in Don Pedro Lake. The narrative toxicity objective in the Basin Plan states, in part, "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life." The narrative toxicity objective further states that "The Regional Water Board will also consider … numerical criteria and guidelines for toxic substances developed by the State Water Board, the California Office of Environmental Health Hazard Assessment, the California Department of Health Services, the U.S. Food and Drug Administration, the National Academy of Sciences, the U.S. Environmental Protection Agency, and other appropriate organizations to evaluate compliance with this objective." (CRWQCB-CVR, 1998; http://www.swrcb.ca.gov/~rwqcb5/bsnplnab.pdf).

Numeric criteria for mercury in fish tissue have been developed for both human health and wildlife protection. The U.S. Environmental Protection Agency (USEPA) recently established a human health protection criterion of 0.3 milligrams per kilogram (mg/kg; equivalent to parts per million [ppm]) methylmercury in the edible portions of fish (USEPA, 2001b). This criterion is used to determine attainment with the narrative toxicity objective.

Evidence of Impairment

The Toxic Substances Monitoring Program (TSMP) analyzed composite samples of trophic level 3 and 4 fish from the northernmost arms of Don Pedro Lake (Moccasin Creek, Tuolumne River, and Woods Creek) (SWRCB, 1995). Trophic level (TL) 3 fish (e.g., bluegill, carp, and sucker) feed on zooplankton, phytoplankton, and benthic invertebrates. Trophic level 4 fish (e.g., largemouth bass) consume trophic level 3 fish as part of their diet. The TSMP sampled 32 TL 4 fish (largemouth bass) between 1981 and 1987. The TL4 fish had an average mercury concentration of 0.54 ppm, which exceeds the USEPA criterion of 0.3 ppm.

Extent of Impairment

Data are available only for the northernmost arms of Don Pedro Lake. However, the entire 12,960-acre lake is probably impaired because there are other tributaries to the lake that may act as mercury inputs.

Potential Sources
The principal source of mercury in the Tuolumne River watershed is historic gold mining sites (OMR, 2000).

TOXIC SUBSTANCES MONITORING PROGRAM (TSMP)

FRESH WATER BIOACCUMULATION MONITORING PROGRAM

DATA BASE DESCRIPTION

Revised
September 1995

Prepared By

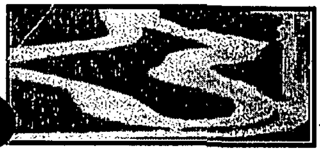
Del Rasmussen
Monitoring and Assessment Unit
Division of Water Quality

State Water Resources Control Board
CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

Don Pedro Reservoir

STANUM	STANAME	CDATE	COMMON	SPECTYPE	NUMBER	AGE	WEIGHT	LENGTH	TISSUE	HG_W	Species Averages (Based on Sample #)	Species Averages (Based on Fish #)
536.31.16	Don Pedro Reservoir/Moccasin Creek	8/20/86	Carp	FF	[illegible]	4-5	2845.0	[illegible]	F	0.21	0.190	0.194
536.31.16	Don Pedro Reservoir/Moccasin Creek	7/24/85	Carp	FF	4	3-4	3418.0	570.0	F	0.17		
536.31.16	Don Pedro Reservoir/Moccasin Creek	9/2/87	Sucker	FF	6	6	753.4	399.0	F	0.46	0.460	0.46
536.31.16	Don Pedro Reservoir/Moccasin Creek	7/13/84	Largemouth Bass	FF	5	4-5	983.7	390.0	F	0.87	0.698	0.6725
536.31.16	Don Pedro Reservoir/Moccasin Creek	7/24/85	Largemouth Bass	FF	3	2-4	825.1	373.0	F	0.74		
536.31.16	Don Pedro Reservoir/Moccasin Creek	8/20/86	Largemouth Bass	FF	5	4-5	1290.5	418.0	F	0.69		
536.31.16	Don Pedro Reservoir/Moccasin Creek	9/2/87	Largemouth Bass	FF	7	2	355.0	283.0	F	0.49		
536.31.15	Don Pedro Reservoir/Tuolumne River	9/2/87	Carp	FF	6	4-5	2744.0	[illegible]	F	0.20	0.165	0.16181818
536.31.15	Don Pedro Reservoir/Tuolumne River	8/20/86	Carp	FF	6	5-6	4027.0	624.0	F	0.13		
536.31.15	Don Pedro Reservoir/Tuolumne River	8/20/86	Largemouth Bass	FF	6	2-3	589.4	325.0	F	0.38	0.330	0.33
536.31.15	Don Pedro Reservoir/Tuolumne River	9/2/87	Largemouth Bass	FF	6	1-2	229.2	251.0	F	0.28		
536.31.08	Don Pedro Reservoir/Woods Creek	9/21/81	Bluegill	FF	8	3-4	99.2	166.0	F	0.26	0.260	0.260

TL3:	0.238	0.24457143
TL4:	0.575	0.5440625



About California Dams

Berkeley Digital Library Project

Pat → back Monday

DWR. 1993, Dams within Jurisdiction of the State of California. DWR Bulletin 17 as presented by the Berkeley Digital Library Project

About the California Dams database

The information in this database comes from DWR's Bulletin 17, which provides information about 1395 dams within the jurisdiction of the State of California. Bulletin 17 was converted to a database using a document-specific image decoder developed by Gary Kopec. For more information about image decoding, see Advanced Structured Document Examples

- Click here to see the Dams Schema
- Click here to download the dams database (0.8MB text file)

About the Query Form

Search

Click once on this button after you've filled in the fields you want to search on. This initiates a query to the database.

Clear Form

Click once on this button to clear the form and start a new query.

Max # Dams to Return

If you want to limit your result set, type in the maximum number of dams you want to see. This field is pre-set to 200; if it's left blank, the default is 50.

Dam Name

Enter a name or part of a name. Case is unimportant. For a list of all dams in alphabetical order, see Bulletin 17, Dams Within Jurisdiction of the State of California.

County

Enter a county. Case is unimportant. There are 60 California counties represented. For a list of all dams by county, see Bulletin 17, Dams Within Jurisdiction of the State of California.

Owner

Enter a name or part of a name. Case is unimportant. There are 637 different owners represented in the database; the most common are:

- PAC GAS AND ELECTRIC CO (94)
- FOREST SERVICE (63)
- U S BUREAU OF RECLAMATION (45)
- CITY OF LOS ANGELES (34)
- LA CO DEPT OF PUBLIC WORKS (31)
- CORPS OF ENGINEERS (30)
- SOUTHERN CALIF EDISON CO (30)
- EAST BAY MU DISTRICT (26)
- CITY COUNTY SAN FRANCISCO (18)
- STATE DEPT OF WATER RESOURCES (18)
- METROPOLITAN WATER DIST (16)
- STATE DEPT FISH AND GAME (15)
- RIVERSIDE COUNTY FCWCD (15)

- CITY OF SAN DIEGO (14)

Stream

To look for dams on a particular river or stream, enter a name or part of a name. Case is unimportant. There are 942 different streams represented. The ones having more than 5 dams are:

- OFFSTREAM (93)
- TRIB PIT RIVER (10)
- TRIB DRY CREEK (10)
- PIT RIVER (9)
- ROCK CREEK (9)
- BEAR RIVER (8)
- DRY CREEK (8)
- TR WINDSOR CR (7)
- TR RUSSIAN RV (7)
- TRIB POPE CREEK (7)
- NFK FEATHER RV (6)
- DEER CREEK (6)
- INDIAN CREEK (6)

DWR ID

If you know the DWR ID number of the dam you are looking for, enter it here. Examples of DWR IDs are 1065-007, 1065-008, 1065-005.

DWR ID

If you know the national identification number of the dam you are looking for, enter it here. Examples of national IDs: CA01351, CA01380, CA01251.

Year Built

Use this field to find dams that were built before, during, or after a particular year. From the drop-down menu, choose *before, during or after* and then type in the year.If you type in a year without choosing from the menu, *during* will be used.

Dam Type

Choose one of the types from the list if you are looking for a particular type of dam. The different types and the number of that type are as follows:

- Earth (1000)
- Gravity (110)
- Earth and Rock (72)
- Rock Fill (49)
- Variable Radius Arch (43)
- Hydraulic Fill (29)
- Constant Radius Arch (23)
- Flashboard & Buttress (20)
- Multiple Arch (18)
- Reinforced Concrete Tank (13)
- Slab and Buttress (7)
- Inflatable Rubber (3)
- Crib(2)
- None recorded(2)

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Dams Within Jurisdiction of the State of California

Department of Water Resources
Bulletin 17
June 1993

DWR Bulletin 17 provides information about 1395 dams within the jurisdiction of the State of California. The bulk of the printed bulletin is a single multi-page table with one three-line entry for each dam. The information from this table was extracted using document image decoders that were specialized for the actual character shapes in the scanned document images. No attempt was made to correct the OCR errors; thus, for example, several obvious errors appear in the list of county names below. Primary access to the on-line table is via a database query interface. In addition, a number of simple groupings are provided below, such as by county or the first letter of the dam name.

- Click *here* to access a database query form.
- Click on one of the groups below to access an alphabetical listing of dams within that group.
- Click on particular page:

Comments and suggestions are welcome at www@elib.cs.berkeley.edu

---

Dams Grouped by First Letter of Name

1 3 4 A B C D E F G H I J K L M N O P Q R S T U V W Y

Dams Grouped by County

- ALAMEDA
- ALPINE
- AMADOR
- BUTTE
- CALAVERAS
- COLUSA
- CONTRA COSTA

- EL DORADO
- FRESNO
- GLENN
- HUMBOLDT
- IMPERIAL
- INYO
- KERN
- KINGS
- LAKE
- LASSEN
- LOS ANGELES
- MADERA
- MARIN
- MARIPOSA
- MEHDOCINO
- MENDOCINO
- MERCED
- MODOC
- MONO
- MONTEREY
- NAPA
- NEVADA
- ORANGE
- PLACER
- PLUMAS
- RIVERSIDE
- SACRAMENTO
- SAH DIEGO
- SAHTA CLARA
- SAN BENITO
- SAN BERNARDINO
- SAN DIEGO
- SAN FRANCISCO
- SAN JOAQUIN
- SAN LUIS OBISPO
- SAN MATEO
- SANTA BARBARA
- SANTA CLARA
- SANTA CRUZ
- SHASTA
- SIERRA
- SISKIYOU
- SOLANO
- SONOMA
- STANISLAUS
- SUTTER
- TEHAMA
- TRINITY
- TULARE
- TUOLUMNE
- VENTURA

- YOLO
- YUBA

Last modified 02/02/1996 10:25:02

Dams Within Tuolumne County

DWR Bulletin 17 provides information about 42 dams within Tuolumne county. The name of each dam is listed below together with the page number of the dam's entry in the printed bulletin.

- Click on the *name* to access an HTML-formatted version of the entry (using HTML 3.0 markup) with links to the corresponding page images and to pages of OCR output generated using a commercial "omni-font" OCR package (XIS ScanWorX).
- Click on the *page number* to access the image of the page plus links to adjoining pages and to the OCR output. Note that the pages are identified by their "real" page numbers, i.e. the numbers at the bottoms of the printed pages.

Bulletin 17

Last modified 02/02/1996 10:31:10

Don Pedro

Page 20 OCR 20 Tuolumne Cty 'D' dams Photo? Bulletin 17

General Information

Name	DWR Number	National ID	Owner	Year Completed
DON PEDRO	68-007	CA00281	TURLOCK IRRIGATION DIST	1971

Location Information

County	Latitude	Longitude	Crest Elevation	Stream
TUOLUMNE	37 d, 42.0 m	120 d, 25.2 m	855.0 ft 260.6 m	TUOLUMNE RIVER
Baseline / Meridian	**Section**	**Township**	**Range**	
MD	3	3S	14E	

Dam Characteristics

Dam Type	Parapet Type	Crest Length	Total Freeboard	Height
ERRK	none	1900 ft 579 m	55.0 ft 16.8 m	568 ft 173 m
Material Volume	**Parapet Height**	**Crest Width**	**Operating Freeboard**	
16750000 cu yd 12806212 cu m	? ?	40 ft 12 m	25.0 ft 7.6 m	

Reservoir Characteristics

Storage Capacity	Drainage Area	Reservoir Area
2030000 acre-ft 2504004 sq dm	1542.0 sq mi 3993.78 sq km	12960 acre 5245 hect

OMR. 2000.
www.consrv.ca.gov/omr/
AMLU/amlurpt

California's Abandoned Mines

A Report on the Magnitude and Scope of the Issue in the State
Volume I

Department of Conservation
Office of Mine Reclamation
Abandoned Mine Lands Unit
June, 2000

TABLE OF CONTENTS: VOLUME I

LIST OF TABLES

Acknowledgements

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EXECUTIVE SUMMARY

Overview

Since the Gold Rush of 1849, tens of thousands of mines have been dug in California. Many of these mines were immediately abandoned when insufficient minerals were found, others were abandoned later when poor economics of the commodity made mining unprofitable, while still others were abandoned in 1942 after the issuance of War Production Board Order L-208. The result is that California's landscape contains tens of thousands of abandoned mine sites, many of which pose health, safety, or environmental hazards. Every year people fall victim to the hazards of abandoned mines. Many sites possess serious physical safety hazards, such as open shafts or adits (mine tunnel). Thousands of sites have the potential to contaminate surface water, groundwater, or air quality. Some are such massive problems as to earn a spot on the Federal Superfund list.

In the interest of environmental and public health and safety, the Department of Conservation (DOC) undertook a three-year effort to determine "the magnitude and scope of the abandoned mine problem in California."[1] An inventory of abandoned mines was accomplished, culminating in this report to the Governor and Legislature. Prior to this effort, the number of abandoned mines reported was based solely on legacy databases and ranged from a low of 7,000 to a high of 20,000 abandoned mines. To get a more accurate picture of the nature and extent of this problem, existing literature and data were collected, input, and spatially analyzed through the implementation of a Geographic Information System (GIS). Data gaps were identified, and a field program was implemented to acquire site specific information. Data were collected at selected abandoned mine sites, by watershed, in various bioregions throughout the state. Significant mine features were photographed and precisely located by differentially corrected Global Positioning System (GPS). A standardized assessment and ranking protocol were applied to potential physical and chemical hazards observed. Field data, in addition to information collected from existing sources, were entered into a relational database and spatially and statistically analyzed for this report[2]. The following itemizes our key findings.

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[1] "Magnitude and scope" are the exact words from the FY 97/98 Budget Change Proposal (BCP) that funded the effort. Under this original BCP, the program was to continue at a reduced level beginning in FY 2000/2001. A new FY 2000/2001 BCP continues the funding at near the original level for an additional two years providing that "of the $153,000 appropriated in this item for support of the Abandoned Mine Inventory, no funds shall be expended on or after January 1, 2001, unless and until a statute is enacted authorizing the Department of Conservation to remediate, and complete reclamation of, surface mines operated since January 1, 1976, that have been illegally abandoned and that pose a threat to public health and safety or the environment, but for which no reclamation plan is in effect and for which no financial assurances exist." Chapter 52, Statute of 2000, for Fiscal Year 2000/2001.

[2] A full explanation of the methods and data behind this report are provided in Volume II.

Key Findings [3]

- Based on field investigations and statistical extrapolations, it is estimated that there are approximately 39,000 (95% confidence interval from 29,300-69,800) *historic and inactive mine sites* in the state.
- Of these, *4,290 or 11% are estimated to present environmental hazards.*
- Also *32,760 abandoned mines, or 84%, are estimated to present physical safety hazards.*
- There are approximately *128,800 mining features*[4] (95% confidence from 102,700-160,600) in the state.
- Approximately 48,944, or 38%, of these features are hazardous openings[5].
- Our research confirmed that a *field visit to each site is necessary for assessment of physical hazards.*
- Geo-environmental modeling can help prioritize field visits to sites with suspected chemical hazards; however, a field visit is necessary to confirm the existence and magnitude of these hazards.
- An estimated *50% of the abandoned mines are on private lands.*
- Approximately *1.5% of the abandoned mines are on state lands.*
- And *48% are on federal lands*, primarily on Bureau of Land Management and US Forest Service property.

Other State and Federal AML Programs

The following are common themes of other state and federal abandoned mine lands (AML) programs:

- Cooperative arrangements between state and federal agencies leverage limited funds available at both levels of government.
- AML inventory and watershed assessments are done simultaneous with remediation projects.
- Most states have an education component built around the national "Stay-Out, Stay-Alive" slogan.
- The federal program for coal-producing states and the state programs of non-coal producing states such as Nevada and South Dakota, redistribute all or a portion of the costs of environmental clean-up to the active mining industry.

Options

The findings presented in this report lead to three options for addressing California's abandoned mine problem; they are: "no action", short-term, and long-term options. Short-term options are those that require no significant changes in funding or program mandates, whereas long-term options may

[3] The numbers listed in this section are based on statistical modeling and GIS analyses that are more fully explained in Volume II of this document. These numbers are subject to change as the models improve.

[4] Mining "features" include all of the workings, tailings or waste, and processing facilities

[5] Openings include adits, shaft, tunnels and other underground workings that open to the surface.

require significant additional funding, legislation or new programs. All options are more fully detailed later in the document beginning on page 47.

No Action Option (no change in program direction):

- Continue current funding plan. This plan provides a base funding of $250,000 (2.5 person-years) annually for the ongoing Abandoned Mine Inventory. An additional $153,000 (2.1 person-years) is added to this sum for fiscal years 2000/01 and 2001/02 with spending contingent upon the passage of additional legislation for the reclamation of illegally abandoned surface mines that operated after January 1, 1976 (date SMARA was enacted). (See footnote on previous page for budget control language.) This option requires no changes in legislation (beyond that stipulated above), funding or program mandates; and bases policy decisions on the current level of information.

Short-Term Options (redirection within existing DOC or other State Agencies' programs):

- Provide additional staffing and funding to complete the abandoned mine lands inventory in a shorter time frame; expected completion time proportional to funding. For example, 10 staff positions could complete the inventory in approximately 26 years.
- Prioritize high-risk watersheds for inventory and assessment based on enhanced geo-environmental models.
- Prioritize inventory of physical hazards based on enhanced exposure models, and initiate mitigation of hazardous openings under existing laws. (The current laws are punitive to property owners, based on Health and Safety Code as cited in Table 2.)
- Focus the limited remediation resources on watershed-based efforts that address cumulative impacts.
- Study and quantify the impacts of mercury released from historic hydraulic mining.
- Work with other agencies to develop a recycling program to handle the mercury currently being recovered by recreational and small-scale placer mining.
- Develop a mine hazard awareness and education program for the public that is similar to the "Stay-Out, Stay-Alive" programs of other states.
- Direct a portion of the funds collected under the *Safe Drinking Water, Clean Water, Watershed Protection, and Flood Protection Act of 1999* to address the environmental hazards of abandoned mine lands.
- Direct a portion of the funds in the CALFED program towards inventorying, assessing and remediating abandoned mine lands to address the CALFED objectives of habitat restoration, water quality and watershed management.
- Implement an agency CEQA review process that specifically addresses projects on or near hazardous abandoned mines (Currently, no program in DOC or other agency is specifically funded for this task.)

Long-Term Options:

- Fund a public grant program to assist local governments in the remediation of physical hazards.
- Amend SMCRA (Federal) to provide funding for remediation of abandoned mines in states without coal production.
- Amend the Surface Mining and Reclamation Act (SMARA, State) to provide funding for the remediation of abandoned mines.
- Redirect a portion of mine claim maintenance fees (Federal) to states to use for abandoned mine land remediation on federal lands.
- Consider instituting a pollution trading mechanism that would allow active mine operators and others, such as water treatment plants, to receive credits for remediating the environmental hazards of abandoned mines.
- Consider supporting House Resolution 2753, the *Abandoned Mine Restoration Act of 1999*, which establishes the *Restoration of Abandoned Mine Sites* (RAMS) program within the Army Corps of Engineers.
- Consider creating an abandoned mine lands program that parallels California's *Leaking Underground Fuel Tank* program, which places a fee on the industry, as a source of remediation funding.
- Consider supporting "Good Samaritan" provisions within the Clean Water Act (Federal), such as the *Good Samaritan Abandoned or Inactive Mine Waste Remediation Act* (1999) sponsored by Senator Baucus (D-MT).
- Consider supporting changes to the 1872 Mining Law to allow the use of royalties paid by current mining companies to be used to remediate abandoned mines on federal lands.
- Consider supporting changes to the Surface Mining and Reclamation Act of 1975 (SMARA) to ensure that active mines do not become abandoned.

BACKGROUND

California is rich in mineral wealth. In 1998, California ranked second in the nation in production of both gold and non-fuel mineral commodities. The mining of minerals such as gold, silver, copper, lead, zinc, chromium and many others has provided enormous economic wealth to the state, as well as to the nation for over 150 years. In addition, historical mining is part of the rich cultural heritage of California, and is largely the basis for the infrastructure upon which the state was built. Understanding the legacy of historical mining can help us place into perspective what has happened in the past, how that affects the decisions we make in the present, and how we can effectively meet the challenges this mining legacy places on California's future.

In contrast to today's high-tech mining industry, California's historic mining industry was developed in a time of less-sophisticated mining methods and before modern environmental regulations. As a result, California's rich mining legacy has left unreclaimed tens of thousands of abandoned mine sites, many of which are health, safety or environmental hazards (A.1). Thousands of these mines cause surface or ground water quality problems, and several sites have such massive problems as to earn a spot on the National Priorities List (Superfund). These environmental consequences are not limited to the abandoned mines themselves. Contaminated runoff from abandoned mines impacts tens of thousands of acres of land, groundwater, and hundreds of streams, rivers, and lakes throughout the state. Preliminary investigation of existing data revealed that the scope and magnitude of the abandoned mine problem has been previously under-estimated. And because the majority of these sites date back to the 19th century, the individuals or companies responsible for the problem are no longer present to assist with remediation and reclamation.

While some information on a few of our abandoned mine lands (AML) is available from other state, local, or federal agencies, there has not been a statewide clearinghouse for information nor a coordinated statewide effort to address abandoned mine lands in California. A coordinated watershed approach has not been used for decision-making, resulting in the highest profile sites consuming what little remediation dollars have been made available. The low level of knowledge about the location and impacts of abandoned mines is becoming more evident as the state's population moves into high-density abandoned mine lands areas such as the Sierra Nevada foothills.

California is not unique in its attempt to address abandoned mine issues, other western states face similar issues and concerns. In 1993 and 1994 while considering amendments to 1872 General Mining Law[6], funding for AML clean-up was one of several proposed amendments. This law enacted 130 years ago, in conjunction with the Homestead Act, promoted the development and settlement of the west. One requirement for receiving funds from an

[6] The General Mining Law of 1872, as amended, provides private access to hardrock mineral resources on federal lands.

amended General Mining Law, would have been the existence of a statewide abandoned mine inventory, with priorities for remediation[7].

The Department of Conservation's (DOC) Office of Mine Reclamation, which administers the state's reclamation portions of the Surface Mining and Reclamation Act (SMARA 1975), noted that California would not qualify for these remediation funds without the requisite inventory. In fiscal year 1997/98, the new Abandoned Mine Lands Unit (AMLU) was funded in the Office of Mine Reclamation. This program is charged with locating, inventorying, and characterizing the state's historic, inactive, and abandoned mines. As part of their abandoned mine lands (AML) effort, DOC initiated the AML Task Force and entered into Cooperative Agreements or Memoranda of Understanding with the National Park Service and Bureau of Land Management; an agreement with the US Forest Service is still in process.

Over the period from July 1997 to June 2000, the unit was given $450,000 and 4.2 person-years per year to accomplish a statewide inventory and produce a report. Despite unforeseen delays in start-up[8], staff collected and entered data for 778 mine sites and 3,980 features into the AMLU database[9] (A.4).

As in other states around the country, locating, inventorying, and characterizing the state's AML are the first steps in obtaining state, as well as federal, monies to mitigate some of the more serious AML environmental problems and to close dangerous adits and shafts. As part of this information gathering effort, a statewide priority list was proposed to help focus limited resources and reduce competition among stakeholders for remediation dollars (B.1, B.2). Additionally, AMLU digitized the mine symbols from the 2,869 7.5-minute USGS topographic maps that cover California. To date, 50.5% of these have been completed (A.5). The work on this data layer will continue until the state is complete, at which time it will be made available to other agencies and the public.

California's Mining History

California is endowed like no other state with rich geologic diversity. Ranking third in total area, it is also the fourth most mountainous state. There are eleven distinct geomorphic provinces containing equally distinct mineral deposits. As a result, more mineral commodities have been developed in California than in any other area of similar extent and California currently ranks second nationwide in non-fuel mineral production.

Over 700 mineral commodities have been identified in the state, 45 of which only occur here. In recent years, California lead the nation in the production of asbestos, boron, cement, diatomite, mercury, pumice, rare earths, sand, gravel, talc and tungsten. It has been one of the top three states in

[7] The proposed amendments to the 1872 Mining Law addressing funding for AML reclamation have yet to be enacted.

[8] The Chronology given as an appendix in Volume II details the amount of time taken to get the program staffed and outfitted with necessary equipment.

[9] The relational AMLU database is part of an overall Geographical Information System (GIS) that allows for complex spatial analyses. Examples of spatial analyses are included in this volume.

production of bromide, calcium chloride, chromite, feldspar, gold, gypsum, iron ore, platinum, potash, sulfur ore and tin.

The incredible legacy of California mining is that more than any other single source in our first century, it drove our economy, financed our infrastructure, developed our capital, and ultimately gave us early statehood, respect and power. Yet there has been a deferred environmental cost. One that we have largely chosen to defer to future generations. As a result of this legacy, the state is left with environmental hazards such as unstable underground workings, acid rock drainage (ARD), and heavy metal and asbestos contamination.

While the discovery of gold at Sutter's Mill in 1848 is often considered the beginning of California's mining legacy, mining throughout Southern California was already well established on a small-scale. Spanish and Mexican settlers found gold in southern California in 1775, 1812, 1814, 1824 and 1842. There is evidence of mining being done in every major mountain range in southern California during the Mission and Rancho periods.

A major reason for Spanish colonization of California was the search for mineral wealth. Experienced miners from Mexico had discovered a number of the first known deposits of many of the commodities mined today. Although major exploitation did not occur during the Mission Period, after the discovery of gold in Placerita Canyon in the San Fernando Valley in 1842, hundreds of Los Angelenos converged upon the area. Experienced miners from the Mexican State of Sonora were quick to follow. Ultimately they produced over $100,000 in gold that was shipped both to Mexico and the East Coast of the United States for further processing (Wagner 1970).

Yet for most Californians, the benchmark event was the 1848 "rediscovery" of gold in the South Fork of the American River by workers of the Sutter Mexican land grant known as Los Rios de los Americanos. Before the end of the year, every Californian who could do so had traveled up to the foothills in search of the easy to reach "placer" gold.

Meanwhile, as news reached far away places, thousands set out by land and sea on the perilous adventure that in three to four months, perhaps more, would bring them to California. They arrived throughout 1849, immediately heading for the foothills of the Sierra Nevada and covering every major river canyon with multitudes of hastily constituted gold camps.

Between 1848 and 1967, California was the source of more than 106 million ounces of gold. This total, worth over $40 billion dollars by 1999 prices, was far greater than any other state, and represented over 35% of US production (Clark 1966).

During this era in Northern California, quicksilver mines were operating in the Coast Ranges south of San Francisco. They supplied mercury to the gold mines of the Sierra for use as an amalgamator. In fact, the quicksilver mines, more than any other factor, were the origin of development in the San Jose area.

Table 1: Summary of Commodities in MAS/MILS.

Commodity	Frequency	Percentage
Gold	13,994	47.86
Sand and Gravel	2,187	7.48
Stone	1,669	5.71
Copper	1,394	4.77
Unknown	1,363	4.66
Chromium	1,219	4.17
Manganese	917	3.14
Tungsten	749	2.56
Silver	635	2.17
Clay	578	1.98
Mercury	534	1.83
Calcium	410	1.40
Lead	406	1.39
Others	3,184	10.89
	29,239	**100.01**

Metallic Mining

Gold

Placer Mining

For the first few years after 1848, gold was strewn liberally throughout the rivers and was easily had. This was the only time that the individual could strike it rich; later, it would require capital and thus would be the province of corporations. Consequently, for half a decade, gold recovery far exceeded any period following.

At first, all it took was a gold pan, some crevicing tools, and a shovel. Soon, miners learned that a little wooden box with a sluice in the bottom, called a rocker, greatly sped up the process of separating out the gold. In drier climes, like the California deserts, gold seekers dry washed, tossing the sands and gravel up time after time in a blanket until they had separated out the gold.

After having removed the easily obtainable gold by the relatively unsophisticated methods of panning, or shoveling river sands and gravels through a sluice box or rocker, the miners were forced to use more ingenious methods. They diverted miles of river into flumes to get to the normally submerged channel. On occasion, when a river formed a significant bend, like Oxbow on the Middle Fork of the American River, they tunneled through solid rock to reroute the river, thus exposing hundreds of feet of the former bed.

Early pictures show Northern Sierra river canyons completely devoid of any large trees, so demanding was the need for the lumber to build the flumes, dams, large scale sluice boxes, plank roads, bridges, and the hastily constructed habitations. The absence of trees compounded other issues. Major erosion became a problem. The rivers' wildlife diminished with the absence of streamside vegetation, and loss of habitat.

Despite seemingly endless miles of rivers and streams, the thousands of seekers had largely exhausted the easy to reach gold in the river channels within the first three to four years of the 1850s. Miners had limited options at that point, either to locate gold in more remote locales, or seek the gold by other, more sophisticated methods. It is clear by the recorded dates of settlement of hundreds of Northern California towns that the gold seekers did relocate in every area, as there aren't many locales that did not have, albeit often short, some initial mining activity. So, a miner could continue to operate at a fairly simple level, with pick and shovel, pan and rocker, if he kept moving to more remote areas. (Averill, 1946)

Hydraulic Mining

Hydraulic mining was being perfected simultaneous to the increasingly complex placer methods mentioned above. This type of mining was most prevalent in the region north of the true Mother Lode, in an area sometimes referred to as the "Northern Mines", from El Dorado County in the south to Lassen County in the north.

Hydraulic mining consisted of channeling water into successively narrower, confined pipes, which at the same time rapidly lost elevation, and thus created huge pressure. At the end of the pipe was an ingenious device known as a monitor, which acted like a giant nozzle, blasting the water out in a steam like a cannon.

This original-to-California process was perfected to exploit a tremendous opportunity. In ancient geologic time, several enormous river channels originating hundreds of miles to the east had moved westerly across the state prior to the formation of the Sierra range. When the Sierra was created, the intense upward movement shattered these ancient rivers leaving them as huge segmented beds of gravel as likely to be at the top of a mountain as in a canyon (Lindgren 1911, Lawler 1995).

The ancient gravels when washed down and separated, on a grand scale, could easily be mined for gold. All it took was mercury to separate the gold out, and within a couple hundred miles were the largest mercury reserves in our nation. These gravel beds were discovered and worked throughout the Northern Sierra, and soon after, around the Klamath, Siskiyou, Trinity and Warner Mountains farther north.

As entire mountainsides and whole valleys could be torn apart with relative ease, it wasn't surprising that many syndicates quickly adopted this new technology. One person operating a monitor could do the work of hundreds. Mining Engineer W.S. Keyes reported in an 1867 report that "if wages were $4 a day, the cost of washing one cubic yard with a pan would be $20; with a rocker, $5; but with the hydraulic method, 20 cents".

Hydraulic mining dramatically increased the sediment loads of rivers, leading to raised river bottoms and forcing river towns like Marysville and Sacramento to build miles of costly levees to prevent flooding. Additionally, property values dropped, river boats couldn't reach ports, and the flow from city hydrants became a turgid gruel of mud and water (Kelley 1959). According to University of California, Davis (UC Davis) geochemist Rob Zierenberg, "there is large amount of sediment still moving down [the rivers]" (Rockwell 2000). This sediment has not only been attributed to millions of dollars of property damage from flooding over 150 years, it could be a major factor in the loss of our inland fisheries (Jacobs 1993).

Hydraulic mining was to enjoy a heyday of some thirty years before it was significantly slowed by California's first environmental court decision. In 1884, the Sawyer decision said that the mines were enjoined from placing mining debris in watercourses that were a tributary to navigable streams. The wording suggested a loophole, and the loophole soon used was that if the mines could construct a debris dam, then they could continue operations. Not surprisingly, that's just what many companies did. These dams worked usually until the next significant flood.[10]

According to the federally appointed special investigator — geologist Grove Gilbert, who engaged in a 14-year study of the extent of the debris — 1,555 million cubic yards were washed into the Sacramento River basin from 1852-1909. This equates to eight times the amount of earth moved to build the Panama Canal. This figure, however, does not include any rivers or streams that are not tributaries to the Sacramento[11] (Gilbert 1917).

With the new restrictions on hydraulic mining, impacted miners had several options. They could build drift tunnels, they could operate clandestinely, or they could devise some way of stopping the sediment from entering the rivers.

Drift tunnels were underground passageways that sought the contact points between the ancient riverbeds and the bedrock below. Drifting involved both economic and actual risk. Much developmental work was needed to prepare the tunnels. And since they ran through partially cemented gravels, the tunnels would often present the danger of caving in on their workers. Miles of drifts and hydraulic tunnels still exist today, presenting a dangerous lure to the increasing numbers of backcountry curiosity seekers.

The Caminetti Act of 1893, resulted in the creation of a California Debris Commission (CDC) to manage the mines and their impact on the rivers. In its first year, the newly founded commission grappled with nearly 100 permits from hydraulic mining companies — approving 70 (Haygood 1981). By its own records the Debris Commission issued 800 permits from 1893–1935. The Commission was, as well, the enforcing entity of the conditions of the permits. California's Division of Mines issued a 1928 report identifying much of the remaining workable gravels (Root 1928).

The government provided assistance to the industry by allocating monies for four large government built debris dams on the Yuba, Bear, and American Rivers. These dams took years to build, and in fact, only two of the four were completed. But they still bought the industry more time. Ironically, by the time two dams were completed in the early 1940s — on the main stem of the Yuba, and the north fork of the American — most of the hydraulic mining activities had ceased.

There were still 41 active hydraulic mines in 1941, and 23 at the end of the war. During the decade 1945–55, CDC regulated 25 mines. There were 8 reporting in the next decade. Some indications from local histories in the Gold Country suggest a number of smaller mines operated for years surreptitiously

[10] After the 1884 Sawyer Decision ultimately resulted in many of the hydraulic activities diminishing, the intricate system of water conveyances that redirected water to the monitors became the precursor to California's modern day water system. The miners and their contractors had built an elaborate network of dams, flumes and ditches, many of which, still intact, deliver water to foothill communities and valley towns.

[11] Not covered in the CDC figures were the extensive hydraulic mines of the Trinity, Klamath and Scott River basins in Northwest California, as well as the Coast Ranges generally. Nor were sites in Southern California included; thus it does not come close to estimating a total for California.

(Thompson 1998). According to the Debris Commission's issuance of permits, hydraulic mining continued until at least 1965. While most historians wrote that the activity was greatly diminished after Sawyer, few of them take into account that increased technology allowed for more efficient hydraulic equipment in the later period.

California has over 26,000 miles of "blue line streams" (streams delineated with a blue line on the USGS topographic maps), up to half of which may have been impacted by hydraulic mining. The Debris Commission was ultimately concerned with effects downstream in the agricultural valley, not so much the effects above. As the 1990s have been the decade of reflection on our watersheds, a great deal of additional information needs to be compiled about the environmental effects of the historical hydraulic mining.

It is not the sedimentation issue alone, however, that is of such concern regarding these numerous and extensive hydraulic sites. The huge sluices — either on the surface, or in extensive drain tunnels — were liberally laced with mercury to capture the gold washing through. Tons of mercury (a potent neuro-toxin) were used in the mines, and lost to the environment (Knudson 1991). This issue has recently come to light, and is the target of a multi-million dollar study by the USGS.

Hard Rock Mining

Miners discovered that Sierra rivers had cut through a 200-mile long network of quartz veins running north to south in the low foothills of the mountains. They often contained gold concentrations so high that town after town was developed along the so-called Mother Lode to tap the riches. After the easy to get gold on the surface was exhausted, miners went underground to follow the quartz veins.

Thousands of underground ventures began in the areas where gold was found. This proved to be true not only for the Mother Lode but in regions to the north, east, and south of it — along the entire length of the 450-mile mountain range. These underground mines were developed in relationship to the wealth of the minerals discovered, or sometimes, in relationship to the wealth of the investors. Under any circumstances, the hard rock mining operations tended to be far more technical ventures. So, if the gold proved to be of good quantity or quality, the operation became more than a simple tunnel. Vast underground workings were developed, requiring consolidations, cooperation, and capitalization. Some mines alone have hundreds of miles of underground shafts.

Not surprisingly, it is the gold mines that represent the greatest number of abandoned sites in the state today. They constitute almost 50% of the 30,000 mineral locations identified in the former US Bureau of Mines database (MAS/MILS). Of that total, at least half are all or partially underground. These underground mines present one of the most attractive nuisances the West has to offer. Federal public land agencies in California — National Park Service, Bureau of Land Management and Forest Service — have attempted mitigation measures to reduce their liability. California is the only western state to not have a state abandoned mine safety program (WGA 1998).

Whether the method is underground or surface mining, the formations that contained the gold were also often rich in sulfides. Acid rock drainage

(ARD) can occur when sulfide minerals normally confined to below the surface are exposed to air and water as a result of mining activity. A chemical and biological reaction takes place resulting in the creation of sulfuric acid, which dissolves metals and which, in concentrations, can be very harmful to aquatic life. It is the metal-loading that causes a greater environmental concern than the acidity.

Dredging

The later half of the 19th Century was a time of invention, innovation and industrialization. Iron and steel and metal fabrication was perfected to the point where large machines revolutionized mining technology. An invention that added one more dimension to mining was the California gold dredge. The dredges, often the size of a large building, were designed to float on a body of water. As they moved along excavating everything in their way, they created their own ponds underneath them. In this manner of locomotion, they could move along river and stream channels and process the alluvial gravels, separating out the gold as they went.

Many of the rivers in the Central Valley bear the trail of the dredges, where miles of windrows may be found. This unique form of California technology was imported worldwide in the century following its invention. Some of the giant dredges operated on California rivers up until the 1960s. So productive was this form of "low grading" that it constituted the bulk of the gold mining revenues in the 20th Century. Extensive areas on the Feather, Yuba, American and the Tuolumne as well as hundreds of miles of small streams remain in a substantially altered state as a result.

The Modern Era

Two events were largely responsible for the decline of the traditional mines and methods. One was the government order in World War II to close down the gold mines because they were not considered an essential war time industry. The other was declining gold prices, which beset the industry in the early 1950s. The low prices, coupled with the considerable expense to dewater and rehabilitate the mines after the order was lifted, closed down even some of the longest running operations.

Today some mines wait for the gold price to go back up; others continue minimal exploration, hoping for another pay streak. More importantly the technology of recovery has completely changed things again. Large open pit operations, employing cyanide heap leach recovery, dominate the industry.

Silver and The Comstock Lode

Ten years after the Gold Rush of '49, when many individual miners were out of work, a miraculous discovery was made on the eastern edge of California. A vast body of high-grade silver was found at Virginia City, Nevada. This started another rush, in this case mainly of California miners and capitalists, over to the eastern side of the Sierra.

While not occurring in California, the impacts were felt as much here as in Nevada. The supplies, equipment, manpower and transportation were all mainly from California. "The Sierra was devastated for a length of nearly 100 miles to provide the 600 million board feet of lumber that went into the Comstock Mines, and 2 million cords of firewood were consumed by mines and mills by 1880", reported mining attorney Grant H. Smith after witnessing the scene 110 years ago (Brechin 1998). The Comstock discovery rekindled a desire by California miners to explore further. As a result many new finds of all types of commodities were made east of the Sierra Nevada down to the Colorado and Mojave deserts. Miners that were involved in exploration and development at Virginia City went on to locate productive silver mines in Southern California, particularly in Inyo and San Bernardino Counties.

In 1878 new legislation requiring government silver purchases made silver paramount to gold, and often, the metal of choice by miners throughout the West. In the remaining decades of the 19th Century, advances in mining technology made it possible for the mines to exploit deep lodes and still profit.

Many of the larger operations were forced to close and never reopened after the Panic of 1893 when silver prices collapsed. Yet, silver continued to be an important mineral mined in California up until the 1950s. It still is often recovered and processed as a byproduct of gold production in California.

Silver mining boomtowns in California's past include Calico, Randsburg, and Cerro Gordo. Often the results with these largely underground operations have been mountains laced with tunnels, much like the labyrinth of gold mining districts. As silver has tended to be found in drier areas, the tunnels tend to be intact and not flooded with water, thus, often accessible. To an inquisitive explorer today, a significant number of these mines offer extensive, dangerous subterranean passageways often lined with very unstable ceilings.

Copper

While California is not thought of as a big copper producing state, the total value of the mineral with respect to other metallic commodities mined here rank it second behind gold (Jenkins 1957). Often mined as a byproduct of zinc and tungsten mining in the state, copper has been extracted from mines in at least 12 California counties.

There exists a California copper-belt running northwest to southeast from the Oregon border along the Sierra foothill region almost to the bottom of the San Joaquin Valley. Records from the former Bureau of Mines show there to be nearly 1,400 copper mines or prospect locations mainly along this zone, although there were some exploited copper deposits in the Mojave Desert as well. Some of California's larger historic copper mines are now Superfund sites. Notably, mines like Iron Mountain, Penn, and Walker are all well known to the EPA as they present challenging and expensive clean-ups.

Some copper-laden areas, particularly in Shasta County were mined more for the concentrations of related sulfides, which were used for silver ore processing. These sulfides, when exposed to air and water, create sulfuric acid that then puts metals into solution. These heavy metals at high concentrations — typically silver, chromium, cobalt, copper, nickel, mercury and zinc — cause environmental damage to aquatic ecosystems, and impact water supplies.

Mercury

Around 90% of the mercury mined in the United States has been mined in California. The country's two largest mines have been the New Almaden in Santa Clara County, and the New Idria in San Benito County. Production has almost entirely come from the Coast Range, with the greatest concentration of mercury mines in Lake County. In general, mercury was mined in the Coast Range and imported for use in the Sierra Nevada gold fields.

Mercury readily binds to gold, a property that allows miners to easily extract gold from slurries. Since mercury was relatively inexpensive, and so plentiful in California, large amounts of it were used in this state for gold processing. By design or by mistake, much of it escaped into the environment. According to UC Davis research toxicologist Darell Slotton, "at least 7.6 million pounds of mercury were lost in the Sierra during the gold rush" (Knudson 1991). Since mercury continued to be used in nearly every gold extraction process up until the 1950s closures, it is conceivable that the amount lost is considerably higher (Buel 1998).

Mercury has been recognized for centuries as a highly toxic substance. Because of its capacity to bio-accumulate in various organisms, some species of sport fish are so impacted by mercury that they are considered to be above safe limits for consumption in some parts of the state, most notably, the Delta and San Francisco Bay.

So, the mercury problem is threefold. First, is the challenge for clean-up of various forms of mercury in the coastal mountains where it was extracted. Second, the location and clean up of the area where the elemental mercury was used, the gold mining belt along the western slope of the Sierra. Third, the challenge presented by the extensive deposition of mercury in hundreds of miles of rivers and streams, and the San Francisco Bay-Delta.

Tungsten

California has been the leading U.S. producer of tungsten since its discovery in 1905. Most of the precious metal has been mined on the eastside of the Sierra in Inyo County at high elevations. There are also numerous old mines and prospects throughout the California desert. Its principal uses are as a hardener in metal alloys (especially in tools), for welding, and for filaments in lights (DMG 1966). As is the situation with other potentially strategic minerals, production in this country has diminished in favor of less expensive foreign sources; in this case, China. But reserves do exist in California, should the need for them ever arise.

The remnant, abandoned tungsten mines in California tend to be large, very deep underground systems, most often occurring in drier climates, all of which contributes to the hazard to the public posed by indiscriminant entry.

Chromium

The mineral chromite contains another strategic element essential to the strength of steel, chromium, often a component of this state's abundant serpentine rock areas. Between 1869 and 1940, California supplied the bulk of the U.S. domestic supply.

It was during the world wars that the demand for this metal created an intense amount of mining, mainly in the Coast Ranges. There is also a prominent serpentine ledge throughout the Sierra foothills, with a number of historic mines there as well. The US Bureau of Mines reported over 1,200 chromium mines in California in the 1950s (MAS/MILS).

Like most of the metals mined in California, the method of mining was determined by the character of the ore which was worked and thus could have been open pit or underground. Chromium, another of the heavy metals becomes a concern only when changed into its hexavalent form. Hexavalent chrome is a carcinogen and is found under certain environmental conditions in wetlands and water bodies.

Manganese

Manganese bearing rocks exist throughout the state. There are over 700 known deposits in 44 counties, although most of the mining has occurred along the coastal zones. This strategic mineral's fortunes too, have been dependent on government induced demand, most notably during the world wars. Manganese is one of a number of minerals that the U.S. Government deemed to be "strategic"; and thus it has been subsidized and stockpiled during certain periods. When this program ended in 1959, all California manganese mines closed (DMG 1966).

Manganese, too, is considered a "heavy metal", and as such can pose an environmental hazard if accumulations are present in water travelling through manganese mine sites.

Lead

Lead mining in California has been significant, although not dominating the market as has been the case with other mineral commodities. The MAS/MILS database indicates a total of 406 lead mines or prospects in California. Often lead mining occurs in concert with another mineral, mainly gold or silver. The Inyo Mountains on the East Side of the Owens River Valley has been the most productive area. The Cerro Gordo and Darwin Districts had particularly high production. One mine at Cerro Gordo has over 15 miles of underground workings.

Lead is considered highly toxic to all living organisms and is known to effect growth, learning, development, behavior, reproduction and metabolism (Eisler 1988).

Zinc

Another mineral historically associated with vast underground workings is zinc, for which California ranked fourth nationally in total tonnage extracted. Zinc appears in the desert regions, in the Sierra foothills, and in Shasta County.

As with many of the previously mentioned metals, production has followed U.S. Government related needs. The price for zinc for the most part, has not justified mining in California since World War II. There are nearly 100 abandoned zinc sites statewide.

Some of the zinc mine sites were found to have exceptional physical hazards, some pose chemical hazards, and a few present both. According to Environmental Protection Agency (EPA) spokesman Fraser Felter, until expensive mitigation measures were undertaken in the 1990s, the Iron Mountain Mine in Shasta County contributed 1,400 pounds of zinc daily into the Upper Sacramento River (Martin 1992).

Zinc plays a complex role in living organisms and is regarded as both an essential nutrient and a toxin. Aquatic systems are most susceptible when elevated zinc levels are associated with low pH, low alkalinity, low dissolved oxygen and eleveted temperatures. This report can not adequately address the peculiar role of zinc, so the reader may refer to (Eisler 1988) for more information.

Non-Metallic Mining

Coal

Many Californians are surprised to hear of the state's early and relatively brief coal mining history. While there are small, scattered deposits in 43 counties, only 12 counties have had mining. Only five areas saw any extended mining: Alberhill in Riverside County, Ione in Amador, Stone Canyon in Monterey, Corral Hollow in Alameda, and the Mount Diablo District in Contra Costa. The mines of Contra Costa yielded over 60% of the total tonnage (Jenkins 1957).

The coal mining period really only lasted a little more than two decades on a large scale, largely between 1887 and 1907. In the early 1900s, when the infrastructure became sufficient, California imported cheaper coal from the eastern US.

Issues associated with coal mining are well documented and include extensive underground workings; and low pH waste that can contaminate water and may also carry heavy metals.

It is ironic that coal mining revenues fund the abandoned mine mitigation programs in most western (and eastern) states and that California, which has no active coal mines, does not qualify for the Surface Mining Control and Reclamation Act (SMCRA) monies.

Boron

Boron deserves mention because California contains the world's largest known reserves, supplies the bulk of the boron produced, and in terms of total historic dollar value, boron passed gold as the greatest non-fuel commodity.

As most of the boron is simply extracted off ancient lakebeds, the past mining has not been very problematic. Management of boron particulate at the older, abandoned sites can sometimes be an air quality concern.

Asbestos

Serpentine, the principal host rocks for asbestos deposits in California, and the state's official rock, is abundant. This resilient fibrous material became a backbone of the construction industry in the 1960s, although it had been mined in California since 1887. There are over 170 mines that have produced asbestos, all but a fraction are currently inactive. A large mass northwest of Coalinga constitutes one of the largest asbestos deposits in the world.

Long term exposure to ambient airborne asbestos fibers has been linked to chronic respiratory illnesses and lung cancer. Unresolved are the hazards from ingested asbestos fibers. Although naturally occurring, and therefore released, the asbestos being transported in certain coastal streams poses another concern for state health officials (EPA 2000).

Atlas Mine, in San Benito County, with exposed asbestos wastes spread over a 200-acre area, was considered a major human health hazard prior to its delisting as a Federal Superfund site in 1998.

Uranium

California has been a uranium mining state, with nearly 300 sites, now mostly inactive in California. While the desert sites were plentiful, the deposits have never been economically viable in the long term. Most of those sites were only active during the great boom in post-war California.

Uranium mining exposes radioactive wastes, allowing them to come into contact with air and water. Proper disposal of the wastes can be problematic. Monitoring and sometimes treatment is necessary (Ripley et al 1996).

The Abandoned Mine Lands Task Force

As the previous section discussed, California is rich in geologic diversity and mining history. To assist in the development of a consistent, statewide policy regarding the diversity of abandoned mine issues, DOC initiated the AML Task Force. The first meeting was held on July 9, 1997; meetings continue to be held approximately quarterly. Membership was originally limited to state government departments whose regulatory responsibilities have potential application to abandoned mine issues. Since the original meeting, membership has been expanded to include federal agencies with responsibilities, as well. Representatives from industry and environmental groups were also invited.

Members and frequent participants in the Abandoned Mine Lands Task Force include representatives from:

State Government
Department of Conservation
Department of Fish and Game
State Water Resources Control Board
Department of Toxic Substances Control
Department of Parks and Recreation
State Lands Commission
State Mining and Geology Board

Others
California Mining Association
Mining Companies
Consulting Companies
Interested Individuals

Federal Government
Forest Service
Bureau of Land Management
National Park Service
Environmental Protection Agency
Army Corps of Engineers
Geological Survey

Intergovernmental
CALFED Bay-Delta Program

The goals for the Task Force were stated by the group as:

- To advise DOC in the production of a single, state-wide inventory of abandoned mine sites for California that would be officially recognized by state government departments, local and federal agencies, the mining industry and environmental organizations;
- To agree upon a state-wide definition for abandoned mine;
- To support the Western Governors' Association/National Mining Association joint efforts relating to abandoned mine issues; and
- To position California to compete for federal dollars that might be forth-coming for abandoned mine reclamation.

Definition of Abandoned Mine

The Task Force agreed on the initial need to define the term "abandoned mine". The Surface Mining and Reclamation Act (SMARA) defines abandoned surface

B Tables

B.1 List of Mines with Potentially Significant Environmental Hazards [18].

The following table contains a partial list of mines that have been identified as having significant or potentially significant environmental hazards. The data is based on information directly obtained by OMR or provided by other governmental agencies (prior to 3/27/2000). This list should not be considered as a statement of fact that such hazards do exist, even if a number of the sites have well-documented environmental hazards. Many of the sites presented here have not been sufficiently studied to determine whether identified issues are significant. Additionally, this list is a compilation of known information and does not preclude the possibility of unlisted mines having significant environmental hazards.

County	Mine Name	Hazard	Exposure	Risk	Issues	Remediating Entity[19]
Alpine	Leviathan Mine	5	5	5	ARD, Heavy Metals	SWRCB
Amador	Newton	4	5	5	ARD, Heavy Metals, Tailings In Stream	
Calveras	Penn	5	5	5	ARD, Heavy Metals	EBMUD, SWRCB
Lake	Sulfur Bank	5	5	5	ARD, Mercury	EPA
Mariposa	El Portal Barite	4	5	5	ARD	USFS, NPS
Nevada	Pine Hill	4	5	5	ARD, Heavy Metals	
Placer	Gold Run	4	5	5	Mercury	
San Luis Obispo	Pick and Shovel	5	4	5	Chromium, Heavy Metals	
Santa Clara	New Almaden	5	5	5	Mercury	EPA
Shasta	Balaklala	4	5	5	ARD, Heavy Metals	PRP
Shasta	Green Horn	4	5	5	ARD, Heavy Metals, Cyanide	
Shasta	Iron Mountain	5	5	5	ARD, Heavy Metals	EPA, PRP

[18] Sites are listed in descending order of risk. Rankings are 1 to 5, with 5 being the greatest hazard, exposure and risk. Environmental hazards were discussed in this volume. Exposure is the likelihood that the public will have contact with the site. The terms and their derivation are discussed in detail in Volume II.

[19] For those sites where remedial action is currently being taken the party is listed as follows: BLM – Bureau of Land Management; CNG – California National Guard; EBMUD – East Bay Municipal Utilities District; EPA – Environmental Protection Agency; NPS – National Park Service; PRP – Potentially Responsible Party; SWRCB – State Water Resources Control Board; USFS – U.S. Forest Service. In addition, state and federal trustees are involved at numerous sites assessing resource damages.

County	Mine Name	Hazard	Exposure	Risk	Issues	Remediating Entity[19]
Shasta	Mammoth Mine Complex	5	4	5	ARD, Heavy Metals	PRP
Alpine	Zaca	4	4	4	ARD	
Amador	Argonaut	4	4	4	ARD, Arsenic	
Fresno	Atlas	4	4	4	Asbestos	PRP, BLM
Lake	Abbot	3	5	4	Mercury	
Mariposa	Blue Moon	4	4	4	ARD, Heavy Metals	
Mariposa	Clearing House	3	5	4	Cyanide, Mercury, Tailings In Stream	
Mariposa	Crane Flat	2	5	4	ARD, Heavy Metals	
Mariposa	Crane Flat	3	5	4	ARD, Heavy Metals	
Mariposa	Green Mountain Mine	4	4	4	ARD, Heavy Metals	
Mariposa	Hasloe	3	5	4	Mercury, Tailings In Stream	
Mariposa	Losch	3	5	4	Tailings In Stream	
Mariposa	Mountain King	3	5	4	Mercury, Tailings In Stream	
Mariposa	PineTree - Josephine	3	5	4	ARD, Mercury, Cyanide	
Mariposa	Red Cloud	3	5	4	Cyanide, Mercury, Tailings In Stream	
Napa	Silverado	4	4	4	ARD, Heavy Metals, Eroded Tailings	
Nevada	Lava Cap	4	4	4	ARD, Arsenic	EPA
Nevada	Malakoff	3	5	4	Mercury	
Nevada	North Star Central Shaft	3	5	4	Mercury, Heavy Metals	
Placer	Polarstar	3	5	4	Mercury	
Nevada	Red Dog/You Bet Diggins	3	5	4	Mercury	
Nevada	San Juan	4	4	4	ARD	
Nevada	Spenceville	4	4	4	ARD, Heavy Metals	
Nevada	Unknown	3	5	4	ARD, Heavy Metals	
Placer	Valley View	3	5	4	ARD, Heavy Metals	
Plumas	Walker	4	4	4	ARD, Sediment, Airborne Tailings	USFS
San Benito	New Idria	4	4	4	Mercury	

County	Mine Name	Hazard	Exposure	Risk	Issues	Remediating Entity[19]
San Luis Obispo	Buena Vista	4	4	4	ARD, Mercury	
San Luis Obispo	Klau	4	4	4	Mercury	
San Luis Obispo	La Trinidad	3	5	4	Chromium, Heavy Metals	
San Luis Obispo	Primera	3	5	4	Chromium, Heavy Metals	CNG
San Luis Obispo	Rinconada	4	4	4	Mercury	
Santa Clara	Guadalupe	4	4	4	Mercury	
Santa Clara	Western	3	5	4	Sediment, Poss.Heavy Metals	
Shasta	Afterthought	4	4	4	ARD, Heavy Metals	
Shasta	Golinsky	4	4	4	ARD, Heavy Metals	PRP
Shasta	Keystone	3	5	4	ARD, Heavy Metals	
Siskiyou	Buzzard Hill	4	4	4	ARD, Heavy Metals	
Siskiyou	Siskon	4	4	4	ARD, Heavy Metals	
Yuba	Wellman Creek	3	5	4	ARD, Heavy Metals	
Alameda	Leona Heights	3	4	3	ARD, Heavy Metals	
Alameda	Livermore Coal Company	3	3	3	Heavy Metals	
Alameda	Tesla	3	3	3	Heavy Metals	
Alpine	Morning Star	3	3	3	ARD, Heavy Metals	
Amador	Central Eureka	4	3	3	ARD, Heavy Metals	EPA
Amador	Kennedy Tailings	3	3	3	Arsenic	
Butte	Texas Gold	3	4	3	Sediment, Mercury, Cyanide	
Colusa	Elgin	3	3	3	Mercury	
El Dorado	Hazel Creek	3	3	3	Heavy Metals, Lead, ARD	
Fresno	Coalinga Asbestos	3	3	3	Asbestos	PRP, EPA
Humboldt	Copper Bluff	3	3	3	ARD, Heavy Metals	EPA
Inyo	Cerro Gordo	3	4	3	Lead, Heavy Metals	
Inyo	Estelle Tunnel	3	3	3	Heavy Metals	
Inyo	Morning Star	3	4	3	Lead, Heavy Metals	
Inyo	Reward	3	4	3	Heavy Metals	
Inyo	Snowcaps	3	3	3	Poss. Heavy Metals	
Kern	Hobo	3	4	3	Mercury, Sediment	

County	Mine Name	Hazard	Exposure	Risk	Issues	Remediating Entity[19]
Kern	Unknown	3	4	3	Large Tailings	
Kings	Bright Star Tailings	3	3	3	Mercury, Arsenic, Heavy Metals	
Lake	Anderson Springs	3	3	3	Mercury	
Lake	Corona	3	3	3	Mercury	
Lake	Turkey Run	3	3	3	Mercury	
Lassen	Honey Lake Mine	3	3	3	Large Waste Pile	
Madera	Hart Iron Deposit	3	4	3	ARD, Heavy Metals	
Madera	Unknown	3	3	3	ARD	
Marin	Gambonini	3	3	3	Mercury	EPA, SWRCB
Mariposa	Argo	3	4	3	ARD	
Mariposa	Bondurant	3	4	3	ARD, Eroded Tailings	
Mariposa	Garibaldi	3	3	3	ARD Potential	
Mariposa	Louisa	2	5	3	Mercury, Large Tailings	
Mono	Par Value	2	5	3	Tailings In Stream	
Napa	La Jolla	3	3	3	Mercury	
Napa	Oat Hill and Extension	3	3	3	Mercury	
Napa	Twin Peaks	3	3	3	Mercury	
Nevada	Allison Ranch	2	5	3	ARD, Heavy Metals	
Nevada	Blue Lead	3	4	3	Mercury	
Nevada	California Gold & Copper Corp.	3	4	3	ARD, Heavy Metals	
Nevada	Champion	3	3	3	ARD, Heavy Metals	
Nevada	Idaho Maryland Tailings	3	4	3	Cyanide, Arsenic, Heavy Metals	
Nevada	Last Chance	3	4	3	ARD, Heavy Metals	
Nevada	Le Du	3	4	3	Mercury	
Nevada	Numitor	2	5	3	ARD, Heavy Metals	
Nevada	Poore Mine	3	3	3	Mercury	
Nevada	Steephollow	2	5	3	Mercury	
Nevada	Stockton Hill Mine	3	4	3	ARD, Heavy Metals	
Placer	Algol Copper	3	3	3	ARD, Heavy Metals	
Placer	Dairy Farm	3	4	3	ARD, Heavy Metals	
Placer	Nichols Diggings	3	4	3	Mercury	
Placer	Parker Ranch	2	5	3	Chromium	

County	Mine Name	Hazard	Exposure	Risk	Issues	Remediating Entity[19]
San Bernardino	Garvey	3	3	3	Sediment, Mercury, Cyanide	
San Bernardino	Lester	3	4	3	ARD, Heavy Metals	
San Bernardino	Mineral Spring	3	4	3	Ard	
San Bernardino	Mollusk Mine	3	4	3	Heavy Metals	
San Bernardino	Umberci Mine	3	4	3	Lead, Sediment	
San Luis Obispo	Oceanic	3	4	3	Mercury	
San Luis Obispo	Single Jack Mine	3	3	3	ARD, Sediment	
Santa Barbara	Gibraltar	3	3	3	Mercury	USFS
Santa Clara	Black Horse	2	5	3	ARD, Tailings In Stream	
Shasta	Bully Hill Mine	3	4	3	ARD, Heavy Metals	
Shasta	El Dorado	3	3	3	ARD, Heavy Metals	
Shasta	Engle	3	3	3	ARD, Heavy Metals	
Shasta	Friday-Louden	3	4	3	ARD, Heavy Metals	
Shasta	Gladstone	4	3	3	ARD, Heavy Metals	
Shasta	Great Western	3	4	3	ARD, Heavy Metals	
Shasta	Midas	4	3	3	ARD, Heavy Metals	
Shasta	Mt. Shasta	3	3	3	ARD, Heavy Metals	
Shasta	Old American	3	3	3	ARD, Heavy Metals	
Shasta	Rising Star	3	4	3	ARD, Heavy Metals	
Shasta	Shasta King	3	4	3	ARD, Heavy Metals	
Shasta	Stowell	3	3	3	ARD, Heavy Metals	
Shasta	Summit	3	3	3	ARD, Heavy Metals	
Sierra	Craigs Flat	3	3	3	Mercury	
Sierra	Drifting Howard	3	4	3	Mercury	
Sierra	Harmony Hydraulics	3	3	3	Mercury	
Sierra	Morristown Diggings	3	4	3	Mercury	
Sierra	Mugginsville Adit	3	3	3	ARD, Mercury	
Sierra	Pioneer Placer Diggings	3	4	3	Mercury	
Sierra	Tennessee	3	3	3	ARD, Heavy Metals	
Sierra	Young American	3	4	3	Mercury	

County	Mine Name	Hazard	Exposure	Risk	Issues	Remediating Entity[19]
Trinity	Altoona	3	4	3	ARD	
Yolo	Reed	3	3	3	ARD, Heavy Metals, Mercury	PRP

County	Mine Name	Chemical Risk	Physical Risk	Description
San Luis Obispo	Primera	4	1	This Chromium mine consists of a very large pit and massive waste/tailings dump which is severely eroded into the bordering drainages. Heavy metal runoff and sediment contaminates Chorro Creek and Reservoir and caused massive off-site erosion of downstream drainage. Site is currently undergoing remediation.
San Luis Obispo	Rinconada	4		Large mercury mine and CERCLA site (not on NPL). Extensive underground mine workings and multiple openings. Has a 10 acre waste/tailings dump contaminating watershed, prompting RWQCB recommendations for mitigation. Site receives high visitation.
San Luis Obispo	Eucalyptus No. 1	1	5	Chromite, lead, and zinc mine with steep, vertical pit and six dangerous openings. Site receives high visitation.
Santa Barbara	Gibraltar (Los Prietos, Sunbird, Santa Ynez)	3		CERCLA (not on NPL) site located at Santa Barbara's largest reservoir. This once large mercury mine has been polluting the major drinking water source for the City of Santa Barbara since the 1920s.
Santa Clara	New Almaden	5		Extensive mercury mine locality and CERCLA site near San Jose. Not on NPL list. Site is in process of being remediated to county park.
Santa Clara	Western	4	5	Over 400 acre magnesium mine and mill in Santa Clara County which contains over 1 million yards of tailings. Over 30 openings, some very deep vertical shafts.
Santa Clara	Guadalupe	4		Santa Clara County mercury mine on RWQCB investigation list. Active until 1971. Produced over 100,000 flasks of mercury.
Shasta	Balaklala	5	5	Large underground copper producer near Shasta Reservoir. Contaminates Shasta Lake with very low pH ARD and heavy metals. NPDES permit and Cease and Desist Order adopted by RWQCB. CERCLA site (Not on NPL). Multiple openings, large volume of tailings. Reclamation in progress.
Shasta	Iron Mountain	5	5	One of the most contaminated mine sites in the country, this Shasta County copper mine has the world's most acidic ARD. Past spills responsible for as much as half of the heavy metal contamination of San Francisco Bay. Multiple openings and acidic seeps at several locations covering 1500 acres. Superfund (on NPL) costs have exceeded $200 million dollars in efforts to mitigate pollution of the Sacramento River.

County	Mine Name	Chemical Risk	Physical Risk	Description
Shasta	Greenhorn	5	4	Copper and gold mining operation with large volume of waste rock and tailings eroding into creek that is tributary to Whiskeytown Reservoir. Documented ARD and heavy metal impacts. Cyanide tailings dam failed in 1949 causing extensive environmental damage. NPDES permit and Cease and Desist Order issued by RWQCB. Multiple collapsed openings with ARD seeps. One open adit, highwalls, quarry.
Shasta	Mammoth Mine Complex	5	4	Expansive Copper site with extensive underground workings in Shasta Copper-Zinc Belt. Includes the Friday-Louden Portal among others. This CERCLA (not on NPL) site has documented ARD and heavy metal seeps which directly contaminate Shasta Lake. Massive volumes of tailings and waste rock.
Shasta	Keystone	4	4	Shasta Copper-Zinc Belt underground mine with significant ARD discharges into West Squaw Creek, tributary to Shasta Lake. Under clean up order from RWQCB. Two open adits. ARD seeps. Mitigation of ARD in progress.
Shasta	Afterthought	4		Began as a gold mine, became a copper mine from 1910-1952. Sulphide tailings and waste rock producing very acidic ARD and heavy metal pollution from numerous open adits, which ultimately flows into the Sacramento River near Redding.
Shasta	Copper Mountain	4		Copper, zinc mine with ARD and heavy metal issues. CERCLA site. Not on NPL.
Shasta	Golinsky	4		Copper mine located in Shasta Copper-Zinc Belt. Documented ARD polluting Shasta Lake. Dangerous openings. USFS planning remediation.
Shasta	Great Western	3	5	Lode gold mine and mill with multiple openings, including three hazardous shafts. Large volumes of sidecast waste and tailings. High visitation.
Shasta	Franklin/Milkmaid	3	5	Underground gold mine along road in heavily visited recreational area. Features more than a dozen dangerous, open adits and shafts.
Shasta	Bully Hill Mine	3	4	Large underground copper, zinc mine containing numerous adits and large volume of tailings which discharge ARD into Shasta Lake. Site is visible for miles and receives heavy visitation from boaters.
Shasta	Rising Star	3		Copper, gold, silver, and lead producer in the Shasta Copper-Zinc Belt which has contributed ARD runoff to Shasta Reservoir. Large volume of waste/tailings and 3 collapsed adits.
Shasta	Shasta King	3	3	Copper, gold, and silver mine with at least one open adit, potentially other openings. Massive tailings and waste dump, and ARD/heavy metal contamination of West Squaw Creek. RWQCB is monitoring.

County	Mine Name	Chemical Risk	Physical Risk	Description
Shasta	Stowell	3		Copper mine in Shasta Copper-Zinc belt with documented ARD and heavy metal impacts. Currently being monitored by RWQCB.
Shasta	Silver Falls	2	5	Extensive underground silver mine with as many as 16 adits, including a 3000' ungated, horizontal opening reported to contain carbon monoxide. Moderate volumes of waste and tailings on site. Large amount of trash and drums.
Sierra	Pioneer Placer Diggings	3	5	200 acre hydraulic site near La Porte. ARD seeps observed along with and two extremely dangerous steep vertical shafts leading to water-filled drain tunnel. Thousands of feet of vertical or nearly vertical highwalls. Potential mercury impacts.
Sierra	Mountain View	3	5	Sierra hard rock gold containing 8 openings, some vertical, most open.
Sierra	Tennessee	3	2	Gold mine with drainage through site that continues for .5 miles to Canyon Creek (tributary to North Yuba). 4 adits with ARD seeps. The tailings and waste rock are eroding into the stream bed. Unlabeled drums on site. At least two more adits reported. Reported attempts at ARD mitigation.
Siskiyou	Buzzard Hill	4	2	Underground gold operation showing evidence of cyanide processing. Known ARD producer, and waste/tailings in creek below site showed elevated levels of copper, chromium, cobalt, nickel, iron, zinc, mercury. Open adits remain. Evidence of frequent visitation.
Siskiyou	Grey Eagle Tailings	4		Massive, eroding tailings pile from historic copper mining operation adjacent to Indian Creek, a tributary of the Klamath River. ARD, heavy metals contaminating creek. CERCLA site (not on NPL).
Trinity	Drinkwater Gulch	4		CERCLA site. Not on NPL.
Tuolumne	Starr King	4		Gold mine and CERCLA site with potential ARD issues. Not on NPL.

California's Abandoned Mines

A Report on the Magnitude and Scope of the Issue in the State
Volume II

Department of Conservation
Office of Mine Reclamation
Abandoned Mine Lands Unit

June 2000

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3.5 Lake Shasta Watershed

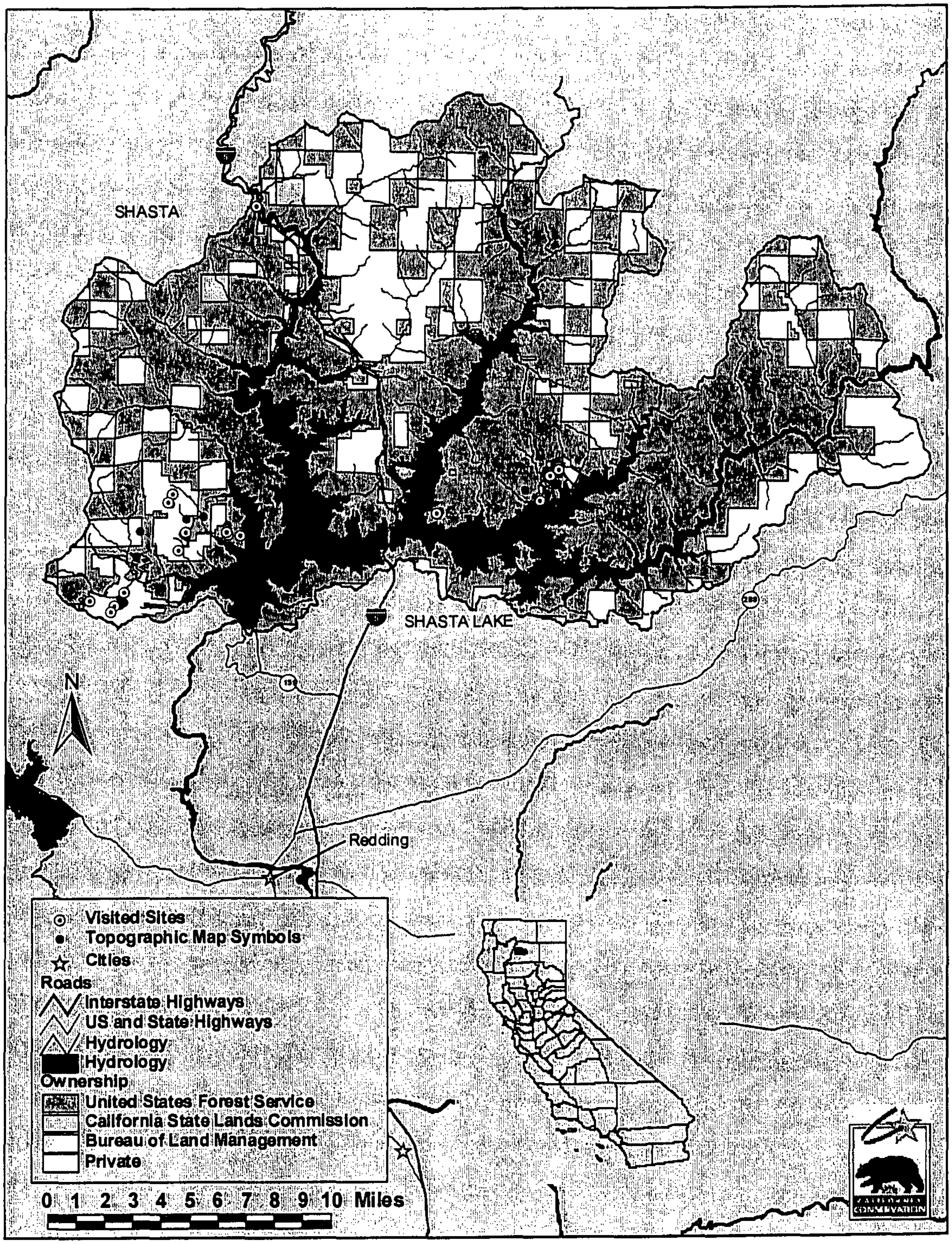


Figure 3.6: Lake Shasta Watershed, Area Map.

The most prominent features of the Lake Shasta Watershed are the 46 square mile reservoir, and Shasta Dam. This watershed has a total area of 375 square miles, and forms the headwater drainage for the Sacramento River. The Lake Shasta Watershed is located in west-central Shasta County, and is approximately 18 miles long, and 30 miles wide. It is adjacent to the Clear Creek Watershed on the west, and the Sacramento River Watershed to the south. With over 370 miles of shoreline and a capacity of 4,552,000-acre feet of water, Lake Shasta is one of the largest reservoirs in California. There are no communities located within the watershed, however there are numerous resorts, cabins, and camping areas around the lake, which is a major recreation, tourism, and sport-fishing destination. This watershed provides water for consumption and domestic use to the city of Redding, which has a population of 78,490 (1995 estimate). It also provides water for the nearby communities of Anderson, Cottonwood, Summit City, Project City, Pine Grove, and Central Valley. In addition, this watershed supplies the downstream communities of the Great Central Valley, such as Red Bluff, Corning, etc. In all, it is estimated that the Lake Shasta Watershed may provide the Sacramento River and the Central Valley Water Project with water for consumption and domestic use for populations in the hundreds of thousands, in addition to large scale industrial and agricultural (irrigation) use.

Table 3.29: Lake Shasta Watershed Land Ownership Summary

Government Level	Agency	Acres	Percent
Federal	USFS	173,364	72
	BLM	165	0
Sum (Federal)		*173,529*	*72*
State	DFG	7	0
	State Lands Commission	1,892	1
	Sum (State)	1,899	1
Private	Private	64,373	27
Sum (Total)		*239,801*	*101*

The climate of this watershed varies with elevation. Lake level forms the lower elevation and varies with storage requirements. The elevation of the Shasta Dam Spillway is 1,065 feet and the highest elevation in the watershed is 4,156 feet (Bohemotash Mountain). The climate at lake level is characterized by mild summers and cool, wet winters. The annual average rainfall is 60 inches. The higher elevations are characterized by mild summers and cold, wet winters with significant snowfall. (CERES 1998).

The Lake Shasta Watershed encompasses an area bordered by the Cascade Ranges to the north and east, the Klamath Ranges to the west, and the Great Central Valley to the south. The topography is generally characterized by steep mountains and narrow canyons. The creeks and streams that are tributary to Lake Shasta are generally steeply graded and fast-flowing. However, the main tributaries of the Upper Sacramento River, McCloud River, and Lower Pit River tend to be wider and slower. Other tributaries to Lake Shasta are: Backbone Creek, Little Backbone Creek, Squaw Creek, West Squaw Creek, Salt Creek, Horse Creek, Town Creek, Campbell Creek, Charlie Creek, and Sugarloaf Creek. Little Backbone Creek, West Squaw Creek, Horse Creek, Town Creek, the Lower Pit River, and Shasta Lake are listed as impaired under Section 303(d) of the Federal Clean Water

Act as a result of contamination with cadmium, copper, lead, and zinc from abandoned mines within the watershed (USEPA 2000).

The Lake Shasta Watershed is comprised of the Klamath Ranges (KR), High Cascade Ranges (CaRH), and Cascade Range Foothills (CaRF) biological subregions, which are components of the Northwest California (NW) and Cascade Range (CaR) biological regions as defined in the Jepson Manual (Hickman 1993). The plant communities of these subregion vary by elevation across the watershed and include mixed chaparral, oak woodland, and mixed evergreen, with mixed oak and conifer forest as elevation increases. Ponderosa pine, Jeffrey pine and white fir are the dominant conifers. White fir and mixed conifer forest generally characterize the highest elevations. Manzanita, ceanothus, toyon, and poison oak are dominate in the chaparral and oak woodland (Alden 1998). Logging, wildfire, and mining activities have left surface disturbance that is characterized by moderate to severe erosion and the loss of soils favorable to re-forestation. This has allowed chaparral shrub species to proliferate in the previously forested areas. The watershed has been heavily impacted by alterations caused by Shasta Dam and the Lake Shasta Reservoir. Threatened and endangered species in this watershed include the Northern Spotted Owl, Bald Eagle, and Shasta Salamander. (CERES 1998). Townsend's Big-Eared Bat, a species of special concern, have been reported at several abandoned mines in the adjoining Clear Creek Watershed (Whiskytown NPS 1999).

The Lake Shasta Watershed is located in the southeastern portion of the Klamath Range. The geology of the watershed includes metamorphosed silicic volcanics and pyroclastic deposits (Paleozoic Copley Greenstone, overlain by Balaklala Rhyolite); metamorphosed volcanic and sedimentary rocks (Bully Hill Rhyolite); metamorphosed marine sedimentary rocks of the Paleozoic Bragdon Formation; miscellaneous combined geologic units; and by the intrusions of quartz diorite along the McCloud River arm of the watershed. The area encompassing the western third of the watershed is known as the West Shasta Copper-Zinc District. This is a region where stratified formations, fractures, faults, and shear zones occurring in the Balaklala Rhyolite were found to contain massive sulphide ores which contained large deposits of copper and zinc with lesser quantities of lead, gold, silver, and cadmium. Another highly mineralized area of copper, zinc, lead, gold, and silver deposits occurs in the eastern quarter of the watershed, and is known as the East Shasta Copper-Zinc District. In this region, the sulphide ores are associated with shear zones and fault contacts in the Bully Hill Rhyolite (Lydon and O'Brian 1974).

3.5.1 Short History of Mining

Lode gold was first mined in the 1860's from gossans overlying sulphide ores in the West Shasta Copper-Zinc District. While this region was to become better known for copper and zinc production, considerable quantities of gold and silver were also produced. The most productive lode gold operation was the Uncle Sam Mine, which operated a 30-stamp mill and produced over a million dollars in gold and silver from 1886 to 1913. However, beginning in the 1890's large amounts of gold and silver were being produced as a by-product of the smelting of copper ore. It soon was no longer profitable to specifically mine for gold and silver in this region (Clark 1998).

Copper was the principal commodity mined in the Lake Shasta Watershed. Copper mined from both the West and East Shasta Copper Districts accounted for more than half of the state's total production. Copper mining began in 1862 at Copper City, which was flooded when the Lake Shasta Reservoir was filled. The lack of a smelter required shipping the ores to Europe for processing, so both production and profit were limited. In 1894, an English company acquired the Iron Mountain Mine, which is located a few miles south of the watershed. In 1896, this company built a smelter at Keswick that eliminated the need to ship ore out of the country for processing. This development led to the expansion of copper mining within the Lake Shasta Watershed. Large mines were developed in the West Shasta Copper District, and included the Mammoth and Balaklala mines. The largest mine complex in the East Shasta Copper District was the Bully Hill mine. Various sites at the Mammoth Mine complex may have been worked for gold as early as the 1880's, however records of copper production did not begin until 1905. The Mammoth complex of mines included the Friday-Louden, Sutro, Summit, Mayflower, and Golinsky sites and was itself developed by nine adits and thousands of feet of workings. A smelter was built at Kennett (later to be inundated by Lake Shasta) in 1907, which operated until 1924. More than 3 million tons of copper ore were produced from the Mammoth complex before mining ceased in 1925.

The Balaklala Mine began operations in the 1890's. By 1902, more than 20 adits and thousands of feet of workings had been developed. In 1906, a smelter was built at Coram (near what is now, Shasta Dam). A 3-mile long aerial tramway was built to transport ore from the massive workings to the smelter, which was closed in 1911 due to litigation over smoke emissions. It has been estimated that more than one million tons of ore were mined here. The mine continued production until the 1920's and shipped ore to be refined at the Mammoth smelter at Kennet. Other large copper mines in the West Shasta Copper-Zinc District included the Keystone and Shasta King mines, which operated between the 1860's and the late 1920's. The Bully Hill and Rising Star complex was the largest operation in the East Shasta Copper-Zinc District. During the years these mines were in operation, more than a half-million tons of ore was mined between 1900 and 1950. At least nine adits and thousands of feet of workings were developed at this site. A smelter was put into operation in 1901, but ceased operation in 1910 because increasing zinc content made refining more difficult, and because of litigation over emissions. In 1918, an experimental smelter was constructed at nearby Winthrop to process the zinc ores, but by 1925, ore was again being shipped to Europe for smelting. Between 1927 and 1951, activity at this site was limited to exploration and the reprocessing of smelter slag. The emissions from copper smelting severely impacted air quality and caused massive environmental degradation and the loss of forests throughout the region. By 1919, most of the smelters had been shut down due to litigation resulting from the environmental damage caused by ore refining. The cost of shipping the copper ore for refining elsewhere, combined with the high cost of grinding the ore to concentrates made further mining of copper and zinc ores in this watershed unprofitable, and most mining had ceased by the 1920's (Lydon and O'Brian 1974).

Iron was first mined in this watershed in 1902 at the Shasta Iron Mine to provide flux for the copper smelter at Bully Hill. A smelter was put into operation nearby in 1907 to produce pig iron from the mine. More than 15,000 tons of iron ore was mined from trenches and quarries between 1907-1914. The smelter was shut down following WW I, but iron ore production continued until 1925. The mine became active again in WW II, and produced quantities of iron ore for use as marine ballast. Barges were required to transport the ore across Lake Shasta, following the completion of Shasta Dam. In 1948, production ceased, and litigation arising from loss of access to the mineral deposits due to the rising lake level was settled (Lydon and O'Brian 1974).

Limestone was mined from the Holt and Gregg quarries beginning in 1894 and processed in kilns to produce lime for agricultural and construction use through 1927. Beginning in 1896, limestone from these and several other small quarries were used to provide flux material for the copper smelters located at Iron Mountain, Bully Hill, Corum, and Kennett until their operations ceased.

3.5.2 Current Mining

There is currently no active mining in the Lake Shasta Watershed. The Balaklala, Keystone, and Mammoth Complex (Friday-Louden) mines of the West Shasta Copper-Zinc Mining District, and the Bully Hill Mine of the East Shasta Copper-Zinc Mining District are undergoing active remediation attempts, but are otherwise inactive.

3.5.3 Sample Study

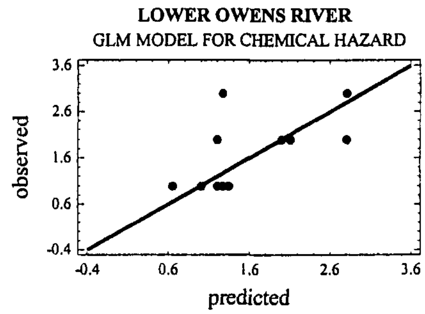
The Lake Shasta Watershed was chosen at random from a larger dataset of bioregions (Hickman 1993). Topographic mining symbols were digitized from the sixteen USGS 7.5 Minute topographic maps encompassing the watershed, and the geology (DMG 750k) was spatially analyzed by major reclassified rocktype ("Reclass"). The watershed was stratified into three generally homogeneous units based on geology. These were Cenozoic through Precambrian marine sedimentary and metasedimentary rocks; Cenozoic through Precambrian volcanic and metavolcanic rocks; and Cenozoic through Precambrian granitic and associated intrusive rocks. Sixteen topographic symbols were randomly selected for field inventory. All but two sites were located in the same rocktype. At least one mine site for each rocktype was field visited. In addition, eleven Principle Areas of Mine Pollution (PAMP) were associated with the randomly selected symbols and included in the sample study. This sample represents 85% of the PAMP in this watershed. Of the total of 68 topographic mining symbols delineated for this watershed, approximately 29% were field visited by AMLU staff. Three sites included in this sample were inventoried by the USFS. Thirteen "topographic symbol" sites were field inventoried by OMR staff for this study.

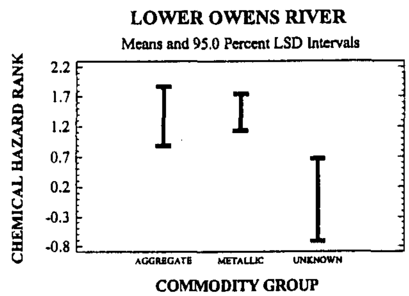
3.5.3.1 Results of Analysis and Modeling

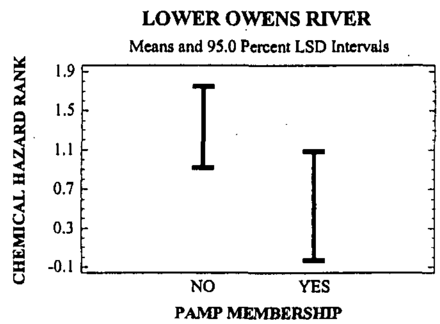
The sampled sites were evaluated for physical and chemical hazards and then ranked by the severity of each type of hazard.

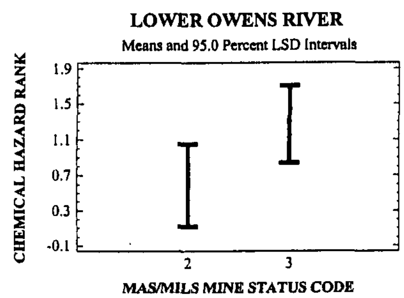
Table 3.30: Field verified Chemical Hazard Ranking Numbers

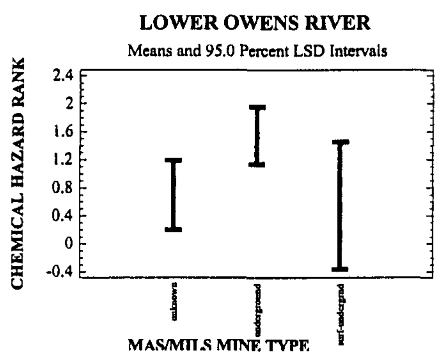
Rank	Count	Percent	Definition of Rank
1	4	25	Very low probability of releasing hazards into the environment
2	7	44	Low probability of releasing hazards into the environment
3	2	12	Moderate probability of releasing hazards into the environment











The following table is a summary by rank for predicted rankings of sites in the MAS/MILS database. Within this study area, approximately 100 MAS/MILS sites could not be predicted. The excluded MAS/MILS sites included raw prospects, mineral locations, processing plants, surface or placer operations, and all non-metallic commodities. These sites could not be predicted because the sampled sites did not have sufficient correspondence with these categories.

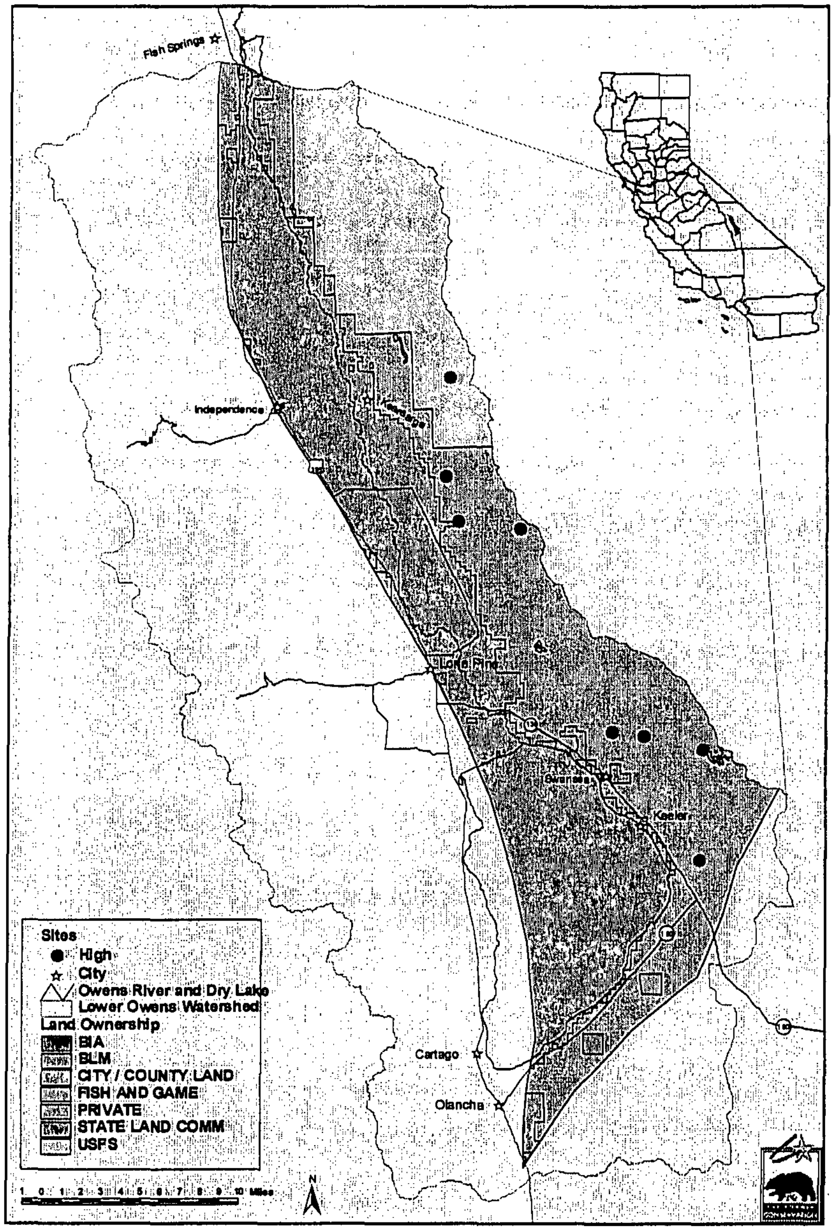


Figure 3.10: Plot of MAS/MILS mineral occurrences with a predicted chemical hazard rank of three or more.

Table 3.40: Chemical hazard predictions for MAS/MILS mineral occurrences.

Rank	Count	Relative Frequency	Cumulative Frequency	Cum. Rel. Frequency
0	13	0.1130	13	0.1130
1	60	0.5217	73	0.6348
2	34	0.2957	107	0.9304
3	8	0.0696	115	1.0000

The results indicate that for this watershed there is a low to moderate probability for a site which represents a significant chemical hazard. The cumulative chemical hazard ranking score for this 331,981 acre watershed is 1728 (density 0.005205) — indicating a low cumulative chemical impact potential. It should be remembered that these results are based on metallic, stone or aggregate mines where the site is at least a developed prospect. Therefore, the contributions from non-metallic sites are not included.

3.6.3.3 *Predicted Physical Hazard Rankings*

The *physical hazard ranking* was also predicted by regression analysis with a General Linear Model. The prediction model utilizes the field verified *physical hazards ranking*. The results of the predictive model (r^2=57%, p<0.0001) are then applied to the MAS/MILS database for the watershed using MAS/MILS database information about the mine type (TYP), geologic rocktype group (Rocktype) and the potential for arsenic (derived from MRDS). The results of the regression model for physical hazards and its components are displayed in below.

Table 3.41: Summarized statistics for the physical hazard GLM.

Analysis of Variance for PHYSICAL HAZARD

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	66.2714	6	11.0452	8.68	0.0000
Residual	35.6144	28	1.27194		
Total (Corr.)	101.886	34			

Type III Sums of Squares

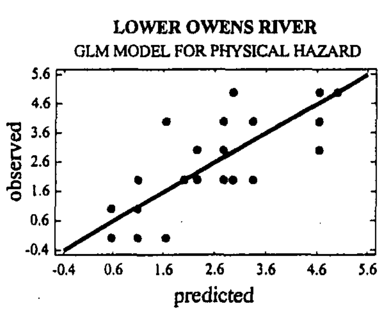
Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
TYPE_CODE	24.3597	2	12.1798	9.58	0.0007
ROCKTYPE_N	27.9151	3	9.30502	7.32	0.0009
AS	4.82857	1	4.82857	3.80	0.0615
Residual	35.6144	28	1.27194		
Total (corrected)	101.886	34			

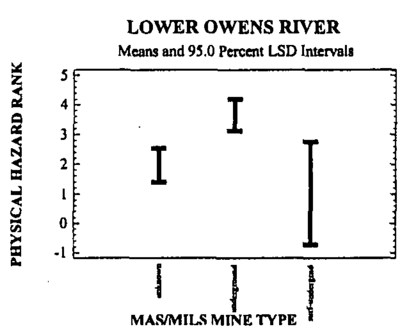
R-Squared = 65.0448 percent

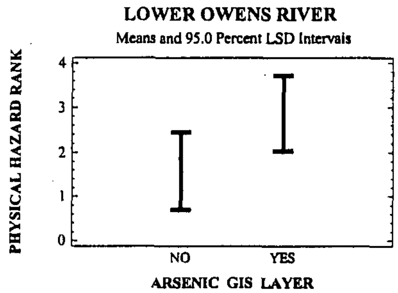
R-Squared (adjusted for d.f.) = 57.5544 percent

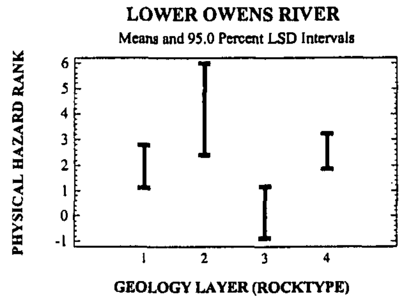
All F-ratios are based on the residual mean square error.

The following graphs depict the tests among means for each component of the GLM regression analysis.









The following table is a summary by rank for predicted rankings of sites in the MAS/MILS database. Within this study area, approximately 100 MAS/MILS sites could not be predicted. The excluded MAS/MILS sites included raw prospects, mineral locations, processing plants, surface or placer operations, and all non-metallic commodities. These sites could not be predicted because the sampled sites did not have sufficient correspondence with these categories.

Table 3.42: Physical hazard predictions for MAS/MILS mineral occurrences.

Rank	Count	Relative Frequency	Cumulative Frequency	Cum. Rel. Frequency
0	33	0.2870	33	0.2870
1	18	0.1565	51	0.4435
2	32	0.2783	83	0.7217
3	26	0.2261	109	0.9478
5	6	0.0522	115	1.0000

The results indicate that for this watershed there is a moderate probability for a site which represents a significant physical hazard. The cumulative physical hazard ranking score for this 331,981 acre watershed is 26,394 (density 0.0795) indicating that AML sites in the watershed likely poses a moderate threat of physical hazards. It should be remembered that these results are based on metallic, stone or aggregate mines where the site is at least a developed prospect. Therefore, the contributions from non-metallic sites are not included.

3.6.3.4 Predicted Hazardous Openings

A hazardous opening is defined as an opening (shaft, adit, drift, decline, tunnel, etc.) that is large enough and deep enough for someone to become trapped in or from which a fall could cause serious injury. For this purpose, a depth or length of 10 feet is used.

There are 126 topographic symbols indicative of an opening as shown on the topographic maps for the sampled sites (The number of topographic openings is digitized by AMLU from the USGS quad.). 198 openings were verified in the field for these sites, and 143 (or 72%) were found to be potentially hazardous. Using a simple regression model, we can predict the number of openings in the field (r^2=71%, p<0.0001) based on the number of openings shown on the topographic sheet. The predicted value is 680 openings. Once again, applying a simple regression to the predicted openings, we estimate that there are 518 hazardous openings in the watershed (r^2=85%, p<0001).

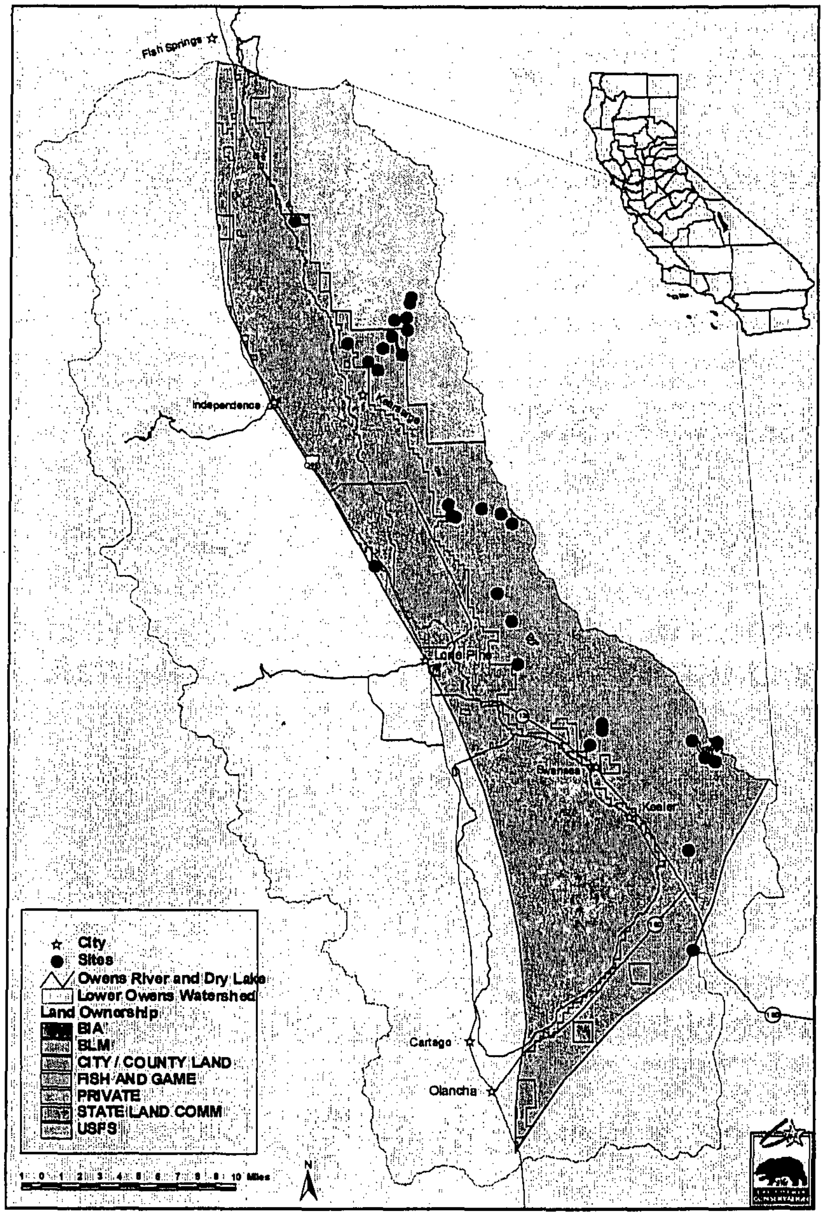


Figure 3.11: Plot of MAS/MILS mineral occurrences with a predicted physical hazard rank of three or more.

3.6.4 Summary of Findings

In this watershed, there is a low probability for a site which presents a significant chemical hazard. Cumulatively, there is a low probability for a significant impact to the environment. Individual mines in this watershed have a moderate probality of presenting a physical hazard, and cumulatively the watershed has large number of hazardous openings.

Table 3.43: Summarized findings for the Lower Owens Watershed.

Total Watershed Area (Acres)	331,981
Predicted Cumulative Chemical Ranking Score	1,728
Predicted Cumulative Chemical Ranking Score Density	0.005205
Predicted Cumulative Physical Ranking Score	26,394
Predicted Cumulative Physical Ranking Score Density	0.0795
Predicted Hazardous Openings	518

3.7 *Merced River Watershed*

The Merced River Watershed (Merced) lies in the Central Sierra Nevada. It lies almost entirely within Mariposa County with a small sliver of the western-most extremity of the watershed in Merced County and the southeastern extremity in Madera County.

Major, through-going roads are limited to State Highways 41, 49, and 120. While the county has been historically sparsely populated, it is now experiencing the same rapid expansion as the more northerly foothill counties. With the presence of Yosemite Park, the region experiences very high levels of tourism and outdoor recreation is a primary industry.

Land management and ownership is summarized in Table 3.44. Essentially, 80% of the Merced is public land managed by three Federal Agencies; Forest Service (USFS), Bureau of Land Management (BLM), and the National Park Service (NPS), with the remaining 20% under private ownership. Lands managed by the NPS form a single large contiguous parcel. Lands managed by the USFS essentially form a single large contiguous parcel, having only discrete private in-holdings surrounded by USFS managed public lands. However, the lands managed by the BLM are quite different. Public lands managed by BLM are highly fragmented, and at times it is difficult to discern whether one is dealing with a private inholding in public lands or a remnant of public land within private land.

Table 3.44: Land Ownership in the watershed.

Ownership	Agency	Acres	Percent
Federal	USFS	176,368	25.1
	BLM	70,252	10.0
	NPS	320,060	45.5
Sum		*566,680*	*80.6*
State	Lands Commission	311	0.04
	Fish & Game	121	0.02
Sum		*432*	*0.06*
Private		136,300	19.4
Totals		*703,412*	*100.06*

For the 49 sites visited, 46% of the mine features observed and catalogued occurred on private land. However, 76% of the observed and catalogued mine features occurred on lands adjacent to or within public lands. Thus presenting a significant potential for interaction with users of public lands, e.g. outdoor recreationists and tourists.

The Merced is comprised of six Hydrologic Areas, the five summarized in Table 3.45 and the Mountain Star King . Together they have a total area of 703,412 acres. However, the study was limited to the five Hydrologic Areas in which mining has been documented.

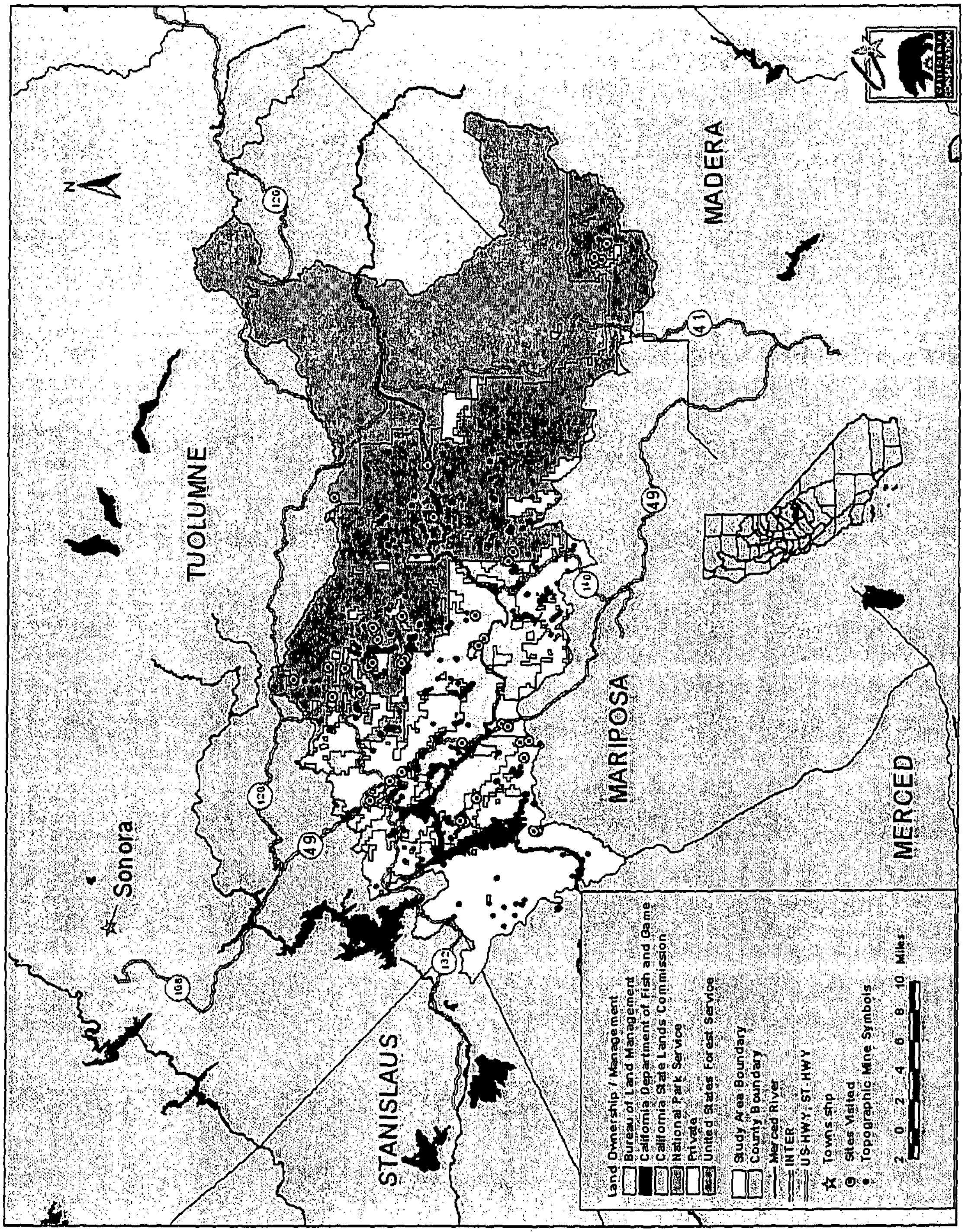


Figure 3.12: Merced River Watershed, Area Map.

The main stem of the Merced River is 164 miles long from its headwaters in eastern Yosemite National Park to its confluence with the San Joaquin River. The segment down-stream of Lake McClure has been listed as impaired under section 303(d) of the federal Clean Water Act. The California Unified Watershed

Assessment rates the Merced as a functional, but at-risk watershed. The Merced is rated 5, serious problems, low vulnerability, on the USEPA Index of Watershed Indicators.

Table 3.45: Summary of Hydrologic Areas with Mining in the Merced River Hydrologic Unit.

Area	Acres
Yosemite	121,867
North Fork Merced	160,856
Buckhorn Peak	80,379
Kassenbaum Flats	39,709
South Fork Merced	154,021
Total	556,832

This watershed may provide habitat for as many as 16 threatened or endangered plants, four threatened or endangered animals , and 12 animal species of concern, including two bats, and four invertebrates of concern.

The Merced encompasses the Northern High Sierra Nevada (SNH), Central Sierra Nevada Foothills (SNF), and San Joaquin Valley (SnJV) biological subregions, which are components of the Sierra Nevada (SN) and Great Central Valley (GCV) BioRegions, respectively, as defined in the Jepson Manual (Hickman 1992). The SnJV occurs on the western boundary of the watershed and encompasses approximately 1% of the watershed. It is characterized by grasslands with sparse oaks. The SNF occupies the western and west-central portion of Merced Watershed, encompassing approximately 28% of the watershed. It is characterized by a mix of scrub-oak manzanita chaparral and grasslands. The SNH occurs west-central through the eastern boundary of the Merced, encompassing approximately 71% of the watershed. This subregion is typically characterized by conifer forests interspersed with alpine valley grasslands and associated stands of mixed deciduous. However, in the western third of this region, extensive clear cuts have resulted in a setting more closely related to a manzanita dominated chaparral.

Located within the central portion of the Sierra Nevada Geomorphic Province, the Merced encompasses the southern termini of the Sierran Mother Lode and Copper Belts and the sculpted granites of Yosemite National Park. The geology of the Merced is dominated by the granitic highlands made famous by Yosemite National Park. Granites and related plutonic rocks occupy approximately 45% of the area of the Merced. They occur in the eastern half of the watershed. While they comprise the largest single geologic unit, only 10% of the mining activity occurred in granitic terrain. The mining that did occur was not in the granites themselves, but rather in exotic non-granitic blocks incorporated into the granitic terrain, during its formation. Metasedimentary and related rocks occupy approximately 30% of the area of the Merced. They occur primarily in the central and west-central portion of the watershed and define the southern extent of the "Mother Lode". This geologic setting was host to approximately 55% of the mining activity that occurred in the Merced.

The metasedimentary rocks that hosted the ore veins were typically Mesozoic marine sediments that have been altered to slates, phyllite, quartzite, and marbles. Of these, slates are by far the most abundant, being the host rock for over 50% of the gold-bearing quartz veins that typify the "lodes" of this region. Volcanic and related rocks occupy approximately 22% of the area of the Merced. They occur primarily in the western portion of the watershed and define the "Foothills Copper Belt". This geologic setting hosted approximately 33% of the mining that has occurred in the Merced. The rocks of this region are typified by volcanic and metamorphosed volcanic rocks (greenstones) of Mesozoic age that originated as undersea volcanic eruptions. These rocks are the dominant rocks of this region, with minor amounts of highly metamorphosed sedimentary rocks that where the temporal and spatial contemporaries of the volcanic rocks. The volcanic rocks and to a much lesser degree the interlaced metasedimentary rocks, host massive sulfide deposits (pyrites) that are the source of the rich copper ores.

3.7.1 Short History of Mining

The Merced shares much of the same history of mining as the main mother load to the north. Sporadic mining was carried out by Mexican miners until about 1848 when the massive influx of Anglo miners heralded the "gold rush" . By 1849 placer mining was occurring at a fevered pitch throughout the watershed. In addition to the classic small-scale placer operations, the Merced was experiencing large-scale hydraulic mining at sites such as Australian Gulch. As competition for placer claims grew, miners began looking for the source of the placer gold. Toward the end of 1849, several of the major lode gold ore bodies had been discovered and development was well under way .

However, unlike their neighbors to the north, this portion of the mother load did not possess extensive high-grade ore veins. Rather, lode gold deposits in this region consisted of "pocket gold". Typically, ore bodies consisted of extensive stringers of low-grade ore that would lead into a pocket of very high grade ore. Thus, the lode mines of the Merced experienced a significantly different economic reality than those working in the "heart" of the mother lode (Aubrey L. E. 1904, Castello 1921). This translated into mining operations that were difficult to capitalize and difficult to maintain profitability (i.e., operating). For example, one of the longest operating and most successful mines in the region, the Mountain King, when faced with diminishing availability of fuel resources for steam-power, chose to invest its limited capital reserves in conversion to electric power with the construction of a hydro-electric diversion on the Merced River, rather than upgrade their milling operations (Castello 1921). The Mountain King was still using mercury amalgamation when it closed in the early 1930's, long after the more efficient cyanization process had become the standard for the wealthier mines in the north (William Imhoff, personal communication, review of diary of Mountain King Mine superintendent 1999).

The Merced also supported extensive copper mining. Copper mining came late to this region, getting started in early 1863. A copper boom ensued, but by 1867 the demand for copper fell dramatically and copper mining essentially halted. A small resurgence began in the northern copper belt in 1875. By 1884, a few of the larger mines such as the La Victoria had resumed limited, small-scale operations. Low-level activity continued until the on-set of World War I. The war driven demand resulted in many of the mines reopening and the larger ones working at full capacity. However, shortly after the end of World War I, the demand for copper plummeted and the mines closed. This cycle repeated itself with the onset of World War II. Large operations such as the La Victoria and the Blue Moon were reopened and operated at capacity through the war years. As with the previous cycle, by 1948 the mines had closed (Bramel, H. R. et al 1948).

In addition to gold and copper, lead, zinc, barite, jade, and iron were mined. Of these, barite was the most significant. The El Portal Barite mine was the principle source of barium in the entire Sierra Nevada Region. The development of the oil industry in the adjacent Great Valley, created a large demand for barium (barite) as a weighting agent for drilling fluids used in the oil industry (Laizure C. M. 1930). The El Portal Mine and its sister the Barite Queen flourished until their closure in the late 1940's .

At the turn of the century and into the 1920's, several iron deposits underwent developmental work and some limited mining. Of those the most notable was the Hart Iron Deposit which is located adjacent to the southern boundary of Yosemite National Park (Root L. L. 1928). While the proven reserve was sufficiently large to be of economic interest, the lack of a transportation infrastructure precluded this deposit from being mined.

In the last twenty years, the Merced has seen several flurries of activity related to the "run-up" in gold prices. The vast majority of activity was exploration and re-evaluation of known ore bodies. During the gold price run-up of the mid 1980's, the major copper mines experienced extensive drilling. For example, one can today find many thousands of feet of rock cores, in boxes, and the remnants of a complete core laboratory at the Blue Moon – American Eagle site.

3.7.2 Current Mining in the Watershed

Currently, there is one active large-scale gold mine within the Merced, operated by the Colorado Quartz-Gold Corporation. Numerous small-scale placer and lode operations are currently active within the watershed. Also, some of the larger historic mines such as the Hasloe are experiencing recreational mining by mining clubs comprised of history buffs reliving the romance of a bygone era. In addition, historic dredge tailings are being mined for aggregate.

3.7.3 Sample Study

The Merced Watershed was chosen as a "target watershed" based on stakeholder priorities. The sample design employs a stratified random approach in which the population is subdivided into relatively homogeneous groups or strata based on geology. Mine symbols shown on United States Geologic Survey (USGS) Topographic maps were used as the "population" to be sampled. All total, 50 localities were selected for evaluation. However, only 49 were visited as AMLU personnel were denied access to one site in the western portion of the watershed.

3.7.3.1 Watershed Summary and Results of Analysis and Modeling

The sampled sites were evaluated for physical and chemical hazards and then ranked by the severity of each type of hazard (Table 3.46, Table 3.47).

Table 3.46: Field Verified Chemical Hazard Rankings.

Rank	Count	Percent	Definition of Rank
0	21	43	No probability of releasing hazards into the environment
1	3	6	Very low probability of releasing hazards into environment
2	10	20	Low probability of releasing hazards into environment

Rank	Count	Percent	Definition of Rank
3	8	16	Moderate probability of releasing hazards into environment
4	6	12	High probability of releasing hazards into environment
5	1	2	Very high probability of releasing hazards into environment
Total	*49*	*99*	

Table 3.47: Field Verified Physical Hazard Rankings.

Rank	Count	Percent	Definition of Rank
0	8	16	No physical hazards
1	14	29	Very few physical hazards
2	5	10	Few physical hazards
3	10	20	Moderate amount of physical hazards
4	6	12	Large amount of physical hazards
5	6	12	Very large amount of physical hazards
Total	*16*	*99*	

3.7.3.2 Predicted Chemical Hazard Rankings

The rankings above were then used to create a statistical model which could be used to make predictions about the characteristics of all the abandoned mines found in the watershed (for a more detailed discussion of the modeling methodology, see section 2). The *chemical hazard ranking* was predicted by regression analysis with a General Linear Model that allows for a combination of categorical and quantitative data. The predictive model employed information from MAS/MILS on production status (CUR), overlain with "reclass" (from Geology GIS layer) and whether or not the site was a member of the Principle Areas of Mine Pollution (PAMP) database. The salient points of the model are summarized below.

Table 3.48: Summarized statistics for the chemical hazard GLM.

Analysis of Variance for CHEM_APR

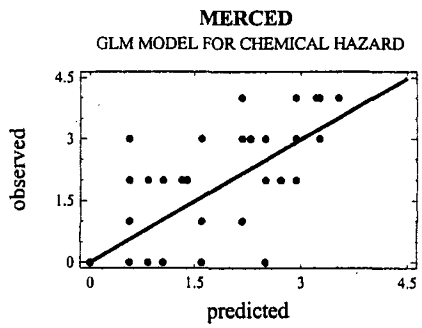
Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	58.35	8	7.29	6.68	0.0000
Residual	43.65	40	1.09		
Total (Corr.)	102.0	48			

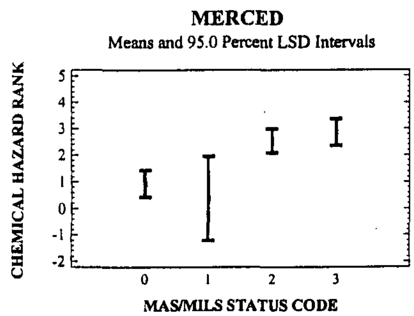
TYPE III Sums Of Squares

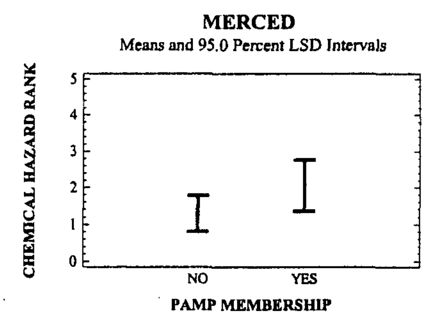
Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
PAMP	3.39	1	3.39	3.11	0.0854
CUR_CODE	24.76	3	8.25	7.56	0.0004
RECLASS	9.56	4	2.39	2.19	0.0875
Residual	43.65	40	1.09		
Total (Corr.)	102.0	48			

All F-ratios are based on the residual mean square error.
R-Squared = 57.21 percent
R-Squared (adjusted for d.f.) = 48.65 percent

The following graphs depict the tests among means for each component of the GLM regression analysis.







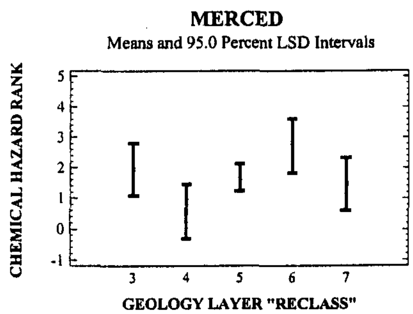


Table 3.49: Predicted chemical hazard rankings for MAS/MILS mineral occurrences.

Rank	**Count**	**Percent**	**Definition of Rank**
0	74	14	No probability of releasing hazards into the environment
1	149	27	Very low probability of releasing hazards into environment
2	264	49	Low probability of releasing hazards into environment
3	47	9	Moderate probability of releasing hazards into environment
4	4	1	High probability of releasing hazards into environment
5	0	0	Very high probability of releasing hazards into environment
Total	*538*	*100*	

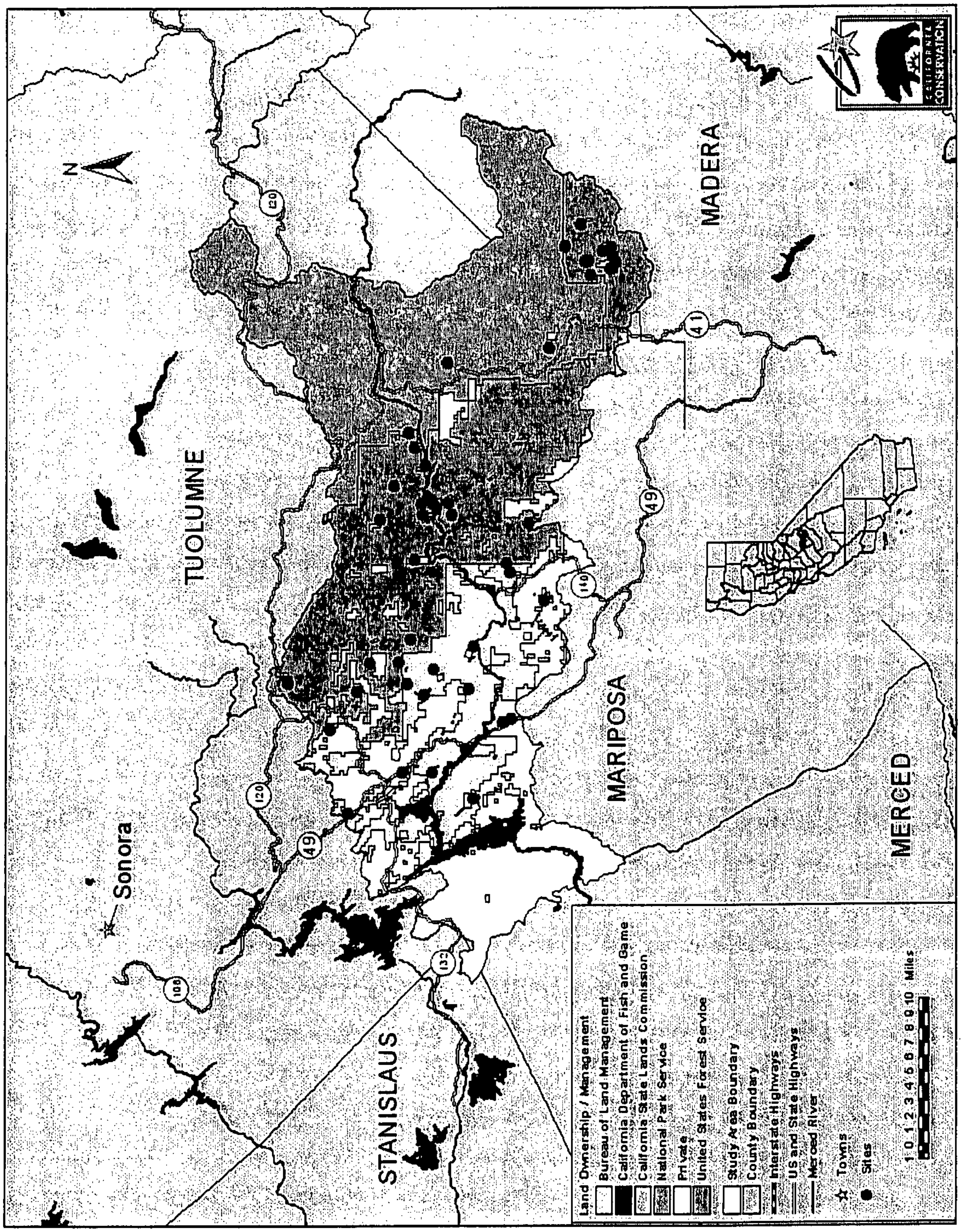


Figure 3.13: Map of MAS/MILS sites with a predicted chemical hazard ranking of 3 or above.

3.7.3.3 Predicted Physical Hazard Rankings

A reliable model for predicting *physical hazard rankings* required the use of information outside of MAS/MILS and the accessible GIS layers. In summary, either a field visit is required to consistently and accurately determine rankings, or reconciliation between the topographic symbol database and MAS/MILS is required. Therefore, we are unable to predict this score.

3.7.3.4 Predicted Hazardous Openings

Forty-three (43) topographic symbols indicative of an opening and 24 prospect symbols were shown on the topographic maps for the sampled sites. One hundred forty-four (144) openings were verified in the field for these sites, and 106 (or 74%) were found to be potentially hazardous. While it was found that we could not construct a predictive model for hazardous openings, we were able to construct a model for openings in general.

The number of openings can be predicted with an R-squared value of 62% at a $p<0.0001$ level based on the number of prospect and opening symbols shown on the topographic map, coupled with which topographic map the symbols occur on. The number of prospect and opening symbols on the USGS topographic maps are derived from digital records created by AMLU from USGS quad sheets.

The predicted number of openings for the study area is 513 (95% confidence limits are 222-819 openings). We documented 144 openings within this sample set, of which 106 were hazardous. Using this same ratio (of hazardous to total), the estimated number of hazardous openings for the study area is 378.

3.7.4 Summary of Findings

In this watershed there is a low to moderate probability for a site which presents a significant chemical hazard, and cumulatively, the AML sites in the watershed may pose a significant chemical threat to the environment. We were unable to predict *physical hazard rankings*, but the watershed as a whole has many hazardous openings (estimated to be 378).

Table 3.50: Summarized Findings for the Merced Watershed.

Watershed Area with Mining (Acres)	556,832
Predicted Cumulative Chemical Ranking Score	173,685
Predicted Cumulative Chemical Ranking Score Density	0.31
Predicted Cumulative Physical Ranking	Unable to Predict
Predicted Hazardous Openings	378

3.8 North Yuba Watershed

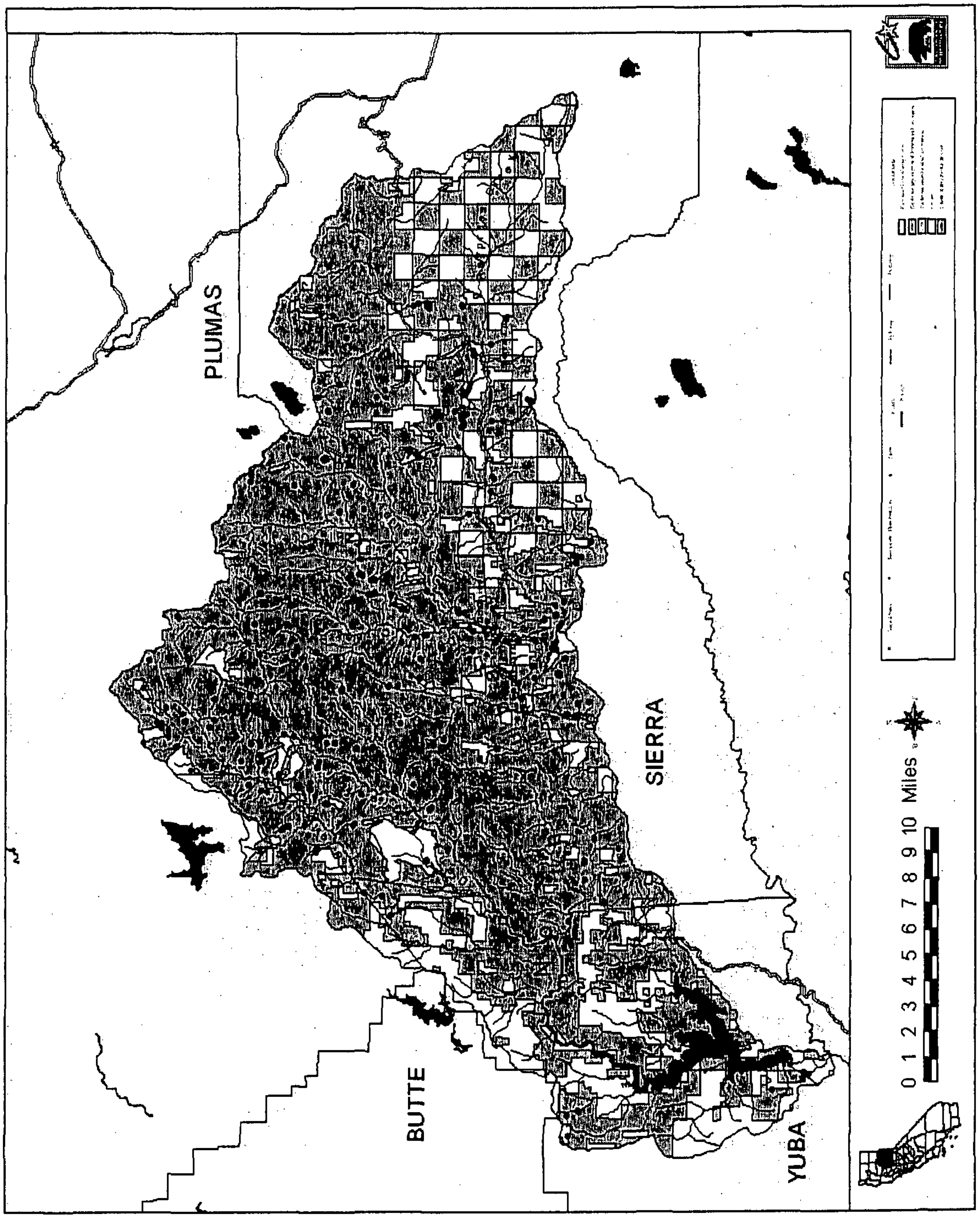


Figure 3.14 : North Yuba Watershed, Area Map.

The North Yuba Watershed is located in the Northern Sierra Nevada Mountains. This watershed is lies in parts of three counties: Yuba, Sierra, and Plumas. The

3.8 North Yuba Watershed

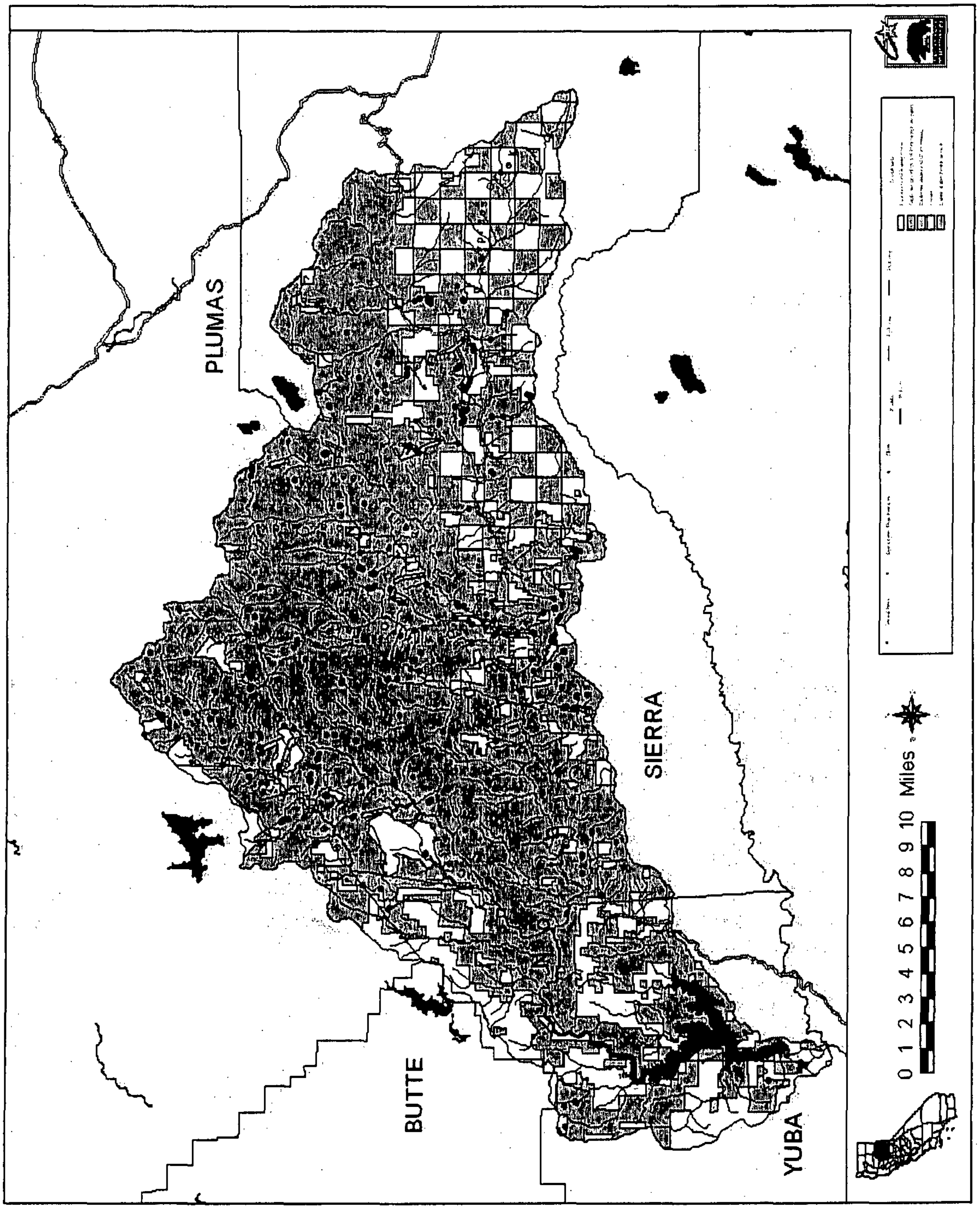


Figure 3.14 : North Yuba Watershed, Area Map.

The North Yuba Watershed is located in the Northern Sierra Nevada Mountains. This watershed is lies in parts of three counties: Yuba, Sierra, and Plumas. The size of the watershed is approximately 40 miles long and 18 miles wide with a total area of 490 square miles. The elevation ranges within this watershed ranges from a minimum of 1224 feet at New Bullards Bar dam, in the southwestern area of the watershed, to a maximum of 8107 feet at Haskell Peak in the northeastern area. The geology of the area includes Cenozoic Volcanic Rocks, Cenozoic-Precambrian Plutonic, and Mesezoic-Palezonic-Precambrian. The volcanic rocks are mostly Miocene and Pliocene lahars. This watershed lies between the towns of Nevada City to the South, Portola to the East, Quincy in the North, and Oroville to the West. This watershed is sparsely populated with less than 10,000 residents. The "Sixteen-to-One" Mine is located in this watershed and has been featured on Public Broadcasting Station (PBS) as a working tourist mine.

Table 3.51: Land Ownership Summary for the North Yuba Watershed.

Government Level	Agency	Acres	Percent
Federal	US Forest Service	241106	76.76
Federal	Bureau of Land Management	18	0.005
Sum (Federal)		241124	76.77
State	State Parks	46	0.01
State	State Lands Commission	3	0.0009
Sum (State)		49	0.016
Private	Private	72915	23.21
Sum (Private)		72915	23.21
Sum (Total)		*314088*	*100*

The climate of this watershed has cool wet winters and hot dry summers, with frequent afternoon summer thundershowers. Annual precipitation is mostly in the form of rain below 3,500 feet in elevation and ranges from 55-85 inches annually. Snow accumulates at elevations above 5,000 feet and range from 24 inches to 60 inches annually.

The topography of the area varies from west to east. That is, steep incised river channels and moderately tall mountains characterize the western region of the watershed. However, in the eastern region the watershed has steeper slopes, deeper incised river channels and higher mountains. Some of the main tributaries that make up the North Yuba River are located on the north side of the river: Canyon Creek, Slate Creek, Pauley Creek, Lavezzola Creek, Fiddle Creek and Haypress Creek.

The North Yuba watershed is contained entirely in the Northern Sierra Nevada Mountain Range Ecoregion (Hickman 1993). The plant communities are predominantly mixed-conifer series and Ponderosa Pine (at lower elevations) and white fir series (at higher elevations). Canyon Live oak series on steep canyon slopes and mixed and chaparral shrublands on steep south slopes (Miles et. al. 1997).

3.8.1 Short History of Mining

This watershed was a very important and productive gold mining region that played a central role in the California Gold Rush of 1849. One of the first parties to arrive in this region was lead by William Downie, after whom the town of

Downieville was soon named. Because of the large number of gold seekers arriving in the area, a mining district was quickly organized with fixed claims of "30 feet per man". Many rich strikes were made, and the population of the area soared to more than 5000 by 1851. In 1852, sailors began deserting their ships in San Francisco Bay to seek riches at the Forest Diggings, which later became known as the Alleghany District (Clark 1998).

Within a few years, mining districts were established throughout the watershed. All of the surface placer deposits in this watershed were mined intensively and included in-stream mining of the North Yuba River and it's tributaries. This was soon followed by extensive hydraulic operations at Howland Flat, La Porte, Poverty Hill, Port Wine, Morristown, Chip's Flat, Scales, and Minnesota. These hydraulic mines were worked intensively from the 1850's to the mid 1880's, and intermittently during the 1930's. Beginning in the 1850's, drift mining was also developed. Major drift mines in the watershed included the Bald Mountain, Live Yankee, and Ruby mines. In 1853, lode gold mining began in the watershed. The most productive lode gold districts were Allegheny, Downieville, and Sierra City. Major lode gold mines included the Sixteen-to-One, Sierra Buttes, Brush Creek, and Plumbago. Gold production in the watershed peaked in 1861, but several lode gold operations continued production of commercial quantities well into the 1960's. In 1942, War Production Board Order L-208 closed most of the mines. By the 1950's, there were only 15 lode gold mines still in operation. (DMG Vol. 52)

The North Yuba Watershed contains seven major mining districts: Port Wine, La Porte, Alleghany, Poverty Hill, Downieville, Poker Flat, and Sierra City. The most productive were the La Porte, Allegheny, Sierra City, and Poker Flat districts. The La Porte District produced more than $60 million in placer gold, mostly by hydraulic mining, from 1855 to 1871. Drift and lode gold mining remained commercially profitable and continued until 1918. The Alleghany District had an estimated production of both placer and lode gold exceeding $50 million. Drift and hydraulic operations continued until the mid 1880's, when lode mining became more prevalent. The Allegheny District remained productive following WW II, and commercially successful lode mining continued until the 1960's at the Sixteen-to-One and Brush Creek mines. The Sierra City District was extremely productive from 1870 to 1914. Estimates of gold output in this district total more than $30 million. The Sierra Buttes Mine was reported to have produced over $17 million in gold alone. The Poker Flat District was heavily mined by hydraulic operations until the 1880's. Howland Flat, one of the largest hydraulic mines in the watershed is estimated to have produced $14 million. The Downieville District is famous, not only for being the first mining district established in this watershed, but for the sheer volume and size of gold nuggets recovered from the placer deposits during the early months of the "Gold Rush". The Port Wine and Poverty Hill districts were characterized mainly by extensive hydraulic and drift mining. From the 1850's to the 1960's, the mines of the North Yuba Watershed produced over $155 million in gold, making this one of the most productive watersheds in California for lode and placer gold production. (Clark 1998)

3.8.2 Current Mining

Only three mines remain active in the watershed today. One mine is a sand and gravel operation, and another produces decomposed granite. The third is the illustrious Sixteen-to-One Mine in the Alleghany District, which is still actively producing lode gold. After closing in 1965, the mine was re-opened in the late 1980's and has been active ever since. In addition to gold production, it is also a tourist mine offering underground tours.

3.8.3 Sample Study

The North Yuba Watershed was chosen at random from a larger data set of bioregions. Topographic mining symbols were digitized from the thirteen USGS 7.5-minute topographic maps that encompass the watershed. Then the watershed was stratified by the four rocktypes that make up this area. These rocktypes types were: Cenozoic Sedimentary Rocks, Cenozoic Volcanic Rocks, Cenozoic-Precambrian Plutonic Metavolcanic and Mixed Rocks, and Cenozoic-Precambrian Plutonic Metavolcanic, and Mixed Rocks. Ten topographic mine symbols were randomly select by rocktype in addition to five Principal Areas of Mine Pollution (PAMP). This makes the total population of samples to be thirty mine sites. Due to poor location, denied access and time constraints we obtained thirty samples but the distributions among rocktypes vary. For more details on sampling techniques refer to the Methods section of this document.

3.8.3.1 Watershed Summary: Results of Analysis and Modeling

The sampled sites were evaluated for physical and chemical hazards and then ranked by the severity of each type of hazard.

Table 3.52: Field verified Chemical Hazard Rankings.

Rank	Count	Percent	Definition of Rank
0	11	37	No probability of releasing hazards into the environment
1	2	7	Very low probability of releasing hazards into the environment
2	14	47	Low probability of releasing hazards into the environment
3	2	7	Moderate probability of releasing hazards into the environment
4	1	3	High probability of releasing hazards into the environment
Total	*30*	*101*	

Table 3.53: Field verified Physical Hazard Rankings.

Rank	Count	Percent	Definition of Rank
0	4	13	No physical hazards
1	7	23	Very few physical hazards
2	11	37	Few physical hazards
3	6	20	Moderate amount of physical hazards
4	1	3	Large amount of physical hazards
5	1	3	Very large amount of physical hazards
Total	*30*	*99*	

3.8.3.2 Predicted Chemical Hazard Rankings

These rankings were then employed in a statistical model which was used to make predictions about the characteristics of all the abandoned mines found in the watershed (for a more detailed discussion of the modeling methodology, see section 2). The *chemical ranking* was predicted by regression analysis with a General Linear Model that allows for a combination of categorical and quantitative data. The predictive model utilized the field verified *chemical hazard rankings* and the results of the model (r-squared 50%, p=0.0075) are applied to the MAS/MILS database for the watershed using the potential for native mercury (derived from the MRDS database) and the "Reclass" geology (derived from the 750K surface geology). The results of the regression model for *chemical hazards* and its' components are displayed below.

Table 3.54: Summarized Statistics for the GLM Model of Chemical Hazards.

Analysis of Variance for Chemical Hazard

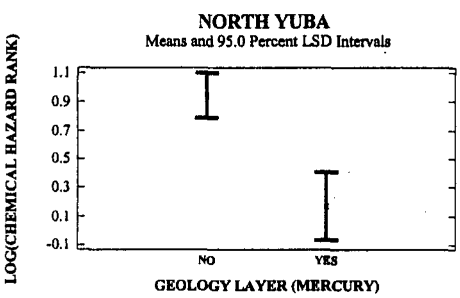
Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	1.27757	6	0.212929	5.19	0.0075
Residual	0.491861	120	.0409884		
Total (Corr.)	1.76943	18			

Type III Sums of Squares

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Hg	0.49954	1	0.49954	12.19	0.0045
RECLASS#	1.15846	5	0.231692	5.65	0.0066
Residual	0.491861	12	0.0409884		
Total (corrected)	1.76943	18			

All F-ratios are based on the residual mean square error.
R-Squared = 72.2023 percent
R-Squared (adjusted for d.f.) = 58.3035 percent

The following graphs depict the tests among means for each component of the GLM regression analysis.



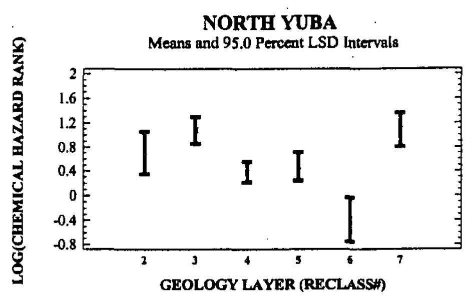


Table 3.55: Predicted Chemical Hazard Rankings Numbers for MAS/MILS Records in the North Yuba Watershed.

Rank	Count	Percent	Definition of Rank
1	76	13	very low probability of releasing hazards into the environment
2	490	83	low probability of releasing hazards into the environment
3	22	4	moderate probability of releasing hazards into the environment
Total	588	100	

The results indicate that this watershed has a low to moderate probability for a site, which presents a significant chemical hazard. The cumulative Chemical Hazard Ranking Score for the 314,088 acre watershed is 250,824, indicating that AML sites in the watershed pose a moderately significant chemical threat to the environment.

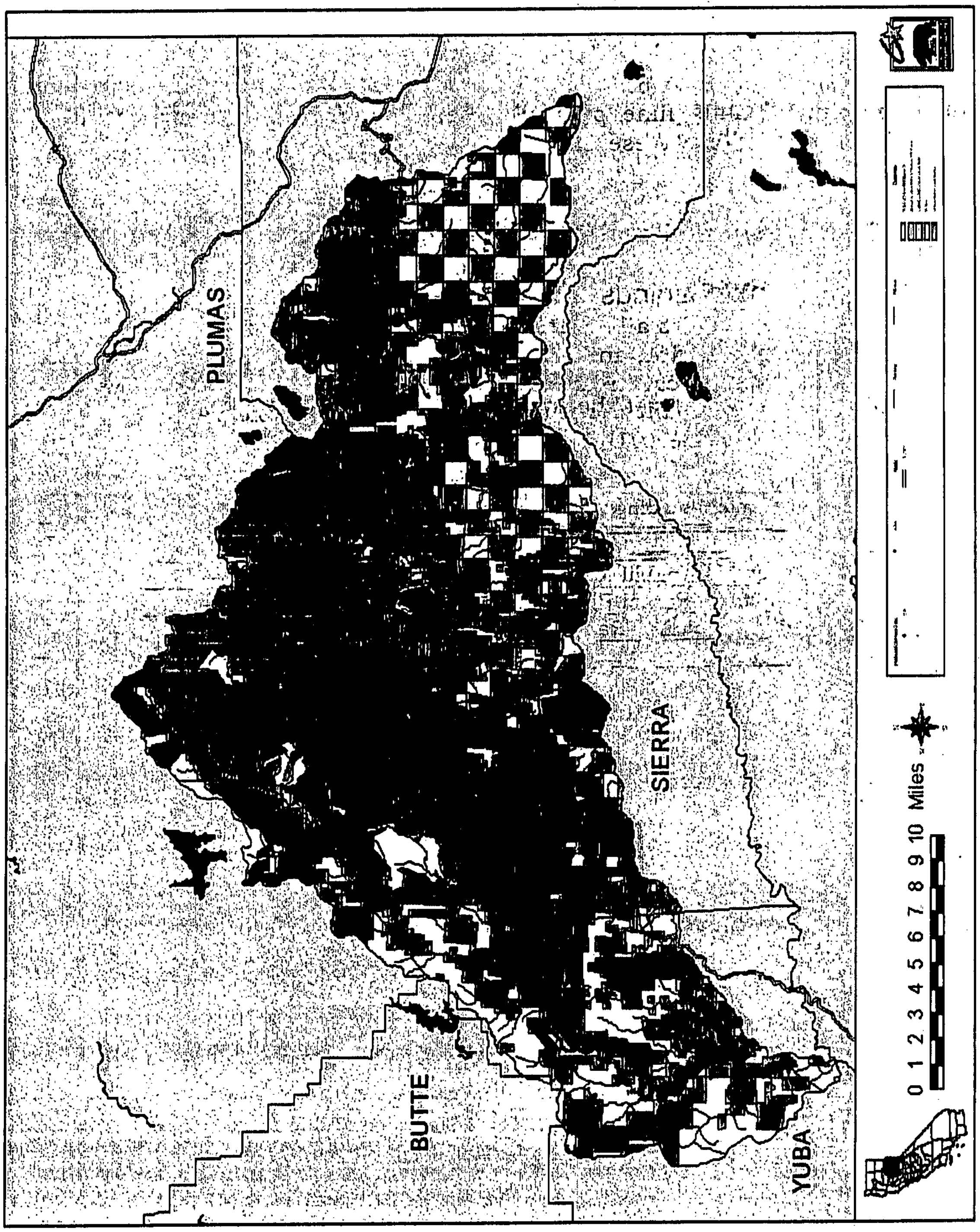


Figure 3.15: Predicted MAS/MILS sites with a Rank 3 or Greater *Chemical Hazard*.

3.8.3.3 Predicted Physical Hazard

Unable to predicted physical hazard because of the low R-squared value.

3.8.3.4 Predicted Hazardous Openings

Fifteen symbols indicative of an opening where shown on the topographic maps for the sampled sites and nine prospects were shown. Thirty-four openings were verified in the field for these sites, and twenty-four (or 71%) were found to be potentially hazardous.

The number of hazardous openings can be predicted with an R-squared value 40% at a p<0.0054. The predicted number of hazardous openings is 101.

3.8.4 Summary of Findings

In this watershed, there is a low to moderate probability for a site which presents a significant chemical hazard, and cumulatively, the AML sites in the watershed may pose a significant chemical threat to the environment. We were unable to predict the *physical hazard rankings*, but the watershed as a whole has many hazardous openings (estimated to be 101).

Table 3.56: Summarized Findings for the North Yuba Watershed.

Total Watershed Area (Acres)	314,088
Predicted Cumulative Chemical Ranking Sore	250,824
Predicted Cumulative Chemical Ranking Score Density	0.7986
Predicted Cumulative Physical Ranking	Unable to Predict
Predicted Hazardous Openings	101

3.9 Point Buchon Watershed

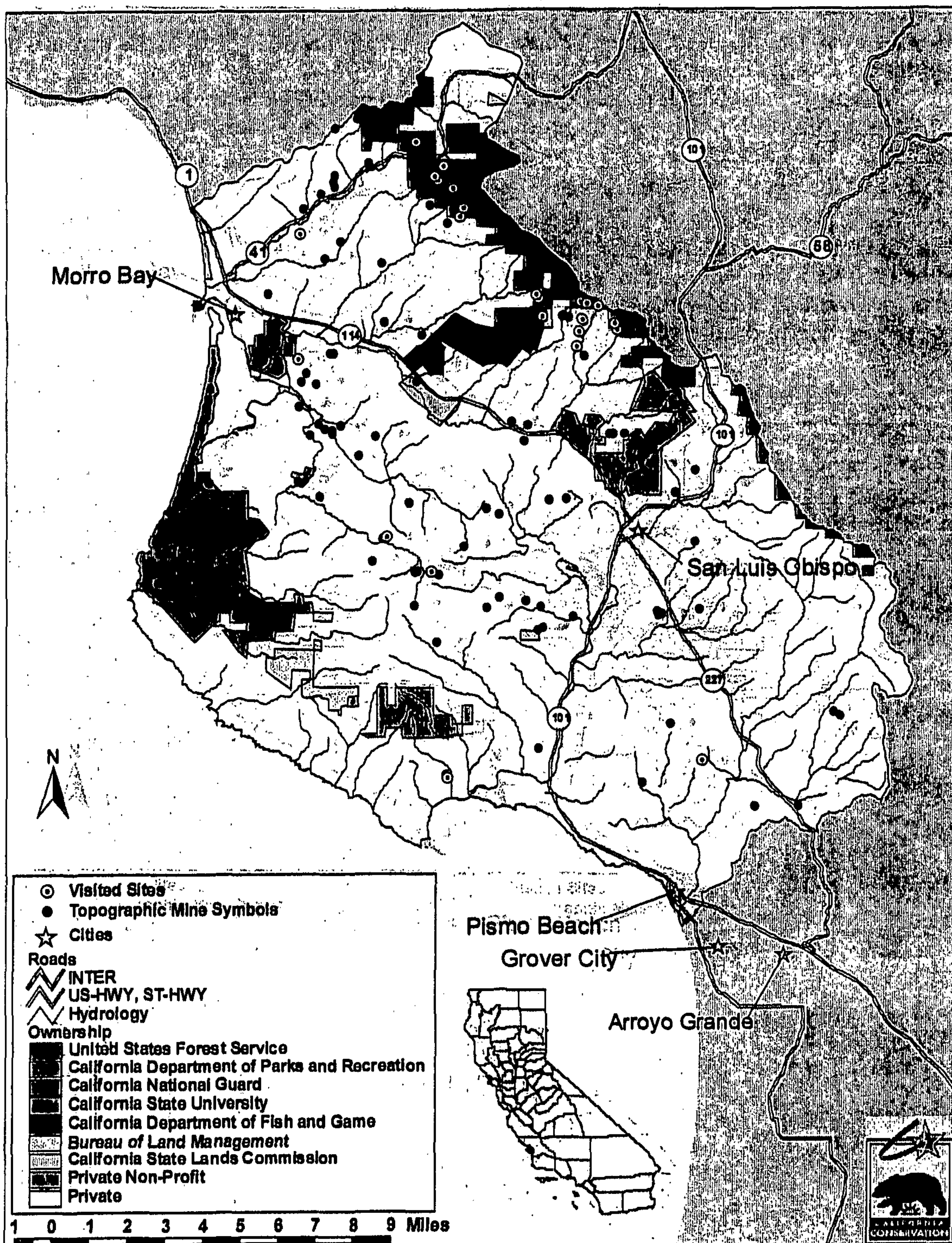
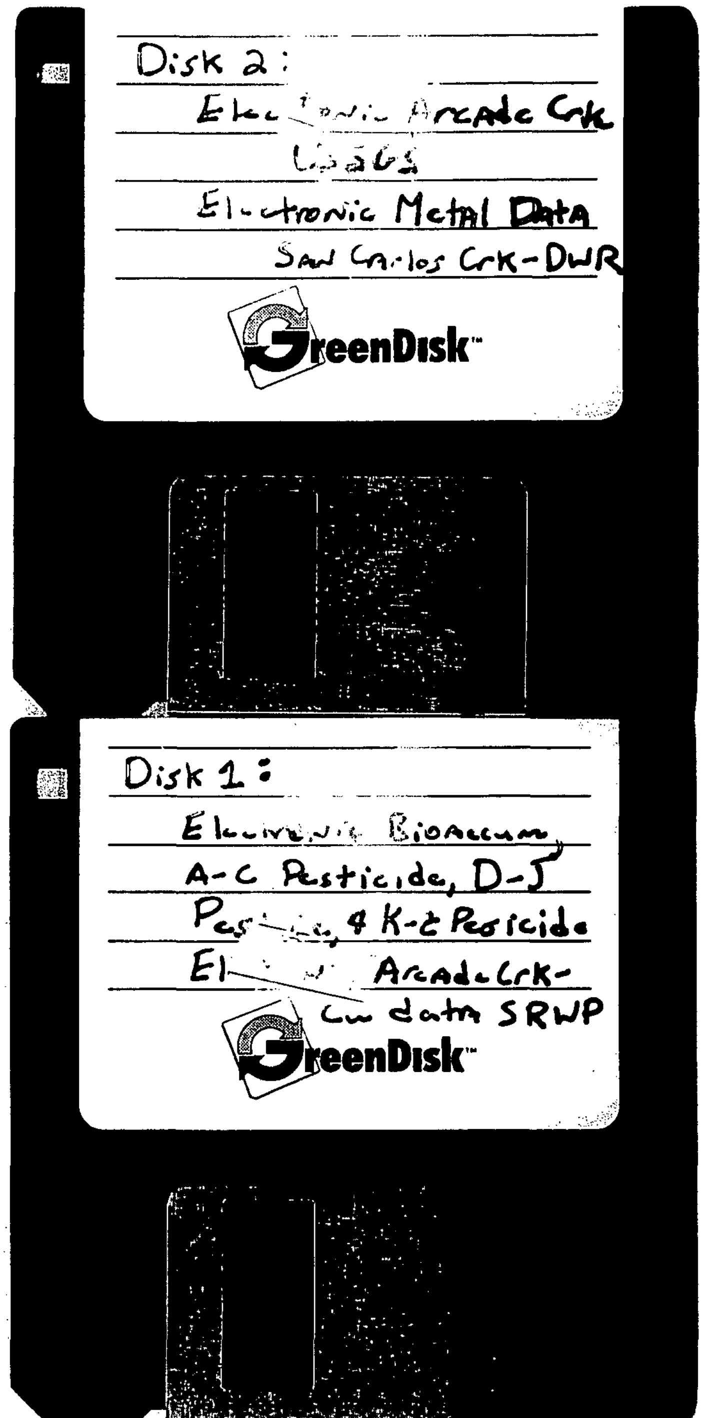


Figure 3.16: Point Buchon Watershed, Area Map.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Arcade Crk
USGS
Electronic Metal Data
San Carlos Crk - DWR
GreenDisk
Disk 1:
Bioaccum
A-C Pesticide, D-J
K-Z Pesticide
Arcade Crk-
data SRWP
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