Attachment 4

Site Evaluation and Compliance at Keswick Dam

Site Evaluation and Compliance at Keswick Dam Iron Mountain Mine Five-Year Review

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1.0 Introduction

This technical memorandum evaluates the effectiveness of remedial actions in reducing copper and zinc discharges from the Iron Mountain Mine (IMM) site during the period from August 2003 through January 2008. Effectiveness is evaluated on the basis of the observed copper and zinc load removed from the contaminant discharges at the IMM site and the reduction in the copper and zinc discharges from Spring Creek Debris Dam (SCDD), located downstream from the IMM site. This memorandum also evaluates copper loads originating from other mines in the West Shasta Mining District.

2.0 Background

Iron Mountain is located approximately 9 miles northwest of Redding, California. The mountain is bordered to the south/southwest by Slickrock Creek and to the north/northwest by Boulder Creek, as shown on Figure 1 (all figures are located at the end of this technical memorandum). Acid mine drainage (AMD) from abandoned mine workings, waste piles, and other area sources discharges and contaminates Boulder and Slickrock Creeks. These creeks flow into Spring Creek, which subsequently flows into Spring Creek Reservoir, Keswick Reservoir, and Sacramento River.

The Bureau of Reclamation (Reclamation) constructed SCDD in the early 1960s to meter the contaminated discharge from Spring Creek into Keswick Reservoir and Sacramento River. Reclamation monitors the daily flow from SCDD and routinely performs analytical testing on the discharge waters to determine the metal concentrations of copper and zinc.

3.0 Iron Mountain Mine

Surface water from IMM is transported via Spring Creek through Spring Creek Reservoir (the impoundment created by SCDD) and into Sacramento River at Keswick Reservoir. The metal load in Lower Spring Creek, downstream from SCDD, represents the metal load

contribution from IMM to Sacramento River and is composed of effluent from the IMM treatment plant and area sources of AMD in the Boulder Creek watershed.

3.1 Records of Decision

The U.S. Environmental Protection Agency (EPA) has selected and implemented several major remedial actions at the IMM site. EPA initiated a remedial investigation for the IMM site in September 1983. Since that time, the area has been intensively studied. Five Records of Decision (ROD) have been signed, and all projects authorized under the first four RODs for remediation of AMD at IMM have been completed.

ROD 1 (EPA, 1986) provided for diversion of Slickrock Creek around contaminant-bearing landslide debris, the diversion of Upper Spring Creek to the Flat Creek drainage, and a partial cap on Brick Flat Pit and seven subsidence areas. ROD 2 (EPA, 1992) and ROD 3 (EPA, 1993) provided for the treatment of AMD by using a high-density sludge (HDS) treatment process and onsite disposal of treatment residuals in Brick Flat Pit.

ROD 4 (EPA, 1997) provided for treatment of AMD discharges from IMM sources in the Slickrock Creek watershed. ROD 4 provided for the design and construction of a 220-acre-foot retention reservoir (Slickrock Creek Retention Reservoir [SCRR]) to collect AMD from IMM for treatment. ROD 4 also provided for diversion facilities for clean surface water, erosion control for arsenic-laden tailings, an additional AMD conveyance pipeline, and a tunnel for the gravity discharge of treated effluent to Spring Creek. These measures treat essentially all AMD discharges from Slickrock Creek, comprising 60 to 70 percent of the remaining uncontrolled copper and 40 to 50 percent of uncontrolled zinc and cadmium. Implementation of ROD 4 and other remedial source-control actions reduced contaminant discharges from SCDD by more than 95 percent.

ROD 5 (EPA, 2004) provided for a remedy that will prevent the migration and deposition of contaminated sediment from Spring Creek Arm of Keswick Reservoir (Spring Creek Arm) to Sacramento River and reduce metal loads and suspended solids associated with the contaminated sediment. The final remedial design for ROD 5 was submitted to EPA in September 2007 (CH2M HILL, 2007a and 2007b).

3.2 Treatment Plant Operations

In response to ROD 2 and ROD 3, the Responsible Party constructed an aerated simple mix plant at Minnesota Flats in 1993 and 1994. Because of the excessive sludge volumes and poor handling characteristics of the aerated simple mix sludge, EPA constructed the high-density sludge Minnesota Flats Treatment Plant (MFTP), with startup in January 1997. Since operations began in September 1994, MFTP has continued round-the-clock operations through the fourth five-year review period. Except for short down-time periods during heavy storm events or periods of planned maintenance during the dry season, the plant has run continuously 24 hours per day, 7 days per week. The site operator, Iron Mountain Operations (IMO), reports daily inflow and metal concentrations that are used to compute the total copper and zinc loads collected for treatment. Comparison of influent and effluent data collected since 2004 shows that the treatment process, on average, is 99.7 percent effective in removing dissolved metals from AMD.

Table 1 lists the copper and zinc loads collected from AMD at MFTP for Water Years 2004 through 2008. During this period, EPA's remedial action at the IMM site prevented the discharge of approximately 600,000 pounds of copper and 2 million pounds of zinc by treating approximately 1.5 billion gallons of AMD.

TABLE 1
AMD, and Copper and Zinc Load Inflow to MFTP
Site Evaluation and Compliance at Keswick Dam, Iron Mountain Mine Five-Year Review

Water Year	AMD Inflow to MFTP (gallons)	Copper Inflow to MFTP (lb)	Zinc Inflow to MFTP (lb)
2004	214,020,000	158,000	528,000
2005	426,470,000	150,000	532,000
2006	586,810,000	222,000	661,000
2007	157,240,000	52,000	188,000
2008	68,450,000	13,000	56,000
Total	**1,452,990,000**	**595,000**	**1,965,000**

Note:
Water Year 2008 includes data from October 1, 2007, through January 31, 2008.

3.3 Spring Creek Debris Dam Discharges

Contaminants from Boulder Creek and treated effluent from MFTP discharge through SCDD into Keswick Reservoir, as depicted on Figure 1. As reported in the second five-year review memorandum *Site Evaluation and Compliance at Keswick Dam, Iron Mountain Mine Five-Year Review* (CH2M HILL, 2003), the State of California Regional Water Quality Control Board (Water Board), EPA, and Reclamation have routinely collected samples at SCDD to monitor pH, total copper, total zinc, and total cadmium in the reservoir discharge.

During the period 1983 through 1994, the pH of the water retained in Spring Creek Reservoir typically ranged from 2 to 3, with an average of 2.8 computed for the 264 samples collected. During the period from November 1996 through May 1998, the pH of the water ranged from 3.75 to 5.2, with an average of 4.5 computed for the 46 samples collected. From September 1999 through July 2003, the pH of SCDD discharge ranged from 3.00 to 5.45 with an average of 4.2 computed for the 356 samples collected. (CH2M HILL, 2003)

From August 2003 through January 2008, the pH of SCDD discharge ranged from 2.97 to 7.07 with an average of 4.71 for the 321 samples collected by Reclamation and EPA. A plot of the SCDD discharge pH from October 1998 through January 2008 is provided on Figure 2.

Reclamation computes the average daily discharge from SCDD by using SCDD outlet gate settings. Flows measured using the outlet gate discharge curves have been favorably compared to flows estimated using the standard broad-crested weir located just downstream of the outlet gates. Reclamation's Northern California Area Office samples SCDD discharges weekly, and more often during high-flow conditions or when the reservoir is within 75 percent of capacity. The historical metal concentrations fluctuate as a function of reservoir inflow and treatment at the IMM site.

For the metal load calculations presented in this memorandum, a linear variation between the actual reported values of daily copper and zinc concentrations was assumed.

Average daily copper and zinc discharge loads from SCDD were calculated using the computed daily concentrations and Reclamation average daily discharges for Water Year 1970 through January of Water Year 2008. The annual and cumulative copper and zinc discharges for the period are presented on Figures 3 and 4, respectively. Appendix Tables A-1, A-2, and A-3 list the datasets illustrated on Figures 3 and 4. Since 1970, approximately 5.13 million pounds of copper and 22.7 million pounds of zinc were discharged from SCDD into Keswick Reservoir and Sacramento River.

Table 2 lists the copper and zinc loads (in pounds) discharged from SCDD for Water Years 2004 through 2008. For this period, approximately 27,400 pounds of copper and 73,200 pounds of zinc were discharged from SCDD into Keswick Reservoir and Sacramento River.

TABLE 2
Copper and Zinc Discharge from Spring Creek Debris Dam
Site Evaluation and Compliance at Keswick Dam, Iron Mountain Mine Five-Year Review

Water Year	SCDD Discharge (acre-ft)	Annual Copper Discharge (lb)	Annual Zinc Discharge (lb)
2004	37,200	14,500	27,900
2005	25,600	4,000	15,200
2006	28,000	5,800	21,000
2007	3,600	1,800	5,500
2008	2,400	1,300	3,600
Total	**96,800**	**27,400**	**73,200**

Note:
Water Year 2008 includes data from October 1, 2007, through January 31, 2008.

3.4 Total Copper and Zinc Load Percent Reduction

Table 3 lists the combined copper and zinc loads for the IMM site for Water Years 2004 through 2008. The combined loads include IMM contaminant flows, collected and treated at MFTP, and SCDD discharge loads. For the fourth five-year review period, the combined loads for IMM were approximately 620,000 pounds of copper and 2 million pounds of zinc.

For the fourth five-year review period, collection and treatment of portal discharges have resulted in an average reduction in copper and zinc discharges of 96 percent. For the complete water years (2005 through 2007) since SCRR came online, reductions in copper and zinc discharges were 97 percent. The percent reduction is calculated as the load removed by treatment divided by the total load. The total load is calculated as the load discharged from SCDD and the load removed by treatment.

For Water Year 2008, the percent reductions are possibly lower than Water Years 2005, 2006, and 2007, because of first-flush events that occur early in the water year. Data for Water Year 2008 extend from October 1, 2007, through January 31, 2008. The percent reduction is expected to generally increase as the water year progresses. For Water Year 2004, the percent reduction is lower because SCRR did not come fully online until late in the water year (May).

These calculated values do not take into account the reduction in copper and zinc contaminant loads as a result of other remedial actions at the IMM site, including the construction of the Slickrock Creek clean water diversion, capping of Brick Flat Pit and subsidence areas, and removal of sulfide tailings and waste piles in Boulder Creek.

TABLE 3
MFTP and SCDD Combined Copper and Zinc Loads
Site Evaluation and Compliance at Keswick Dam, Iron Mountain Mine Five-Year Review

Water Year	SCDD Discharge (acre-ft)	MFTP and SCDD Combined Copper Load (lb)	MFTP and SCDD Combined Zinc Load (lb)	Copper Discharge Reduction (%)	Zinc Discharge Reduction (%)
2004	37,200	172,300	556,000	92	95
2005	25,600	153,500	546,700	97	97
2006	28,000	227,700	681,900	98	97
2007	3,600	53,600	193,800	97	97
2008	2,400	14,400	59,600	91	94
Total	**96,800**	**621,500**	**2,038,000**	**96**	**96**

Note:
Water Year 2008 includes data from October 1, 2007, through January 31, 2008.

3.5 Slickrock Creek Retention Reservoir

Completion of SCRR and associated facilities, in combination with completed remedial actions to control the sources of AMD, was expected to result in a total reduction of contaminants discharged from SCDD to 5 percent of the pre-1994 discharge.

For Water Years 2005 through 2007, the actual copper and zinc discharge from SCDD was approximately 2 percent of pre-1994 discharge. The annual average copper and zinc loads for Water Years 2005 through 2007 were divided by the average loads for Water Years 1970 through 1994. Annual loads are reported in Appendix Table A-2.

4.0 Water Quality Compliance at Keswick Reservoir

During the fourth five-year review period, Reclamation conducted routine discharge sampling at locations downstream of SCDD (LSC), Shasta Dam (SRS), and Keswick Dam (SRK2). The sampling locations are shown on Figure 1. Sampling and testing was typically conducted weekly during normal dam operations.

The purpose of the sampling was to assist Reclamation in regulating discharges from SCDD to meet water quality objectives for Sacramento River downstream of Keswick Dam. During the fourth five-year review period (August 2003 through January 2008), Reclamation collected approximately 263 water quality samples at LSC, 241 water quality samples at SRS, and 243 water quality samples at SRK2.

4.1 Water Quality Objectives in Sacramento River Below Keswick Dam

Two sets of water quality objectives establish criteria for protection of aquatic life in the upper Sacramento River and were identified as chemical-specific applicable or relevant and appropriate requirements in ROD 5 (EPA, 2004). These objectives are described in the *Water*

Quality Control Plan for the Sacramento River and San Joaquin River Basins (Basin Plan) (Water Board, 1998) and the California Toxics Rule (CTR) (provided in Water Board, 2003a). The Basin Plan establishes maximum concentration criteria and the CTR establishes 4-day continuous concentration criteria. In addition, the Water Board has developed a total maximum daily load (TMDL) program for dissolved cadmium, copper, and zinc in the upper Sacramento River because concentrations exceeded water quality standards (Water Board, 2002).

The specific criteria identified for total and dissolved copper include the following:

- The Basin Plan establishes the maximum dissolved copper concentration for the upper Sacramento River as 5.6 µg/L.
- The CTR sets objectives for dissolved and total copper concentrations by using an assumed water hardness (as calcium carbonate) of 40 mg/L. The CTR establishes 4.1 µg/L as the 4-day average continuous concentration and 5.7 µg/L as the 1-hour-average maximum concentration for dissolved copper. The CTR establishes 4.3 µg/L as the 4-day average continuous concentration and 5.9 µg/L as the 1-hour-average maximum concentration for total copper.
- The upper Sacramento River TMDL report (Water Board, 2002) states that Water Board staff will develop additional mine remediation and other activities as needed to address dissolved copper concentrations in Shasta Dam releases that exceed 1.3 µg/L. This goal is in response to expected reductions in copper concentrations from remedial actions implemented at IMM.

Table 4 shows the water quality objectives for dissolved and total copper and the number of samples that exceeded the limits of the approximately 243 samples collected by Reclamation from August 2003 to January 2008.

TABLE 4
Total and Dissolved Copper Compliance at Keswick Dam
Site Evaluation and Compliance at Keswick Dam, Iron Mountain Mine Five-Year Review

Parameter	Basin Plan Maximum Limit (µg/L)	Number of Exceedances	CTR 4-Day Average (µg/L)	Number of Exceedances (Percent Exceedance)	CTR 1-Hour Average (µg/L)	Number of Exceedances
Dissolved Copper	5.6	0	4.1	4 (2 %)	5.7	0
Total Copper	N/A	N/A	4.3	7 (3%)	5.9	0

Notes:
N/A = Not applicable; the Basin Plan does not define limits for total copper.

4.2 Dissolved Copper Discharged from Shasta Lake

During the period from August 2003 through January 2008, Reclamation conducted sampling and testing on 241 days at SRS (see Figure 1). The reported total and dissolved copper concentrations are shown on Figure 5. The reported dissolved copper concentration exceeded 1.3 µg/L on 128 of the 241 days reported (53 percent).

West Squaw Creek and Little Backbone Creek are the primary sources of elevated dissolved and total copper concentrations discharged from Shasta Dam as described in *Shasta Lake Copper Input Loads Data Evaluation Report* (CH2M HILL, 2008), *Metals Distribution within Shasta Lake, Shasta County California, Interim Report* (Water Board, 2003b), and the proposed Basin Plan Amendment for West Squaw Creek (Water Board, 2004b).

Mining Remedial Recovery Company, Inc. (MRRC) has implemented several remedial actions, including installation of bulkhead seals (plugs), to limit metals-laden water discharge to Shasta Lake from West Squaw Creek. These actions are described in the *Use Attainability Analysis for the Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for Beneficial Uses at West Squaw Creek, Shasta County* (UAA) (Water Board, 2004a). The UAA reports that remedial actions have resulted in an estimated percent reduction of 95 percent of pre-plug copper loads from West Squaw Creek, and an estimated current annual copper load of 16 pounds per day. There is some uncertainty regarding the effectiveness of these remedial actions and the current copper loads. Data collected for EPA in West Squaw Creek during the five-year review period suggest that the remedial actions taken by MRRC have not achieved a 95 percent load reduction, and that current copper loads in West Squaw Creek are higher than estimated in the UAA (CH2M HILL, 2008).

The Water Board adopted Resolution R5-2004-0090, which includes the UAA. The UAA was conducted to demonstrate that the current beneficial uses assigned to West Squaw Creek are not achievable (Water Board, 2004). Specifically, the UAA states that the stream cannot support fish and other pH- or metal-sensitive aquatic species or the spawning of selected fish species defined in the Basin Plan (Water Board, 1998). The Basin Plan amendments do not become effective until accepted by the State Water Board, Office of Administrative Law and EPA. The UAA proposes changing the beneficial use requirements for West Squaw Creek, and to focus future remediation efforts on the Little Backbone Creek watershed (and other watersheds).

Water quality samples and creek flow rates in West Squaw Creek and Little Backbone Creek were collected by MRRC on a quarterly basis during the five-year review period and by EPA during the 2006, 2007, and 2008 water year wet seasons. Figures 6 and 7 show comparisons of copper loads calculated by MRRC and EPA in West Squaw Creek and Little Backbone Creek. In general, MRRC samples were not collected during the periods of highest flows in the creeks. Data collected for EPA during the wet season and include periods of high precipitation and high flow.

Table 5 shows EPA flow and load data for West Squaw and Little Backbone Creeks collected from December 2006 through February 2008. Discharge data presented in Table 5 are discrete measurements obtained using a constant tracer dilution injection rate method (CGI, 2008; CH2M HILL, 2008). Figures 8 through 11 present EPA copper concentration and load data for West Squaw and Little Backbone Creeks for a similar period. Continuous discharge data were obtained using a pressure transducer and data logger to record creek stage and the discharge rating curve of stage versus tracer-dilution discharge measurements. "Grab sample" loads presented on Figures 10 and 11 were calculated using the discharge rating curve, and are considered to be less accurate than the "tracer dilution" loads calculated using discrete discharge measurements.

TABLE 5
2006-2008 EPA Copper Load Comparison for West Squaw Creek and Little Backbone Creek
Site Evaluation and Compliance at Keswick Dam, Iron Mountain Mine Five-Year Review

Date	West Squaw Creek				Little Backbone Creek			
	Flow (ft^3/sec)	Dissolved Copper (lb/day)	Total Copper (lb/day)	pH	Flow (ft^3/sec)	Dissolved Copper (lb/day)	Total Copper (lb/day)	pH
12/28/2006	53	45	85	5.67	18	40	42	3.79
01/11/2007	12	16	27	6.60	4	18	19	3.84
02/09/2007	40	16	37	7.17	15	35	36	3.29
02/22/2007	199	92	172	7.00	124	120	127	3.38
03/07/2007	47	33	66	6.82	14	20	21	4.71
03/27/2007	17	12	24	7.06	6	17	18	4.18
12/04/2007[a]	15	5	19	7.12	5	16	16	4.29
12/18/2007	283	101	213	5.70	67	105	108	4.16
1/4/2008[b]	388	251	355	6.51	N/A	N/A	N/A	N/A
1/28/2008[a]	159	180	240	6.64	53	71	74	5.04
2/1/2008	62	83	104	6.53	20	32	32	4.30
2/24/2008[a]	598	81	387	7.01	580	344	469	4.52

[a]One crew performed dilution testing at both creeks sequentially, beginning with West Squaw Creek. The length of the West Squaw Creek test was consistent with other events. The length of the Little Backbone Creek test was shortened to account for daylight limitations.

[b]High winds prevented sampling at LBC.

Notes:

N/A = not available

Source: CGI, 2008

Figures 8 and 9 present total and dissolved copper concentrations in West Squaw Creek and Little Backbone Creek, respectively. EPA dissolved copper concentration data collected in West Squaw Creek in 2007-2008 are elevated compared to 2003 and projected 2004 copper concentrations reported in the UAA (Water Board, 2004a). Figures 8 and 9 demonstrate that the ratio of dissolved to total copper in West Squaw Creek averaged approximately 0.5, due to the higher pH in this creek compared to Little Backbone Creek, which had a dissolved to total copper ratio of approximately 1.0. On September 28, 2007, and January 11, 2007, the pH in West Squaw Creek was lower (5.37 and 5.5 respectively), and the ratio of dissolved to total copper approached 1.0.

Both West Squaw Creek and Little Backbone Creek copper concentrations generally exhibited a seasonal trend, with higher copper concentrations in the dry season and during low flow conditions, and lower copper concentrations during periods of higher flow. The highest copper concentrations in West Squaw Creek were detected during the dry season, on September 28, 2007, and following a large storm event, on January 11, 2008. Grab sampling on January 11, 2008, was performed following 6 inches of rain at Shasta Dam between January 4th and 7th. The West Squaw Creek dissolved copper concentration was 520 µg/L, discharge was 66 cfs (obtained from stage versus discharge correlation), and dissolved copper load was calculated as 186 lb/day on January 11, 2008. The high copper concentration and load indicates the response of metal load sources to the high rainfall and flushing conditions.

Figure 10 compares West Squaw Creek and Little Backbone Creek dissolved copper loads; Figure 11 compares total copper loads. EPA 2007-2008 wet season data include dissolved copper loads up to 250 lb/day and total copper loads close to 400 lb/day from West Squaw Creek during large flushing conditions. Figures 10 and 11 demonstrate that West Squaw Creek and Little Backbone Creek are currently contributing similar copper loads.

4.3 Dissolved Copper Concentrations at Keswick Dam

During the period from August 2003 through January 2008, Reclamation conducted sampling and testing on 243 days at SRK2 (see Figure 1). The reported dissolved copper concentrations measured at SRK2 and at SRS are shown on Figure 12. The dissolved copper concentration did not exceed the Basin Plan limit of 5.6 µg/L on any of the 243 days during which samples were collected. The dissolved copper concentrations at SRK2 exceeded the CTR of 4.1 µg/L on only 4 of the 243 reported days (only 2 percent). For comparison, during the third five-year review period, the 5.6 µg/L dissolved copper standard was exceeded 15 days out of 246 days when samples were collected, and the CTR chronic exposure limit of 4.1 µg/L was exceeded more than 72 days (EPA, 2003).

Figure 13 shows total copper concentrations measured by Reclamation at LSC from October 1998 through January 2008. After SCRR began operating, the total copper concentrations at LSC decreased from an average concentration of 600 µg/L between August 2003 and February 2004 to 180 µg/L between March 2004 and January 2008. Startup and shakedown testing of SCRR began in March 2004. SCRR was completed in May 2004.

Figure 14 shows dissolved copper loads calculated using copper concentration data for samples and releases from Keswick Dam and Shasta Dam between August 2003 and January 2008. The dissolved copper loads calculated at each dam are similar and are highly dependent on the release.

Figure 15 shows the total and baseline dissolved copper loads calculated for Sacramento River below Shasta Dam, and a cumulative plot of the copper load discharged from Shasta Lake that exceeds the calculated baseline for Water Year 2006. The baseline copper load is calculated as the discharge from Shasta Dam multiplied by the TMDL goal of 1.3 µg/L for dissolved copper (Water Board, 2002). The baseline represents the copper load that would discharge from Shasta Dam if the copper concentrations were within the TMDL goal of 1.3 µg/L. The cumulative copper load exceeding the baseline for each water year represents the amount of excess metal load (in pounds) that would need to be addressed to meet the TMDL goal of 1.3 µg/L.

Figure 16 shows the total copper load discharged from SCDD from October 1998 through January 2008. From August 2003 through January 2008, copper loads averaged 21 lb/day annually and 45 lb/day during winter months (December through March). Since startup of SCRR in May 2004, copper loads averaged 14 lb/day annually and 24 lb/day during winter months. Only data from Water Years 2005 and 2006 were used in this calculation because they were the first complete water years since SCRR startup. Water Year 2007 was not included in the calculation because it had below-average precipitation.

Figures 17 through 20 show cumulative plots of the dissolved copper load discharged from Shasta Lake and Keswick Reservoir that exceed the calculated baseline for Water Years 2004, 2005, 2006, and 2007, respectively. These figures also show the cumulative total copper load discharge from SCDD. For the complete water years since SCRR came online (2005, 2006, and 2007), Shasta Lake contributed 17,000 pounds of copper above the baseline value, which is greater than the total copper load from IMM (12,000 pounds).

5.0 Summary

During the entire period between August 2003 and January 2008, Sacramento River below Keswick Dam met the Basin Plan maximum dissolved copper concentration for upper Sacramento River of 5.6 µg/L. The dissolved copper concentrations exceeded the California Toxics Rule chronic exposure limit of 4.1 µg/L on only 4 days (only 2 percent of the days sampled), compared to exceedances on 29 percent of the days sampled during the third five-year review period (EPA, 2003).

The IMM interim remedy continues to rely on Reclamation water management actions to provide for the safe release of the continuing IMM contaminant discharges from the Boulder Creek watershed, which are estimated to constitute 5 percent or less of the overall historic IMM discharges of copper and zinc. The Reclamation water management actions are necessary to reduce the likelihood of uncontrolled spills and meet the water quality objectives in Sacramento River below Keswick Dam. The final ROD for the IMM site will need to consider the entire water system that impacts Sacramento River, including discharge from IMM and SCDD, and metal loads from other mines in the West Shasta Mining District that discharge to Shasta Lake.

Data from Water Years 2006 and 2007 show that the majority of copper loads to the upper Sacramento River watershed are currently coming from the inactive copper mines in the Shasta Lake watershed. Although IMM has historically contributed the majority of copper

loads to the water system, remedial actions implemented at the IMM site have reduced the magnitude of metal loads from IMM entering Sacramento River by more than 95 percent.

Table 6 shows percent reductions for copper and zinc load discharges from SCDD during the fourth five-year Review period (after startup of SCRR) as compared to the third five-year review period (before startup of SCRR). Copper loads were 70 percent lower and zinc loads were 47 percent lower during the fourth five-year review period compared to the third five-year review period. With the exception of Water Year 2006, the water years during the fourth five-year review period were at or below historical averages for precipitation (CH2M HILL, 2008), and the 2008 water year data only extends through January 31, 2008. Because of these reasons, the water discharged from SCDD was 23 percent lower during the fourth five-year period.

TABLE 6
Comparison of SCDD Load Discharges During the Third and Fourth Five-Year Review Periods
Site Evaluation and Compliance at Keswick Dam, Iron Mountain Mine Five-Year Review

Review Period	Water Years	SCDD Discharge (acre-feet)	Copper Load Discharge (lb)	Zinc Load Discharge (lb)
Third Five-Year Review	1999 – 2003	125,000	90,000	137,000
Fourth Five-Year Review	2004 – 2008	96,800	27,400	73,200
Percent Difference		23%	70%	47%

Note:
Water Year 2008 includes data from October 1, 2007, through January 31, 2008.

At the time of the fourth five-year review, the Water Board is continuing to work with MRRC to implement remedial actions at the inactive mines above Shasta Lake. During the fourth five-year review period, the water from Shasta Dam had a dissolved copper concentration of less than 1 µg/L to 3.4 µg/L. The TMDL goal was exceeded on more than 50 percent of the days recorded from August 2003 through January 2008 in the Sacramento River below Shasta Dam. The upgradient Shasta Lake water quality could negatively impact the water management component of the IMM remedy, especially during sustained periods of above average precipitation.

6.0 Works Cited

Central Valley Regional Water Quality Control Board (Water Board). 2004a. *Use Attainability Analysis for Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for Beneficial Uses at West Squaw Creek, Shasta County.* July.

Central Valley Regional Water Quality Control Board (Water Board). 2004b. *Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for Beneficial Uses at West Squaw Creek, Shasta County.* July.

Central Valley Regional Water Quality Control Board (Water Board). 2003a. *A Compilation of Water Quality Goals.* August.

Central Valley Regional Water Quality Control Board (Water Board). 2003b. *Metals Distribution within Shasta Lake, Shasta County California, Interim Report.* May.

Central Valley Regional Water Quality Control Board (Water Board). 2002. *Upper Sacramento river TMDL for Cadmium, Copper and Zinc.* April.

Central Valley Regional Water Quality Control Board (Water Board). 1998. Fourth Edition of the *Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins.* September.

CGI Technical Services, Inc. (CGI). 2008. *2007-2008 Hydrologic and Metals Loading Report, Tracer-Dilution Discharge Measurement and Metals Loading Study, Little Backbone Creek and West Squaw Creek, Shasta County, CA.* May.

CH2M HILL. 2008. Final *Shasta Lake Copper Input Loads Data Evaluation.* May.

CH2M HILL. 2007a. *Bidding Requirements and Contract Documents for the Construction of the Spring Creek Arm of Keswick Reservoir Removal Remedial Action.* Final. September.

CH2M HILL. 2007b. *Spring Creek Arm of Keswick Reservoir Sediment Removal Remedial Action, Redding, California, Part 5, Drawings.* Final. September.

CH2M HILL. 2003. *Site Evaluation and Compliance at Keswick Dam, Iron Mountain Mine Five-Year Review.* September 15.

CH2M HILL. 1998. *Site Evaluation, Iron Mountain Mine.* September 25.

U.S. Environmental Protection Agency (EPA). 2004. *Record of Decision, Iron Mountain Mine, Shasta County, California* (ROD 5). September.

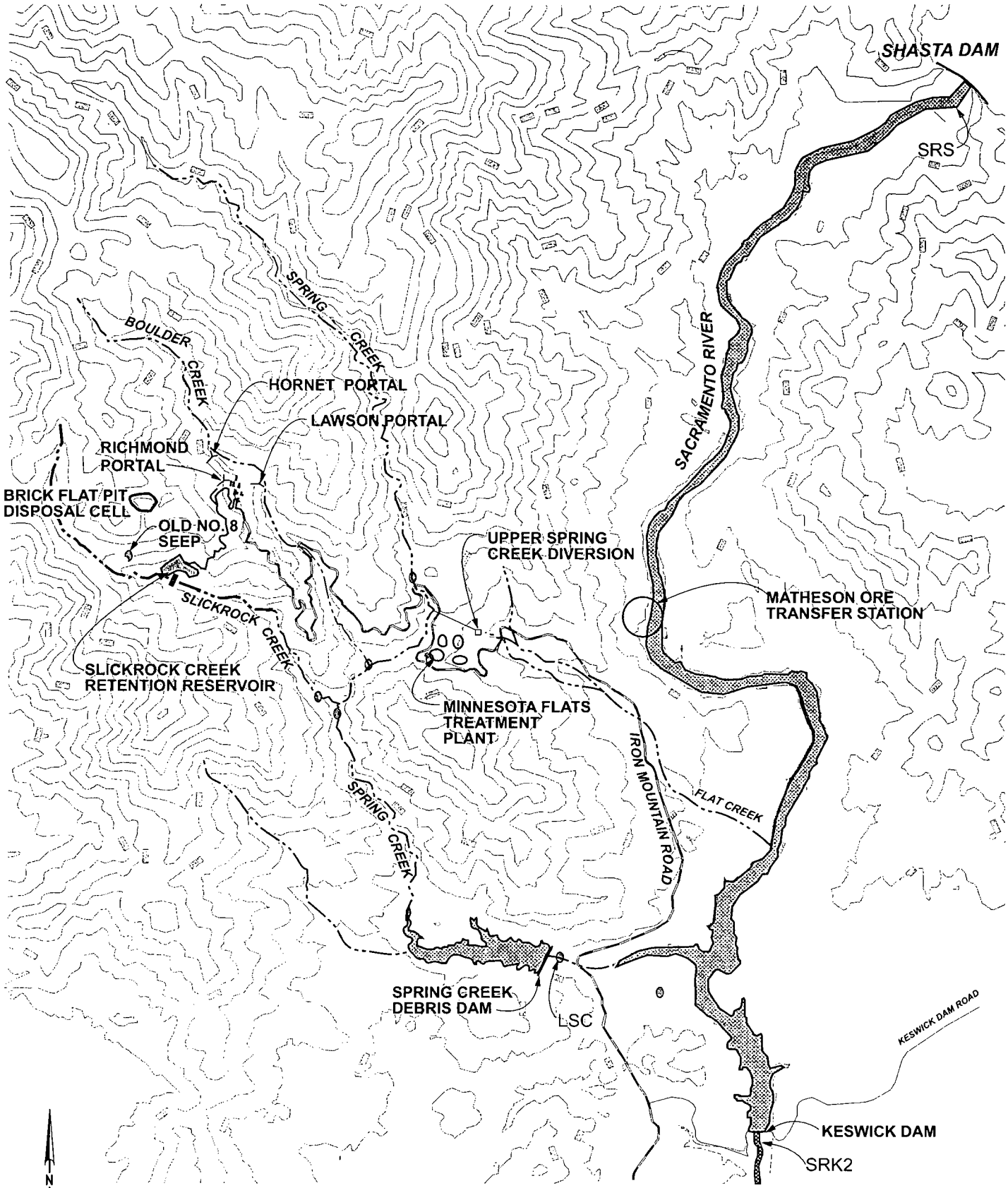
U.S. Environmental Protection Agency (EPA). 1997. *Record of Decision, Iron Mountain Mine, Shasta County, California* (ROD 4). September.

U.S. Environmental Protection Agency (EPA). 1993. Record of Decision, Old/No. 8 Seep, Iron Mountain Mine, Shasta County, California (ROD 3). September.

U.S. Environmental Protection Agency (EPA). 1992. Record of Decision, Boulder Creek Operable Unit, Iron Mountain Mine, Shasta County, California (ROD 2). September.

U.S. Environmental Protection Agency (EPA). 1986. *Record of Decision, Iron Mountain Mine, Redding, California* (ROD 1). October.

Figures



SAMPLE ID	LOCATION
LSC	SCDD DISCHARGE ABOVE WEIR
SRK2	SACRAMENTO RIVER BELOW KESWICK DAM
SRS	SACRAMENTO RIVER BELOW SHASTA DAM

FIGURE 1
LOCATION MAP
2008 FIVE-YEAR REVIEW
IRON MOUNTAIN MINE

ES022008008RDD_01 (4/23/08)

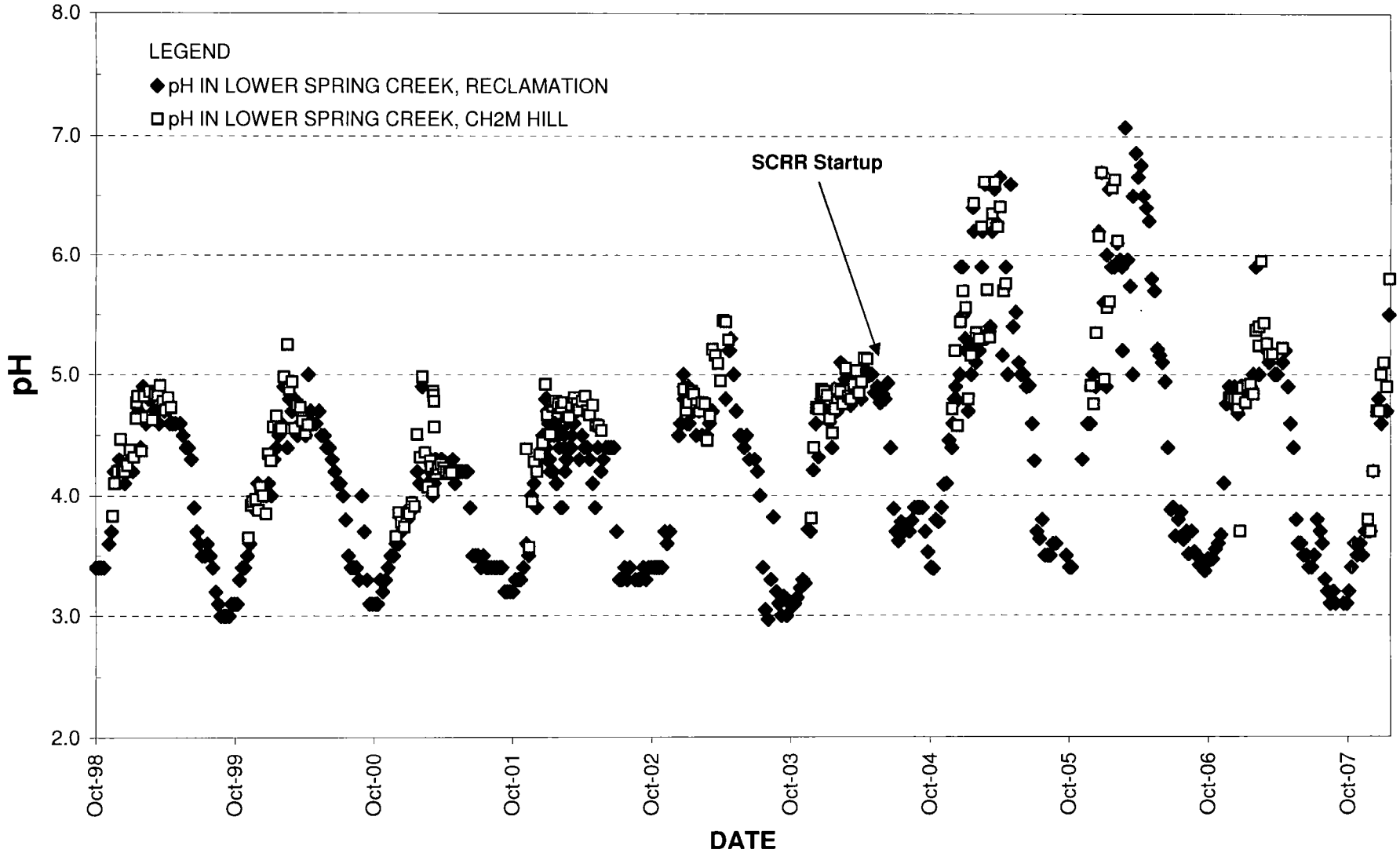


FIGURE 2
SPRING CREEK DEBRIS DAM DISCHARGE
pH MEASUREMENTS
2008 FIVE-YEAR REVIEW
IRON MOUNTAIN MINE

SCDD-pH-Figure2.xls: FIG2-pH

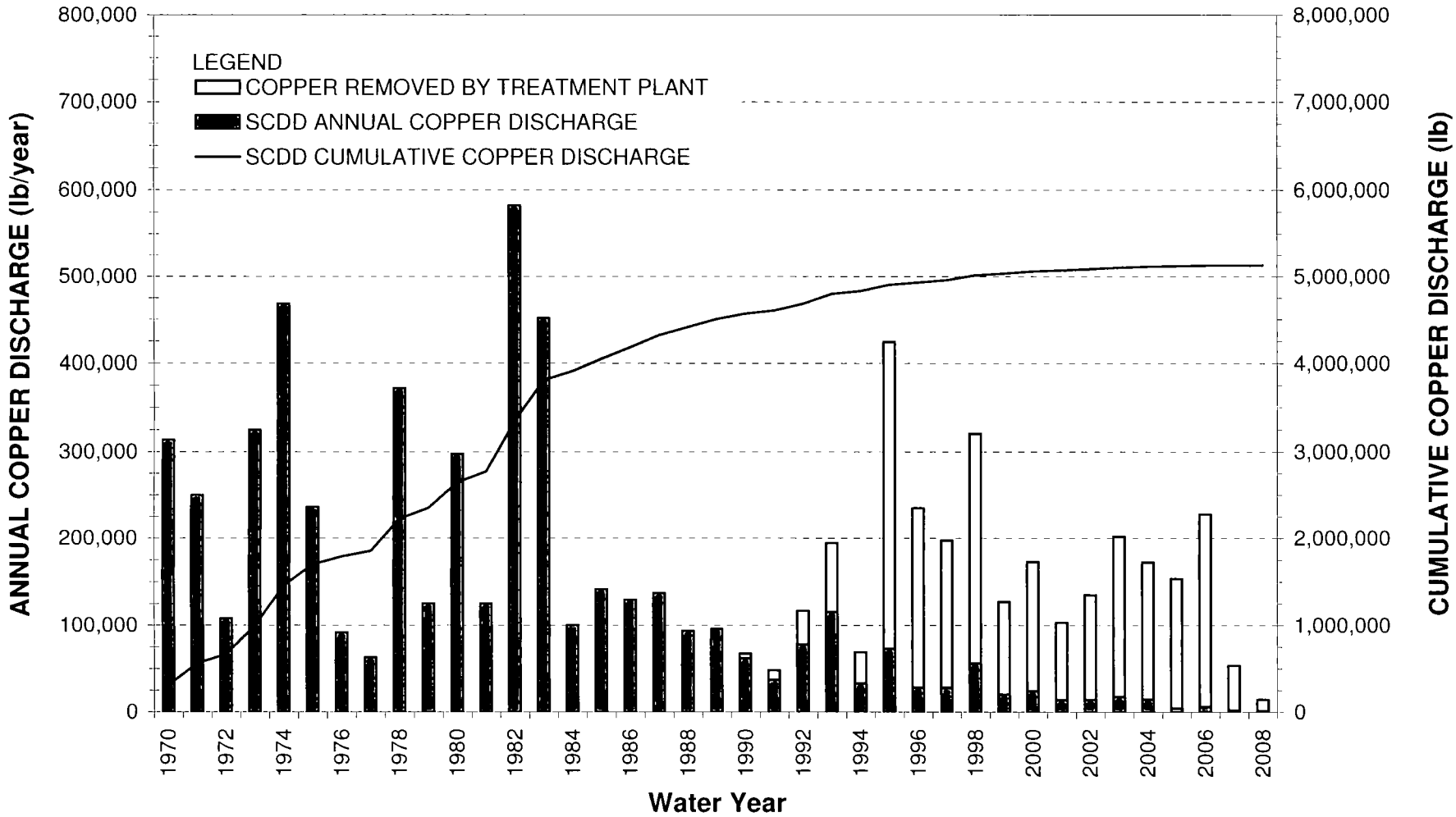


FIGURE 3
COPPER DISCHARGE, WATER YEARS 1970 THROUGH 2008
2008 FIVE-YEAR REVIEW
IRON MOUNTAIN MINE

1994-2008: Copper Removed by Treatment Plant = 2,273,000 lb
Note: Water Year 2008 data extend through January 31, 2008

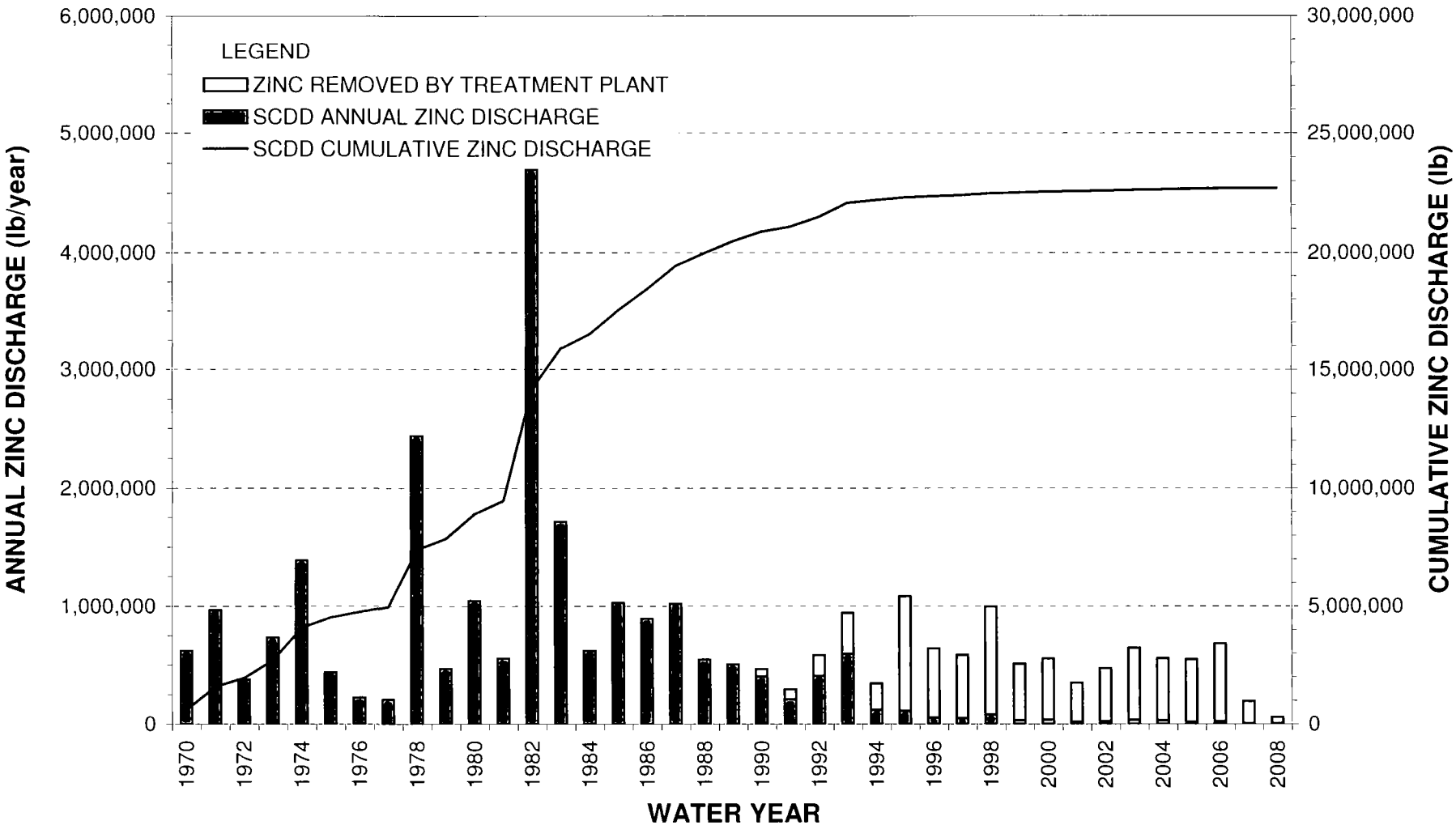
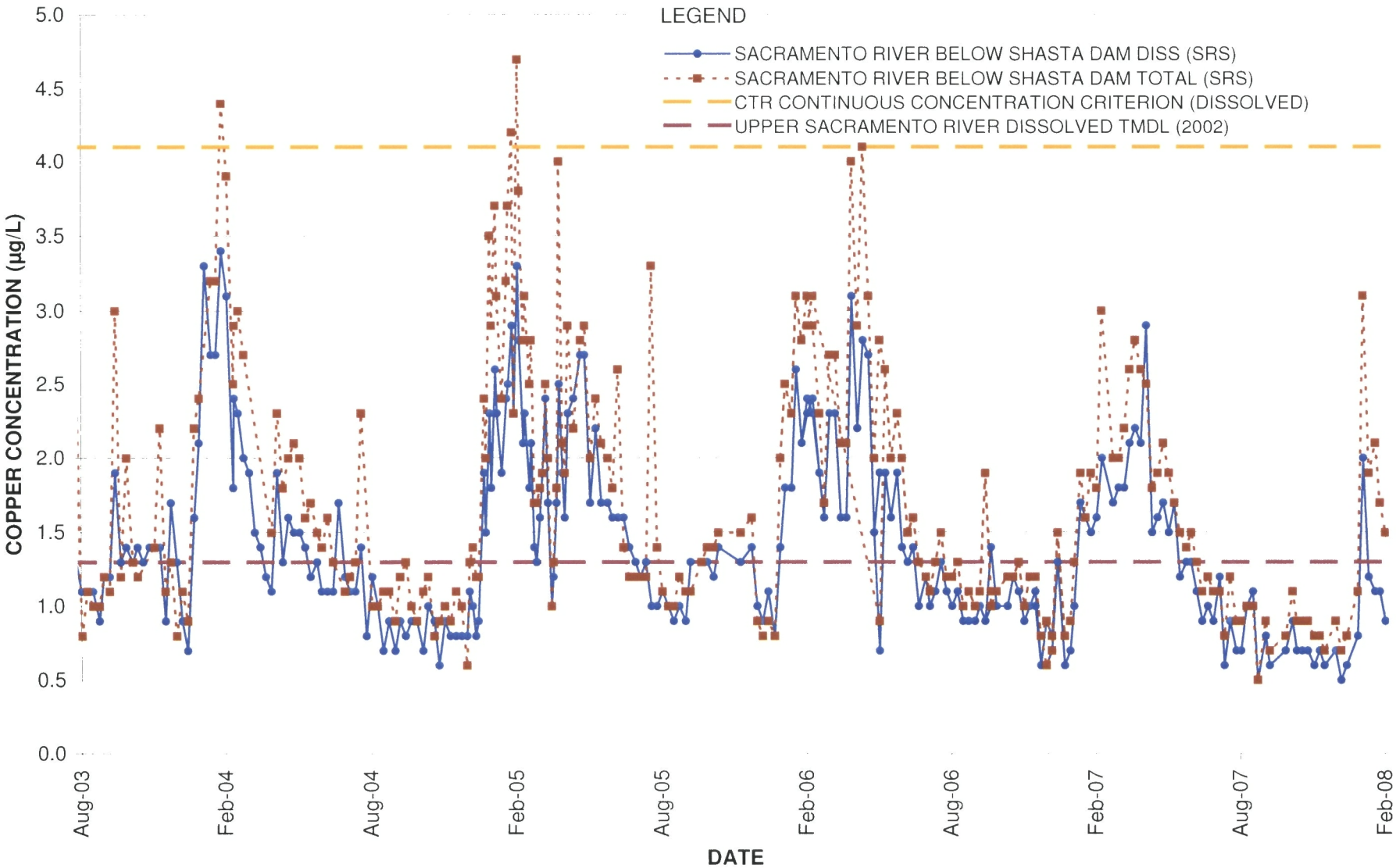


FIGURE 4
ZINC DISCHARGE, WATER YEARS 1970 THROUGH 2008
2008 FIVE-YEAR REVIEW
IRON MOUNTAIN MINE

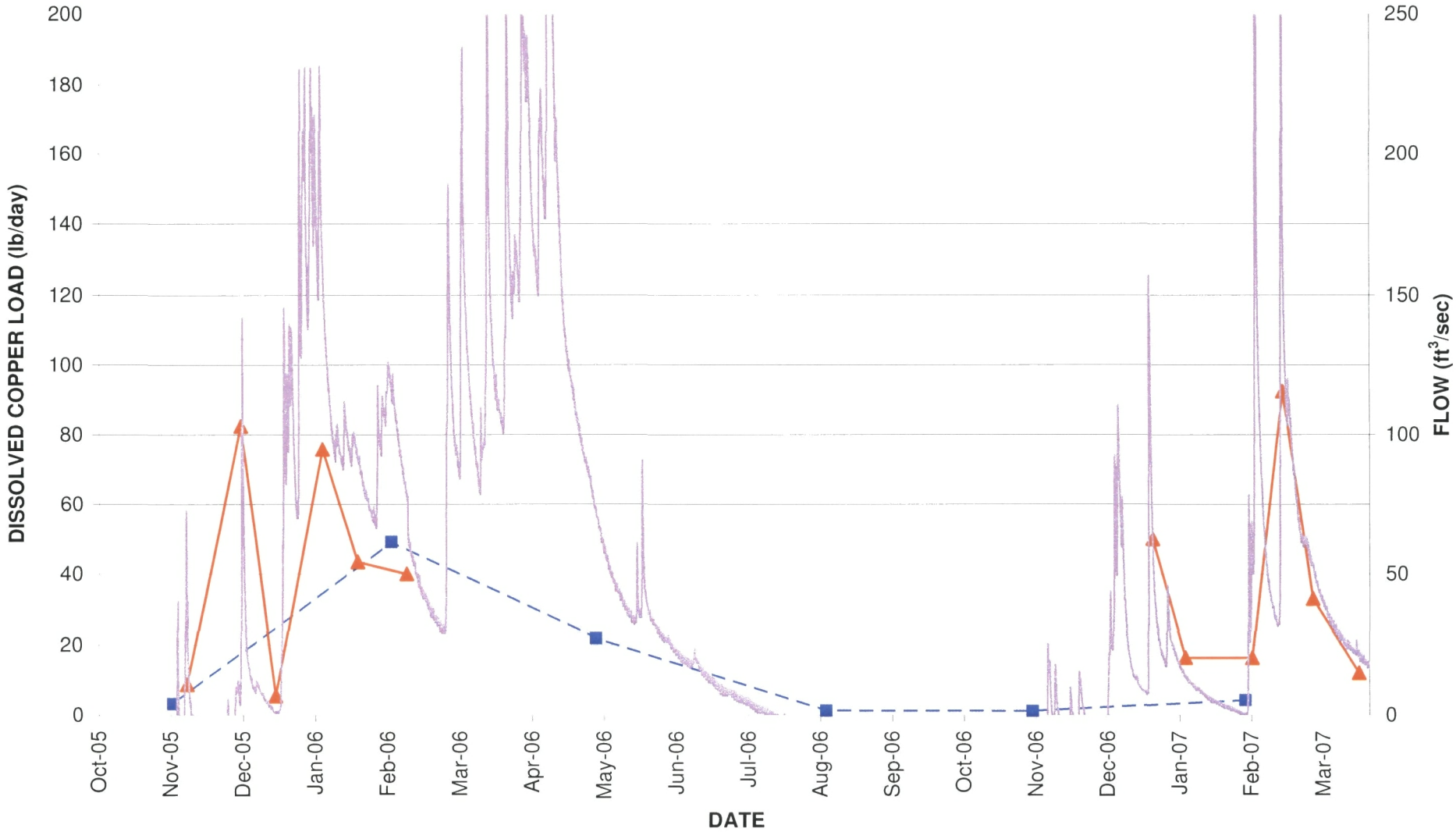
1994-2008: Zinc Removed by Treatment Plant = 7,595,000 lb
Note: Water Year 2008 data extend through January 31, 2008



NOTES:
1. CTR = CALIFORNIA TOXICS RULE. CRITERION IS FOR A HARDNESS OF 40 mg/L.
2. TMDL = TOTAL MAXIMUM DAILY LOAD. UPPER SACRAMENTO RIVER TMDL (WATER BOARD, 2002) STATES THAT REGIONAL BOARD STAFF WILL DEVELOP ADDITIONAL MINE REMEDIATION AND OTHER ACTIVITIES AS NEEDED TO ADDRESS DISSOLVED COPPER CONCENTRATIONS IN SHASTA DAM RELEASES THAT EXCEED 1.3 µg/L.
3. DATA SOURCE: BUREAU OF RECLAMATION

FIGURE 5
DISSOLVED AND TOTAL COPPER CONCENTRATIONS IN SACRAMENTO RIVER BELOW SHASTA DAM
2008 FIVE-YEAR REVIEW
IRON MOUNTAIN MINE

Shasta-Keswick-5yr-Review.xls\FIG5-T&D-SRS



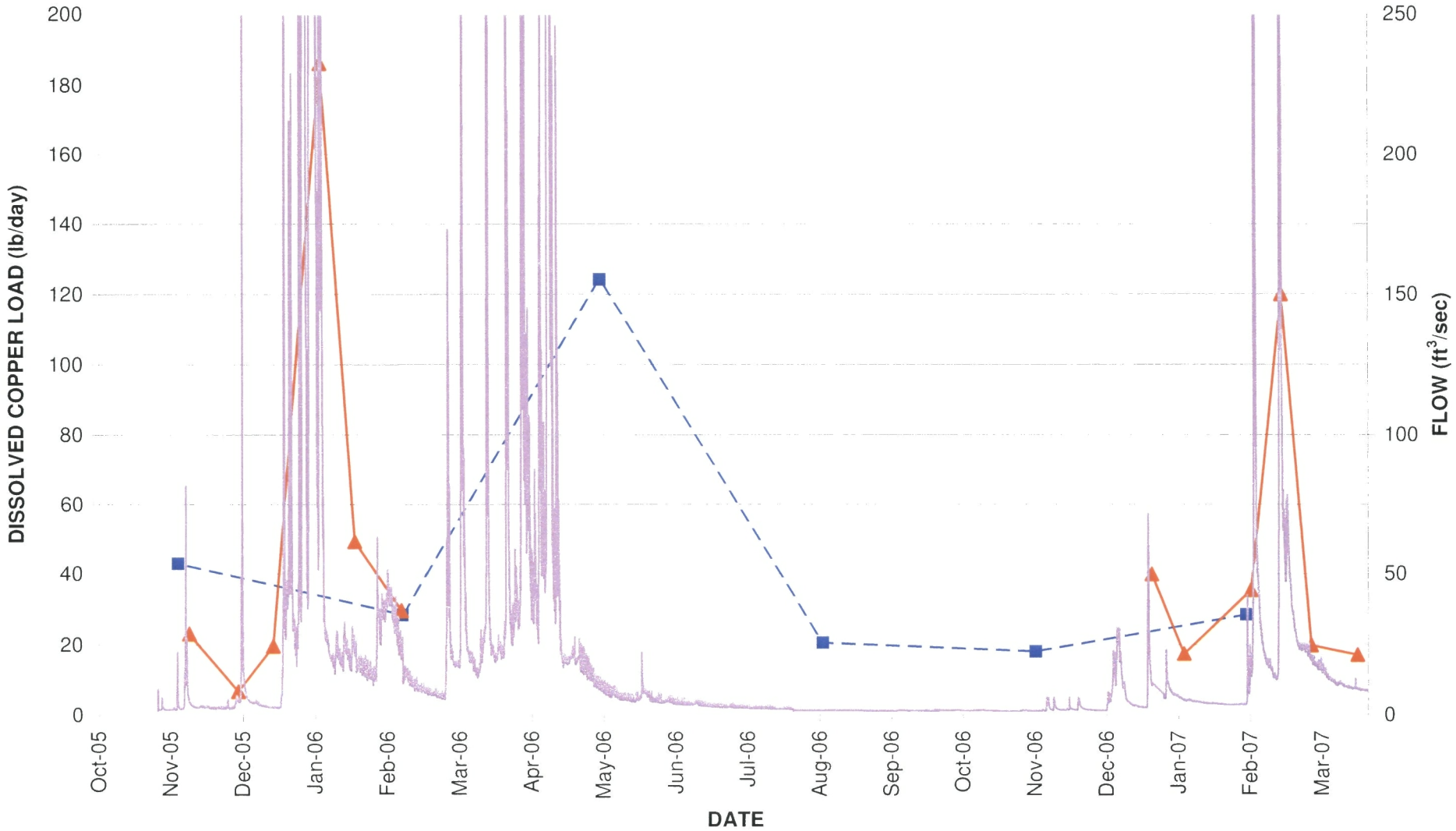
LEGEND

- MRRC DISSOLVED COPPER
- EPA DISSOLVED COPPER
- EPA CONTINUOUS FLOW

NOTES: EPA LOAD COMPUTED BY USING LITHIUM TRACER STUDY FOR DETERMINATION OF FLOW.

FIGURE 6
MRRC AND EPA DISSOLVED COPPER LOAD DATA
WEST SQUAW CREEK 2005-2007
2008 FIVE-YEAR REVIEW
IRON MOUNTAIN MINE

LBC_and_WSC_Vestra_Data.xls\FIG6



LEGEND

- MRRC DISSOLVED COPPER
- EPA DISSOLVED COPPER
- EPA CONTINUOUS FLOW

NOTES: EPA LOAD COMPUTED BY USING LITHIUM TRACER STUDY FOR DETERMINATION OF FLOW.

FIGURE 7
MRRC AND EPA DISSOLVED COPPER LOAD DATA
LITTLE BACKBONE CREEK 2005-2007
2008 FIVE-YEAR REVIEW
IRON MOUNTAIN MINE

LBC_and_WSC_Vestra_Data.xls\FIG7

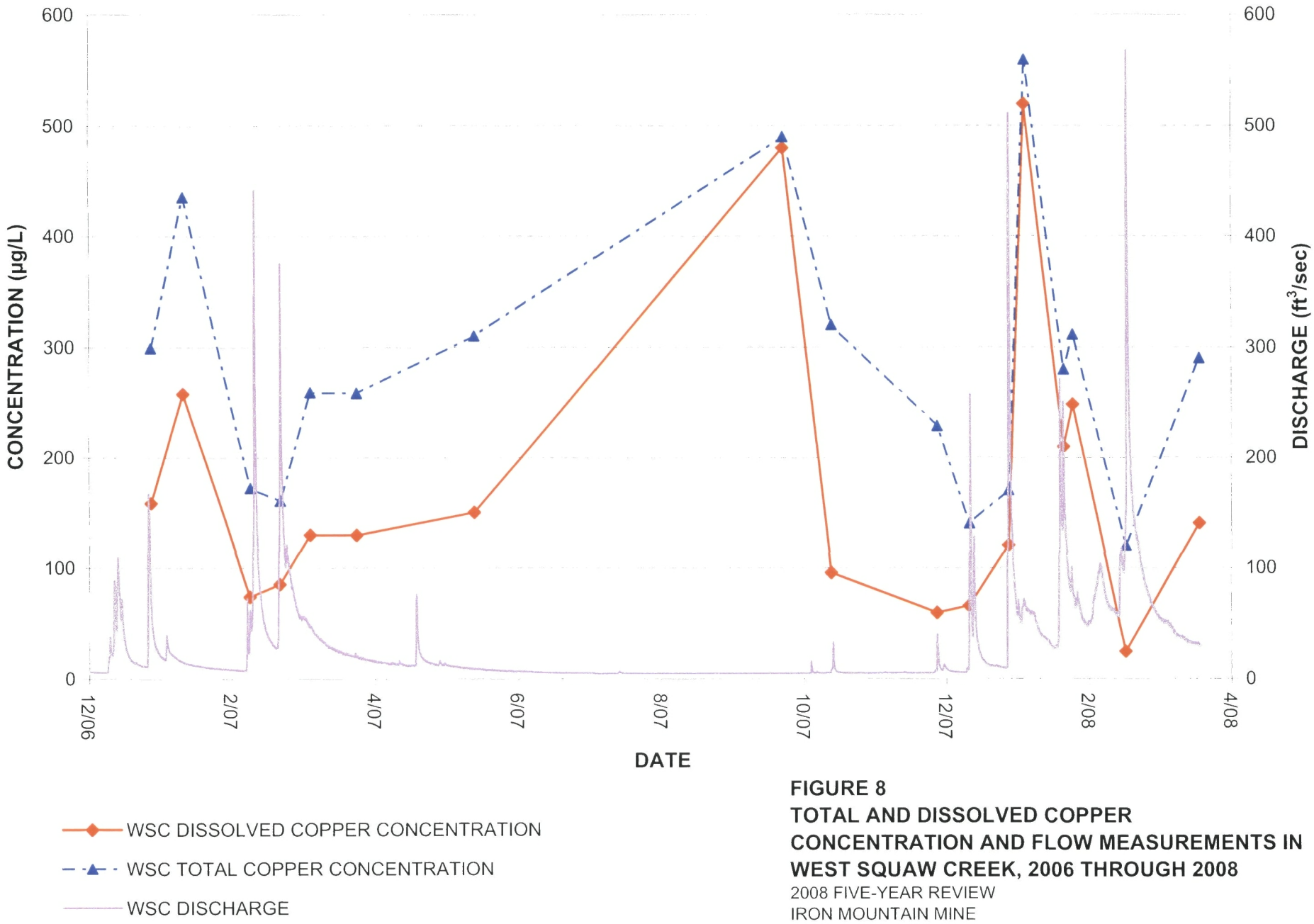
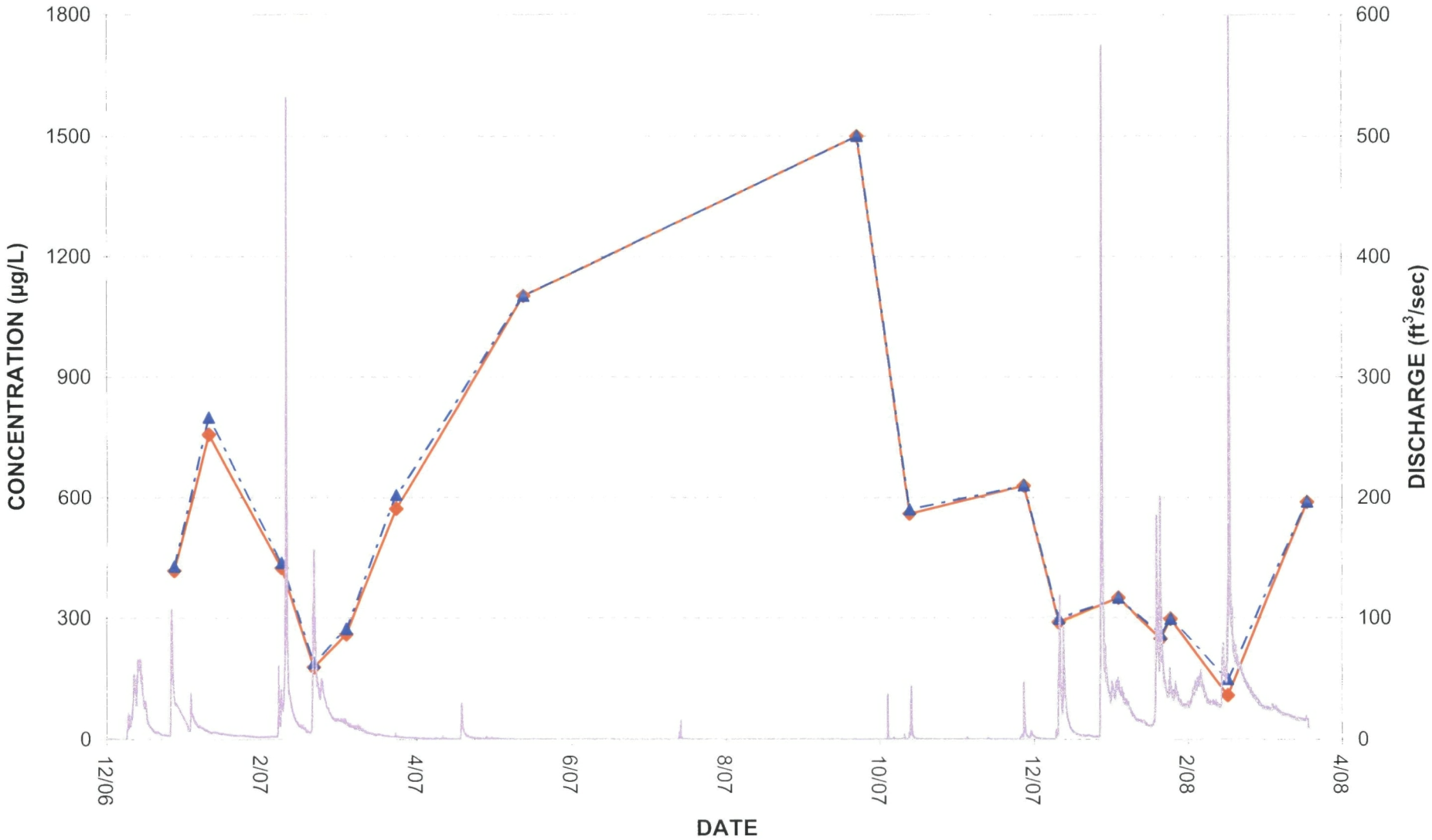


FIGURE 8
TOTAL AND DISSOLVED COPPER CONCENTRATION AND FLOW MEASUREMENTS IN WEST SQUAW CREEK, 2006 THROUGH 2008
2008 FIVE-YEAR REVIEW
IRON MOUNTAIN MINE

WSC-LBC-2007-2008Data.xls



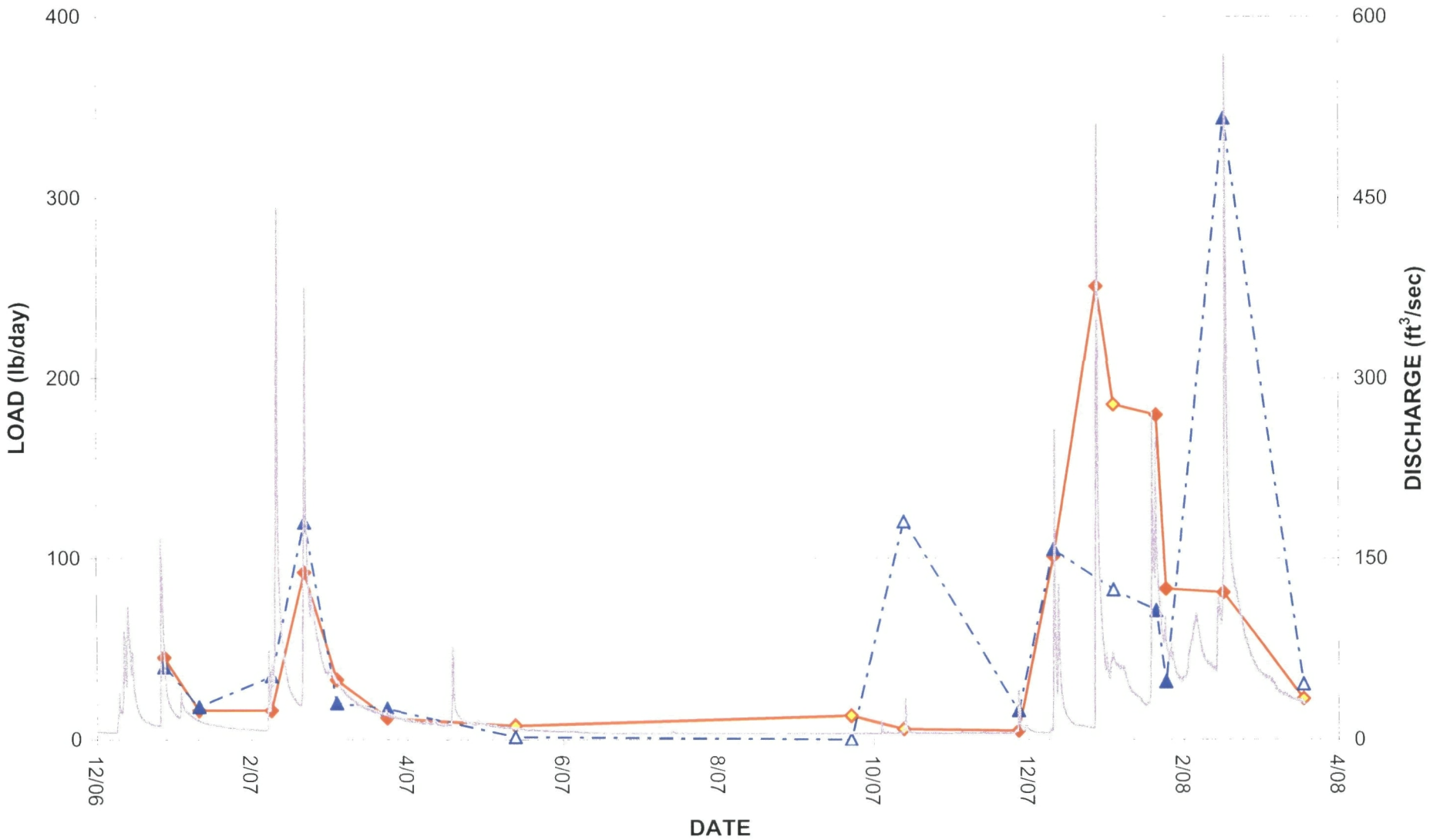
LBC DISSOLVED COPPER CONCENTRATION

LBC TOTAL COPPER CONCENTRATION

LBC DISCHARGE

WSC-LBC-2007-2008Data.xls

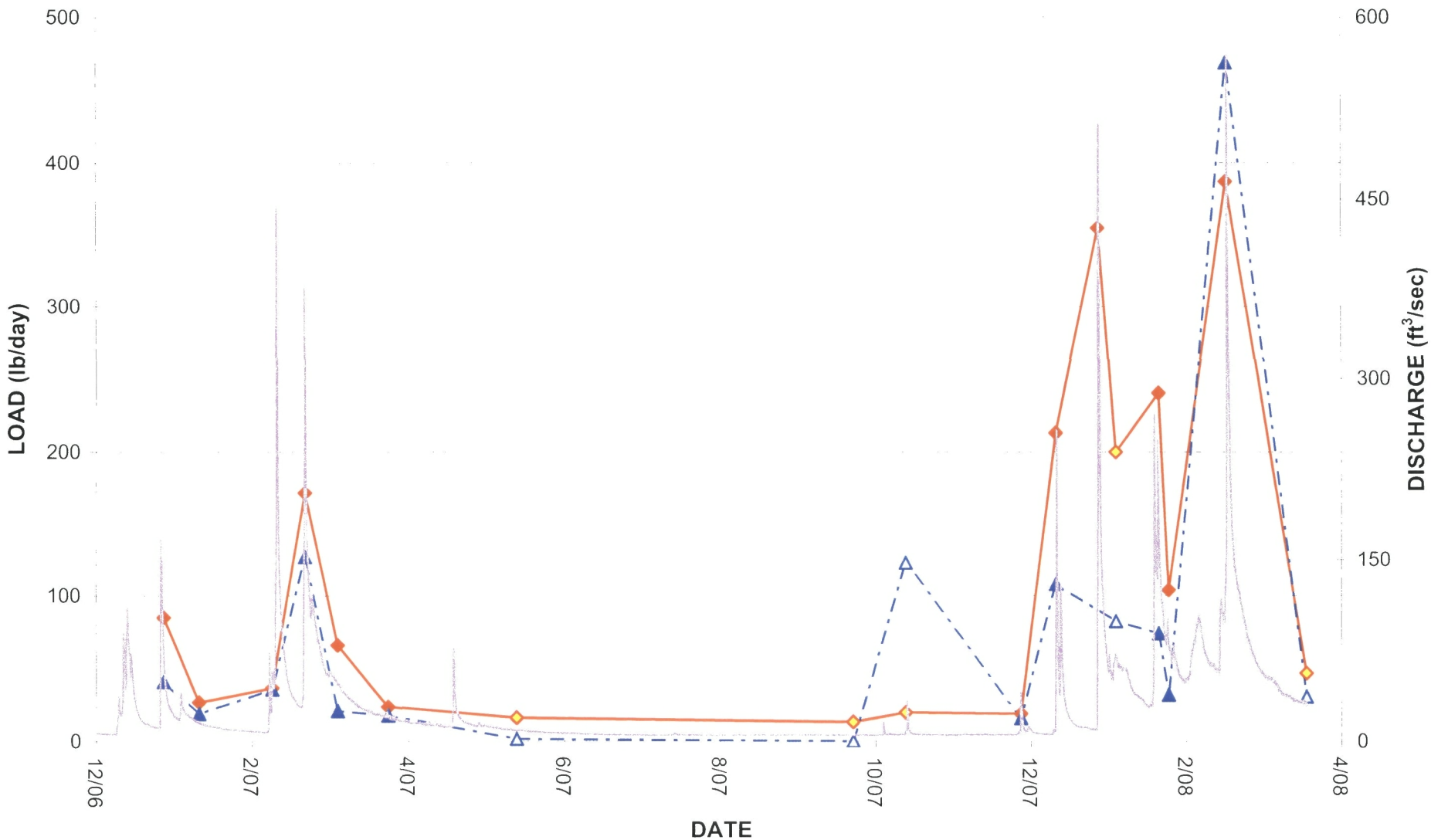
FIGURE 9
TOTAL AND DISSOLVED COPPER CONCENTRATION AND FLOW MEASUREMENTS IN LITTLE BACKBONE CREEK, 2006 THROUGH 2008
2008 FIVE-YEAR REVIEW
IRON MOUNTAIN MINE



WSC DISSOLVED COPPER LOAD, TRACER DILUTION
WSC DISSOLVED COPPER LOAD, GRAB SAMPLES
LBC DISSOLVED COPPER LOAD, TRACER DILUTION
LBC DISSOLVED COPPER LOAD, GRAB SAMPLES
WSC DISCHARGE

WSC-LBC-2007-2008Data.xls

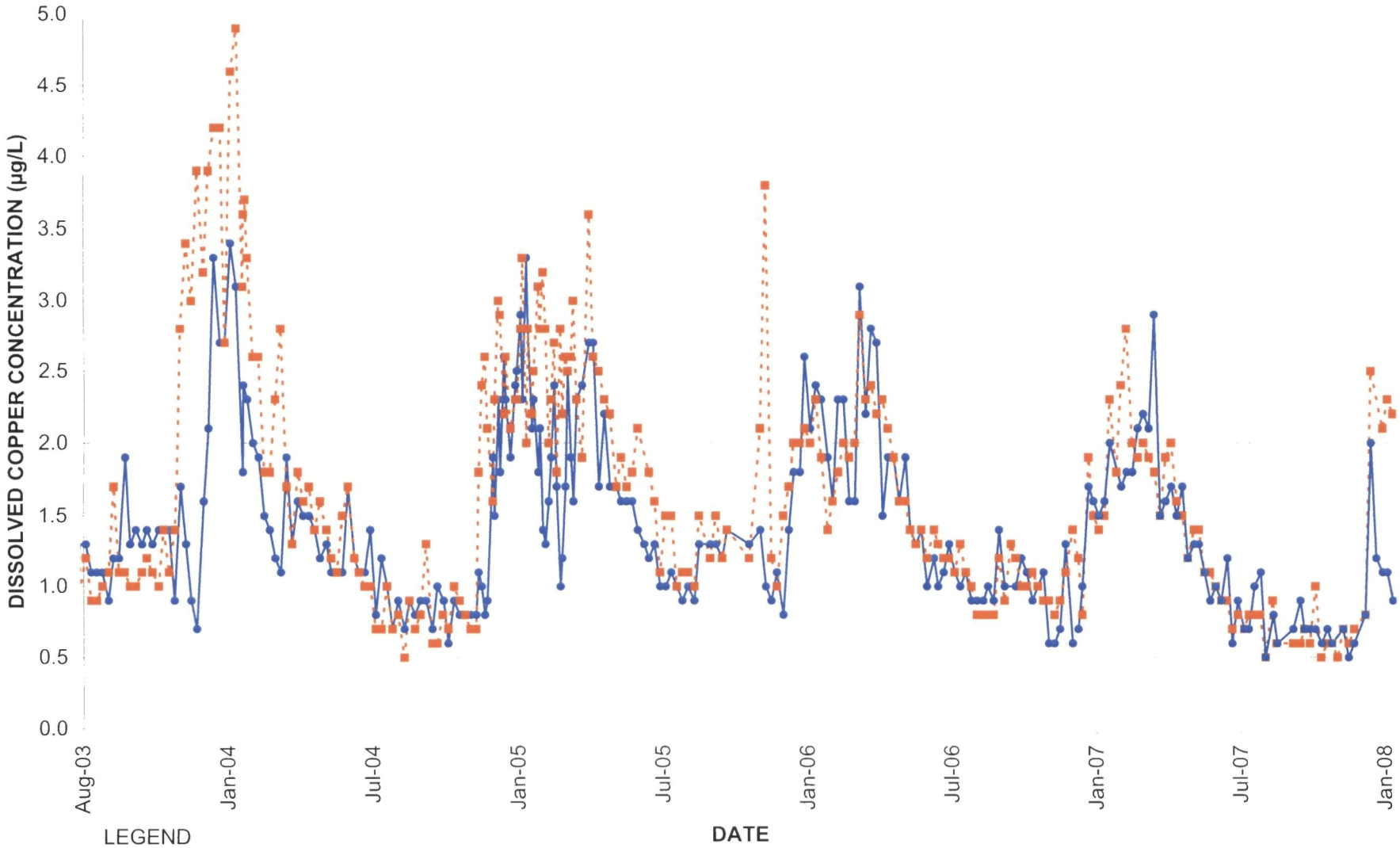
FIGURE 10
DISSOLVED COPPER LOAD AND FLOW MEASUREMENTS IN WEST SQUAW CREEK AND LITTLE BACKBONE CREEK, 2006 THROUGH 2008
2008 FIVE-YEAR REVIEW
IRON MOUNTAIN MINE



WSC TOTAL COPPER LOAD, TRACER DILUTION
WSC TOTAL COPPER LOAD, GRAB SAMPLES
LBC TOTAL COPPER LOAD, TRACER DILUTION
LBC TOTAL COPPER LOAD, GRAB SAMPLES
WSC DISCHARGE

WSC-LBC-2007-2008Data.xls

FIGURE 11
TOTAL COPPER LOAD AND FLOW MEASUREMENTS IN WEST SQUAW CREEK AND LITTLE BACKBONE CREEK, 2006 THROUGH 2008
2008 FIVE-YEAR REVIEW
IRON MOUNTAIN MINE



NOTES:
DATA SOURCE: BUREAU OF RECLAMATION

FIGURE 12
DISSOLVED COPPER CONCENTRATIONS IN SACRAMENTO RIVER BELOW SHASTA AND KESWICK DAMS
2008 FIVE-YEAR REVIEW
IRON MOUNTAIN MINE

Shasta-Keswick-5yr-Review.xls\FIG12-Cu-SRS_SRK

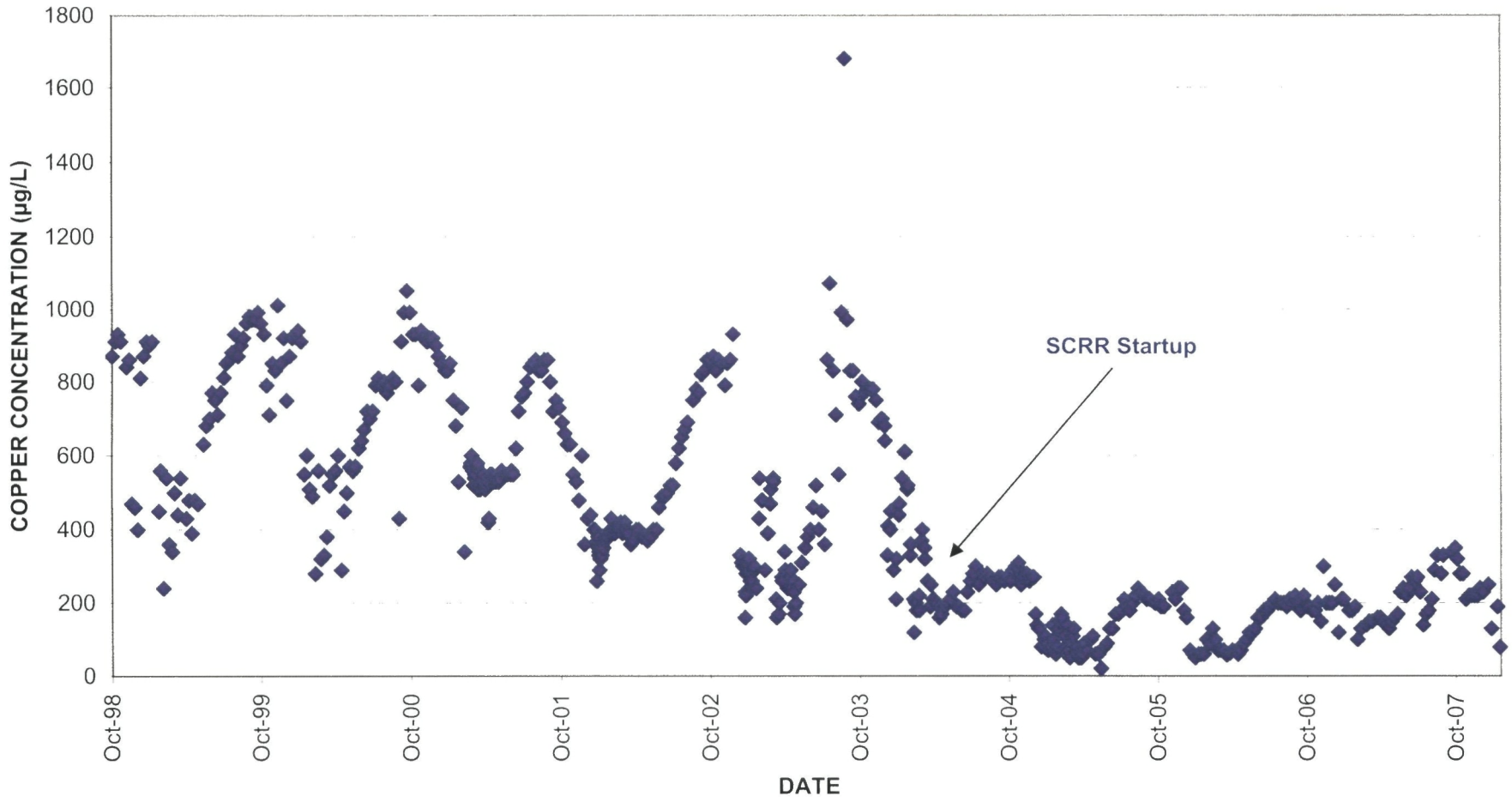
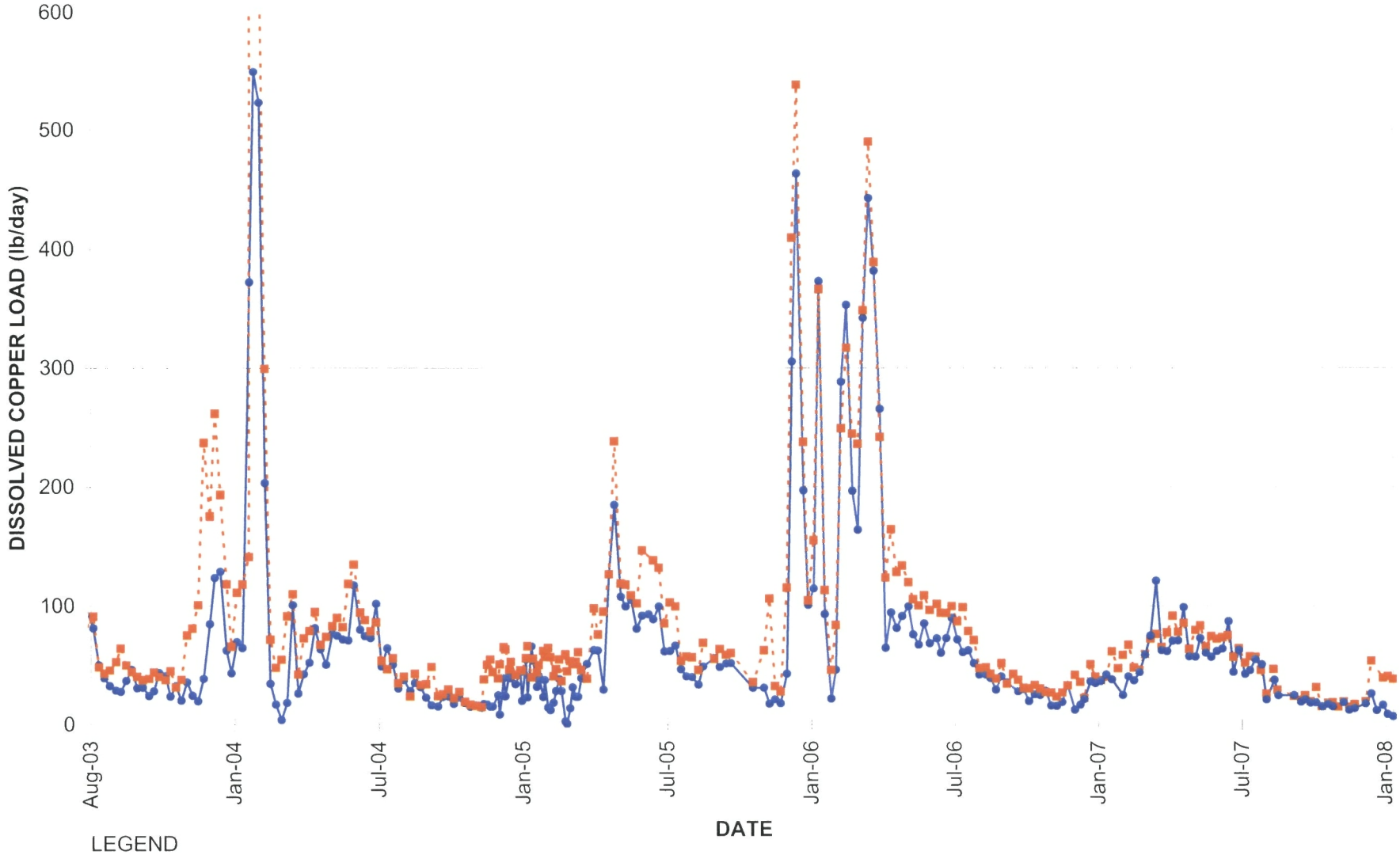


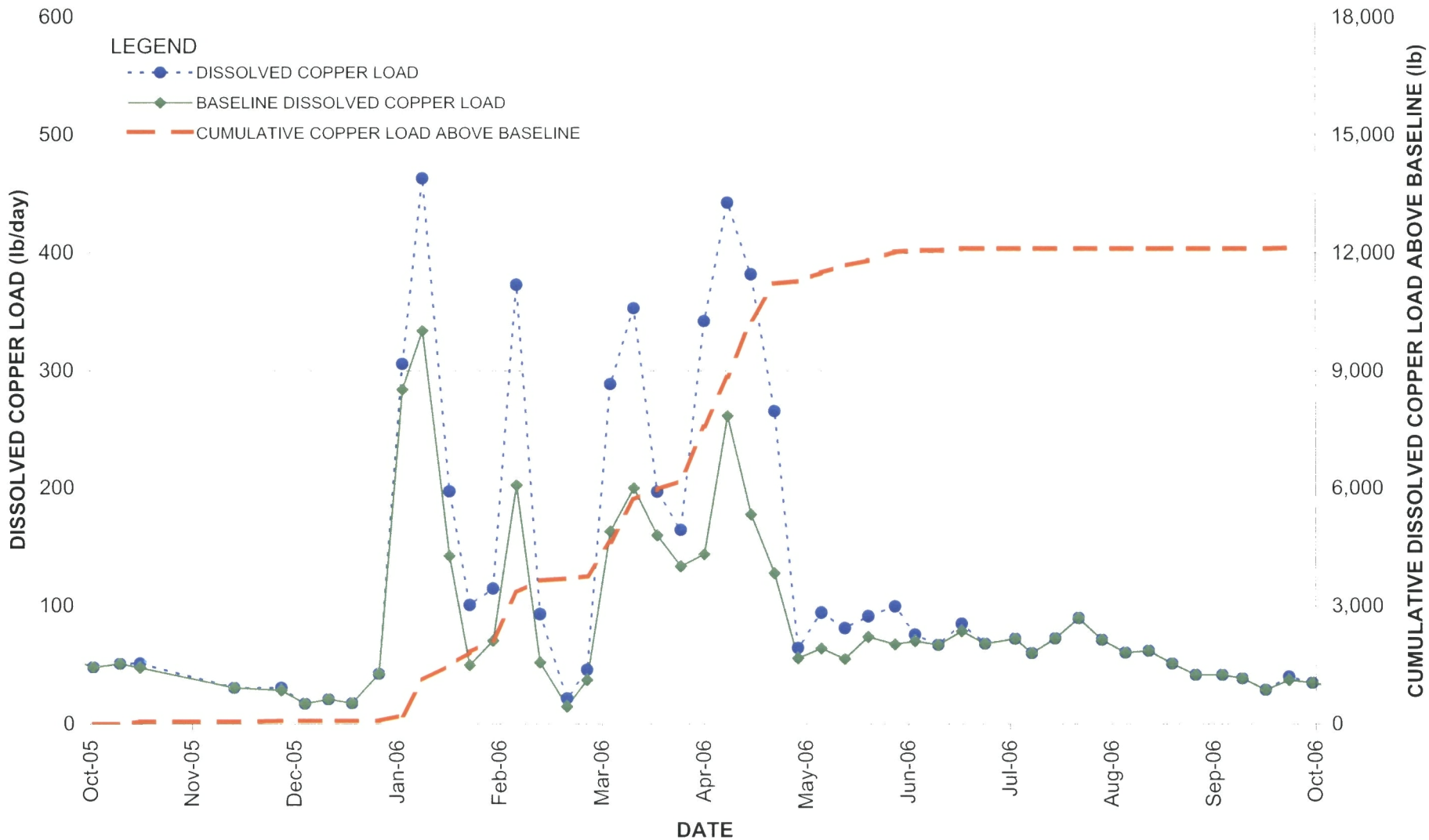
FIGURE 13
SPRING CREEK DEBRIS DAM COPPER CONCENTRATIONS
2008 FIVE-YEAR REVIEW
IRON MOUNTAIN MINE



NOTES:
DATA SOURCE: BUREAU OF RECLAMATION

FIGURE 14
SHASTA DAM AND KESWICK DAM DISSOLVED COPPER LOADS
2008 FIVE-YEAR REVIEW
IRON MOUNTAIN MINE

Shasta-Keswick-5yr-Review.xls\FIG14-SRS-SRK2-Load



NOTE:
THE BASELINE DISSOLVED COPPER LOAD IS CALCULATED AS A DISSOLVED COPPER CONCENTRATION OF 1.3 µg/L MULTIPLIED BY THE SHASTA DAM DISCHARGE. UPPER SACRAMENTO RIVER TMDL (WATER BOARD, 2002) STATES THAT REGIONAL BOARD STAFF WILL DEVELOP ADDITIONAL MINE REMEDIATION AND OTHER ACTIVITIES AS NEEDED TO ADDRESS DISSOLVED COPPER CONCENTRATIONS IN SHASTA DAM RELEASES THAT EXCEED 1.3 µg/L.
DATA SOURCE: BUREAU OF RECLAMATION

FIGURE 15
SHASTA DAM DISSOLVED COPPER LOAD
2006 WATER YEAR
2008 FIVE-YEAR REVIEW
IRON MOUNTAIN MINE

Shasta-Keswick-5yr-Review.xls\FIG15-SRS-Load-2006WY

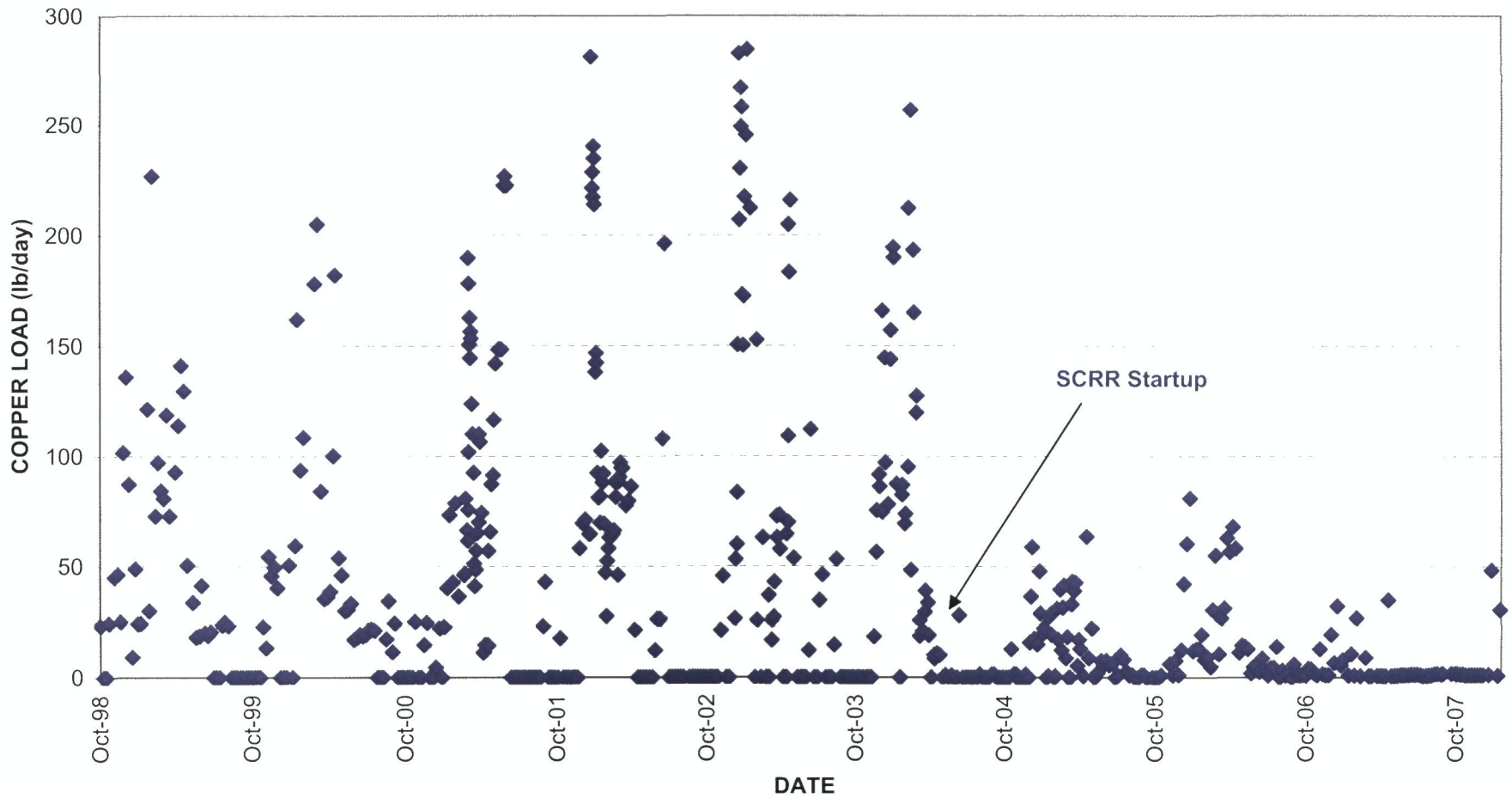
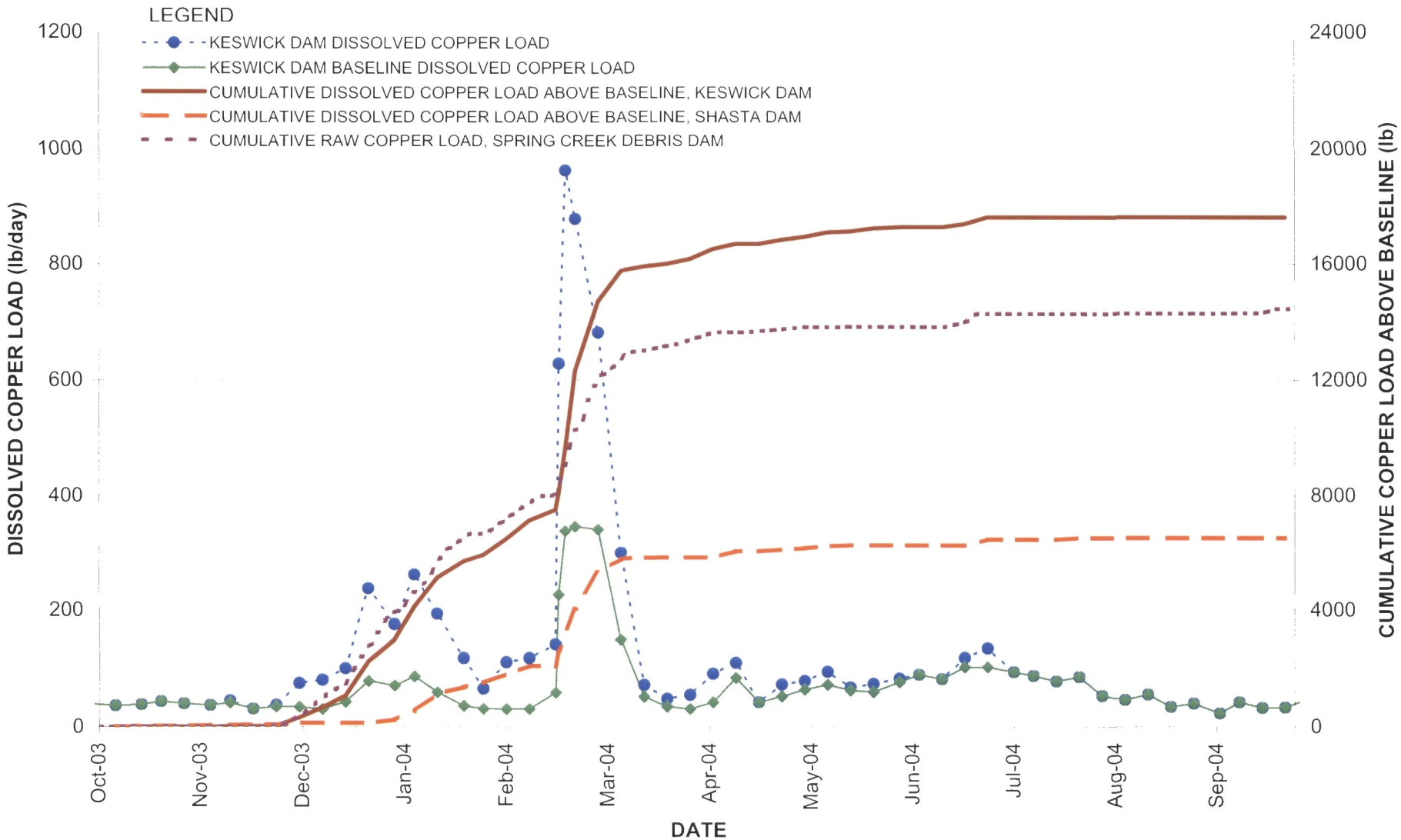


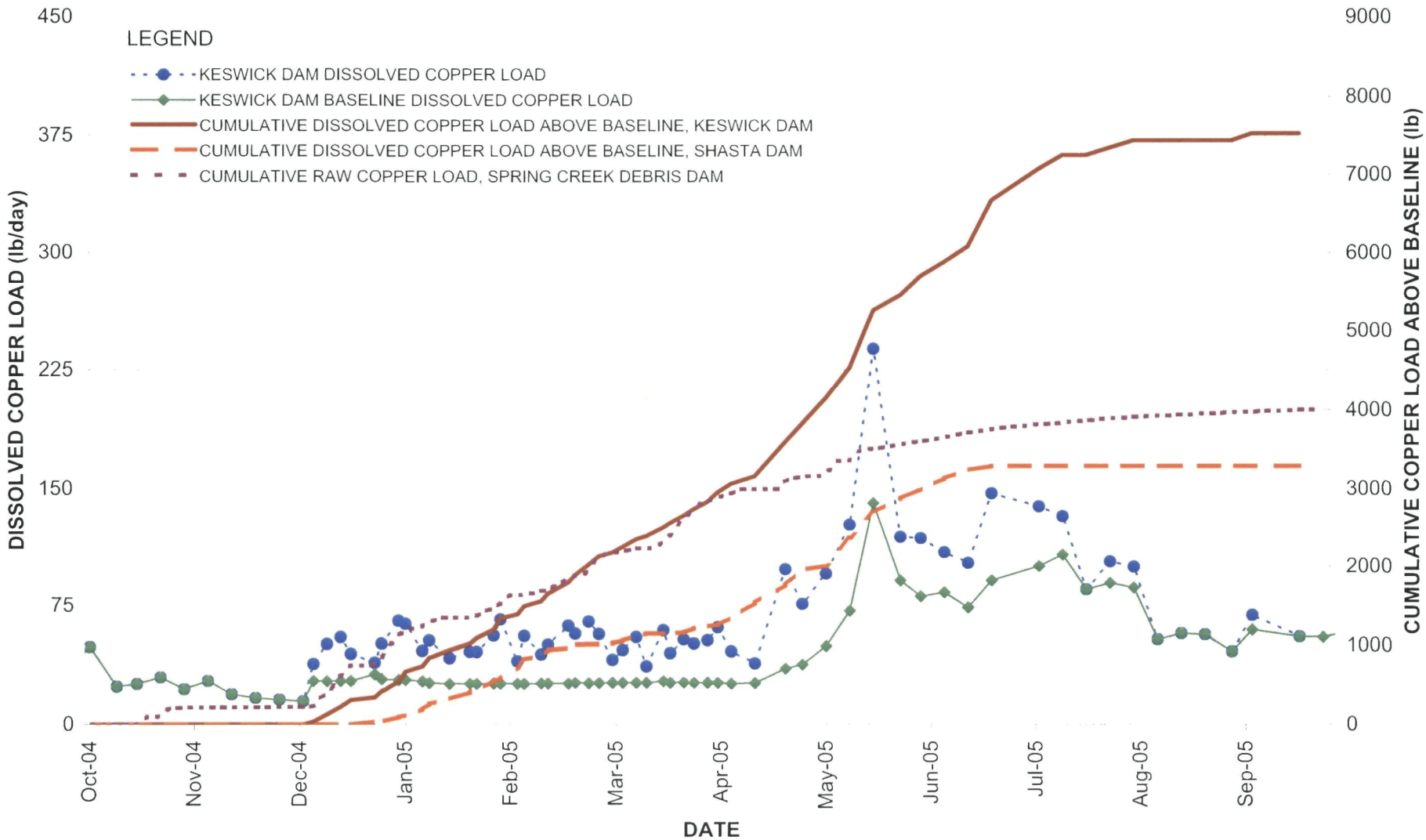
FIGURE 16
SPRING CREEK DEBRIS DAM COPPER LOADS
2008 FIVE-YEAR REVIEW
IRON MOUNTAIN MINE



NOTES:
1. DATA WERE COLLECTED BY BUREAU OF RECLAMATION.
2. AVERAGE RATIO OF DISSOLVED TO TOTAL COPPER FOR LSC WAS 0.95 FOR DATA COLLECTED BY CH2M HILL DURING 2005-2006 AND 2006-2007 WET SEASONS.
3. THE BASELINE DISSOLVED COPPER LOAD IS CALCULATED AS A DISSOLVED COPPER CONCENTRATION OF 1.3 µg/L MULTIPLIED BY THE DAM DISCHARGE.
4. DATA SOURCE: BUREAU OF RECLAMATION

FIGURE 17
KESWICK DAM DISSOLVED COPPER LOAD
2004 WATER YEAR
2008 FIVE-YEAR REVIEW
IRON MOUNTAIN MINE

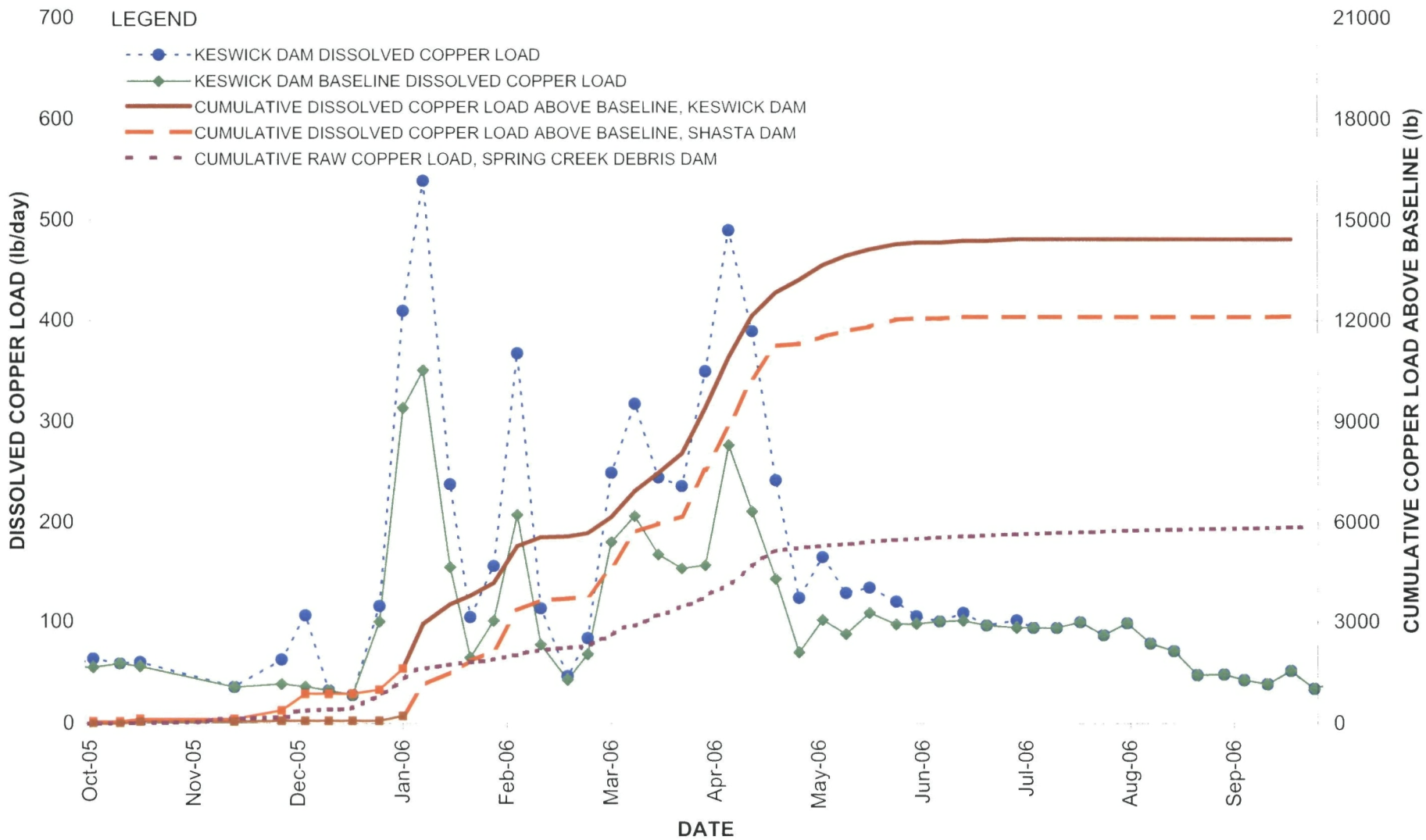
Shasta-Keswick-5yr-Review.xls\FIG17-WY2004



NOTES:
1. DATA WERE COLLECTED BY BUREAU OF RECLAMATION.
2. AVERAGE RATIO OF DISSOLVED TO TOTAL COPPER FOR LSC WAS 0.95 FOR DATA COLLECTED BY CH2M HILL DURING 2005-2006 AND 2006-2007 WET SEASONS.
3. THE BASELINE DISSOLVED COPPER LOAD IS CALCULATED AS A DISSOLVED COPPER CONCENTRATION OF 1.3 µg/L MULTIPLIED BY THE DAM DISCHARGE.
4. DATA SOURCE: BUREAU OF RECLAMATION

FIGURE 18
KESWICK DAM DISSOLVED COPPER LOAD
2005 WATER YEAR
2008 FIVE-YEAR REVIEW
IRON MOUNTAIN MINE

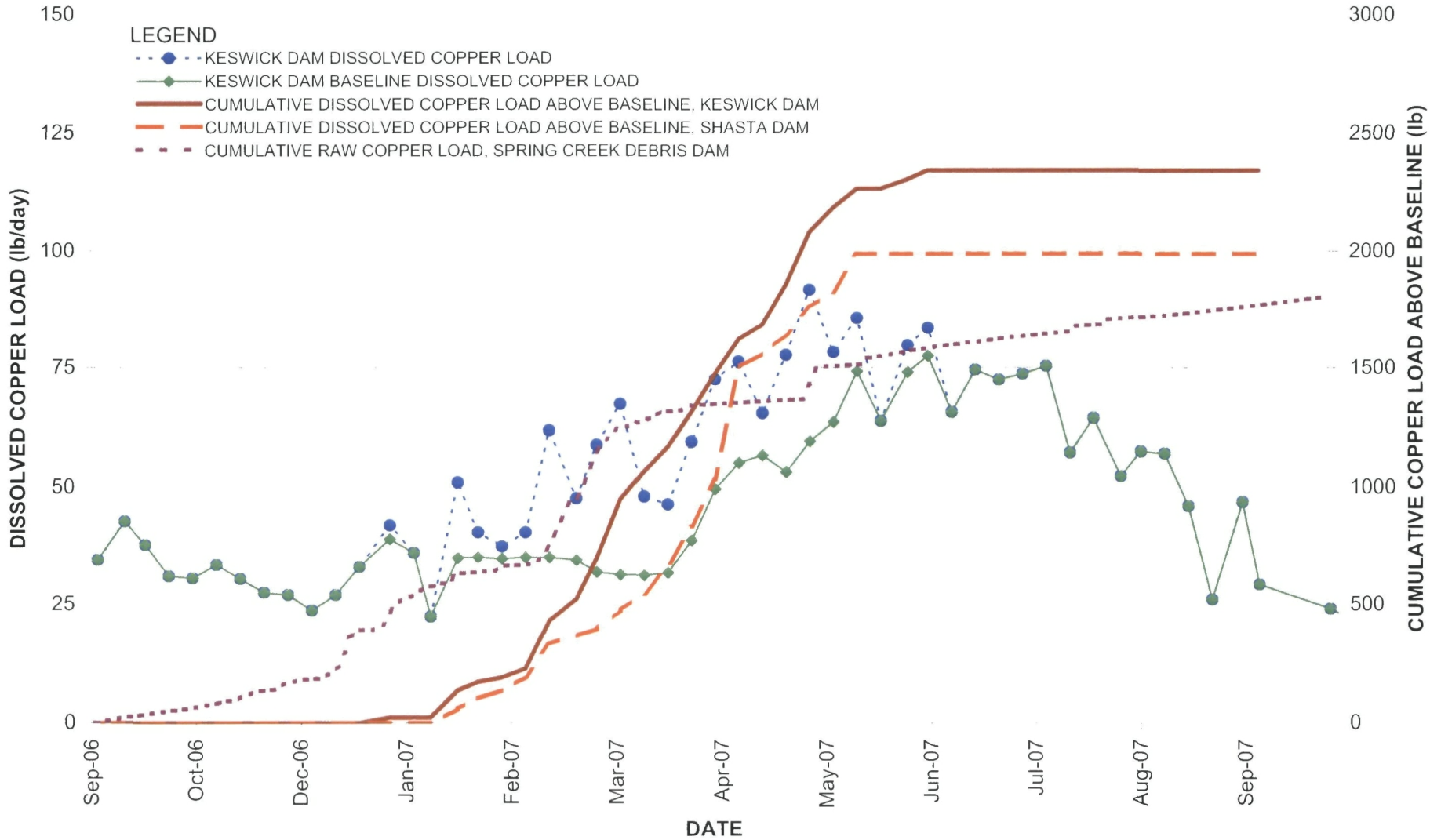
Shasta-Keswick-5yr-Review.xls\FIG18-WY2005



NOTES:
1. DATA WERE COLLECTED BY BUREAU OF RECLAMATION.
2. AVERAGE RATIO OF DISSOLVED TO TOTAL COPPER FOR LSC WAS 0.95 FOR DATA COLLECTED BY CH2M HILL DURING 2005-2006 AND 2006-2007 WET SEASONS.
3. THE BASELINE DISSOLVED COPPER LOAD IS CALCULATED AS A DISSOLVED COPPER CONCENTRATION OF 1.3 µg/L MULTIPLIED BY THE DAM DISCHARGE.
4. DATA SOURCE: BUREAU OF RECLAMATION

FIGURE 19
KESWICK DAM DISSOLVED COPPER LOAD
2006 WATER YEAR
2008 FIVE-YEAR REVIEW
IRON MOUNTAIN MINE

Shasta-Keswick-5yr-Review.xls\FIG19-WY2006



NOTES:
1. DATA WERE COLLECTED BY BUREAU OF RECLAMATION.
2. AVERAGE RATIO OF DISSOLVED TO TOTAL COPPER FOR LSC WAS 0.95 FOR DATA COLLECTED BY CH2M HILL DURING 2005-2006 AND 2006-2007 WET SEASONS.
3. THE BASELINE DISSOLVED COPPER LOAD IS CALCULATED AS A DISSOLVED COPPER CONCENTRATION OF 1.3 µg/L MULTIPLIED BY THE DAM DISCHARGE.
4. DATA SOURCE: BUREAU OF RECLAMATION

FIGURE 20
KESWICK DAM DISSOLVED COPPER LOAD
2007 WATER YEAR
2008 FIVE-YEAR REVIEW
IRON MOUNTAIN MINE

Shasta-Keswick-5yr-Review.xls\FIG20-WY2007

Appendix

Table A-1

Copper and Zinc Load Discharge From SCDD

Site Evaluation and Compliance at Keswick Dam, Iron Mountain Mine Five-Year Review

Water Year	SCDD Discharge (acre-ft)	Annual Copper (lb)	Cumulative Copper (lb)	Annual Zinc (lb)	Cumulative Zinc (lb)
1970	39,248	313,471	313,471	620,080	620,080
1971	32,334	249,828	563,298	967,460	1,587,539
1972	10,236	107,645	670,943	377,701	1,965,241
1973	38,853	324,551	995,494	733,315	2,698,556
1974	62,806	468,516	1,464,010	1,386,576	4,085,133
1975	31,213	236,319	1,700,329	440,408	4,525,540
1976	7,495	91,300	1,791,629	225,771	4,751,311
1977	2,955	63,044	1,854,674	208,976	4,960,288
1978	57,180	371,769	2,226,443	2,437,129	7,397,417
1979	15,156	125,212	2,351,655	468,785	7,866,202
1980	32,820	297,479	2,649,133	1,045,093	8,911,295
1981	24,276	124,935	2,774,068	554,420	9,465,715
1982	52,290	582,541	3,356,609	4,695,683	14,161,398
1983	83,856	451,591	3,808,199	1,714,696	15,876,094
1984	29,441	99,875	3,908,075	619,616	16,495,710
1985	19,680	141,365	4,049,439	1,028,050	17,523,760
1986	38,364	129,532	4,178,971	892,608	18,416,368
1987	16,813	136,958	4,315,929	1,019,126	19,435,495
1988	16,964	93,301	4,409,230	544,878	19,980,372
1989	19,579	95,706	4,504,936	504,504	20,484,876
1990	13,709	61,750	4,566,687	401,006	20,885,882
1991	4,730	36,728	4,603,414	209,692	21,095,574
1992	14,671	77,884	4,681,298	406,776	21,502,350
1993	23,240	114,970	4,796,268	591,205	22,093,556
1994	4,191	32,739	4,829,006	118,666	22,212,222
1995	40,952	72,601	4,901,607	110,379	22,322,601
1996	18,669	28,170	4,929,777	52,568	22,375,169
1997	28,856	27,851	4,957,628	47,313	22,422,483
1998	74,989	55,993	5,013,621	78,674	22,501,157
1999	25,769	19,957	5,033,578	31,465	22,532,622
2000	34,495	24,109	5,057,687	34,204	22,566,826
2001	15,831	13,561	5,071,247	18,294	22,585,120
2002	18,140	13,909	5,085,157	21,080	22,606,200
2003	31,294	17,594	5,102,751	32,708	22,638,908
2004	37,155	14,466	5,117,217	27,872	22,666,780
2005	25,593	4,001	5,121,218	15,167	22,681,948
2006	28,038	5,848	5,127,066	20,973	22,702,921
2007	3,636	1,807	5,128,872	5,483	22,708,404
2008	2,389	1,297	5,130,170	3,612	22,712,016
Total	1,077,903	5,130,170		22,712,016	

Notes:

1. Water Year 2008 includes data from October 1, 2007, through January 31, 2008.

Table A-2

Copper and Zinc Load Collected by MFTP

Site Evaluation and Compliance at Keswick Dam, Iron Mountain Mine Five-Year Review

Water Year	Plant Inflow (gal)	Influent Copper (lb)	Influent Zinc (lb)
1970			
1971			
1972			
1973			
1974			
1975			
1976			
1977			
1978			
1979			
1980			
1981			
1982			
1983			
1984			
1985			
1986			
1987			
1988			
1989			
1990	4,352,979	5,849	64,682
1991	5,380,272	11,658	85,316
1992	10,467,006	38,920	176,265
1993	25,305,355	79,182	351,492
1994	22,098,293	36,302	226,877
1995	162,372,924	351,478	972,529
1996	108,883,298	206,954	585,914
1997	107,146,938	169,516	537,979
1998	192,784,060	264,375	917,420
1999	107,791,992	107,154	477,614
2000	123,216,791	148,803	518,829
2001	86,938,235	89,408	330,862
2002	108,703,282	121,023	451,705
2003	151,703,449	184,276	610,797
2004	214,017,287	157,821	528,160
2005	426,468,214	149,546	531,520
2006	586,814,629	221,820	660,945
2007	157,239,602	51,775	188,292
2008	68,450,010	13,110	55,940
Total	2,670,134,617	2,408,970	8,273,139

Notes:

1. Water Year 2008 includes data from October 1, 2007, through January 31, 2008.

Table A-3

Total Iron Mountain Copper and Zinc Load

Site Evaluation and Compliance at Keswick Dam, Iron Mountain Mine Five-Year Review

Water Year	SCDD Discharge (acre-ft)	Annual Copper (lb)	Annual Zinc (lb)	Percent Reduction Water Year	Copper (%)	Zinc (%)
1970	39,248	313,471	620,080			
1971	32,334	249,828	967,460			
1972	10,236	107,645	377,701			
1973	38,853	324,551	733,315			
1974	62,806	468,516	1,386,576			
1975	31,213	236,319	440,408			
1976	7,495	91,300	225,771			
1977	2,955	63,044	208,976			
1978	57,180	371,769	2,437,129			
1979	15,156	125,212	468,785			
1980	32,820	297,479	1,045,093			
1981	24,276	124,935	554,420			
1982	52,290	582,541	4,695,683			
1983	83,856	451,591	1,714,696			
1984	29,441	99,875	619,616			
1985	19,680	141,365	1,028,050			
1986	38,364	129,532	892,608			
1987	16,813	136,958	1,019,126			
1988	16,964	93,301	544,878			
1989	19,579	95,706	504,504			
1990	13,709	67,600	465,688	1990	9%	14%
1991	4,730	48,385	295,008	1991	24%	29%
1992	14,671	116,804	583,041	1992	33%	30%
1993	23,240	194,152	942,698	1993	41%	37%
1994	4,191	69,040	345,543	1994	53%	66%
1995	40,952	424,078	1,082,908	1995	83%	90%
1996	18,669	235,124	638,483	1996	88%	92%
1997	28,856	197,367	585,292	1997	86%	92%
1998	74,989	320,368	996,094	1998	83%	92%
1999	25,769	127,111	509,079	1999	84%	94%
2000	34,495	172,912	553,033	2000	86%	94%
2001	15,831	102,969	349,156	2001	87%	95%
2002	18,140	134,932	472,786	2002	90%	96%
2003	31,294	201,871	643,505	2003	91%	95%
2004	37,155	172,287	556,032	2004	92%	95%
2005	25,593	153,547	546,687	2005	97%	97%
2006	28,038	227,667	681,918	2006	97%	97%
2007	3,636	53,582	193,775	2007	97%	97%
2008	2,389	14,407	59,553	2008	91%	94%
Total	1,077,903	7,539,139	30,985,155			

Notes:

1. Water Year 2008 includes data from October 1, 2007, through January 31, 2008.