CDM

ADMINISTRATIVE RECORD

1165450 - R8 SDMS

Basin Mining Area, Operable Unit 2
Jefferson County, Montana

Draft Remedial Investigation
Volume I - Text, Tables, Figures

December 2002

10041002

502757

Remedial Investigation Report

CDM

1331 17th Street, Suite 1050
Denver, Colorado 80202
tel: 303 295-1237
fax: 303 295-1895

ENVIRONMENTAL
PROTECTION AGENCY

JAN 3 2003

MONTANA OFFICE

December 31, 2002

Mr. Mike Bishop
Remedial Project Manager
U.S. Environmental Protection Agency, Region VIII
301 South Park Avenue
Helena, Montana 59626

Project: Contract No. 68-W5-0022
Work Assignment No. 945-RICO-08K5
DCN: 3282-945-RT-RIRT-16456

Subject: Draft Remedial Investigation Report, Basin Mining Area Superfund Site Operable Unit 2, Jefferson, County Montana

Dear Mr. Bishop:

CDM Federal Programs Corporation (CDM) is please to submit two copies of the above-referenced document. The report consist of two volumes. Volume I is the text, tables, figures, and plates. Volume II will be transmitted under separate cover. It consists of Appendices A, B, C, D, E & F.

Copies of this document will be transmitted to the Stakeholder Group upon your approval.

If you have any questions regarding this information, please contact me in Denver at 720-264-1104.

Very truly yours,

Clinton S. Werden
Project Manager
CDM Federal Programs Corporation

Enclosure

cc: B. Rennick, CDM Federal, Helena
DCN

RESPONSE ACTION CONTRACT
FOR REMEDIAL, ENFORCEMENT OVERSIGHT, AND NON-TIME CRITICAL REMOVAL ACTIVITIES AT SITES OF RELEASE OR THREATENED RELEASE OF HAZARDOUS SUBSTANCES IN EPA REGION VIII

U. S. EPA Contract No. 68-W5-0022

Draft Remedial Investigation Report
Basin Mining Area Superfund Site
Operable Unit 2
Jefferson County, Montana

Volume I
(Text, Tables, Figures and Plates)

December 31, 2002

Work Assignment No.: 945-RICO-081Y
Document Control No.: 3282-945-RT-RIRT-16456

Prepared for:

U. S. Environmental Protection Agency
Region VIII
301 South Park Avenue
Helena, Montana 59626

Prepared by:

CDM Federal Programs Corporation
1331 17th Street, Suite 1050
Denver, Colorado 80202

This page intentionally left blank.

Contents

Contents

Executive Summary

Section 1 Introduction

1.1 Purpose of Report 1-1
1.2 Site Description and Background 1-2
1.2.1 Site Location and Physical Setting 1-2
1.2.2 Site History 1-3
1.3 Report Organization 1-4

Section 2 Remedial Investigation Methodology

2.1 Investigation Objectives 2-1
2.1.1 Data Quality Objectives 2-1
2.1.2 Data Usability Evaluation 2-2
2.2 Previous Investigations 2-2
2.2.1 State of Montana Studies 2-3
2.2.2 U.S. Forest Service Studies 2-4
2.2.3 Bureau of Land Management Studies 2-5
2.2.4 U.S. Geological Survey Studies 2-6
2.2.5 Reclamation Activities 2-6
2.3 Optimizing Characterization of Study Area 2-7
2.3.1 Boulder River AOC Subareas 2-7
2.3.2 Basin Creek AOC Subareas 2-7
2.3.3 Cataract Creek AOC Subareas 2-9
2.3.4 Mine Site Ranking Based on Historical Data 2-10
2.4 EPA Fall 2001 Field Activities 2-10
2.4.1 Mine Site Reconnaissance and Waste Investigation 2-11
2.4.2 Surface Water and Sediment Investigation 2-12
2.4.3 Groundwater/Pore Water Investigation 2-14
2.4.4 Wetland Investigation 2-16
2.4.5 Laboratory Methods and Analysis 2-16
2.4.6 Quality Assurance/Quality Control Summary 2-16
2.5 Coordination with Other Entities 2-18
2.5.1 U.S. Forest Service 2001 Investigation 2-18
2.5.2 U.S. Geological Survey 2001 Investigation 2-19

Section 3 Physical Characteristics of OU2

3.1 Meteorology and Climate 3-1
3.2 Geology 3-2

3.3 Soil 3-3
3.4 Surface Water Hydrology 3-4
3.5 Hydrogeology 3-5
3.6 Demography and Land Use 3-6
3.7 Ecology 3-7
3.8 Site Conceptual Model 3-7
3.8.1 Mining Waste 3-8
3.8.2 Acid Mine Drainage/Acid Rock Drainage 3-8
3.8.3 Contaminated Stream Sediments 3-8
3.8.4 Contaminated Surface Water 3-9
3.8.5 Contaminated Groundwater 3-9
3.8.6 Contaminant Release Process 3-9
3.8.7 Mobilization of Contaminants 3-10

Section 4 COC Selection and RI Data Interpretation

4.1 COC Selection Summary 4-1
4.2 Data Interpretation Approach 4-1
4.2.1 Surface Water and Sediment Data Interpretation Approach 4-2
4.2.2 Mine Waste, Soil, Groundwater and Adit Discharge Data Interpretation Approach 4-3
4.3 Baseline Comparative Evaluation 4-3

Section 5 Nature and Extent of COPCs in the Boulder River Area of Concern

5.1 Overview 5-1
5.2 Boulder River Flow Characteristics 5-1
5.3 Boulder River Surface Water Quality 5-2
5.3.1 Non-Storm Surface Water Quality 5-3
5.3.2 Storm Surface Water Quality 5-4
5.4 Boulder River Basin Sediment Quality 5-6
5.5 COCs at Mine Sites in the Boulder AOC 5-7
5.5.1 COC Concentrations in Mine Waste Rock 5-7
5.5.2 COC Concentrations in Groundwater Discharge 5-8
5.6 COCs in Groundwater in the Boulder River AOC 5-8
5.7 Boulder River AOC Loads 5-8
5.8 Radiological Conditions at Mine Sites 5-10
5.9 Summary and Conclusions 5-10

Section 6 Nature and Extent of COPCs in the Basin Creek AOC

6.1 Overview 6-1
6.2 Basin Creek Flow Characteristics 6-1

6.3 Basin Creek Surface Water Quality 6-2
6.3.1 Non-Storm Surface Water Quality 6-2
6.3.2 Storm Surface Water Quality 6-4
6.4 Basin Creek Sediment Quality 6-5
6.5 COCs at Mine Sites in Basin Creek AOC 6-6
6.5.1 Waste Material Characterization 6-6
6.5.2 COCs Concentration in Groundwater Discharge 6-8
6.6 COCs in Groundwater in Basin Creek AOC 6-9
6.7 Basin Creek Loads 6-9
6.8 Radiological Conditions at Mine Sites 6-11
6.9 Summary and Conclusions 6-11

Section 7 Nature and extent of COPCs in the Cataract Creek AOC

7.1 Overview 7-1
7.2 Cataract Creek Flow Characteristics 7-1
7.3 Cataract Creek Surface Water Quality Characteristics 7-2
7.3.1 Non-Storm Surface Water Quality 7-2
7.3.2 Storm Surface Water Quality 7-4
7.4 Cataract Creek Sediment Quality 7-5
7.5 COCs at Mine Sites in Cataract Creek AOC 7-6
7.5.1 Waste Material Characterization 7-6
7.5.2 COCs Concentrations in Groundwater Discharge 7-8
7.6 COCs in Groundwater in Cataract Creek AOC 7-9
7.7 Cataract Creek 7-9
7.8 Radiological Conditions at Mine Sites 7-11
7.9 Summary and Conclusions 7-11

Section 8 Additional Groundwater and Wetland Investigation

8.1 Groundwater Investigation 8-1
8.2 Wetland Investigation 8-1
8.3 GSI and Pore Water Sampling Methods 8-1
8.4 GSI and Pore Water Sampling Results 8-2
8.4.1 GSI Sampling Result Interpretation 8-2
8.4.2 Pore Water Sampling Result Interpretation 8-2
8.5 Wetland Sampling Results 8-3

Section 9 Contaminant Fate and Transport

9.1 Fate Processes 9-1
9.2 Transport Mechanisms 9-1
9.3 Physical and Chemical Properties of the Site COCs 9-2
9.3.1 Physical and Chemical Properties of Cadmium 9-2

9.3.2 Physical and Chemical Properties of Copper 9-2
9.3.3 Physical and Chemical Properties of Mercury 9-3
9.3.4 Physical and Chemical Properties of Lead 9-4
9.3.5 Physical and Chemical Properties of Zinc 9-5

Section 10 Summary of Risk Assessment

10.1 Ecological Risk Assessment Summary 10-1
10.1.1 Components of the SERA 10-1
10.1.2 Screening-Level Exposure Estimate and Risk Estimation .. 10-4
10.1.3 Baseline Ecological Risk Assessment Summary 10-5
10.1.3.1 BERA Rationale 10-5
10.1.3.2 BERA Problem Formulation 10-5
10.1.3.3 Exposure Characterization 10-9
10.1.3.4 Ecological Effects Assessment 10-10
10.1.3.5 Risk Characterization 10-13
10.1.3.6 Risk Summary 10-14
10.1.3.7 Uncertainty Analysis 10-16
10.1.3.8 ERA Conclusions 10-17
10.1.3.9 Biomonitoring Program to Support the ERA ... 10-19
10.2 Human Health Risk Assessment Summary 10-20
10.2.1 Summary of Risk Characterization in Town of Basin OU1 10-21
10.2.1.1 Site Data Evaluation 10-21
10.2.1.2 Exposure Assessment 10-21
10.2.1.3 Toxicity Assessment 10-23
10.2.1.4 Risk Characterization 10-23
10.2.1.5 Risk-Based PRGs 10-24
10.2.2 Summary of Risk Characterization in Upper Ten Mile Creek 10-25
10.2.2.1 Site Data Evaluation 10-25
10.2.2.2 Chemicals of Potential Concern 10-26
10.2.2.3 Exposure Pathways 10-26
10.2.2.4 Summary of Risks and Hazards 10-26
10.2.2.5 Risk Based Preliminary Remediation Goals 10-29
10.2.3 Summary of PRGs for Basin Watershed OU2 10-29

Section 11 Summary and Conclusions

11.1 Data Interpretation 11-1
11.2 Basin Watershed OU2 Summary of COC Nature and Extent 11-3
11.2.1 Boulder River AOC Nature and Extent 11-3
11.2.2 Basin Creek AOC Nature and Extent 11-4
11.2.3 Cataract Creek AOC Nature and Extent 11-6
11.3 Basin Watershed OU2 COC Water Source Ranking 11-7

11.4 Uncertainty 11-8
11.5 Conclusions 11-9

Section 12 References

Appendices

Appendix A Historical Data Report Summary
Appendix B Mine Site Evaluation Forms
Appendix C Field Equipment Calibration Records
Appendix D Data Validation and Evaluation Summaries
Appendix E Descriptions of Fate and Transport Processes
Appendix F Basin Watershed OU2 Database Printout and CD-ROM

Figures

1.2-1 Site Location
1.2-2 Site Map

2.1-1 Site Subareas
2.4-1 Priority Mine Site Selection Scheme

3.1-1 Environmental Monitoring Station Locations
3.8.1 Site Conceptual Model
3.8.2 Site Photograph - Adit Discharge
3.8-3 Site Photograph -Waste Piles
3.8-4 Site Photograph - Former Mine Structures
3.8-5 Site Photograph - Stream-side Tailings

4.1-1 Historical Stream Flow Mean Daily Values - Boulder River

5.3-1 COCs that Exceeded Ecological Benchmarks in the Boulder River Historically
5.3-2 COCs that Exceeded Human Health Benchmarks in the Boulder River Historically
5.3-3 COCs that Exceeded Ecological and Human Health Benchmarks in the Boulder River in Spring/Summer of 2001
5.3-4 COCs that Exceeded Ecological and Human Health Benchmarks in the Boulder River in Fall of 2001
5.3-5 Sulfate Concentrations in the Boulder River Historically
5.3-6 Sulfate Concentrations in the Boulder River in 2001
5.3-7 COCs that Exceeded Ecological and Human Health Benchmarks in the Boulder River during September 6, 2001 Storm
5.3-8 Sulfate Concentrations in the Boulder River during September 6, 2001
5.4-1 COCs that Exceeded Ecological Benchmarks in the Boulder River Sediment Historically
5.4-2 COCs that Exceeded Ecological Benchmarks in the Boulder River Sediments in 2001
5.7-1 Historical Combined Dissolved COCs Load in the Boulder River
5.7-2 Historical Combined Total COCs Load in the Boulder River
5.7-3 Spring/Summer and Fall 2001 Combined Dissolved COCs Load in the Boulder River
5.7-4 Spring/Summer and Fall 2001 Combined Total COCs Load in the Boulder River
5.9-1 Relative Zinc Concentration Ratios in Surface Water and Sediment Between Reaches in Boulder River During Non-Storm and Storm Flow Conditions

6.3-1 Historical Locations Along Basin Creek Where COCs Exceeded Ecological Benchmarks
6.3-2 Historical Locations Along Basin Creek Where COCs Exceeded Human Health Benchmarks
6.3-3 Locations Along Basin Creek Where COCs Exceeded Ecological and Human Health Benchmarks Based on 2001 Fall Low-Flow
6.3-4 Historical Sulfate Concentrations Along Basin Creek
6.3-5 Fall 2001 Sulfate Concentrations Along Basin Creek
6.3-6 Locations Along Basin Creek Where COCs Exceeded Ecological and Human Health Benchmarks During Fall 2001 Storm High-Flow
6.3-7 Fall 2001 Storm High-Flow Sulfate Concentrations Along Basin Creek
6.4-1 Fall 2001 Locations Along Basin Creek Where COCs in Sediment Exceeded Ecological Benchmarks
6.7-1 Historical Combined Dissolved COCs Load in the Basin Creek
6.7-2 Historical Combined Total COCs Load in the Basin Creek
6.7-3 Spring/Summer and Fall 2001 Combined Dissolved COCs Load in the Basin Creek
6.7-4 Spring/Summer and Fall 2001 Combined Total COCs Load in the Basin Creek

7.3-1 Historical Locations Along Cataract Creek Where COCs Exceeded Ecological Benchmarks
7.3-2 Historical Locations Along Cataract Creek Where COPCs Exceeded Human Health Benchmarks
7.3-3 Locations Along Cataract Creek Where COCs Exceeded Ecological and Human Health Benchmarks Based on 2001 Spring/Summer High-Flow
7.3-4 Locations Along Cataract Creek Where COCs Exceeded Ecological and Human Health Benchmarks Based on 2001 Fall Low-Flow
7.3-5 Historical Sulfate Concentrations Along Cataract Creek
7.3-6 2001 Sulfate Concentrations Along Cataract Creek
7.3-7 Locations Along Cataract Creek Where COPCs Exceeded Ecological and Human Health Benchmarks During Fall Storm High-Flow
7.3-8 2001 Fall Storm High-Flow Sulfate Concentrations Along Cataract Creek
7.4-1 Historical Locations Along Cataract Creek Where COCs Exceeded Ecological Benchmarks in Sediment
7.4-2 Fall 2001 Locations Along Cataract Creek Where COPCs in Sediment Exceeded Human Health Benchmarks
7.7-1 Historical Combined Dissolved COCs Load in the Cataract Creek
7.7-2 Historical Combined Total COCs Load in the Cataract Creek
7.7-3 Spring/Summer and Fall 2001 Combined Dissolved COCs Load in the Cataract Creek
7.7-4 Spring/Summer and Fall 2001 Combined Total COCs Load in the Cataract Creek AOC

8.1-1 Eva May Tailings Sample Locations
8.2-1 Upper Hattie Fergusson Wetland Sample Locations
8.2-2 Rocker Wetland Sample Locations
8.3-1 Schematic of MicroPush Point Function

10.1-1 Site Conceptual Exposure Model with Major Exposure Pathways

Tables

2.1-1 Summary of Data Quality Objectives for Consideration of Historical and Recent Data
2.1-2 Summary of Data Quality Objectives for Fall 2001 Field Sampling Program
2.2-1 Summary of Historical Data Sources
2.2-2 Mine Sites in Basin Watershed OU2 Investigated by the State of Montana
2.2-3 Mine Sites That Impact Lands Administered by USFS
2.2-4 Mine Sites That Impact Lands Administered by BLM
2.3-1 Historical Mine Site Inventory, Previous Work, and Prioritization
2.4.1 Abandoned Mine Sites Categorized by Vein Groups
2.4-2 Abandoned Mine Sites Selected for Priority Characterization vs Actual Mine Sites Investigated
2.4-3 Fall 2001 Sampling Program Summary
2.4-4 Proposed vs Actual Surface Water and Sediment Sample Analysis
2.4-5 Fall 2001 Sampling Program Quality Control Summary

3.1-1 Climate Summary from SNOTEL Monitoring Stations

4.1-1 Summary of Chemicals of Concern
4.1-2 Ecological Benchmark Levels for Inorganic Constituents
4.1-3 Human Health Benchmark Levels for Inorganic Constituents
4.2-1 Summary of COC Nondetects that Exceeded Ecological and Human Health Benchmarks

5.2-1 Summary of Surface Water Flows in the Boulder River
5.3-1 Surface Water COC Concentrations in Boulder River
5.4-1 Boulder River Sediment Mean COC Results
5.5-1 Summary of COC Concentrations Acid Base Accounting Parameters in Mine Waste in Boulder River AOC
5.5-2 Summary of COC Concentrations in Adits and Seep Discharges at Mine Sites in Boulder River AOC
5.5-3 Boulder River Watershed Mine Sites with Radioactivity in Waste Material
5.6-1 Summary of COC Concentrations in Groundwater in the Boulder River AOC
5.7-1 COC Loads in the Boulder River

6.2-1 Summary of Surface Water Flows in the Basin Creek
6.3-1 Surface Water COC Concentrations in Basin Creek
6.4-1 Basin Creek Sediment Mean COC Results
6.5.1 Summary of COC Concentrations Acid Base Accounting Parameters in Mine Waste in Basin Creek AOC

6.5.2 Summary of COC Concentrations in Adit and Seep discharges at Mine Sites in Basin Creek AOC
6.6-1 Summary of COC Concentrations in Groundwater in the Basin Creek AOC
6.7-1 COC Loads in Basin Creek
6.7-2 Summary of COC Loads from Adits and Seep Discharges in Mine Sites in Basin Creek
6.8-1 Basin Creek AOC Mine Site Radioactivity Levels

7.2-1 Summary of Historical Flows in Cataract Creek
7.3-1 Surface Water COC Concentrations in Cataract Creek
7.4-1 Cataract Creek Sediment Mean COC Results
7.5-1 Summary of COC Concentrations Acid Base Accounting Parameters in Mine Waste in Cataract Creek AOC
7.5-2 Summary of COC Concentrations in Adits and Seep Discharges at Mine Sites in Cataract Creek AOC
7.6-1 Summary of COC Concentrations in Groundwater in the Cataract Creek AOC
7.7-1 COC Loads in Cataract Creek
7.7-2 Summary of Point Source Loads by Mine Sites in Cataract Creek AOC
7.8-1 Cataract Creek AOC Mine Sites Radioactivity Levels

8.4-1 Micro Pushpoint Groundwater/Surface water Interface and Pure Water Sampling Results
8.5-1 Wetland Sampling Results

10.1-1 Selection Process for Chemicals of Potential Concern - Surface Water
10.1-2 Selection Process for Chemicals of Potential Concern - Sediment
10.1-3 Selection Process for Chemicals of Potential Concern - Soil
10.1-4 Toxicity Reference Values for Soil COCs
10.1-5 Toxicity Reference Values for Sediment COCs
10.1-6 Toxicity Reference Values for Surface Water COCs
10.1-7 Complete Exposure Pathways
10.1-8 Assessment and Measurement Endpoints
10.1-9 Summary Statistics of COC Concentration Data for Surface Water
10.1-10 Summary Statistics of COC Concentration Data for Sediment
10.1-11 Summary Statistics of COC Concentration Data for Soil/Solid Material
10.1-12 Hazard Quotients for Surface Water Media
10.1-13 Hazard Quotients for Sediment Media
10.1-14 Hazard Quotients for Soil Media
10.1-15 Estimated Risks (Total Dietary Dose/Ingestion TRV) for Representative Birds and Mammals
10.2-1 Summary of Chemicals of Potential Concern for Town of Basin OU1 and Upper Tenmile Creek

10.2-2 Summary of Town of Basin OU1 and Upper Tenmile Creek Exposure Pathway Analysis
10.2-3 Summary of Cancer and Noncancer Risk Estimates for Town of Basin OU1 and Upper Tenmile Creek
10.2-4 Risk-Based Preliminary Remediation Goals[a] for Receptors of Concern Exposed to Chemical of Potential Concern Through Soil and Interior Dust[b] for Town of Basin OU1
10.2-5 Risk-Based Preliminary Remediation Goals[a] for Residents Exposed to Chemicals of Potential Concern Through Ingestion of Drinking Water for Town of Basin OU1
10.2-6 Risk-Based Preliminary Remediation Goals[a] for Recreationists Exposed to Chemicals of Potential Concern Through Ingestion of Surface Water for Town of Basin OU1
10.2-7 Risk-Based Preliminary Remediation Goals[a] for Recreationists Exposed to Chemicals of Potential Concern Through Ingestion of Sediments for Town of Basin OU1
10.2-8 Risk-Based Preliminary Remediation Goals[a] for Recreational Users Exposed to Chemicals of Potential Concern Through Inhalation of Windblown Particulates from Erosion of Soil for Town of Basin OU1
10-2-9 Risk-Based Preliminary Remediation Goals[a] for Receptors of Concern Exposed to Chemicals of Potential Concern Through Ingestion of Solid Media (Waste Rock, Surface Soil, Interior Dust)[b] for Upper Tenmile Creek Site
10-2-10 Risk-Based Preliminary Remediation Goals[a] for Residents Exposed to Chemicals of Potential Concern Through Ingestion of Drinking Water (Surface Water or Groundwater) for Upper Tenmile Creek Site
10-2-11 Risk-Basked Preliminary Remediation Goals[a] for Residents and Recreational Visitors Exposed to Chemicals of Potential Concern Through Incidental Ingestion of Surface Water (including Adit Discharges and Seeps) During Recreational Activities for Upper Tenmile Creek Site
10-2-12 Risk-Based Preliminary Remediation Goals[a] for Recreational Visitors Exposed to Chemicals of Potential Concern Through Incidental Ingestion of Sediments for Upper Tenmile Creek Site
10-2-13 Risk-Based Preliminary Remediation Goals[a] for Receptors of Concern Exposed to Chemicals of Potential Concern Through Inhalation of Windblown Particulates from Erosion of Soil for Upper Tenmile Creek Site

11.3-1 Summary of Mine Sites by Potential To Impact the Environment

Plates

1-1 Documented Historic Mine Site Locations

2-1 Historical Sample Locations by Federal and State Agencies
2-2 Fall 2001 Sample Locations

3-1 Regional Geology and Vein Trends

6-1 Relative Concentration Ratios for Zinc in Basin Creek Surface Water and Sediment During Non-Storm and Storm Flow Conditions

7-1 Relative Concentration Ratios for Zinc in Cataract Creek Surface Water and Sediment During Non-Storm and Storm Flow Conditions

10-1 Distribution of Risk Based on Hazard Quotients for Surface Water and Sediment
10-2 Arsenic in Surface Soils Compared to Human Health Central Tendency Exposure (CTE) Concentrations

11-1 Mine Site Categorization of Relative Potential Impacts to OU2 Compared to Surface Water and Sediment HQs
11-2 Mine Site Categorization of Relative Potential Impacts to OU2 Compared to Surface Water and Sediment Quality in Boulder River
11-3 Mine Site Categorization of Relative Potential Impacts to OU2 Compared to Surface Water and Sediment Quality in Basin Creek
11-4 Mine Site Categorization of Relative Potential Impacts to OU2 Compared to Surface Water and Sediment Quality in Cataract Creek

Acronyms

AA	atomic adsorption
ABA	acid-base accounting
AES	atomic emission spectroscopy
AIMSS	Abandoned and Inactive Mines Scoring System
AMD	acid mine drainage
AML	Abandoned Mine Lands (USGS Initiative)
AMRB	Abandoned Mines and Reclamation Bureau
amsl	above mean sea level
AOC	Administrative Order on Consent
ARD	acid-rock drainage
ARM	Administrative Rules of Montana
ASTM	American Standards for Testing and Materials
BAF	bioaccumulation factor
Basin Watershed OU2	Basin Mining Area Watershed Operable Unit 2
BERA	baseline ecological risk assessment
BLM	Bureau of Land Management
CDM	CDM Federal Programs Corporation
CEC	cation exchange capacity
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CERCLIS	CERCLA Information System
cfs	cubic feet per second
CLP	Contract Laboratory Program
COCs	chemicals of concern
COPCs	chemicals of potential concern
cy	cubic yard
DEQ	Department of Environmental Quality
DQOs	data quality objectives
EE/CA	engineering evaluation/cost analysis
EPA	U.S. Environmental Protection Agency
FS	feasibility study
FeS	pyrite (iron sulfide)
FSP	field sampling plan
gpd/ft	gallons per day per foot
gpm	gallons per minute
GSI	groundwater/surface water interface
GWIC	Groundwater Information Center

HASL	Health and Safety Laboratories
HASP	health and safety plan
HCl	hydrochloric acid
HHRA	human health risk assessment
HQ	hazard quotient
ICP	inductively coupled plasma
$CaCO_3$/1000t	kilograms of calcium carbonate per 1000 tons
$CaCO_3$/L	calcium carbonate per liter
lbs/day	pounds per day
LOAEC	low affects exposure concentration
MBMG	Montana Bureau of Mines and Geology
MDEQ	Montana Department of Environmental Quality
MDFWP	Montana Department of Fish, Wildlife, and Parks
MHE	Mark Henry Equipment
mg/L	milligrams per liter
mg/kg	milligrams per kilogram
ml	milliliter
mR/hr	millirems per hour
MS	mass spectroscopy
NAP	net acid potential
NCP	National Oil and Hazardous Substances Continency Plan
NOAEC	no affects exposure concentration
NPL	National Priorities List
NRCS	Natural Resources Conservation Service
OES	optical emission spectroscopy
OU	operable unit
PAs	preliminary assessments
PbS	galena (lead sulfide)
Pioneer	Pioneer Technical Services, Inc.
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
QC	quality control
RAC	response action contract
RD	remedial design
rfd	reference dose

RI	remedial investigation
RIA	radioimmunoassay
ROD	record of decision
RPM	remedial project manager
RTI	Renewable Technologies, Inc.
SAP	sampling and analysis plan
SCEM	site conceptual exposure model
SCM	site conceptual model
SERA	screening level ecological risk assessment
SNOTEL	snowpack telemetry system
SPLP	synthetic precipitation leaching procedure
STL	Severn Trent Laboratories
SU	standard units
TAL	Target Analyte List Metals
TBE	to be evaluated
TDS	total dissolved solids
TMDL	total maximum daily load
TRV	toxicological reference value
TSS	total suspended solids
ug/l	micrograms per liter
ULSA	unique laboratory sample analysis
USC	United States Code
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USGS	United States Geological Survey
WRCC	Western Region Climate Center
XRF	X-ray fluorescence
ZnS	sphalerite (zinc sulfice)
°C	degrees Celsius
°F	degrees Fahrenheit
%	percent
95 UCL	95% upper confidence limit of the mean

This page intentionally left blank.

Executive Summary

Executive Summary

Introduction

This Remedial Investigation (RI) Report for the Basin Mining Area Watershed Operable Unit 2 (Basin Watershed OU2) was prepared for the U.S. Environmental Protection Agency (EPA) Region VIII under work assignment under work assignment 945-RICO-081Y of EPA's response action contract (RAC) 68-W5-0022 by CDM Federal Programs Corporation (CDM). Basin Watershed OU2 is a subbasin within the Boulder River watershed located in the northern portion of Jefferson County, Montana (Figure 1.2-1).

Mining activities in the Basin Watershed OU2 commenced in the late 1800s with placer operations in the Basin Creek and Cataract Creek watersheds during the early 1860s, and continued intermittently into the 1960s. Mining was most active during the 1890s and early twentieth century. Placer mining activity continued during the first half of the twentieth century and again during the depression of the 1930s. Subsurface mining continued up until the 1960s when the Crystal mine ended production; however, the majority of minerals were mined prior to 1920. Between 1902 and the 1957 the Basin Mining District produced minerals worth an estimated $11,700,309 (MBMG 1960).

Objective

The EPA is conducting a remedial investigation/feasibility study (RI/FS) for Basin Watershed OU2 to (1) determine the nature and extent of impacts to the environment caused by historical abandoned mining-related waste materials; (2) determine the potential threat to human health, ecological receptors, and the environment by the continued presence and release of these materials to the environment; and (3) gather sufficient information to evaluate the potential remedial action alternatives.

This RI report was prepared based on data collected in 2001 and historical data collected by various agencies, and presents the nature and extent of releases of metals/metalloids and low pH water from abandoned mines and mine wastes within OU2. The RI also defines which abandoned mines impact surface water and sediment the most, and which abandoned mines present the most risk to human health and the environment.

Site Description

Basin Watershed OU2 covers an area of 77.2 square miles within the Boulder River watershed located in the Beaverhead-Deerlodge National Forest and in the northern portion of Jefferson County, Montana (Figure 1.2-1). OU2 includes eight miles of the Boulder River (along the southern boundary) and the entire Basin Creek and Cataract Creek watersheds (Figure 1.2-2). From the Boulder River and Interstate 15, OU2 extends northeast to the drainage divide between the Upper Tenmile Creek watershed and OU2, and northwest to the drainage divide between Little Blackfoot

and Ontario watersheds and OU2. High Ore Creek watershed and Red Rock Creek watershed bound OU2 to the east and west, respectively. OU2 excludes the Town of Basin within the town limits because it is being addressed separately under the Superfund program (i.e., as OU1) (CDM 2000a). Basin Watershed OU2 was proposed for addition to the Superfund National Priorities List (NPL) on October 22, 1999 because of abandoned mine-related problems within OU2 and mining waste in the Town of Basin (OU1) (EPA 1999).

Basin Watershed OU2 is mountainous with high and sharp relief, and contains successions of distinct mountain ranges and valleys. Most of the area is covered with forest dominated by lodgepole pine, subalpine fir, Douglas fir, spruce, aspen, and common juniper. A variety of grasses, shrubs, and small trees, described above, are commonly found along creek banks and in open areas. Elevations within OU2 range from approximately 5,000 feet above mean sea level (amsl) along the Boulder River to a maximum of 8,752 feet amsl on Jack Mountain. Rocker Peak and Three Brothers are also above 8,000 feet in elevation. Glaciation was the predominant factor shaping the existing land forms and glacial features cover more than half of OU2, which include cirque basins and moraine deposits, colluvial deposits, terraces, and floodplains. Bedrock underlying the glacial material consists mainly of Cretaceous-age intrusive rocks (U.S. Department of Agriculture [USDA] 1989).

Basin Creek to the west and Cataract Creek to the east transect OU2 in a north-south orientation. Both creeks flow south and discharge to the Boulder River within 1 mile of each other (Figure 1.2-2). From their headwaters, Basin Creek flows approximately 17 miles to the Boulder River, while Cataract Creek flows approximately 13 miles. About 30 named and unnamed tributaries drain to Basin Creek and about 22 drain to Cataract Creek. These surface waters are typically characterized as high-gradient to low-gradient, cold water streams with abundant riffles, shallow pools, and isolated wetlands. Isolated wetlands typically occur in and along creek floodplains. Substrates are most commonly comprised of sand, gravel, and cobbles.

More than 300 abandoned hard rock mines exist within OU2, which are the focus of this RI (Plate 1-1). The Basin Creek Mine and the associated Luttrell Repository, a landfill developed for disposal of local mining waste, exist on the northern OU2 boundary between the Basin Watershed OU2 and Upper Tenmile Creek watershed. This RI does not address either of these areas because the Basin Creek Mine is the subject of separate reclamation requirements under its past operating permit issued and overseen by the Montana Department of Environmental Quality (MDEQ). However, other abandoned mines located on this property, but unrelated to Basin Creek Mine operations have been evaluated. EPA and the U.S. Forest Service (USFS) secured the Luttrell Repository as a joint repository to dispose of mining wastes removed from the area. The repository is operational and managed by EPA.

Previous Investigations

A number of state and federal agencies have performed chemical and physical characterization studies within the boundaries of OU2 (Plate 2-1). These studies were typically focused on mine site- or stream-specific evaluation objectives. Available data included, but was not limited to, (1) pre- and post-mining topographic maps; (2) surface water and sediment quality data; (3) groundwater quality, well location, and depth to water data; (4) tailings, waste rock, and soil geochemistry data; (5) historical and recent surface water flow data; (6) subsurface lithologic data; (7) climatological data; and (8) historic and recent aerial photographs.

Agencies that have performed investigations include: the Montana Department of State Lands/Abandoned Mine and Reclamation Bureau (AMRB), the Montana Bureau of Mines and Geology (MBMG) for Region 1 of the USFS and the Bureau of Land Management (BLM), and the U.S. Geological Survey (USGS). A listing of the historical data sources is presented in Table 2.2-1, with a summary details in Appendix A.

Optimizing the Characterization of OU2

To facilitate evaluation of impacts of inorganic constituents and loading of metals/metalloids to the environmental media in Basin Watershed OU2, OU2 was divided into three areas of concern (AOC) that include: (1) Boulder River AOC, (2) Basin Creek AOC, and (3) Cataract Creek AOC.

Each AOC was further subdivided into subareas as presented in Figure 2.1-1.The Boulder River AOC was divided into two subareas for the purposes of this RI, Upper and Lower Boulder River. The Basin Creek AOC was divided into five subareas based on local tributaries and the areas that they drain. These subareas include: (1) Upper Basin Creek, (2) Jack Creek, (3) South Fork, (4) Middle Basin Creek, and (5) Lower Basin Creek (Figure 2.1-1). The Cataract Creek AOC was divided into four subareas based on the tributaries and the areas that they drain. These subareas include: (1) Upper Cataract Creek, (2) Middle Basin Creek, (3) Uncle Sam Gulch, and (4) Lower Basin Creek (Figure 2.1-1).

To interpret the changes in COCs concentrations and loading in surface water, the mainstem portion of the Boulder River, Basin Creek, and Cataract Creek were divided into reaches. The data was divided into seasons of low flow and high flow. The seasons were categorized as follows: (1) winter low-flow months (December, January, February, and March); (2) spring and summer high-flow months (April, May, June, and July); and (3) fall low-flow months (August, September, October, and November).

Constituents of Concern

The constituents of concern (COCs) include metals/metalloids and low pH (Table 4.1-1) present at concentrations potentially harmful to human health and/or aquatic life in surface water, sediment, surface soils, including exposed mine tailings and waste rock, and groundwater. For the selection of COCs in surface water, sediment, soil and

groundwater, concentrations were compared to conservative benchmark concentrations obtained from EPA and the State of Montana rules, regulations and/or guidance, or from the literature as industry-accepted standards, if needed (Tables 4.1-2 and 4.1-3).

The mobilization of COCs is dependent upon several factors, including: (1) chemical reaction rate; (2) rate of surface and subsurface water flow removing inorganic constituents and allowing the reactions to continue towards completion; (3) erosion and transport of soil-bound constituents via storm water runoff and soils/sediment particulate carried by such flow; and (4) uptake and accumulation of inorganic constituents by plants.

Exposure pathways to the COCs for human and ecological receptors are:

Human Health
- Ingestion of metals-laden soil including waste rock or tailings
- Ingestion of metals-laden surface water
- Ingestion of metals-laden groundwater

Aquatic and terrestrial fauna and flora
- Ingestion of dissolved metals in surface water
- Ingestion of plants, soil, and prey with elevated metals
- Exposure to metals-laden sediment and surface water

Inhalation of metals-laden dust can also contribute to overall exposure and possibly adverse effects. However, dust inhalation is considered relatively minor compared to the other pathways identified.

Data Interpretation Approach

The discussions presented herein were primarily based on the Fall 2001 RI sample results. When possible, averages of older historical data were used to supplement the most recent data. Often, there were fewer data points available then preferred to make nature and extent interpretations. As a result, even in instances when the number of data for a location were not sufficient to provide a high level of confidence in the minimum, maximum, mean values, the results measured were still used and assumed representative for that particular station in Basin Watershed OU2. Further, these data are used to make conclusions.

Existing data from the aforementioned agencies were evaluated with respect to quality control procedures to determine data usability and comparability. The data were categorized as unrestricted use, screening-level, and rejected data. No historical data were rejected, and all data were considered in this RI. All Fall 2001 RI sample results were either validated or evaluated for usability. Data qualified as rejected ® qualifier) were considered unusable. All other data were considered to be valid and acceptable, including those analytes that have been qualified as estimated (J qualifier).

For the data interpretation, all detected values were used. For nondetected results, those with reporting limit values below benchmarks were used. In these cases, the value of the reporting limit was used as the concentration value. Analytical results reported as nondetected with a reporting limit greater than its respective benchmark value were not used in these evaluation to prevent making conclusions that constituent concentrations are above the benchmarks or action levels, when, in fact, the values of the constituents could be below the benchmark or action levels.

Aqueous dissolved concentrations were compared against ecological risk based standards, while total values were compared against human risk based standards. For solid media, detected and usable nondetected (total concentrations) were compared against ecological and human health risk based standards.

A review of the historical surface water and sediment data established that the 1996 to 2000 data consisted of the most comprehensive results (i.e., spatially and temporally). Historical data were only used to support conclusions where needed and to evaluate concentration changes over the length of the stream reaches. Pre-1996 data were not used in interpreting changes in concentrations and loading. The interpretation of mine waste materials (soil, adit discharge, and groundwater data) was not limited to 1996 to 2000. Instead, the evaluations were performed using all available data because of the limited number of historical samples in the database.

Site Conceptual Model

A site conceptual model (SCM) has been developed to describe the dynamic interrelationships between soil/mine waste, sediment, surface water, and groundwater, as well as potential ecological and human receptors in OU2. Figure 3.8-1 presents a schematic overview of the systems that exist in OU2. The elements illustrate the site conditions, common activities, historic impacts to the system, and potential receptors.

Over 300 abandoned mine and ore processing sites have been identified within the Basin Watershed OU2. Most (over 95 percent) of these sites are underground hard rock mines where ore and waste rock extraction occurred. These mine sites are listed in Table 2.3-1 with locations shown in Plate 1-1. A typical mine site consists of one or more adits (i.e., horizontal passageways) or shafts (i.e., vertical passageways), one or more waste rock piles (usually white/yellow to light green or reddish-brown in color), and occasional structural debris (Figures 3.8-2 through 3.8-4 [photographs]).

Mining Waste

Solid mining wastes in OU2 consist of waste rock and tailings material (Figure 3.8-1). Waste piles are typically located close to an adit or shaft, and they consist of a variety of sizes of rock fragments to sand- and silt-sized material. Waste piles vary in size and areal footprint. Generally, waste piles are devoid of vegetation, however, some small waste piles may support sparse vegetation. Water seepage from the toe (or downslope edge) of a waste pile may be present. Tailings are solid-matrix waste products from mineral (ore) processing or concentrating operations. Tailings are typically fine-grained material deposited hydraulically in impoundments or settling

ponds (often near surface water), and like waste rock are usually unvegetated (Figure 3.8.5 [photograph]). These materials, when subject to oxygen-rich environments can produce acidic leachate or acid rock drainage (ARD) that can get into surface water and groundwater.

Acid Mine Drainage/Acid Rock Drainage
Acid mine drainage (AMD) is trace-metal-bearing acidic discharge that typically emanates from underground mine workings through adits or shafts. In addition, ARD can be created within tailings and waste rock piles. AMD and ARD can impact surface water quality through contaminant loading and increased acidity. Iron hydroxide staining, evidenced by orange-red precipitate, may occur along the surface water flow path of discharging adits or seeps (Figure 3.8-1).

Contaminated Stream Sediments
Contaminated stream sediments are typically the result of waste rock and tailings releases through erosion. In addition, stream sediment can be contaminated when COCs precipitate out of AMD/ARD-impacted surface water. Likewise, contaminated stream sediments can be a source of contaminant releases to surface water.

Contaminated Surface Water
Surface water quality can be degraded due to releases of contaminants from waste rock, tailings, and AMD/ARD (Figure 3.8-1). Concentrations of contaminants in surface water are highly dependent upon the release mechanisms, stream flow, and water chemistry. Degradation of surface water quality can be more severe during low stream flow conditions if the amount of contaminants released to the stream, from an adit for example, remains relatively constant. However, erosional impacts from waste rock and tailings typically are greatest during storm events or spring runoff when stream flows are also high.

Contaminated Groundwater
Groundwater can become contaminated due to a number of mechanisms (Figure 3.8-1). Trace-metal-bearing water within an underground mine can migrate to adjacent aquifers. Metal-bearing leachate generated from waste rock and tailings can infiltrate the soil and impact groundwater. In addition, contaminated surface water can recharge groundwater aquifers beneath its course. Likewise, contaminated groundwater can surface through springs or seeps and impact surface waters.

Contaminant Release Processes
Basin Watershed OU2 host rock contains many sulfide minerals associated with metal ore deposits, including pyrite (FeS_2), galena (PbS), and sphalerite (ZnS). Several chemical reactions can occur that result in oxidation of sulfide minerals and generate AMD and ARD.

Summary of COC Nature and Extent

Previous and current investigations have documented contamination and risk to human and ecological health throughout the Basin Watershed OU2. In general,

Cataract Creek AOC has been impacted the most by contaminations associated with historical mining, followed by Basin Creek AOC. Although the Boulder River AOC has historical mines impacting site media, it is also the recipient of all surface water discharges and sediment transported form the Cataract Creek and Basin Creek AOCs. The following subsections summarize the conditions in each AOC.

Boulder River AOC

The Boulder River AOC within the Basin Watershed OU2 is the ultimate recipient of all surface water discharges and sediment transport within OU2. Basin Creek, Kleinsmith Gulch, Cataract Creek, High Ore Creek, and Galena Gulch are the major tributaries. Collectively, Basin, High Ore, and Cataract Creeks contributed 92 percent of the inflow to the Boulder River during the Fall 2001 low-flow. Boulder River averages the highest flow of the streams in the Basin Watershed OU2.

The surface water and sediment quality in the upper part of the river, upgradient from the confluence with Kleinsmith Gulch, was generally of acceptable quality with respect to human health and aquatic life benchmarks. Surface water and sediment benchmarks were first exceeded in Reach 2, where Old Basin Millsite, the Jib, and the Attwater (or golf course) tailings are located in close proximity to the river. Sulfate concentrations, as well as the number and concentrations of COCs progressively increased downstream. The largest increase in sulfate and COC concentrations occurred downstream of the confluence with High Ore Creek.

High Ore creek contributed COCs at concentrations up to 298 times the values seen in Reach 1 of Boulder River. Cataract Creek contributed COCs at concentrations as much as 117 times the values seen in Reach 1, and up to 16 times the concentrations seen in Basin Creek. Cataract Creek contributed the largest sulfate and combined COCs loads among the tributaries. Cataract Creek contributed loads up to six times the loads contributed by Basin and High Ore Creeks.

There were 18 mine sites previously identified in proximity to the Boulder River. During the Fall 2001 RI, it was estimated that eight of the 18 sites had been removed by Interstate Highway 15 construction, as there was no visual evidence of mine remnants. Five of the remaining sites (24JF0183, Merry Widow, Montana Central Railroad Ore Bins, 24JF0517, and 24JF0178) were determined to pose little threat to the Boulder River, because of the minimal amount of waste that was present and/or the great distances between the mine and the Boulder River.

The only mines site near the Boulder River with available data for solid waste material are the Old Basin Millsite, the Jib tailings, and the unnamed tailings near the former Attwater Mill (i.e., existing golf course). These sites are located right on the river (Jib Tailings) or within 1000 feet of the Boulder River. The mean COC concentrations in tailings and mine waste materials exceeded the ecological and human health benchmarks for soil. Mercury concentrations exceeded the soil ecological benchmarks. The ABA at Old Basin Millsite ranged from -87 to 94.4 metric tons calcium carbonate per metric tons of material (MT $CaCO_3$/1000 MT), indicating that there is the potential for leaching of COCs into surface water and groundwater.

No information was available on adit or seep discharges.

The only flowing adit located during the Fall 2001 investigation was the Merry Widow adit. Water quality at the Merry Widow adit was generally acceptable with respect to the COCs, although arsenic was above its human health screening level (Table 5.5-2). Groundwater data near the Boulder River evaluated in this RI included historical data from nine groundwater wells (Table 5.6-1). The groundwater data showed no exceedences of benchmarks.

Based on comparison to conservative benchmarks, the surface water, sediment and soil in the Boulder River AOC are adversely impacted by the remnants of historical mining operations, and pose risk to human and environmental receptors.

Basin Creek AOC

Basin Creek is a gaining stream with flow characteristics that are consistent with typical mountain stream flows, although portions of Basin Creek lose surface water to groundwater. There are more than 30 tributaries to Basin Creek. Data exist for the Lady Leith, Clear Creek, Jack Creek, South Fork Basin Creek, the Buckeye Mine tributary, Grub Gulch, Jimmy's Creek, Joe Bowers Creek, an unnamed creek, and Saul Haggerty Gulch. Lady Leith, Clear Creek, Jack Creek, and South Fork Basin Creek combined accounted for about 44 percent of the total surface inflows to Basin Creek during the fall 2001 low-flow. Of these tributaries, Jack Creek had the highest flow.

Surface water and sediment quality in the Basin Creek AOC are best with respect to human health and aquatic life benchmarks near Basin Creek headwaters upgradient from the confluence with the Lady Leith tributary and in South Fork Basin Creek. Concentrations of COCs and sulfate increased throughout the length of Basin Creek. Benchmarks are first exceeded in Reach 2 near the Buckeye and Enterprise mines, with the most degradation occurring in Reach 5 as a result of Jack Creek.

South Fork Basin Creek had the lowest COCs and sulfate levels among the tributaries in the Basin Creek AOC, while Jack Creek had the highest COCs and sulfate levels. Basin Creek at the mouth discharges arsenic, cadmium, copper, and zinc above their benchmarks to Boulder River. Sulfate and COCs values at the mouth of Basin Creek were 3, and 2 to 13 times higher, respectively, than sulfate levels near the headwaters at Station S001, indicating impact from ARD/AMD.

There are 86 mine sites that were been identified in the Basin Creek AOC (Table 2.3-1). All of these mine sites had COC concentrations above ecological and human health benchmarks for soil. Grub Creek Station mine had the lowest COC concentrations, while the Magdelena Group, Morning Star, and Meyers Gulch shared the highest COC concentrations. At least 19 of the mine sites in Basin Creek AOC had medium to high ARD potentials (Table 6.5-1). The Bullion, North Ada and the Aurora mines are the ones with the highest potential to produce ARD.

Eighteen mine sites with adits and seeps (i.e., groundwater discharges) have been identified in the Basin Creek AOC (Table 6.5-2). Twelve of these sources were

sampled, and all had COCs at concentrations exceeding human health and ecological benchmarks. The Vindicator, Lady Leith and the Bullion mines had the highest point source flow rates, as well as the highest COC concentrations.

Groundwater data evaluated for the Basin Creek AOC in this RI included data from spring water samples, mine shafts, groundwater wells, and two domestic wells in the Lower Basin Creek Subarea (Table 6.6-1). A spring located in Upper Basin Creek Subarea , about 3000 feet upgradient of the Basin Creek and Jack Creek confluence on the east bank of Basin Creek, had the lowest COC concentrations and only arsenic exceeded its respective benchmark. Jack Creek spring samples had COC concentrations as much as 70 times the concentrations in the Upper Basin Creek spring.

Based on the current benchmarks, surface water, sediment, groundwater and soils contribute to risk to human and environmental receptors in the Basin Creek AOC.

Cataract Creek AOC

Cataract Creek is also gaining stream, with flow characteristics that are consistent with typical mountain stream flows. Only Unnamed 1, Snowdrift Creek, and Uncle Sam Gulch tributaries were sampled in 2001, and combined they accounted for about 70 percent of the total surface inflows to Cataract Creek, with Uncle Sam Gulch and Snowdrift Creek having the highest flows.

Surface water and sediment quality in the Cataract Creek AOC is best with respect to human health and aquatic life benchmarks in Reaches 1 and 2 and in Snowdrift Creek. Concentrations of the COCs and sulfate increased along the length of the Cataract Creek. Benchmarks are first exceeded in Reach 3 near the Apollo mine, with the worst deterioration occurring in Reach 5 due to Uncle Sam Gulch. Unnamed Tributary 6 and Uncle Sam Gulch were the biggest sources of contaminated sediment to the creek, both historically and in 2001.

Snowdrift Creek had the lowest COCs and sulfate levels among the tributaries in Cataract Creek AOC while Uncle Sam Gulch had the highest COCs and sulfate levels. Uncle Sam Gulch tributary exceeded benchmarks for arsenic, cadmium, copper, lead, and zinc by up to 300 times. Sulfate values at the mouth of Cataract Creek were 4 times higher than sulfate levels near the headwaters, indicating impact from ARD. Based on the current benchmarks, surface water and sediment contribute to risk to human and environmental receptors in the Cataract Creek AOC.

There are over 200 mine sites that have been identified in the Cataract Creek AOC (Table 2.3-1). Physical and chemical data are available for 67 of these mine sites, and all of these mine sites had COC concentrations above ecological and human health benchmarks for soil. Vogel mine had the lowest COC concentrations among the mine sites in the AOC, while the Boulder Chief, Boston, Ruth, Eva May, and Black Bear shared the highest COC concentrations. At least 38 of these mine sites had medium to high ARD potentials (Table 7.5-1). The Apollo, Cartwright Cabins and the Clipper/Edna mines are the ones with the highest potential to produce ARD.

Fifty-seven mine sites with adits and seeps have been identified in the Basin Creek AOC (Table 7.5-2). Samples were collected from fifty-three of these mine sites, and all had COCs at concentrations exceeding human and ecological health benchmarks. The Crystal, NE SE Section 14, and the Cracker mines had the highest adit discharge flow rates, as well as the highest COC concentrations.

Groundwater data evaluated for Cataract Creek AOC in this RI included data from a pond located at the Alsace, shafts located at the California, Corbitt, Eldorado and Plateau, Klondyke and Overland Creek, and groundwater well data from wells located at NE NW Section 17, and near the Boulder Vestal (Table 7.6-1). The shaft at California had the lowest COC concentrations, while the highest concentrations were detected in the Klondyke and Eldorado and Plateau shafts, and the NE NW Section 17 groundwater well.

Fish Survivability Tissue Characterization

The USGS recently published a study of survivability, population occurrences, and tissue concentrations in fish from surface water within and near OU2 (USGS 2000). These data are very recent and are not incorporated into the database. Cutthroat trout (hatchery-raised) survival at 96 hours was zero percent at all experimental sites (Upper Jack Creek, Bullion Mine Tributary, Uncle Sam Gulch, Morning Glory Mine Tributary, Upper High Ore Creek, and Lower High Ore Creek) during the 1998 and 1999 experimental test periods, except at Lower High Ore Creek where survival was 33% after 96 hours. During the 1999 experimental test period, fish died with in five and eight hours at the Uncle Sam Gulch and Bullion Mine tributaries, respectively. The relationship between metal concentrations and stress and mortality followed a consistent pattern, with higher concentrations resulting in greater and swifter mortality.

This study provides evidence that elevated concentrations of cadmium, copper, and zinc are capable of causing degraded habitat and mortality of aquatic receptors in the tributaries of Basin Creek, Cataract Creek, and High Ore Creek. Fish populations were documented in the streams (likely because of adaptability to COCs); however, increased survival reportedly will not occur unless the concentrations of cadmium (Cd), copper (Cu), and zinc (Zn) in the surface water are reduced to 3 ug/l Cd, 33 ug/l Cu, and 400 ug/l Zn, respectively.

Human and Ecological Risk Evaluation

A screening-level ecological risk assessment (SERA) has been prepared for OU2, which indicates the need for a baseline ecological risk assessment (BERA). The BERA documented unacceptable risk to environmental receptors. Exposure pathways have been evaluated for human health risk assessment (HHRA), and the calculation of risk and preliminary remediation goals (PRGs) were based on and equal to calculated PRGs for Town of Basin OU1 and Upper Tenmile Creek site. Through the evaluation of the historical data , several risk-related data gaps were identified that need to be addressed to complete the remedial investigation at the Basin Watershed OU2. EPA is committed to completing site-specific biomonitoring as part record of decision

(ROD) for Basin Watershed OU2 to evaluate the potential for both human health and ecological effects associated with exposure to mine wastes in OU2.

Basin Watershed OU2 COC Waste Source Ranking

Of the 300-plus mine sites in Basin Watershed OU2, there are approximately 130 mines with characterization data. An estimated 30 do not exist or were unlocatable during the RI. Based on the mine waste and soil chemical data, every existing mine sites in Basin Watershed OU2 has COC concentration in the waste rock, tailings, and/or adit discharge and seeps that exceeded either ecological or human health screening levels. Because elevated COC concentrations exist at every mine site, as well as naturally throughout Basin Watershed OU2, it is likely unfeasible, and technically unnecessary to address all the mine sites.

Because the characterization effort followed a prioritization schedule, most of the mines designated high priority were evaluated. Therefore, all mine sites with usable data were categorized based potential impact relative to each other.

Mine sites with high ARD/AMD potentials were considered to have a high potential for adverse impact to primarily the environment in Basin Watershed OU2. Mine sites with no ABA information were ranked based on their total zinc concentrations relative to the baseline sites (Vogel and Grub Creek Station), and others were grouped based on similar ore veins mined. Table 11.3-1 presents the mine sites in order of relative potential to impact the environment at the Basin Watershed OU2. Plate 11-1 presents the mine site in order of relative potential to impact the environment combined with the surface water and sediment HQs. Plates 11-2 through 11-4 presents the mine sites in order of relative potential to impact the environment combined with the relative surface water and sediment quality in the streams. The proximity of the mine waste to surface water bodies, estimated waste volumes, and other site specifics concerns will be evaluated in the FS to select the final group of priority sites to address.

Basin Creek AOC

Of the 86 mines that have been identified in Basin Creek AOC, 16 are considered to have a high potential to contribute COCs to the environment and present risk to aquatic and human health (Table 11.3-1). The Buckeye, Lady Leith, Enterprise, Josephine, Bullion, Bullion Smelter, and Daily West mines had the most soil COCs that exceeded screening levels. Of these mines the Buckeye and the Bullion mines had the highest COC concentrations. There are at least 16 additional mines considered to have a medium potential to contribute COCs under the right geochemical and climatic conditions to Basin Creek or its tributaries. A total of 60 mines remain in the AOC with no COC data are available (Table 11.3-1).

Cataract Creek AOC

Of the more than 200 mines that have been identified in Cataract Creek AOC, all had COC concentrations that exceeded either ecological or human health benchmarks. In addition there are 29 mines that are considered to have a high potential to contribute COCs to the environment and present risk to aquatic and human life (Table 11.3-1).

The Crystal mine had the highest COC concentrations among these mines. There are at least 22 additional mines considered to have a medium potential to contribute COCs under the right geochemical and climatic conditions to Cataract Creek or its tributaries. A total of 104 mines remain in the AOC that have no associated COC data (Table 11.3-1).

Boulder River AOC

Of the 11 mines that have been identified in the Boulder River AOC, one had results that exceeded either ecological or human health Benchmarks. The proximity of the Basin Quarry and Jib Mines, and their degree of metals concentrations at the mine indicate that under the right geochemical and climatic conditions these mine can contribute media high in metals concentration to the Boulder River and ground water. There are at least 4 additional mines that under the right geochemical and climatic conditions can contribute mine waste media to the Boulder River, however, no COC data are available for these mines.

Uncertainty

The RI program was structured to collect data that would allow conservative characterization of the Basin Watershed OU2. Although recent and historical data were used to evaluate the Basin Watershed OU2, neither all of the mines, nor all of the surface waters within OU2 were visited or characterized. The nature and extent of contamination in OU2 as presented in this RI is based available data points and interpolated between these points. In an effort to streamline characterization, mine groups were used. There is a potential that all mines in the group are not adequately represented by a single mine sites sample. Finally, because of time and funding limitations, mine site waste materials were typically characterized by one or two samples, when in fact, multiple piles and types of waste were present at a mine site.

Conclusions

Based on a weight-of-evidence approach, multiple lines of evidence support the conclusion that unacceptable risk exist to human and ecological receptors from mining-related wastes within the Basin Watershed OU2. Furthermore, site-specific ecological population diversity, survivability and mortality studies indicate that risks to ecological receptors, primarily aquatic receptors, is far greater than risk to humans, particular under current land uses in OU2. The risks primarily exists within the limits of the drainage channels and mine site boundaries, while impacts and therefore risk to receptors quickly decrease beyond the limits of the drainage channels and mine site boundaries.

Of the 10 subareas in Basin Watershed OU2, Uncle Sam Gulch has the highest degree of impact form historical mining. Jack Creek has the second highest degree of impact from historical mining, followed by a portion of Cataract Creek between Uncle Sam Gulch and Saturday Night hill in Lower Cataract Creek subarea. These three areas in Basin Watershed OU2 with high impacts from historical mining, should be considered of high priority for remedial actions. Middle Cataract Creek, and Upper Basin Creek Subarea have medium to high impacts from historical mining and warrant evaluation for remedial actions, while Lower Basin Creek, Middle Basin

Creek, Boulder River AOC, and Upper Cataract Creek Subareas have lower impacts from historical mining and warrant consideration for remedial actions. South Fork Basin Creek Subarea had the least impact from historical mining, and needs no remedial actions.

This page intentionally left blank.

1 Section One

Section 1
Introduction

This draft remedial investigation (RI) report for the Basin Mining Area Watershed Operable Unit 2 (Basin Watershed OU2 or OU2) has been prepared for the U.S. Environmental Protection Agency (EPA) Region VIII under work assignment 945-RICO-081Y of EPA's response action contract (RAC) 68-W5-0022 by CDM Federal Programs Corporation (CDM).

Basin Watershed OU2 was added to the Superfund National Priorities List (NPL) on October 22, 1999 because of the uncontrolled release of low pH water, and high trace metals and metalloid concentrations in mining waste to the groundwater, surface water, soil, and sediment.

The uncontrolled release of these constituents to the environment occurs in some areas where historical mining left exposed waste rock, tailings, and/or draining mine structures behind. EPA is addressing threats to human and ecological health from these abandoned mining operations under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), also known as Superfund, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Under CERCLA, EPA is required to estimate the level of risk to receptors in OU2 and determine the most appropriate remedy. The CERCLA Information System (CERCLIS) identification number for the Basin Watershed OU2 MTD 982572562.

1.1 Purpose of Report

This report presents the results of the Basin Watershed OU2 RI. The RI was conducted to:

- Determine the nature and extent of releases of metals/metalloids and low pH water from abandoned mines and mine wastes in OU2
- Ascertain which abandoned mines impact surface water and sediment
- Establish which abandoned mines present risk to human health and the environment
- Estimate the level of risk to the receptors
- Complete collection of data necessary for the evaluation and selection of remedial strategies, if needed

1.2 Site Description and Background

This section provides an overview of the physical characteristics of OU2 and a brief history.

1.2.1 Site Location and Physical Setting

Basin Watershed OU2 covers an area of 77.2 square miles within the Boulder River watershed located in the Beaverhead-Deerlodge National Forest and in the northern portion of Jefferson County, Montana (Figure 1.2-1). OU2 includes eight miles of the Boulder River (along the southern boundary) and the entire Basin Creek and Cataract Creek watersheds (Figure 1.2-2). From the Boulder River and Interstate 15, OU2 extends north to the drainage divide between the Upper Tenmile Creek watershed and OU2. High Ore Creek watershed and Red Rock Creek watershed bound OU2 to the east and west, respectively. Basin Watershed OU2 incorporates portions of the Basin, Three Brothers, Mount Thompson, Chessman Reservoir, Bison Mountain, and Thunderbolt Creek U.S. Geological Survey (USGS) 7.5-minute quadrangles. The coordinates of OU2 are contained within 46° 26′ 0″ north latitude, 112° 26′ 0″ west longitude, and 46° 15′ 0″ north latitude, 112° 10′ 0″ west, including portions of Townships 6, 7, and 8 North, Ranges 5, 6, and 7 West (Figure 1.2-2). OU2 excludes the Town of Basin within the town limits because it is being addressed separately under the Superfund program (i.e., as OU1) (CDM 2000a).

Basin Watershed OU2 is located within the Northern Rocky Mountain physiographic province, which is characteristically mountainous with high and sharp relief, and contains successions of distinct mountain ranges and valleys. Elevations within OU2 range from approximately 5,000 feet above mean sea level (amsl) along the Boulder River to a maximum of 8,752 feet amsl on Jack Mountain. Rocker Peak and Three Brothers are also above 8,000 feet in elevation. Most of OU2 lies between 6,000 and 7,500 feet amsl. Glaciation was the predominant factor shaping the existing land forms as well as the development of soil. Glacial features cover more than half of OU2, which include cirque basins and moraine deposits, colluvial deposits, terraces, and floodplains. Bedrock underlying the glacial material consists mainly of Cretaceous-age intrusive rocks (U.S. Department of Agriculture [USDA] 1989).

Physical Setting Details:

- 77 square mile coverage
- Glacial land forms and soil origin
- Mountainous with sharp relief
- 5,000 to 8,700 feet elevation range
- Two major watersheds (Basin Creek and Cataract Creek) with approximately 52 tributaries
- Over 300 abandoned mines

Basin Creek to the west and Cataract Creek to the east transect OU2 in a north-south orientation. Both creeks flow south and discharge to the Boulder River within 1 mile

of each other. Basin Creek flows through the Town of Basin, and its confluence with the Boulder River is upstream and west of Cataract Creek's confluence with Boulder River (Figure 1.2-2). From their headwaters, Basin Creek flows approximately 17 miles to the Boulder River, while Cataract Creek flows approximately 13 miles. About 30 named and unnamed tributaries drain to Basin Creek and about 22 drain to Cataract Creek. These surface waters are typically characterized as high-gradient to low-gradient, cold water streams with abundant riffles, shallow pools, and isolated wetlands. Isolated wetlands typically occur in and along creek floodplains. Substrates are most commonly comprised of sand, gravel, and cobbles.

Most of the area is covered with forest dominated by lodgepole pine, subalpine fir, Douglas fir, spruce, aspen and common juniper. A variety of grasses, shrubs, and small trees, described above, are commonly found along creek banks and in open areas.

More than 300 abandoned hard rock mines exist within OU2, which are the focus of this RI (Plate 1-1). The Basin Creek Mine and the associated Luttrell Repository, a landfill developed for disposal of local mining waste, exist on the northern OU2 boundary between the Basin Watershed OU2 and Upper Tenmile Creek watershed. This RI does not address either of these areas because the Basin Creek Mine is the subject of separate reclamation requirements under its past operating permit issued and overseen by the Montana Department of Environmental Quality (MDEQ). However, other abandoned mines located on this property, but unrelated to Basin Creek Mine operations have been evaluated. EPA and the U.S. Forest Service (USFS) secured the Luttrell Repository as a joint repository to dispose of mining wastes removed from the area. The repository is operational and managed by EPA.

1.2.2 Site History

Mining activities in the Basin Watershed OU2 commenced in the late 1800s and continued intermittently into the 1960s. Mining first occurred in the Basin Creek and Cataract Creek watersheds about 1860 as placer operations. The first lode deposits were discovered in the 1870s, with the Eva May, Uncle Sam, Hattie Ferguson, Bullion, and Hope/Katie Mines being significant discoveries (Renewable Technologies, Inc. [RTI] 2001). Miners explored veins of quartz, tourmaline, pyrite, galena, tetrahedrite, sphalerite, arsenopyrite, chalcopyrite, and siderite within the Boulder Batholith for gold, silver, and copper. Some mineral processing facilities were located within OU2. The tailings wastes generated by these facilities were deposited in settling ponds, which were often near streams.

In 1880, the Town of Basin was settled at the mouth of Basin Creek after moving the initial settlement of cabins located at the confluence of Cataract Creek and the Boulder River. Smelters were later constructed near the town to treat the complex ores rich in gold, lead, zinc, and copper.

Mining was most active during the 1890s and early twentieth century. Placer mining activity continued during the first half of the twentieth century and again during the depression of the 1930s. Subsurface mining continued until the 1960s when the Crystal Mine (Basin Creek watershed) ended production; however, the majority of minerals were mined prior to 1920. Between 1902 and 1957 the Basin Mining District produced minerals worth an estimated value of $11,700,309 (Montana Bureau of Mines and Geology [MBMG 1960]).

1.3 Report Organization

This draft RI report is organized according to the format suggested in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988). It includes 12 sections and six appendices. Section 1 includes the introduction and background details. Section 2 summarizes historical characterization efforts performed within OU2, the identification of general data quality objectives (DQOs), and the activities associated with the Fall 2001 data collection. Section 3 presents the physical characteristics of OU2. Section 4 presents the historical data evaluation, use, and selection of chemicals of concern (COCs). Sections 5, 6, and 7 present the nature and extent of contamination in the Boulder River, Basin Creek, and Cataract Creek areas of concern (AOCs), respectively, as defined by the Fall 2001 and historical data. Section 8 presents an evaluation of groundwater conditions within OU2. Section 9 discusses contaminant fate and transport mechanisms. Section 10 summarizes ecological and human health risks relevant to OU2. Section 11 presents a summary of the findings, proposed extent of remedial action, and recommendations. Section 12 contains all references cited in this report.

Appendices A through E (Volume II) contain backup documentation that support the RI program. Appendix A includes a summary of the historical documents reviewed for this document and a quality control (QC) review of any data presented in the report. Appendix B includes all the site inventory forms, including those prepared by other agencies in previous reports created and/or used in the Fall 2001 site investigation. Appendix C presents data validation and evaluation summaries. Appendix D provides a data summary on CD-ROM, and Appendix E includes specifics of the fate and transport processes discussed in Section 9.

Section Two

Section 2
Remedial Investigation Methodology

This section presents the activities performed in conjunction with the Basin Watershed OU2 RI. The RI uses the watershed approach used by EPA and the USGS in their Abandoned Mine Lands (AML) program. In addition, the RI uses, to the extent possible, focused site characterization efforts performed by other state and federal agencies. This section describes:

- Investigation objectives
- The development of DQOs
- Historical and recent field activities performed
- Methods used to evaluate the historical data used in this RI
- The division of Basin Watershed OU2 AOCs into smaller more manageable subareas (Figure 2.1-1)

2.1 Investigation Objectives

The objectives of this RI were to determine the nature and extent of the release of contaminants from former mining operations within OU2, to ascertain which abandoned mines impact surface water and sediment, and to evaluate risk to human health and ecological receptors. These findings will allow for risk reduction and management decisions within the Basin Watershed OU2.

The goal of the RI was to meet these objectives using EPA's presumptive remedy approach and using historical data to the maximum extent possible, while minimizing new data collection. Under the presumptive approach, planning and decision documents prepared for the adjacent Upper Tenmile Creek Superfund site (located to the north) and approved by EPA are used to streamline the site studies, improve consistency between sites, reduce costs, and expedite risk reduction. This approach was deemed appropriate because the sites are adjacent and share similar environmental characteristics. Both Superfund sites are high elevation AMLs in mountainous watersheds, with similar contaminants of potential concern (COPCs), and with similar terrestrial and aquatic receptors.

2.1.1 Data Quality Objectives

This RI used three iterations of DQOs. First, DQOs were established to evaluate historical data. Because of data gaps, a second set of DQOs was developed for data collection. The third DQO evaluation occurred when the recent data were compared against the initial set of DQOs, as described below.

To meet the RI project objectives, evaluation DQOs were established to determine the usability of historical data and whether or not benchmark toxicity values were exceeded by contaminants in OU2 (Table 2.1-1 without bold). These and all subsequent DQOs were developed in accordance with EPA's seven step DQO process (EPA 2001). The historical data were screened for usability and only those data that met the acceptance criteria were used in the RI. A majority of the historical data were of acceptable quality and, therefore, were used in the Basin Watershed OU2 preliminary RI report (CDM 2001a) and this updated RI report. An overview of the historical data collection programs is presented in Section 2.2.

After evaluation of the historical data using these initial DQOs, it was determined that several contaminants exceeded their respective risk-based benchmark concentration. Also, during the preliminary RI process, areas were identified where insufficient data were available to make RI decisions.

Because of these data gaps, a second set of DQOs (Table 2.1-2) was developed to guide a data collection event. A site-wide field sampling program was conducted during Fall 2001 to minimize these gaps. All samples were collected in accordance with the second set of DQOs.

The recent (Fall 2001) data has been evaluated (1) under the field investigation DQOs (Table 2.1-2) to determine if sufficient data has been collected to complete the RI process and (2) under the original DQOs (Table 2.1-1 with bold text modifications) to assess if any of the recent data exceed risk-based benchmark concentrations. The findings of this evaluation in conjunction with the assessment of the historical data are included in Sections 5 through 7.

2.1.2 Data Usability Evaluation

As part of the initial DQOs, the historical environmental data were evaluated to determine their usability for the RI/Feasibility Study (FS) program for OU2. The primary goal of the usability evaluation process was to maximize use of the historical site data in the RI and FS. Data adequacy and, therefore, usability of the existing environmental data were based on the degree to which the data were generated under a quality assurance/quality control (QA/QC) system that met EPA requirements. All relevant physicochemical data and supportive information collected in the programs described below were reviewed for overall quality and usability in the context of its intended use. This effort was conducted in consultation with the EPA remedial project manager (RPM), and is summarized in the Data Summary and Usability Report (CDM 2001c).

2.2 Previous Investigations

A number of state and federal agencies have performed chemical and physical characterization studies within the boundaries of OU2 (Plate 2-1). These studies were typically focused on mine site- or stream-specific evaluation objectives. To maximize

the understanding of known contaminant (metals/metalloids and low pH water) source areas and the extent of environmental impacts, readily available historical reports and associated data were reviewed. Available data included, but was not limited to, (1) pre- and post-mining topographic maps; (2) surface water and sediment quality data; (3) groundwater quality, well location, and depth to water data; (4) tailings, waste rock, and soil geochemistry data; (5) historical and recent surface water flow data; (6) subsurface lithologic data; (7) climatological data; and (8) historic and recent aerial photographs. A listing of the historical data sources is presented in Table 2.2-1, with a summary details in Appendix A. The following subsections present the participating agency, the characterizations and remedial actions performed, a description of the historical data collected, and specifics of their historical data usability.

Agencies that Studied Portions of OU2:

- State of Montana
- U.S. Forest Service
- Bureau of Land Management
- U.S. Geological Survey

2.2.1 State of Montana Studies

Pioneer Technical Services, Inc. (Pioneer) evaluated environmental conditions at 19 abandoned mine sites for the Department of State Lands/Abandoned Mine Reclamation Bureau (AMRB) in the Basin Creek and Cataract Creek watersheds during 1993, 1994, and 1995 (AMRB/Pioneer 1993, 1994, 1995). The mine complexes that were evaluated during these preliminary assessments (PAs) (but not consistent with CERCLA PA guidance) are presented in Table 2.2-2 and Plate 2-1.

The surveys at each of these mine complexes consisted of an inventory of the existing features, including all identifiable adits, shafts, pits, structures, and waste piles. The adits, shafts, and waste piles were checked for discharge or seeps and evaluated for their potential effect on adjacent surface water (e.g., creeks or streams). The surveys included the collection of surface water (including adit discharge), groundwater, and solid matrix (e.g., sediment and soils) samples. A site sketch was prepared for each mine site that documented relevant site features, sample locations, and roads.

Pioneer evaluated the potential to mitigate acid mine drainage (AMD) at each mine site. This included calculating the area available to treat acidic mine water, the potential to use wetlands, and whether carbonate rock or soil was present (AMRB/Pioneer 1993, 1994, 1995).

Local human and ecological receptors were identified within 200 feet of specific source areas and within 1 mile of each mine site. The location of groundwater wells within a 1-mile radius of each mine site, as well as site accessibility and safety hazards for each mine site were also recorded.

All of the surface water, sediment, and groundwater sample data collected by Pioneer during the PA investigations are maintained in the MDEQ Mine Waste Cleanup Bureau (formerly the AMRB) and the Groundwater Information Center (GWIC) databases. These data were obtained electronically and reviewed to determine if they could be used in the RI.

The AMRB/Pioneer data were collected under a structured program by reputable entities. Most data are post-1990 data (any pre-1990 data are not being used in the RI). Based on a review of the reports, the field collection and analytical methods used by AMRB appear adequate. However, there was no evidence of field or laboratory QA/QC measures or data validation that confirms the precision, accuracy, or validity of the analytical results. Lacking this confidence in quality, these data are considered screening-level quality. In addition, unreconcilable data discrepancies identified between the analytical results maintained electronically in the GWIC database and the associated analytical data tables presented in the Pioneer technical reports supported screening-level classification of the data in the GWIC database. Despite some uncertainty, screening-level quality data are used in the RI because they were not deemed unusable or rejected. Professional judgement should be employed when basing decisions on screening-level data, particularly if they were the only data available for an area.

2.2.2 U.S. Forest Service Studies

Between 1992 and 1994, the MBMG evaluated mine sites in the Upper Missouri River drainage basin for Region 1 of the USFS (MBMG 1994, 1995). This drainage basin includes Basin Watershed OU2. These evaluations were focused on identifying sources of risk to human health and the environment from abandoned mine sites in the Basin Creek and Cataract Creek watersheds that were located on or somehow affected lands administered by USFS in the Beaverhead-Deerlodge National Forest.

A total of 92 mines (35 in Basin Creek watershed and 57 in Cataract Creek watershed) were visited and inventoried (Table 2.2-3 and Plate 2-1). Of those visited, 40 mines (13 along Basin Creek and 27 along Cataract Creek) were determined to pose environmental risk to USFS-administered property. The USFS collected environmental samples at most of the priority mine sites identified in the table. These sites are described in detail in MBMG's Open File Report 321, Volumes I (1994) and II (1995) for Basin Creek and Cataract Creek, respectively (Appendix A). The USFS determined that Basin Watershed OU2 within the Beaverhead-Deerlodge

USFS Conclusions Regarding OU2:

- Highest concentration of mines in southwest Montana
- Favorable conditions for AMD
- Lack of natural buffering
- Environmental impacts from abandoned mines exist
- Mine sites that pose most risk are the Crystal and Boulder Chief
- Jack Creek and Uncle Sam Gulch are the two most significantly impacted drainages

National Forest has the following general characteristics: (1) the highest concentration of mine sites in southwestern Montana and (2) geologic materials that favor production of AMD and lack natural buffering.

The USFS concluded that the Beaverhead-Deerlodge National Forest lands have been impacted by abandoned mines. The two OU2 drainages most significantly impacted by abandoned mine sites are Jack Creek (in the Basin Creek watershed) and Uncle Sam Gulch (in the Cataract Creek watershed).

All of the surface water, sediment, soil, and groundwater sample data collected by MBMG for the USFS during site characterization efforts are maintained in the MBMG database. These data were obtained electronically and reviewed to determine if they could be used in the RI. The USFS data are considered quality data because they adequately meet the quality evaluation criteria. These data were collected under a structured program by reputable entities. The data are post-1990 data. Based on a review of the reports, the field collection and analytical methods used by MBMG appear adequate. There was documentation of field and/or laboratory QA/QC measures that demonstrate precision, accuracy, and/or validity of the analytical results. These data are used in the RI as absolute values within the limits of the DQOs (Section 2.1.1).

2.2.3 Bureau of Land Management Studies

During the fall of 1993, the MBMG evaluated 45 mine sites in the Boulder River watershed for the Bureau of Land Management (BLM) (MBMG 1996). Of the 45 mine sites evaluated, only eight mine sites were located in the Cataract Creek watershed and one mine site was located along the Boulder River. There were no mine sites on BLM lands in the Basin Creek watershed (Table 2.2-4 and Plate 2-1). The MBMG characterization effort focused only on those sites that were located on or affected lands administered by the BLM.

The BLM concluded that only the Mantle mine of the nine mine sites evaluated within OU2 had a potential to impact BLM lands (Table 2.2-4). This mine was not sampled because it was located on private land bordering Cataract Creek. In addition to the Mantle mine, the Redwing and Waldy mines were identified as having characteristics of potential impact, but to a lesser degree. The BLM has conducted an engineering evaluation/cost analysis (EE/CA) for the abandoned Redwing/Waldy mine complex located along Big Limber Gulch, a tributary of lower Cataract Creek (Plate 2-1) (personal communication, M. Browne – Butte BLM Office 2001).

All of the surface water, sediment, soil, and groundwater sample data collected by MBMG for the BLM during site characterization efforts are maintained in the MBMG database. These data were obtained electronically and reviewed to determine if they could be used in the RI. The BLM data are considered quality data because they adequately meet the quality evaluation criteria. These data were collected under a structured program by reputable entities. The data are post-1990 data. Based on a

review of the reports, the field collection and analytical methods used by MBMG appear adequate. There was documentation of field and/or laboratory QA/QC measures that demonstrates precision, accuracy, and/or validity of the analytical results. These data are used in the RI as absolute values within the limits of the DQOs (Section 2.1.1).

2.2.4 U.S. Geological Survey Studies

The USGS is in the later stages of a 5-year AML initiative. The Boulder River basin, which includes the Basin Watershed OU2 (Basin Creek and Cataract Creek) is one of two pilot study areas chosen by the USGS to evaluate abandoned mines and issues related to AMD and its effects on the environment. Numerous investigations have been performed and many publications are available concerning surface water quality and flow characteristics, impacts to soil and sediment, acid-neutralizing potential of bedrock and mine waste, leaching potential of mine wastes, and geophysical surveys of mine sites in the Basin Creek and Cataract Creek watersheds. USGS studies typically focused on priority mine sites, including the Buckeye-Enterprise mine complex in the Basin Creek watershed, the Crystal mine in the Cataract Creek watershed, and surface water throughout OU2 (Plate 2-1). Specific USGS studies reviewed and data used in the preparation of this RI are presented in Appendix A.

All of the surface water, sediment, soil, groundwater, and fish tissue sample data collected by USGS during site characterization efforts are maintained in the USGS database. These data were obtained electronically for use in the RI. Data previously published in USGS reports were used as absolute values. Unpublished data were flagged as conditional, pending USGS validation. All USGS data were determined to be quality data and were used in the RI evaluations (Appendix A).

2.2.5 Reclamation Activities

Reclamation activities within OU2 have been initiated at the Buckeye and Bullion mines, with the removal of waste material and disposal of these spoils at the Luttrell Repository on the northern boundary of OU2 (Figure 2.1-1). The USFS has removed about 11,000 cubic yards (cy) of waste rock material from the portion of the Buckeye mine located on forest service land, while EPA's Superfund Removal Program removed approximately 29,000 cy of material from the private property portion of the mine site. Reclamation activities at the Buckeye mine did not address adit discharges at the mine site that drain to Basin Creek.

EPA performed reclamation activities at the Bullion mine with the removal of approximately 30,000 cy of waste material. EPA also filled in a large excavation near the Crystal mine to reduce local recharge and adit discharge from that mine.

The USFS proposed removal of waste material from its portion of land at the Bullion mine during 2002. The USFS also proposed reclamation efforts at the Hector and Lower Hector mines during 2002.

2.3 Optimizing Characterization of OU2

To facilitate evaluation of impacts of inorganic constituents and loading of metals/metalloids to the environmental media, the Basin Watershed OU2 was divided into three AOCs that include: (1) Boulder River AOC, (2) Basin Creek AOC, and (3) Cataract Creek AOC. Each AOC was further subdivided into subareas as presented in Figure 2.1-1 and discussed in the following subsections.

Basin Watershed OU2 AOCs and Subareas:

- Boulder River AOC- 2 subareas
- Basin Creek AOC- 5 subareas
- Cataract Creek AOC- 4 subareas

2.3.1 Boulder River AOC Subareas

Approximately 8 miles of the Boulder River are included in and comprise the southernmost portion of OU2 (Figure 2.1-1). The Boulder River has been divided into two subareas for the purposes of this RI, Upper and Lower Boulder River. The Upper Boulder River subarea includes a 5-mile segment upstream of the confluence of the Boulder River and High Ore Creek, while the Lower Boulder River subarea includes 3 miles of river downstream of High Ore Creek to the confluence of the Boulder River and Little Galena Gulch. The Upper Boulder River subarea receives surface water from Kleinsmith Gulch, Basin Creek, an unnamed tributary on the north bank east of the Town of Basin, Cataract Creek, three unnamed tributaries east of Cataract Creek, Buttermilk Jim Gulch, and an unnamed tributary east of Buttermilk Jim Gulch. The Lower Boulder River subarea receives flow from High Ore Creek, three unnamed tributaries, Boomerang Gulch, and Galena Gulch (Plate 2-1). The Boulder River subareas contain 25 known mine and mill sites (Table 2.3-1).

2.3.2 Basin Creek AOC Subareas

Basin Creek drains the western portion of OU2, an area of nearly 42 square miles of the Beaverhead-Deerlodge National Forest (Figure 2.1-1). The AOC extends from the Town of Basin, Montana, north to the Continental Divide and the Jefferson, Powell, and Lewis and Clark County lines. The AOC is a watershed that is bounded on the west by Red Rock Creek watershed, by the Upper Tenmile Creek watershed to the northeast, the Little Blackfoot and Ontario watersheds to the northwest, and the Cataract Creek drainage to the east. Basin Creek originates on the western slopes of the Three Brothers peaks at an elevation of approximately 8,200 feet amsl and

Basin Creek AOC Highlights:

- 42 square miles
- 17-mile mainstem creek
- 30 named and unnamed tributaries
- Approximately 15 wetland areas
- Over 100 known mine sites
- 5 subareas for RI evaluation

drops to about 5,320 feet amsl at its confluence with the Boulder River, 17 miles south of its headwaters (Figure 2.1-1).

The Basin Creek AOC has been divided into five subareas based on local tributaries and the areas that they drain. These subareas include: (1) Upper Basin Creek, (2) Jack Creek, (3) South Fork, (4) Middle Basin Creek, and (5) Lower Basin Creek (Figure 2.1-1). Each subarea is described below.

Upper Basin Creek Subarea
The Upper Basin Creek subarea consists of the uppermost headwaters of Basin Creek, Grub Gulch, Clear Creek, Jimmys Creek, Joe Bowers Creek, Elk Gulch, Weasel Gulch, and several small, unnamed tributaries, down to the confluence of Basin Creek and Jack Creek. It comprises the north and northwest portions of the Basin Creek AOC (Figure 2.1-1), and it contains 43 known mine sites (Table 2.3-1). Surface water from this subarea flows into Middle Basin Creek subarea.

Jack Creek Subarea
The Jack Creek subarea consists of Jack Creek and all of the unnamed tributaries that feed Jack Creek down to its confluence with Basin Creek (Figure 2.1-1). The subarea comprises the east-central portion of the Basin Creek AOC, and it contains 23 known mine sites (Table 2.3-1). Surface water from this subarea flows into Middle Basin Creek subarea.

South Fork Subarea
The South Fork subbasin consists of all streams that drain into the South Fork Basin Creek, including Fox Creek and three small, unnamed tributaries, down to the confluence of Basin Creek. This is the westernmost subarea of the Basin Creek AOC. No mine sites are located in this subarea (Figure 2.1-1). Surface water from this subbasin flows into Middle Basin Creek subarea.

Middle Basin Creek Subarea
The Middle Basin Creek subarea consists of the drainages from the confluence of Basin Creek and Jack Creek downstream to the confluence of Basin Creek and an unnamed tributary above Saul Haggerty Gulch. Surface waters within the subarea include the Wood and Vacchieu Gulches and several unnamed tributaries. The subarea is located in the lower central portion of the Basin Creek AOC (Figure 2.1-1), and it contains 4 known mine site. Surface water from Upper Basin Creek, Jack Creek, and South Fork subareas comprise the flow in Basin Creek through this subarea. Surface water leaving this subarea flows into Lower Basin Creek subarea.

Lower Basin Creek Subarea
The Lower Basin Creek subarea is located in the southern portion of the Basin Creek AOC (Figure 2.1-1). This subarea consists of the drainages from the confluence of Basin Creek and an unnamed tributary downstream to the confluence of Basin Creek and the Boulder River. Tributaries to Basin Creek in this subarea include Saul

Haggerty, Lily-of-the-West, Meyers, and Spring Gulches, as well as several unnamed tributaries. Thirty-three known mine sites exist within the Lower Basin Creek subarea (Table 2.3-1). Surface water leaving this subarea flows into the Boulder River, within the Upper Boulder River subarea.

2.3.3 Cataract Creek AOC Subareas

Cataract Creek drains the eastern portion of the Basin Watershed OU2, an area of nearly 34 square miles of the Beaverhead-Deerlodge National Forest (Figure 2.1-1). The AOC extends from the Boulder River approximately 1 mile east of the Town of Basin, north to the Jefferson and Lewis and Clark County lines, and Beaverhead-Deerlodge National Forest boundary. The Basin Creek, Upper Tenmile Creek, Prickly Pear Creek, and High Ore Creek watersheds border the Cataract Creek AOC to the west, north, northeast, and east, respectively (Figure 2.1-1). Cataract Creek originates near the Jefferson County line, along the northern edge of OU2, at an elevation of approximately 7,800 feet amsl and drops to approximately 5,280 feet amsl at its confluence with the Boulder River, 13 miles to the south.

Cataract Creek AOC Highlights:

- 34 square miles
- 13-mile mainstem creek
- 22 named and unnamed tributaries
- Over 150 mine sites
- Approximately 5 wetland areas
- 4 subareas for RI evaluation

The Cataract Creek AOC has been divided into four subareas based on the tributaries and the areas that they drain. These subareas include: (1) Upper Cataract Creek, (2) Middle Basin Creek, (3) Uncle Sam Gulch, and (4) Lower Basin Creek (Figure 2.1-1). Each subarea is described below.

Upper Cataract Creek Subarea

The Upper Cataract Creek subarea is located in the northern portion of the Cataract Creek AOC (Figure 2.1-1). This subarea generally consists of the uppermost headwaters of Cataract Creek, Nellie Grant Creek, Trail Creek, Deep Creek, Overland Creek, Branch Creek, and several small, unnamed tributaries down to the confluence with Rocker Creek. Twenty-four known mine sites exist within Upper Cataract Creek subarea (Table 2.3-1). Surface water from this subarea flows to Middle Cataract Creek subarea.

Middle Cataract Creek Subbasin

The Middle Cataract Creek subarea is located in the east-central portion of the Cataract Creek AOC (Figure 2.1-1). This subarea generally consists of the drainages from the confluence of Cataract Creek and Rocker Creek downstream to the confluence of Cataract Creek and Uncle Sam Gulch, including Snowdrift Creek, Hoodoo Creek, Libby Creek, and several unnamed tributaries. Seventy-six known mine sites exist in the Middle Cataract Creek subarea (Table 2.3-1). Surface water from this subarea flows to Lower Cataract Creek subarea.

Uncle Sam Gulch Subarea
Uncle Sam Gulch subarea is located in the east-central portion of the Cataract Creek AOC between Jack Mountain and Rocker Peak (Figure 2.1-1). This subarea consists of Uncle Sam Gulch and an unnamed tributary to Uncle Sam Gulch down to the confluence of Cataract Creek. Seventeen known mines sites exist in Uncle Sam Gulch subarea (Table 2.3-1). Surface water leaving this subarea flows to Lower Cataract Creek subarea.

Lower Cataract Creek Subarea
Lower Cataract Creek subarea is located in the southern portion of the Cataract Creek AOC (Figure 2.1-1). This subarea consists of the drainages from the confluence of Cataract Creek and Uncle Sam Gulch downstream to the confluence of Cataract Creek and the Boulder River. Tributaries to Cataract Creek in this subarea include Deer Creek, Big Limber Gulch, and several unnamed tributaries. Sixty-five known mine sites exist in the Lower Cataract Creek subarea (Table 2.3-1). Surface water leaving this subarea flows to the Boulder River in the Upper Boulder River subarea.

2.3.4 Mine Site Ranking Based on Historical Data

Existing mine sites within OU2 were ranked according to their estimated impact on the environmental media based on the historical data and on rankings assigned by previous investigations. Table 2.3-1 lists the mine sites with their respective ranking. A high rank was assigned to those mines that were identified as potentially impacting agency properties, and/or were scored by MDEQ using the abandoned and inactive mine scoring system (AIMSS) above 0.1. A medium rank was assigned if the mine was identified as potentially impacting agency properties, and was either not scored using AIMSS or whose AIMSS score was less than 0.1. A low rank was assigned to all other sites not meeting these criteria. The MDEQ scored 21 mine sites with scores ranging from 0.005 to 245.76, of which only three were below 0.1.

The historical ranking information and the existence of historical characterization data were used to focus and streamline the Fall 2001 RI sampling activities as discussed in Section 2.4.

2.4 EPA Fall 2001 Field Activities

This section presents the methods employed during the EPA/CDM Fall 2001 field investigation that was targeted at minimizing RI data gaps. The Fall 2001 field investigation was implemented between August 14, 2001 and October 24, 2001. The field investigation included reconnaissance of abandoned mines; sampling and analysis of soil/waste material, sediment, and surface water; and the collection of various multi-media field measurements. This section also describes deviations from the Basin Watershed OU2 Fall 2001 Sampling and Analysis Plan (SAP) (CDM 2001b), including an additional effort to evaluate the presence of COCs in groundwater and wetlands at selected locations. Plate 2-2 presents the locations of all samples collected

during the Fall 2001 field program, including the mine sites investigated by the USFS and the USGS.

2.4.1 Mine Site Reconnaissance and Waste Investigation

Mine site reconnaissance was initiated with securing private property access. Consent for access requests were sent by certified mail to 330 private mine claim owners within OU2. Many of the private properties had several owners. Permission to access private property was considered approved upon receipt of a signed consent for access card from at least one of the owners. A total of 199 signed access agreements were received for 179 private properties within OU2. Although some private mine claims did not have associated surficial mine workings, approved access often facilitated accessing adjacent mine sites. The boundaries of private property within OU2 are shown on Plate 1-1.

Upon visiting each selected mine site, the field crews verified and updated existing reconnaissance data, or completed a new material inventory site investigation log sheet (Appendix B). Information collected included: site features, RI characterization samples, waste material physical characteristics and dimensions, physical characteristics and flow rates of any seeps or adit discharge, existence of potential recharge areas on and around the mine site, site photographs, site coordinates, and field screening for radiation.

Mine Sites Selected for Reconnaissance and Sampling

To streamline characterization efforts, mine site investigations were focused on a set of target mines selected through a prioritization decision matrix (Figure 2.4-1). Mines were considered similar if they existed in a localized vein group (Table 2.4-1). Table 2.4-2 presents the mines that were selected for sampling, notations of actual sampling, and the types of environmental samples collected, including the sites addressed by the USFS and the BLM.

Prioritization Criteria for Mine Site Evaluation:

- Key mine site features, including draining adit or mill
- Within 500 feet of surface water
- No previous sample data
- Mine site greater than 40,000 square feet
- Similar vein group

Sampling included the collection of soil/waste materials, and seep and adit discharges. Surface and subsurface soil/waste samples were collected from a depth of 0 to 2 inches and 6 to 18 inches from one waste material pile at each mine site determined to be a priority. Selection of the pile to be sampled was performed according to specifications stated in the SAP (CDM 2001b).

A total of 130 mine sites were visited and/or sampled, including 105 of the 180 targeted mine sites plus 25 additional field-selected mine sites. Seventy-five of the targeted sites were not investigated because the property owner denied access, they

were being sampled by the USFS, or they could not be located. Mine sites not characterized during this RI may still be visited and evaluated during the remedial design phase, if deemed necessary, provided additional location information and/or permission for access is obtained.

Mine Site Media Samples Collected
A total of 163 soil/waste samples (83 surface, 80 subsurface) were collected during the Fall 2001 sampling program. Samples were analyzed for target analyte list (TAL) metals, acid-base accounting (ABA), radionuclides, and/or soil paste pH. These analyses are summarized in Table 2.4-3.

A total of 51 adit discharge and seep samples were collected and analyzed for total and dissolved TAL metals, water quality parameters, and/or nutrient analysis (Table 2.4-3). QC samples collected during the Fall 2001 sampling event are discussed in Section 2.4-5.

Mine Site Reconnaissance and Waste Investigation Deviations
The mine site reconnaissance and multi-media sampling were performed according to procedures specified in the Fall 2001 SAP (CDM 2001b). However, one sampling modification was implemented to save time and improve mobility. For waste rock and solid media sampling, the SAP required that the sample material be composited and homogenized in stainless steel bowls prior to placement in sample jars. Stainless steel bowls were not used and, instead, samples were composited and homogenized in disposable, one-gallon, plastic zip-top bags prior to collection. This deviation was made to decrease the decontamination time and minimize decontamination solutions carried by the sampling crews. As noted above, 75 mines proposed for investigation were not sampled for various reasons, while another 25 field-selected mines were assessed during the field investigation as described in Table 2.4-2.

2.4.2 Surface Water and Sediment Investigation

The surface water sampling effort included sample collection at selected locations on the creeks and streams within OU2 to better define areas of potential impacts. Thirty surface water sampling stations were located upstream and downstream of major tributaries to Basin Creek, Cataract Creek, and Boulder River. Co-located surface water and sediment samples were collected at each station. Ten of the stations were also sampled by USGS two weeks earlier. Mutual effort could not be coordinated because of analytical capacity limitations.

Six temporary stream gages were also installed, two on each of the three main streams, to monitor base and storm stream flow heights. The gages on Basin Creek were located upstream of Clay Creek and near (upstream) the confluence of Basin Creek and Boulder River (Plate 2-2). The gages on Cataract Creek were located downstream of the confluences with Uncle Sam Gulch and Big Limber Gulch. The gages on Boulder River were located downstream of its confluences with Basin Creek and Cataract Creek (Plate 2-2). Boulder River real-time stream flow data from USGS

gaging station 06033000 was also monitored using the USGS website (http://water.usgs.gov/mt/nwis/rt). The stream gages were monitored every few days for flow stage during low-flow conditions.

A significant rise in surface water elevation (approximately 0.2 foot) and flow was observed on the evening of September 5, 2001, as a result of a storm. Storm samples were collected the following day, September 6, 2001. Although not measured within OU2, precipitation totaling 0.87 inch was measured in the neighboring town of Boulder, Montana on September 6, 2001 (WRCC 2002).

Surface Water and Sediment Samples Collected

A total of 33 surface water stations across OU2 were sampled during the Fall 2001 RI sampling event, 13 on Basin Creek, 14 on Cataract Creek, and 6 on Boulder River. Seven additional opportunistic surface water samples were collected; one from each of the following locations, Rocker Creek headwaters near Bing Hampton mine, Jack Creek headwaters near First Shot/Last Shot mine, Grub Creek, Clear Creek headwaters near the Josephine mine, and Cataract Creek upstream and downstream of the Apollo mine, and downstream of the Eva May mine. Table 2.4-4 presents the proposed surface water sample locations, the actual locations sampled, and a rationale for those stations that required relocation during the Fall 2001 field program.

Sampling at the above-mentioned stations resulted in a 58 surface water samples (39 low-flow and 19 storm water) analyzed for total and dissolved TAL metals, water quality parameters, and nutrients (Table 2.4-3). Thirty-six "bulk" (minus 10-mesh) sediment samples were collected for TAL metals and seven for ABA analysis as shown in Table 2.4-3. In addition, 27 of those samples were sieved to 80-mesh and four to 260-mesh for TAL metal analysis.

Surface Water and Sediment Investigation Deviations

Surface water and sediment samples were collected according to procedures and analyzed for constituents specified in the Fall 2001 SAP (CDM 2001b). Most of the 30 surface water sampling stations were located at or near their intended location, however, four were significantly moved. Proposed locations for stations 006 and 010 were within private property boundaries, to which, access was denied. Both these stations were moved approximately 8000 feet upgradient on their respective streams to locations outside the private property boundaries (Plate 2-2). Stations 014 and 015 were initially located on Cataract Creek headwater tributaries at the northern edge of Cataract meadows. Both these stations were moved to the northwestern edge of Cataract meadows to evaluate the quality of the headwaters in an area that has more abandoned mine sites (Plate 2-2).

Storm water sampling procedures were performed according to the Fall 2001 SAP (CDM 2001b), except for the flow measurements. Storm flows were measured by dividing the channel widths into larger segments than those used during low-flow measurements. This modification was made to decrease the time required to measure

flow, which allowed for the collection of all storm samples during the rising-stream flow period. Stations 014 and 015 were not sampled during the storm event, as planned in the SAP, because of poor accessibility and the long travel time needed to reach them. Also, the SAP specified for the collection of eight opportunistic storm samples at locations upstream and downstream of four mine sites with wastes in, or in close proximity to, streams to evaluate impacts from erosion. Due to time constraints (i.e., storm duration), only one location was sampled upstream and downstream of the streamside mine waste to evaluate the extent of erosional impacts during storm events.

One deviation was required for sediment samples. The SAP specified that 10 percent (about 10 samples) of the minus 80-mesh size fraction of the sediment samples would be sieved to minus 260-mesh (minus 64-micron) and sent to the Montana Department of Fish, Wildlife, and Parks (MDFWP) for internal evaluation purposes. However, only two minus 260-mesh size sediment samples were submitted to the MDFWP, because the bulk samples collected at each of the surface water stations were relatively devoid of this size sediment.

2.4.3 Groundwater/Pore Water Investigation

Investigation of groundwater was originally not a part of the Fall 2001 RI because of the large aerial extent of OU2 and the very low density of existing groundwater wells throughout OU2. An inexpensive groundwater sampling approach was identified and presented to EPA during the field effort. EPA agreed to add limited groundwater sampling to the Fall 2001 field program. The additional groundwater/pore water sampling included the collection of:

- Groundwater/surface water interface samples
- Pore water sample from one waste piles
- Groundwater samples from two existing wells
- Groundwater samples from flooded mine shafts from selected locations within OU2

A total of 20 groundwater/pore water samples were collected (Table 2.4-3). Sampling of the groundwater/surface water interface and sampling of pore water was achieved using a Micro PushPoint device. The Micro PushPoint is a small diameter (1/4-inch) stainless steel tube with perforations at one end and a sampling port at the other. Sampling of one well was accomplished with a disposable bailer, while the other well (i.e., a spring-fed cistern) was sampled by running its dedicated pump. Flooded shafts were sampled with a Van Dorn horizontal sampler.

Groundwater/Surface Water Interface Sampling

Groundwater/surface water interface samples were used to evaluate the quality of the groundwater that discharges to surface water under base flow conditions. To obtain this sample, the Micro PushPoint was inserted into the subsurface at the edge

of the stream bank. To confirm that the probe was in a location of groundwater discharge into the streams, a clear U-shaped tube was used to compare the groundwater head to the surface water level. Positive hydrostatic head (i.e., groundwater discharge) was reflected by a higher water level in the tube versus the surface water level. A lower water level in the tube was indicative of surface water loss to groundwater. In addition to head measurements, the conductivity of the groundwater extracted from the Micro PushPoint was compared to the conductivity of the surface water. Groundwater typically has a higher conductivity than surface water. For collection, the groundwater was purged slowly with a syringe and peristaltic pump for a minimum of three minutes prior to sample collection. The head was checked during and immediately after purging to confirm that the groundwater discharge conditions were not altered by the intrusion of surface water as a result of over-pumping. A total of six groundwater/surface water interface samples were collected (Table 2.4-3).

Groundwater/surface water interface samples were collected on the downgradient edges of the Eva May tailings, Cataract Tails tailings, Cartwright Cabins waste rock, Rocker Creek wetland, and Upper Hattie Ferguson wetland. A groundwater/surface water interface sample was also collected at a location downgradient from the Eva May site on the opposite stream bank (east bank of Cataract Creek) to evaluate the quality of natural groundwater discharging into the stream.

Mine Waste Pore Water Sampling

Pore water within waste materials was collected to evaluate the water quality contributed to groundwater or surface water. To obtain this sample, the screened end of a Micro PushPoint was inserted into waste material. Pore water was then extracted using peristaltic pump. The pore water was purged slowly for approximately three minutes prior to sample collection. Hydrostatic head in the waste materials compared to adjacent surface water was monitored during and after purging. One pore water sample was collected from the waste rock pile at the Apollo mine.

Groundwater Well Sampling

Only two existing groundwater wells were located within OU2 and sampled. Residential wells within the Town of Basin limits were excluded, as they were considered in the OU1 evaluation. One well/piezometer (i.e., 2-inch diameter polyvinyl chlorine [PVC] pipe placed in an open exploratory mine boring) was located 200 feet south of the Boulder Vestal mine adit, and was sampled with a disposable bailer. The well was not purged as typically required, because of time constraints. Because of likely stagnant conditions, this data should be used as screening-level only. The other well (i.e., a spring-fed cistern) belonged to a local resident living near the top of the watershed. The sample was collected from a spigot on the cistern.

Flooded Shafts Sampling
Flooded shafts were sampled to evaluate groundwater quality in potential recharge areas. The shafts were sampled by sending the Van Dorn horizontal sampler to the bottom of the shaft or as far down as possible. Open shafts were sampled at the Alsace, California, Corbit, Eldorado Plateau, Klondyke, Overland, Saint Lawrence, Dorothy Snow, Josephine, and NE NW Section 17 mine sites.

2.4.4 Wetland Investigation

Wetland investigation was originally not a part of the Fall 2001 investigation. At EPA's request, two wetlands were sampled approximately two weeks after the conclusion of the Fall 2001 sampling event. The addition of this focused investigation was to evaluate the impact of mining waste on selected wetlands within OU2. Two wetlands were sampled, including the Upper Hattie Ferguson and Rocker Creek wetlands. These wetlands were selected based on approved access and their proximity to mine waste. Samples collected from the wetlands include surface and subsurface soil, groundwater, and surface water (Table 2.4-3).

2.4.5 Laboratory Methods and Analysis

Soil/waste and sediment samples were analyzed for total metals by contract laboratory program (CLP) laboratories following ILM 04.0 methodology. In addition, all subsurface samples were also analyzed for ABA by Severn Trent Laboratories (STL; an EPA Unique Laboratory Sample Analysis [ULSA] laboratory) using the Sobek method, EPA 600/2-78-054, as modified by EPA Region VIII. Six waste material samples were analyzed for radiochemical parameters by EPA method 901.1 (gross gamma), SW-846 9310 (gross alpha and beta), and Health and Safety Laboratories (HASL) Method 300 (uranium and thorium) (CDM 2001b).

Aqueous samples were analyzed by STL for TAL metals, total dissolved solids (TDS), total suspended solids (TSS), hardness, common anions, and nutrients. TAL metals were analyzed using SW-846 method 6020 for all but mercury. Mercury was analyzed by SW-846 method 7471A. Common ions, TDS, TSS, and hardness were analyzed by EPA methods 130.2, 160.1, 160.2, and 300.0. The nutrients including ortho-phosphate, nitrate/nitrite, and ammonia were analyzed by EPA methods 365.2, 353.2, and 350.1, respectively.

2.4.6 Quality Assurance/Quality Control Summary

The Fall 2001 field program included a number of QA/QC samples to evaluate precision and representativeness in the field processes. Duplicates of all samples were collected at a frequency of 5 percent of the total samples by medium and analyses. Equipment rinsates consisted of the final rinse water (deionized water) after it had been in contact with a sampling tool, and were also submitted at a frequency of 5 percent of the total samples collected by medium and analyses. A summary of the QC samples (i.e., duplicates, equipment rinse blanks, and filter blanks) collected and analyzed are summarized in Table 2.4-5.

Filter blanks were collected to evaluate the potential for cross contamination during filtering for dissolved analysis. American Standards of Testing and Materials (ASTM) analyte-free water was passed through the filter at neutral pH (i.e., 7) and acidified with hydrochloric acid (HCl) to pH of 3 for each filter lot number.

All field measurement equipment were calibrated daily prior to use. An equipment calibration log was kept for each piece of equipment requiring calibration. If the equipment or instruments could not be maintained to the manufacturer's specifications or could not be properly calibrated, that specific piece of equipment was not used. All equipment calibration logs are presented in Appendix C.

The Fall 2001 laboratory data were validated at a frequency of 10 percent and the remaining 90% were evaluated. The USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (EPA 1994) were used for data evaluation and validation. For the validation, all items presented in the guidelines were reviewed if available in the data packages. A validation report was completed for each data package validation and is presented in Appendix D.

For the 90% evaluation of data, the following were reviewed (where applicable)

- Matrix spike/matrix spike duplicate (MS/MSD) relative percent differences (RPDs)
- Laboratory control sample/laboratory control sample duplicate (LCS/LCSD) RPDs
- Laboratory duplicate RPDs
- MS/MSD percent recoveries (%Rs)
- LCS/LCSD %Rs
- Holding times
- Preservation
- Laboratory preparation blanks

During CDM's data validation/evaluation process, realization qualifiers were assigned to the data using a standardized set of qualifiers. The data qualifiers are defined as follows:

J - The associated value is an estimated quantity.

R - The data are unusable (Note: analyte may or may not be present).

U - The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the detection limit.

UJ - The material was analyzed for, but was not detected. The associated value is an estimate and may be inaccurate or imprecise.

2.5 Coordination with Other Entities

EPA organized and continues to facilitate a stakeholder group to promote involvement of many agencies, organizations, special interest groups, and the general public. Their participation is encouraged through document review and comment periods, and public meetings. The stakeholder group includes:

- Town of Basin residents
- Town of Basin officials
- Jefferson County residents
- Jefferson County officials
- Montana Department of Fish, Wildlife, and Parks
- Montana Department of Natural Resources and Conservation
- Montana Department of Environmental Quality
- Montana Bureau of Mines and Geology
- U.S. Forest Service
- U.S. Bureau of Reclamation
- U.S. Environmental Protection Agency
- U.S. Fish and Wildlife Service
- U.S. Geological Survey

These agencies have been able to identify issues and provide input concerning common goals and objectives, investigation strategies, and remedial strategies for OU2, the Town of Basin site (i.e., OU1), and the Upper Tenmile Creek site to the north of OU2. Of these stakeholders, the USFS and USGS conducted investigations concurrent with the EPA/CDM Fall 2001 investigation. To avoid unnecessary duplication, CDM coordinated its efforts to the extent possible with those performed by the USFS and the USGS.

2.5.1 U.S. Forest Service 2001 Investigation

The USFS in conjunction with the MBMG is characterizing the impact of abandoned mines within the Beaverhead-Deerlodge National Forest. The USFS sampled 12 mine and mill sites located on USFS property that they considered priority for reclamation. These sites include Black Bear, Cracker, Gray Lead, Phantom, Sirius, Daily West, Hector, Lady Leith, Lower Hector, Morning, North Ada, and Vindicator mine sites, the Morning Glory tailings, and the Bullion Smelter .

EPA did not characterize these sites other than the collection of adit discharge samples and one duplicate soil sample (from the Sirius mine) for confirmation purposes. Data collected by the USFS from these sites are used in this RI report.

2.5.2 U.S. Geological Survey 2001 Investigation

The USGS performed annual surface water and sediment sampling two weeks prior to the start of the Fall 2001 field effort, and again during the last week in September during the Fall 2001 field effort. Data collected by the USGS are used in this RI report.

This page is intentionally left blank.

Section Three

Section 3
Physical Characteristics of OU2

This section presents the physical characteristics of the Basin Watershed OU2 based on the review of the historical data and published literature. The discussion includes meteorology and climate, geology, soils, surface water hydrology, hydrogeology, demography and land use, and ecology. This section concludes with a site conceptual model (SCM) of the Basin Watershed OU2.

3.1 Meteorology and Climate

The Basin Watershed OU2 has a continental climate modified by Pacific Ocean air masses. Winters tend to be cold and moist, and summers are warm and dry. Climatic data for OU2 was obtained from the Natural Resources Conservation Service's (NRCS) automated SNOTEL (SNOwpack TELemetry) system. Two SNOTEL weather stations (Basin Creek and Frohner Meadow sites) are located near OU2. A third, the Rocker Peak site, is located on Rocker Peak in the Cataract Creek AOC within OU2 (Figure 3.1-1).

The Basin Creek SNOTEL station, located at latitude 45° 48', longitude 112° 31', at 7,180 feet amsl is southwest of OU2. Temperature data are available for the station from June 1991 through December 2000. These data were used to calculate minimum, maximum, and average temperatures by month. Precipitation data are available from August 1981 through December 2000, and were used to calculate average precipitation by month (Table 3.1-1).

Frohner Meadow, located at latitude 46° 27', longitude 112° 12', at 6,480 feet amsl is northeast of OU2. Temperature data are available for the station from June 1989 though December 2000, and they were used to calculate minimum, maximum, and average temperatures by month. Precipitation data are available from October 1979 through December 2000, and were used to calculate average monthly precipitation (Table 3.1-1).

Rocker Peak, located at latitude 46° 22', longitude 112° 15', at 8,000 feet amsl is within OU2 (Figure 3.1-1). Temperature data are available for the station from February 1984 through December 2000 and were used to calculate minimum, maximum, and average temperatures by month. Precipitation data are available from October 1979 through December 2000 and were used to calculate average monthly precipitation (Table 3.1-1).

Climatic Data Summary:

- Three local monitoring stations
- Over 10 years of climatic data
- Generally consistent temperature and precipitation between the three stations
- Coldest months are December and January
- Wettest months are May and June

Overall, the climatic data show that the weather patterns, i.e., temperature and precipitation, are consistent between the

three monitoring stations for more than 10 years of climatic data collection. The data from all three stations indicate that the coldest months are December and January with average daily temperatures ranging from 15 to 20 degrees Fahrenheit (°F). The warmest months are July and August with average daily temperatures ranging from 50 to 56°F. June has the highest average precipitation with 3.4 to 3.9 inches of rain.

3.2 Geology

Four major categories of geologic units are identified and widely distributed in the Basin Watershed OU2: tuff, andesite, and latite of the Cretaceous Elkhorn Mountain volcanics; late Cretaceous/early Tertiary quartz monzonite and granodiorite of the Butte quartz monzonite; Tertiary rhyolite; and Quaternary deposits of alluvium, colluvium, and glacial material (Ruppel 1962; Ruppel 1963; Becraft et al. 1963) (Plate 3-1). Also present in the southwest portion of OU2, are latites of the Lowland Creek volcanics (Ruppel 1963; Becraft et al. 1963). Interspersed throughout these major units are aplite and alaskite dikes and intrusions.

The Elkhorn Mountain volcanics are the oldest rocks exposed in the area and generally consist of quartz latite and andesite (Knopf 1913). These volcanic rocks erupted from the same mass of magma that later crystallized below them to form the Boulder batholith. The Boulder batholith intruded the Elkhorn Mountain volcanics and consists of quartz monzonite and granodiorite. Included within the batholitic rocks are numerous aplite dikes and alaskite bodies (Ruppel 1963; Becraft et al. 1963). Overlying the eroded surface of the batholith is a late Tertiary rhyolite. The rhyolite is the youngest igneous rock in the area and consists of flows, tuffs, and intrusive units. The rhyolite represents a late volcanic episode. Quaternary deposits include stream deposits, glacial deposits, colluvium, and landslide deposits (Ruppel 1963; Becraft et al. 1963).

The prevailing country rock is the Butte quartz monzonite of the Boulder Batholith composed of orthoclase and plagioclase feldspar, quartz, biotite, and horneblende (Knopf 1913). Pre-batholithic rocks consisting of andesites and latites of the Elkhorn Mountain volcanics occur throughout OU2. Elkhorn Mountain volcanics are very well exposed in the Upper and Middle Basin Creek subareas (Figure 3.1-1 and Plate 3-1). The andesites are dark and heavy, dominated by pyroxene and calcic-plagioclase feldspar minerals. Latites are generally characterized by a blue, red, or flint-gray cryptocrystalline groundmass with phenocrysts of plagioclaise and biotite (Knopf 1913). Rhyolite forms the tops of ridges in the northern and western portions of OU2 up to the Continental Divide (Ruppel 1963). The rhyolites are mainly lithoidal lava flows but include some breccias and obsidian. They display a great variety of texture and color including red, grayish-blue, pink, and white. Nearly universal features are pronounced streakiness, flow banding, abundant quartz phenocrysts, and clear, glassy sanadine phenocrysts (Knopf 1913).

Veins in the country rock are composed of either quartz, chalcedony, or quartz and chalcedony (Ruppel 1963; Becraft et al. 1963). Sulfide minerals are found in all three of these vein types but are predominately found in the quartz veins and only in minor amounts in chalcedony veins. Most of the veins are oxidized at the surface. Veins trends are oriented in three main directions, eastnortheast-westsouthwest, westnorthwest-eastsoutheast, and approximately east-west (Ruppel 1963; Becraft et al. 1963) (Plate 3-1). These vein zones are sometimes parallel to shear zones, aplite dikes, and faults found in the study area.

Summary Details of Geology in OU2:

- OU2 consists primarily quartz monzonite, andesite, and latite country rock
- Quartz, chalcedony, and quartz/chalcedony veins dissect the country rock
- Sulfide mineralization occurs mostly in quartz veins
- Pyrite, galena, and sphalerite are common to quartz veins and are also common sources of AMD

Quartz veins are more abundant than any other type. They are found throughout the entire Basin Watershed OU2 (Ruppel 1963; Becraft et al. 1963). Pyrite (FeS_2) is the second most common mineral in quartz veins. Galena (PbS) and sphalerite (ZnS) are also common. These three sulfide minerals are likely sources for generation of AMD.

Chalcedony veins are the second most abundant type of vein. They are found in batholithic rocks located in the southeast portion of OU2 between Big Limber Gulch, High Ore Creek, and the Boulder River. Chalcedony veins contain minor amounts of sulfide minerals and were not of major economic importance. They are generally composed of chalcedony and microcrystalline quartz, opal, and, in places, pyrite and barite (Becraft et al. 1963).

3.3 Soil

Soil in the Basin Watershed OU2 have been formed from surficial glacial deposits composed of locally-derived batholithic bedrock and Elkhorn Mountain volcanics (Ruppel 1962). These deposits include glacial till and outwash deposits. Till deposits form a broad, thin blanket that covers valley walls and the broad, flat areas of the headwaters of Basin Creek and Cataract Creek (Ruppel 1962; Ruppel 1963; Becraft et al. 1963). Outwash deposits can be found in Basin Creek that are well-sorted, fine-grained, and contain sand and gravel lenses composed of Elkhorn Mountain volcanics and decomposed quartz monzonite (Ruppel 1962). The age of the glacial deposits that formed the soil is uncertain, but they may be early Wisconsin (Ruppel 1962).

Because the area is dominated by bedrock, the soil horizons are typically thin. Surface soil is generally silty to sandy with moderate to high organic content, and moist because of the fairly dense vegetative cover.

3.4 Surface Water Hydrology

Surface water bodies within the Basin Watershed OU2 include a portion of the Boulder River (to the south), Basin Creek (to the west), and Cataract Creek (to the east) (Figure 3.1-1 and Plate 1-1). The Boulder River is a meandering mountain stream. The river drains approximately 381 square miles with an annual mean flow of 117 cubic feet per second (cfs) near the Town of Boulder southeast of OU2 (MBMG 1996). Two USGS gaging stations were historically operated on the Boulder River near Basin, Montana (Figure 3.1-1). Gaging station 06031500, at the Town of Basin, was monitored between 1921 and 1923. Station 06032000, located upstream of Basin, was monitored between June 1, 1919 and December 6, 1919; April 1, 1920 and July 22, 1920, and on September 3, 1920. The flow at Station 06031500 ranged from 10 to 1,400 cfs while flow upstream at Station 06032000 ranged from 0.6 to 568 cfs with distinct spring-summer high flow and fall-winter low flow periods. Recent USGS data for the Boulder River (Station 06033000; not mapped) shows comparable flow conditions ranging a minimum of 9 cfs upstream of OU2 and the Town of Basin during low-flow conditions (September) to nearly 700 cfs downstream of OU2 during high-flow conditions (May) during 2001 (USGS 2002a).

Significant tributaries to the Boulder River are Sullivan Gulch (upstream of OU2) and Kleinsmith Gulch, Basin Creek, Cataract Creek, High Ore Creek, and Galena Gulch within OU2 (Figure 3.1-1). Although Sullivan Gulch, Kleinsmith Gulch, High Ore Creek, and Galena Gulch discharge to the Boulder River within OU2, they were not studied and, therefore, are not discussed at length.

Primary surface water features within the Basin Creek AOC include the Basin Creek mainstem and its largest tributaries, Jack Creek and South Fork Basin Creek (Figure 3.1-1). Approximately 28 smaller named and unnamed tributaries drain to Basin Creek. Based on the USGS 7.5-minute quadrangle maps, about 15 isolated wetland areas exist within the Basin Creek AOC, mostly in the northern portions of the AOC (Plate 1-1). The mainstem of Basin Creek is 17 miles in length. No permanent gaging stations are located on Basin Creek; however, USGS studies show flow in Basin Creek to range from 0.02 to 13 cfs in the headwaters to 3.1 to 251 cfs near its confluence with the Boulder River. The flow variations in Basin Creek are seasonal.

Cataract Creek AOC includes the Cataract Creek mainstem, and its primary tributaries Uncle Sam Gulch, Rocker Creek, and Nellie Grant Creek. Nineteen smaller named and unnamed creeks drain to Cataract Creek. Approximately five isolated wetlands exist within northern portions (headwater areas) of the AOC (Plate 1-1). The mainstem of Cataract Creek is 13 miles in length. A gaging station (Station 06031950; Figure 3.1-1) on Cataract Creek near the confluence of Big Limber Gulch was monitored for peak flow between 1973 and 1997 by the USGS (USGS 2000). Flow ranged from 105 to 934 cfs. Peak flow for 1980 was reported at 3,150 cfs; however, this appears to be an anomalous value. Recent USGS studies show flow in Cataract Creek ranges from 0.12 to 12 cfs in the headwaters to 20 to 186 cfs near its confluence

with the Boulder River. Like Basin Creek, the flow variations in Cataract Creek are distinct and seasonal.

Most of the creeks in these AOCs can be described as relatively low- to high-gradient, cold water streams, with abundant riffles, shallow pools, and occasional shallow runs. Substrates of the streams are most commonly comprised of sand, gravel, cobbles, and boulders. Hyporheic flow (i.e., flow within and below the streambed) in these creeks may be as significant as the visable surface water flow. Physically, these surface waters are typical of small, high elevation Rocky Mountain streams.

OU2 Surface Water Highlights:

- Low- to high-gradient streams
- Variable flow rates; typically 1 to 200 cfs in Basin Creek and Cataract Creek
- Distinct high (spring/summer) and base flow (winter and fall) regimes
- Hyporehic zones likely occur in Basin Creek and Cataract Creek
- Boulder River and Cataract Creek are designated B-1 waters by the State
- Basin Creek is designated A-1 water by the State

The Boulder River, Basin Creek, and Cataract Creek are part of the Missouri River drainage, and they are documented recreational fisheries. State of Montana regulations, Administrative Rules of Montana (ARM), classify the Boulder River and Cataract Creek as level B-1 surface water bodies for drinking, culinary, and food processing purposes after conventional treatment. Basin Creek has been classified by the state as an A-1 surface water body suitable for domestic purposes after conventional treatment of naturally-occurring impurities (ARM 1996).

3.5 Hydrogeology

A review of existing well information indicates that two aquifers exist in the area: a shallow unconfined alluvial aquifer and a deeper, fractured bedrock aquifer. Both aquifers are used, or are reserved for use, as potable water sources for the Town of Basin and other remote users within the Basin Watershed OU2. The shallow unconsolidated aquifer exists within the drainages and valleys of Basin Creek, Cataract Creek, and the Boulder River. The unconsolidated aquifer varies in thickness from 26 to 110 feet, and it appears to be thicker near existing drainages. Groundwater flow direction may vary locally, but overall it is likely to parallel the flow direction of the nearby drainages. In the vicinity of the Boulder River, shallow groundwater flow likely trends east with the river. The shallow groundwater aquifer likely is discontinuous and may be perched in some areas. It is especially vulnerable to degradation from surficial source areas. Steep mountain slopes within OU2 probably provide hydrogeologic boundaries to the shallow aquifer in the narrow valleys. Yields from existing wells in the unconsolidated aquifer in and near the Town of Basin range from 5 to 150 gallons per minute (gpm) (CDM 2000a).

Multiple water bearing zones exist within the bedrock aquifer below the unconsolidated aquifer. Groundwater occurrence in bedrock aquifers is commonly associated with fractures and fissures. The maximum depth of water bearing zones found in existing wells in the vicinity of the Town of Basin is 397 feet below ground surface although additional water bearing zones may potentially be found at deeper intervals. Yield from existing wells in the bedrock aquifer range from 5 to 30 gpm. The degree of communication between the unconsolidated and the underlying bedrock aquifers is unknown (CDM 2000a).

Most groundwater use is concentrated in and around the Town of Basin and along the Boulder River where most of the population is located. Some wells are utilized for vacation homes in the upper reaches of Basin Creek and Cataract Creek. Based on the findings presented in the Town of Basin RI, groundwater quality is generally good (CDM 2000a). However, this determination was based on a limited number of groundwater wells in the immediate vicinity of the town that may not be indicative of the groundwater quality throughout OU2.

3.6 Demography and Land Use

Miners first came to Basin, Montana in 1862, working gold placer deposits at the mouth of Cataract Creek. The initial placer deposits gave out after a couple of years, and miners spread out to prospect for lode deposits. Early residents settled near the confluence of Cataract Creek and Boulder River. They later moved to Basin, abandoning the Cataract mining camp. The cluster of cabins that were located at the mouth of Basin Creek officially became Basin City in 1880. Over the next two decades the town was an active camp, supplying the mines and miners in the Basin mining district (Knopf 1913). Basin prospered in spite of disastrous fires and falling silver prices in 1893. By 1905, there were 1,500 residents (Becraft et al. 1963). Mining continued in the Basin and Cataract mining districts until the early 1960s, mostly at larger mines. However, the local work force always remained at a relatively low level.

According to the 1990 Montana Census, there were less than 100 year-round residents, primarily in the Town of Basin (MBMG 1994). Currently, there are 160 boxholders in the local post office. This number varies seasonally by about 10 people.

Land use in the Basin Creek and Cataract Creek AOCs includes historical mining activities throughout the watershed and a variety of recreational uses, such as hunting (predominantly for deer and elk), fishing, camping, four-wheeling, and hiking. Other uses include ranching and grazing livestock in the flatter areas of OU2, logging (although not extensive), and vacation home sites. Permanent or year-round residences are typically concentrated in the area surrounding the town limits of Basin; however, some are also scattered throughout OU2.

The majority of lands within the Basin Creek AOC are public lands managed by USFS under the directive of the Beaverhead-Deerlodge National Forest. The remaining lands are privately owned. Private property boundaries are shown in Plate 1-1.

The majority of lands within the Cataract Creek AOC are public lands managed by USFS as the Beaverhead-Deerlodge National Forest. There are some public lands located in the Big Limber Gulch drainage that are administered by BLM. The remaining lands are privately owned.

Land ownership along the Boulder River is mixed between the State of Montana Department of Transportation, the BLM, and private landowners.

3.7 Ecology

Most of the area is covered with forest dominated by lodgepole pine (*Pinus contorta*), and to a lesser extent, by subalpine fir (*Abies bifolia*), Douglas fir (*Pseudotsuga menziesii*), Engleman spruce (*Picea engelmannii*), quaking aspen (*Populus tremuloides*), and common juniper (*Juniperus communis*). A large variety of grasses, shrubs, and small trees, including some of those previously mentioned, are commonly found along creek banks and in isolated stands in open areas.

Isolated wetland areas exist within the floodplains of the smaller tributaries, particularly in the upper (northern) portions of the Basin Creek and Cataract Creek AOCs. Detailed wetland inventories have not been completed, but they will be performed if wetland areas may be impacted by proposed remedial options.

Salmonid fish, aquatic invertebrates, piscivorus birds, omnivorous birds, benthic macroinvertebrates, small burrowing mammals, soil microbes, and large game species are also found within OU2 (CDM 1999).

3.8 Site Conceptual Model

A SCM has been developed to describe the dynamic nature of Basin Watershed OU2. The following sections will identify the primary elements from which to build an understanding of the interactions and relationships inherent to mining impacted watersheds. Understanding these components and interactions will assist in identifying impacts and potential receptors.

The SCM is intended to describe the nature of the different environs of the watershed; identify the interrelationships between soil/mine waste, sediment, surface water, and groundwater impacts to the system; and identify potential ecological and human receptors. Figure 3.8-1 presents a schematic overview of the watershed systems that exist in OU2. The elements illustrate the site conditions, common activities, historic impacts to the system, and potential receptors.

Over 300 abandoned mine and ore processing sites have been identified within the Basin Watershed OU2. Most (over 95 percent) of these sites are underground hard rock mines where ore and waste rock extraction occurred. These mine sites are listed in Table 2.3-1 with locations shown in Plate 1-1. A typical mine site is characterized by one or more adits (i.e., horizontal passageways) or shafts (i.e., vertical passageways), one or more waste rock piles (usually white/yellow to light green or reddish-brown in color), and occasional structural debris (Figures 3.8-2 through 3.8-4 [photographs]). The following sections describe the various environmental impacts within OU2, including elevated metals and metalloids and low pH material from uncontrolled sources like waste rock, tailings, and AMD, and contaminated groundwater, surface water, and stream sediments.

3.8.1 Mining Waste

Solid mining wastes in OU2 consist of waste rock and tailings material (Figure 3.8-1). Waste piles are typically located close to an adit or shaft, and they consist of a variety of sizes of rock fragments to sand- and silt-sized material. Waste piles vary in size from several 10s to 1,000s of cubic yards, and they may be confined to a small footprint (10s of feet in diameter) to covering an acre or more. Occasionally, waste piles may plunge several 10s to 100s of feet in elevation down a hillside. Generally, waste piles are devoid of vegetation. However, some small waste piles may support sparse vegetation. Water seepage from the toe (or downslope edge) of a waste pile may be present. Tailings are solid-matrix waste products from mineral (ore) processing or concentrating operations. Tailings are typically fine-grained material deposited hydraulically in impoundments or settling ponds (often near surface water), and like waste rock are usually unvegetated (Figure 3.8.5 [photograph]). In addition, when subject to oxygen-rich environments, these materials can result in the production of acidic leachate or acid rock drainage (ARD) that can get into surface water and groundwater.

3.8.2 Acid Mine Drainage/Acid Rock Drainage

AMD is trace-metal-bearing acidic discharge that typically emanates from underground mine workings through adits or shafts. In addition, ARD can be created where surface infiltration, or groundwater seeps or springs daylight from within waste rock or tailings. AMD and ARD can impact surface water quality through contaminant loading and increased acidity. Iron hydroxide staining, evidenced by orange-red precipitate, may occur along the surface water flow path of discharging adits or seeps (Figure 3.8-1).

3.8.3 Contaminated Stream Sediments

Contaminated stream sediments are typically the result of waste rock and tailings releases through erosion. In addition, stream sediment can be contaminated when COPCs precipitate out of AMD-impacted surface water. Likewise, contaminated stream sediments can be a source of contaminant releases to surface water.

3.8.4 Contaminated Surface Water

Surface water quality can be degraded due to releases of contaminants from waste rock, tailings, and AMD/ARD (Figure 3.8-1). Concentrations of contaminants in surface water are highly dependent upon the release mechanisms, stream flow, and water chemistry. Degradation of surface water quality can be more severe during low stream flow conditions if the amount of contaminants released to the stream, from an adit for example, remains relatively constant. However, erosional impacts from waste rock and tailings typically are greatest during storm events or spring runoff when stream flows are also high.

3.8.5 Contaminated Groundwater

Groundwater can become contaminated due to a number of mechanisms (Figure 3.8-1). Trace-metal-bearing water within an underground mine can migrate to adjacent aquifers. Metal-bearing leachate generated from waste rock and tailings can infiltrate the soil and impact groundwater. In addition, contaminated surface water can recharge groundwater aquifers beneath its course. Likewise, contaminated groundwater can surface through springs or seeps and impact surface waters.

3.8.6 Contaminant Release Processes

Basin Watershed OU2 host rock contains many sulfide minerals associated with metal ore deposits, including pyrite (FeS_2), the most common sulfide. Because pyrite is the most widespread of all sulfide minerals, it is shown in the following four chemical reactions to describe the oxidation process that releases metals and acid associated with AMD and ARD.

$$2FeS_2\,(s) + 7\,O_2 + 2H_2O = 2Fe^{2+} + 4\,SO_4^{2-} + 2\,H^+ \qquad (1)$$

$$Fe^{2+} + O_2 + 4H^+ = Fe^{3+} + 2H_2O \qquad (2)$$

$$Fe^{3+} + 3\,H_2O = Fe(OH)_3\,(s) + 3\,H^+ \qquad (3)$$

$$FeS_2\,(s) + 14\,Fe^{3+} + 8\,H_2O = 15\,Fe^{2+} + 2\,SO_4^{2-} + 16\,H^+ \qquad (4)$$

Where: S = sulfur; O = oxygen; H_2O = water; Fe^{2+} = ferrous iron; Fe^{3+} = ferric iron; SO_4^{2-} = sulfate; H^+ = hydrogen ion; and $Fe(OH)_3$ = ferric hydroxide.

Acid generation is illustrated in reactions 1, 3, and 4. The oxidation of sulfur in pyrite is shown in reactions 1 and 4. The hydrolysis of ferric iron into ferric hydroxide is shown in reaction 3. The acid generated in these examples can, in turn, dissolve other metallic compounds, releasing more dissolved metals to the environment. The dissolved ferrous iron created by sulfur oxidation (reaction 1) and released to the environment is subsequently oxidized to ferric iron (reaction 2), and it is a source for further acid generation (reaction 3). The oxidation of ferrous iron occurs slowly at the lower pH values typical of AMD and ARD. When the ferric iron is hydrolyzed (reaction 3), in addition to acid generation, it quickly forms the insoluble ferric

hydroxide that precipitates out of solution and coats the stream bottom with a solid orange material.

Ferric iron, a strong oxidizing agent, can oxidize pyrite or other metal sulfides releasing acidity along with ferrous iron and dissolved metals such as copper, cadmium, lead, and zinc (Stumm & Morgan 1981). The rate of these reactions depends on the type of metal sulfide mineral present, particle size of the metal sulfides, temperature, light, bacteria, and the presence of water and air.

Bacteria such as Thiobacillus ferroxidans are known to act as catalysts in the oxidizing reaction of metal sulfides. These bacteria increase acid generation by oxidizing sulfide minerals for energy production, and producing sulfuric acid as a metabolic product. They are also known to accelerate the oxidation of ferrous iron to ferric iron under the right pH conditions (LeRoux North & Wilson 1973). Water is essential because it is a reactant in the oxidation process, a medium for the bacteria, and a transportation mechanism for the oxidation products. Temperature and light are catalysts in weathering and oxidation of metal sulfide minerals. The higher the ambient temperature the faster the reaction. The metabolic activity of Thiobacillus ferroxidans is also temperature dependent, peaking at about 30 to 35 degrees Celsius (°C), and falling with both increasing and decreasing temperature (Roman & Benner 1973).

3.8.7 Mobilization of Contaminants

The mobilization of COPCs is dependent upon several factors, including:

- Chemical reaction rate
- Rate of surface and subsurface water flow removing inorganic constituents and allowing the reactions to continue towards completion
- Erosion and transport of soil-bound constituents via storm water runoff and soil and sediment particulate carried by such flow
- Uptake and accumulation of inorganic constituents by biota

Leached metals/metalloids may be released directly into surface waters under normal flow conditions, while storm events can transport both dissolved and particulate forms (Figure 3.8-1). The deposited particulates may contribute to the metals/metalloids loading in surface water through leaching and resuspension. Precipitated COPCs in stream sediment can also become a source to surface water when they become remobilized due to dissolution or resuspension. Uptake by biota can reduce the availability of COPCs in surface waters and soil. Biota may in turn become contaminant sources to animals.

Impacted surface water also seeps into the subsurface, potentially contaminating subsurface soil and groundwater. Impacted groundwater is transported

downgradient within fractured bedrock, as well as surficial alluvium. At higher elevations, groundwater moves through fractures, fissures, and other voids in competent bedrock toward the valley bottoms where it may discharge to unconsolidated alluvial material along the stream channels, resurface as a discharge to soil or surface water, or recharge deeper bedrock aquifers (Figure 3.8-1).

This page is intentionally left blank.

4

Section Four

Section 4
COC Selection and RI Data Interpretation

This section summarizes the COC selection process and discusses the interpretation of the RI data for Basin Watershed OU2. As noted previously, both historical and 2001 data were used.

4.1 COC Selection Summary

Table 4.1-1 presents the COCs identified for this RI, through a screening process outlined in the initial steps of the BERA (CDM 2002). All chemicals detected in the OU2 were retained for initial screening against conservative risk-based benchmark values. Chemical-specific benchmarks were selected from a federal and state regulatory standards and guidelines, and published and accepted site-specific values calculated from other Superfund sites in EPA Region 8 (as needed). Retained COCs are matched with their respective ecological and human health benchmark values for evaluation in the RI (Table 4.1-2 and 4.1-3).

However, for the purposes of evaluating and describing the nature and extent of COCs in this RI, only arsenic, cadmium, copper, lead, mercury, and zinc are discussed. These metals/metalloids are common to mining sites, are drivers of toxicity concerns to human and ecological receptors, and are recognized by EPA and other federal agencies as indicators of mining-related contamination (EPA 2000).

4.2 Data Interpretation Approach

The discussions presented herein were primarily based on the Fall 2001 RI sample results. When possible, averages of older historical data were used to supplement the most recent data. Often there were fewer data points available then preferred to make nature and extent interpretations. As a result, even in instances when the number of data for a location were not sufficient to provide a high level of confidence in the minimum, maximum, mean values, the results measured were still used and assumed representative for that particular station in Basin Watershed OU2. Further, these data are used to make conclusions.

Existing data from the aforementioned agencies were collected, formatted, and assembled into a Site-wide database. Because the data were collected by different agencies using a variety of sample collection, sample preparation, and analytical methods, the data were evaluated with respect to quality control procedures to determine data usability and comparability. The data were categorized as unrestricted use, screening-level, and rejected data. No data were rejected, and all data was considered in this RI.

All Fall 2001 RI sample results were either validated or evaluated for usability in the RI (Section 2.4.5). Data qualified as rejected (R qualifier) were considered unusable.

All other data were considered to be valid and acceptable, including those analytes that have been qualified as estimated (J qualifier). For the data interpretation, all detected values were used. For nondetected results, the reporting limit values that were below benchmarks were used. In these cases, the value of the reporting limit was used as the concentration value. Analytical results with nondetected reporting values greater than benchmarks were not used in these evaluation to prevent making conclusions that constituent concentrations are above the benchmarks or action levels, when, in fact, the values of the constituents could be below the action levels. Table 4.2-1 summarizes the number of nondetect results that exceeded benchmark values by COC.

Aqueous detected and usable nondetected data (dissolved concentrations) were compared against ecological risk based standards, while total values were compared against human risk based standards. For solid media, detected and usable nondetected (total concentrations) were compared against ecological and human health risk based standards.

When sample results exceed ecological or human health standards, it is only stated in the text that the sample or COC exceeded benchmarks for purposes of brevity, and no detail regarding which benchmark was exceeded is spelled out. Details regarding whether the sample or COC exceeded ecological or human health benchmarks is presented in the tables, where dissolved concentrations were compared against ecological benchmarks, and total concentrations against human health benchmarks.

4.2.1 Surface Water and Sediment Data Interpretation Approach

Of the Fall 2001 surface water sample results, 87 analytical result were rejected, 85 of those results were for mercury, one for silver, and one for copper. Historical surface water data used included results for samples collected between 1996 and 1999. These data had the most comprehensive results for constituent concentrations and measurement of flow. Surface water data prior to 1996 typically were limited to one or two sample results per location with no flow measurement results. Pre-1996 concentrations are used to support conclusions where needed and to evaluate concentration changes over the length of the streams.

Of the Fall 2001 sediment sample results, 16 analytical result were rejected, all of the rejections were for selenium. Historical sediment data prior to 1996 typically showed lower concentrations than the 1996 and recent data, mostly collected by the USGS. The differences are likely a result of differing sampling methods. The USGS performed their analyses on the less than 0.18-mm size fraction, whereas it is possible that pre-1996 samples were analyzed as "bulk" samples (i.e., not sieved). However, available documents do not describe the sampling methods used for the pre-1996 data. Therefore, for the historical sediment data, primarily 1996 to present data were used.

To streamline the surface water and sediment quality interpretations, the mainstem streams were divided into reaches and the data were divided into seasons of low flow and high flow. Historical daily stream flow data were reviewed for the USGS surface water gaging station named Boulder River near Boulder, Montana (USGS Station 06033000; latitude 46° 12′ 40″, longitude 112° 05′ 27″) for 1996, 1997, 1998, and 1999 (Figure 4.1-1). Although 38 river miles southeast of the Town of Basin, this is the closest continuously monitored gaging station to OU2, and it is considered representative of local flow conditions in the Boulder River. Figure 4.1-1 indicates that 100 cfs is a good cut off between low-flow and high-flow periods of discharge, with flow higher than 100 cfs representing high-flow events. The data from the gaging station show that January, February, March, August, September, October, November, and December, on average, have discharges below 100 cfs and, therefore, are considered low-flow months. May, June, and July, on average, have discharges above 100 cfs and, therefore, are considered high-flow months. The increased flow is a direct result of snow melt runoff and the rainy season (Section 3.1). The month of April typically begins with discharges below 100 cfs for the first two weeks, but averages above 100 cfs for the whole month. Therefore, April is included in the high-flow period for the purposes of this RI.

The flow seasons are categorized as follows: (1) winter low-flow months (December, January, February, and March); (2) spring and summer high-flow months (April, May, June, and July); and (3) fall low-flow months (August, September, October, and November). These divisions consider the calendar year and seasons, and seasonal sampling data. Low-flow or base flow conditions could be considered fall/winter low-flow; however, most low-flow data represent the fall time frame. Few data points exist for the winter season and, therefore, the data analysis was segregated.

4.2.2 Mine Waste, Soil, Groundwater and Adit Discharge Data Interpretation Approach

Of the Fall 2001 soil, groundwater, and adit discharge sample results, 22 analytical result were rejected, 11 groundwater results for mercury, and 11 soil results for selenium. The historical data results for mine waste material, soil, groundwater data and point sources used in these interpretations was not limited to post-1996 data. Instead, all historical data were considered because of the limited number of samples.

It was unfeasible to sample all of the over 260 abandoned mine sites in Basin Watershed OU2. To minimize the number of mine sites to sample, while being able to evaluate as many mine sites as possible, some sites were grouped together because they mined the same ore vein. Table 2.4-1 presents the vein grouping based on veins presented on plate 3-1. Sample results from one or more mine site sampled in a vein group were used to infer potential characteristics of the remaining mine sites in the group with no sample data. Actual geology at each mine site and size of the historical operations may vary, but this way mine sites could be identified for any additional sampling during the design stages of this RI.

4.3 Baseline Comparative Evaluation

A number of background soil, sediment and surface water samples have been collected in Basin Watershed OU2. These background samples were collected either at locations where low or no evidence of local mining existed, or from locations where minimal historical mining occurred to potentially represent background, since mineralized zones exist throughout the whole watershed. Even a "natural" soil sample has been collected from under a tree that was estimated to have ben in the watershed for 50 to 100 years. There are differing opinions on background. Some believe that background conditions are adequately represented high in the watershed (e.g., near the hydraulic divide between Basin Watershed OU2 and Upper Tenmile Creek), while others believe that background conditions are adequately represented by areas lower in OU2 where no mining occurs (e.g., South Fork Basin Creek), where surface water and groundwater travel over and through the natural rocks and soil, but the area is not mineralized. With varying opinions on true background, identifying representative background sample locations that adequately represent the conditions in the watershed is a difficult task at best.

Therefore, background data collected within OU2 and surrounding areas were not used in the traditional evaluation against background. Instead, a baseline concentration approach was used, since it is well understood that the process of exposing previously unexposed mined ore related material typically results in some degree of ARD related contamination. Also because it is unfeasible to remediate all of the 260 plus abandoned mine site, it becomes important to identify the relative extent of contamination or contamination potential among the mine sites.

Locations with the lowest COC concentrations per AOC in each media were selected based on zinc concentrations, since zinc is common among all site, and is considered a driver. Table 4.3-1 presents two locations in each AOC where the lowest zinc concentrations were detected. These baseline value were then used as the basis of comparison for other measured concentrations throughout the respective AOC to calculate the relative ratio in concentrations. Resulting in relative concentration ratios among the mine sites.

5

Section Five

Section 5
Nature and Extent of COCs in the Boulder River Area of Concern

The following subsections present the nature and extent of COCs in the eight-mile section of the Boulder River AOC within the Basin Watershed OU2 (Figure 1.2-2).

5.1 Overview

The Boulder River AOC within the Basin Watershed is the culmination of all surface water discharges and sediment transport within OU2. The Boulder River AOC was divided into five reaches for data analysis (Plate 2-1). The reaches were assigned based on significant features (i.e., tributaries or key sample stations) and were used to facilitate data interpretations and discussions. The objectives of the Boulder River AOC investigation were to identify the major sources of contaminant loading to the river, determine the nature and extent of the COCs in the AOC, and evaluate the risk to human and ecological health. Existing recent and historical data for soil, surface water, and sediment were used to achieve these objectives, and the sample locations for these data are presented in Plates 2-1 and 2-2.

5.2 Boulder River Flow Characteristics

The average base flow in the Boulder River during winter and fall low-flow months ranged from 17 to 29 cfs and 8 to 33 cfs, respectively. The average flows in the spring/summer months were as much as 24 times the low flows, with a range of 265 to 694 cfs (Table 5.2-1 and Figure 4.1-1). The following paragraphs describe contributions to Boulder River.

Boulder River Flow Characteristics in OU2:

- Boulder River is gaged at several locations by USGS
- High flow is typically an order of magnitude higher than low flow (10 to 30 cfs versus 250 to 700 cfs)
- Fall 2001 was considered extreme low-flow, due to the drought conditions
- Basin Creek contributes the most volume to Boulder River, followed by Cataract Creek, then High Ore Creek
- Boulder River flow equals or exceeds the total contribution from Basin, Cataract, and High Ore Creeks
- Overall, Boulder River is a gaining stream, but it likely looses and gains in different segments of the river

During the Fall 2001 RI, the river flow was well below the historical average, reflecting the extremely dry conditions of that year (Table 5.2-1). Collectively, Basin, High Ore, and Cataract Creeks contributed 92 percent of the inflow to the Boulder River at that time, with the remaining inflow attributable to unsampled tributaries, seeps, and/or subsurface flows. Comparatively, Basin Creek contributed flow 1.3 times the flow discharged by Cataract Creek, and 20 times the flow discharged by High Ore Creek. Historically, Basin Creek, Cataract Creek and High Ore Creek

accounted for 81, 100, and 92 to 96 percent of the total volume of inflow to the Boulder River, respectively. Basin Creek, generally contributed the most flow, followed by Cataract Creek, and then High Ore Creek. From a perspective standpoint, upstream flow in Boulder River is approximately equal or greater than the combined flows added by Basin Creek, Cataract Creek, and High Ore Creek.

Spring/summer flow measurements collected in the Boulder River in April and May 2001 by the USGS (407 and 694 cfs) were slightly higher than the mean historical spring/summer flows (Table 5.2-1). However, this may be attributable to hydrological events upstream of OU2, since Basin and Cataract Creeks, at 75 and 43 cfs respectively, contributed less than the historical mean spring/summer flows. During the spring/summer sampling event, Basin Creek's flow was 1.8 times the flow in Cataract Creek, and 50 times the flow in High Ore Creek. During the September 6, 2001 storm event, flows in the Boulder River increased by as much as 5 times the pre-storm low-flow (Table 5.2-1). There are not sufficient flow data to determine if Basin Creek flow is consistently higher than Cataract Creek and High Ore Creek.

In Basin Watershed OU2, Boulder River is a gaining stream, with flow characteristics that are consistent with typical low-gradient mountain stream flows. Mean monthly flows are the highest during the spring/summer months, while flows during the remainder of the year are an order of magnitude lower. Basin, Cataract, and High Ore Creeks combined account for most of the surface water flow increase in Boulder River with Basin Creek contributing the most flow. However, Boulder River flow exceeds the combined flows of all three of these creeks.

5.3 Boulder River Surface Water Quality

Table 5.3-1 presents the average historical and 2001 sample concentrations for the COCs and selected physical parameters measured in the Boulder River and its tributaries during high- and low-flow conditions. Results above benchmark concentrations are identified in bold-underlined font. Benchmark values are the initial conservative screening levels developed during this RI and BERA (CDM 2002) (Section 4.1).

Figures 5.3-1 and 5.3-2 present the historical concentration data for COCs that exceeded the benchmark levels in the Boulder River during the different flow regimes. The data are presented by station and reach for mainstem and tributary locations. Figures 5.3-3 and 5.3-4 present the COCs exceeding the benchmark levels at stations sampled during the Fall 2001. Figures 5.3-5 and 5.3-6 depict sulfate changes and inputs along the river historically and during 2001.

A discussion of non-storm and storm water quality in the Boulder River follows. The discussion refers to exceedences of ecological and human health benchmark values by reach of the Boulder River.

5.3.1 Non-Storm Surface Water Quality

During the Fall 2001 RI sampling, the Boulder River had no concentrations of COCs above benchmark levels upstream of Basin Watershed OU2. However, during high-flow months, arsenic, copper, and lead exceeded benchmarks (Table 5.3-1, and Figures 5.3-1 through 5.3-4). Sulfate (Figure 5.3-6) was consistent between high- and low-flow conditions.

Boulder River Surface Water Quality Highlights:

- Surface water upstream of OU2 is of generally good quality
- ARD/AMD impacts are obvious in both flow regimes
- Water quality degrades in Reach 2 above Basin Creek with the introduction of Cu and Zn
- Basin Creek is a minor contributor of COCs compared to High Ore Creek (worst contributor) and Cataract Creek
- COCs increase in number (addition of Cd, As, and Pb in Reach 4) and concentration with increasing downstream distance
- Recent (Fall 2001) and historical concentrations are fairly similar
- Dilution during high flow does not appear to be a significant process in the Boulder River

During Fall 2001 in Reach 2 (i.e., low-flow), slight increases in sulfate and other COC concentrations were measured; however, only total and dissolved copper were above benchmark concentrations (Figure 5.3-2). Historically, total mercury has also exceeeded benchmarks in Reach 2 (Figure 5.3-2; Table 5.3-1), but this was not evident in Fall 2001 data.

Concentrations of COCs in Reach 2 were as much as 24 times the concentration in Reach 1, and about four times the ecological and human health benchmarks, indicating a source of COCs to surface water in this reach. No data exist to evaluate concentrations in Reach 2 under high-flow conditions.

During 2001 in Reach 3, sulfate concentrations increased after the confluence of Basin Creek and Boulder River (Figure 5.3-6). Even with contributions from Basin Creek, the COC concentrations remained fairly constant through Reach 3 of Boulder River and similar to Reach 2 concentrations (Table 5.3-1). Only copper continued to exceeded its respective benchmark levels. Historically, Reach 3 also contained dissolved cadmium and zinc above benchmarks (Table 5.3-1 and Figure 5.3-1) during winter and spring/summer flows. Basin Creek, with COC concentrations up to 20 times those measured in Boulder River, had minimal impact (from cadmium, copper, and zinc) to surface water quality in the river. This is likely the result of the dilution by the Boulder River. Even with dilution, COC concentrations in Reach 3 were between one to three times ecological and human health benchmark levels (Table 5.3-1).

Also during 2001 in Reach 4, after the confluence of Cataract Creek with Boulder River, COC concentrations dramatically increased, over 3.5 times the concentrations measured in Reach 3. In addition, sulfate levels increased by 30 percent. Total and

dissolved copper concentrations continued to exceed benchmarks in Reach 4, while dissolved cadmium and zinc were detected above benchmark levels for the first time (Table 5.3-1; Figure 5.3-4). Historically, the same COCs have been detected above benchmarks in Reach 4 (Table 5.3-1, and Figures 5.3-1 and 5.3-2). Based on these recent and historical data, Cataract Creek has a more significant impact on the Boulder River than Basin Creek. Cataract Creek contributed almost twice the sulfate concentrations measured in Basin Creek (Figure 5.3-5). Further, Cataract Creek contributed COC concentrations ranging from one to 16 times the concentrations measured in Basin Creek (Figures 5.3-1 and 5.3-2), indicating significantly higher mining-related impacts in Cataract Creek.

Fall 2001 data for Reach 5 show continually increasing concentrations of COCs in the Boulder River after its confluence with High Ore Creek. Arsenic, cadmium, zinc and sulfate concentrations increased by 10 to 40 percent in the river downgradient of High Ore Creek. Lead nearly tripled in concentration. These recent COCs concentrations were 2 to 3 times the ecological benchmarks and twice the human health benchmarks. Concentrations, historically, approached levels up to five times the human health benchmarks and six times ecological benchmarks (Table 5.3-1).

In summary, surface water quality in the Boulder River upstream of OU2 typically contained only low concentrations of COCs, which equates to generally acceptable water quality with respect to conservative human health and aquatic life benchmarks under both normal high- and low-flow conditions. Field-measured pH levels were all near neutral conditions (i.e., 7), and within MDEQ surface water standards. These physical conditions remained relatively unchanged through the AOC. Sulfate, which is an ARD/AMD indicator, increased by as much as 80 percent from upstream to downstream locations within the AOC during the low-flow months (Table 5.3-1), indicating impact from ARD/AMD. COC concentrations in surface water first exceeded standards protective of human health and aquatic life in Reach 2, and continued to increase steadily in each subsequent reach. The most significant impact to Boulder River occurred in Reaches 4 and 5, first in the number of COCs above benchmarks (Reach 4), then in the concentrations of COCs in surface water (Reach 5).

5.3.2 Storm Surface Water Quality

During the Fall 2001 RI sampling, a storm occurred on September 5 and 6, 2001. Precipitation was recorded at 0.87 inch for September 6, 2001 in Boulder, Montana. Flow in the Boulder River during the September 6, 2001 storm event increased to levels between 3 and 4 times the Fall 2001 low-flow rate (58 cfs versus 11 cfs at Cataract Creek) and about twice the historical low-flow average (Tables 5.2-1).

Figure 5.3-7 depicts which COCs exceeded benchmarks along the Boulder River during the September 6, 2001 storm. Figure 5.3-8 shows how sulfate concentration changed along the length of the Boulder River.

Fall 2001 Storm Water Summary:

- Flow increased 3 to 4 times base flow
- COCs were measured at higher concentrations
- Dissolved concentrations were similar to low flow, while total concentrations increased significantly
- Exceedence patterns mimicked base flow, but with higher concentrations
- Surface water remained neutral from upstream to downstream
- Increased concentrations from resuspension a likely occurrence

During the storm event, the Boulder River upstream of OU2 had no COCs above benchmarks (Reach 1). By the end of Reach 2, the concentrations of cadmium, copper, lead, and zinc were approximately three to six times higher than in Reach 1. Dissolved copper, total copper, and total lead in Reach 2 exceeded benchmarks (Table 5.3-1).

In Reach 3, total arsenic, dissolved cadmium, and total and dissolved zinc are added as COCs that exceeded benchmarks. During this storm event, arsenic, cadmium, copper, lead, and zinc concentrations remained above benchmarks downstream, while increasing in concentration (Figures 5.3-7 and 5.3-8). As in non-storm events, High Ore Creek contributed the worst water quality to Boulder River with the most COCs exceeding benchmarks at the highest concentrations, followed by Cataract Creek, then Basin Creek. High Ore Creek also contributed 10 times the sulfate concentrations that the other two tributaries (250 milligrams per liter [mg/L] versus 25 mg/L).

The field-measured pH levels during the storm flow were all less than surface water standards, and remained unchanged along the length of the river (Table 5.3-1). Sulfate concentrations in Boulder River itself remained relatively consistent (Table 5.3-1 and Figure 5.3-8), suggesting dilution. COC concentrations do not indicate dilution occurred. The TDS concentrations remained within 10 percent of values measured under low-flow, however the TSS ranged from 4 to 20 times the low-flow values (Table 5.3-1), as expected. Increased turbidity was visibly evident.

In summary, although water quality is degraded during storm events, dissolved COC concentrations remained relatively similar to water quality conditions under low-flow conditions, total COPC concentrations increased to levels as high as 120 times their respective concentration measured at low-flow. Storm flow COC concentrations in Boulder River ranged from 1.2 to 18.5 times the benchmarks, compared to 1.1 to 5 times measured during low-flow. In addition, the increased flow from the storm event resuspended potentially contaminated sediments, leading to further deterioration of water quality. Degradation from dissolution does not appear to be occurring evidenced by unchanged, near neutral pH and unchanged dissolved COC concentrations.

5.4 Boulder River Basin Sediment Quality

Sediment samples collected from the Boulder River include instream sediment samples, stream terrace gravel deposits, overbank sediments, and fluvial tailings cores. Historical samples showed concentrations of arsenic, cadmium, lead, and zinc above ecological benchmarks that generally increase in a downgradient direction along the length of the Boulder River (Table 5.4-1 and Figure 5.4-1). Human health criteria are not considered for sediment.

Sediment Quality Highlights:

- Sediment COC distribution mimicked surface water COCs with many benchmark level exceedences
- Impacted sediment first occur in Reach 2
- Reach 5 has the highest COC concentrations
- Number and concentration of COCs progressively increases downstream
- High Ore Creek contributes the most contaminated sediments, followed by Cataract Creek, then Basin Creek

During the Fall 2001 RI field investigation, only instream sediment samples were collected and evaluated. The samples were first sieved to minus 10-mesh, minus 80-mesh, and minus 260-mesh (a few samples) sizes, then analyzed. Sediments in Reach 1 had the fewest COCs (only arsenic) above ecological benchmarks (Figure 5.4-2). The number of COCs exceeding benchmarks increased in Reach 2, and included arsenic, copper, and zinc. One potential source of these COCs is streamside waste material at the Old Basin Millsite (Plate 1-1).

In Reach 3, cadmium and lead increased in concentrations such that they also exceed benchmarks (Figure 5.4-2). Sample data indicated that Basin Creek is a source of these COCs as well as elevated concentrations of copper, arsenic, and zinc in sediment. Sediment quality along the river continued to degrade as evidenced by the increase in the concentrations of arsenic, cadmium, copper, lead and zinc in Reach 4. Similar to Reach 3, the primary source of the sediments high in arsenic, cadmium, copper, lead and zinc is Cataract Creek. Further downstream, High Ore Creek contributes even higher concentration of these COCs. Below High Ore Creek, most COC concentrations increased. These COCs remain above ecological screening level throughout Reach 5.

Three sediment fractions were analyzed during the Fall 2001 RI sampling. The highest COPC concentrations were detected in the fine (minus 260-mesh) size fraction, followed by the minus 80-mesh. COPC concentrations in the minus 260-mesh were as much as five times the concentrations detected in the minus 80-mesh size, and ranged from three to 16 times the concentrations detected in the minus 10-mesh size (Table 5.4-1).

In summary, the concentrations of COCs and the frequency of COCs exceeding their respective sediment benchmarks increased in a downstream direction along the

length of the river. Sediment in Reach 4 had the most COCs at the highest concentrations in the river, followed by Reach 5. Boulder River flow decreases in Reach 4, which increases the rate of suspended sediment, and provides rationale for this occurrence. Cataract and High Ore Creeks were the most notable sources of contaminated sediment to the river. Unnamed tailings in Reach 3 is also a likely contributor of contaminated sediments in and on downstream banks of the Boulder River. With the absence of mine sites along the Boulder River (as described below), tributaries and streamside tailings are likely the primary contributors of COCs to sediment.

5.5 COCs at Mine Sites in the Boulder River AOC

There were 18 mine sites previously identified within the Boulder River AOC (Table 2.3-1). During the Fall 2001 RI, it was estimated that eight of the 18 sites had been removed by the highway construction (Table 2.4-1), as there was no visual evidence of mine remnants. Five of the remaining sites (24JF0183, Merry Widow, Montana Central Railroad Ore Bins, 24JF0517, and 24JF0178) were determined to pose little threat of mining-related impacts to the Boulder River, because of the minimal amount of waste that was present and/or the large distances between the mine and the Boulder River.

Included in the mine sites are two streamside tailings areas; Jib tailings and unnamed tailings area near the former Attwater Mill (i.e., existing Basin golf course). These two areas were sampled during the Town of Basin RI (CDM 2000a), were identified as sources of COCs to the Boulder River, and are scheduled to be addressed as part of the Town of Basin Record of Decision (ROD), (CDM 2001f). Although source removal will be effective in mitigating a long-term source of metals, the extent of removal and associated PRGs may not be sufficient to reduce aquatic risk. Contaminated sediments outside the removal area must be consideeed.

5.5.1 COC Concentrations in Mine Waste Rock

EPA was not able to obtain consent for access to the Jib (Hope/Katie Complex), Lotta, Obelisk, or Last Chance mines for Fall 2001 sampling. The only mine site near the Boulder River with available data (i.e., historical) for solid waste material is the Old Basin Millsite. This site is comprised of several mine waste piles that are located within 1000 feet of the Boulder River.

The mean arsenic, lead, antimony, and thallium concentrations in tailings and mine waste materials at the Old Basin Millsite exceeded the ecological and human health benchmarks for soil (Table 5.5-1). Mercury concentrations exceeded the soil ecological benchmarks. Also, the mine waste and tailings contain arsenic, cadmium, lead, mercury, and zinc at concentrations that would exceed their respective sediment screening level. If these materials were transported into the Boulder River, they would likely have an adverse affect on sediment quality.

The Town of Basin RI reported elevated concentrations of arsenic, copper, lead, and zinc in these tailings (Table 5.5-1).

ABA at the Basin Millsite ranged from -87 to 94.4 pounds of calcium carbonate per 1000 tons of material (lbs CaCO3E/1000t), indicating that there is the potential for leaching of these COCs into the groundwater. Paste pH of the mine waste ranged from less than 3.5 to 6.2. The proximity of the Hope/Katie/Jib Millsite and the concentrations of metals at the mine indicate that under normal geochemical and climatic conditions this mine may contribute elevated metals concentrations to the Boulder River and groundwater.

5.5.2 COC Concentrations in Groundwater Discharges

No historical information was available on the recent occurrence of adit or seep discharges in the Boulder River AOC. The only flowing adit located during the Fall 2001 investigation was the Merry Widow adit. Water quality at the Merry Widow adit was generally acceptable with respect to the COCs, although arsenic was above its human health screening level (Table 5.5-2).

5.6 COCs in Groundwater in the Boulder River AOC

Historical groundwater data near the Boulder River evaluated in this RI included data from nine groundwater wells (Table 5.6-1). The groundwater data showed no exceedences of benchmarks. In addition, the groundwater media was evaluated throughout the town during the Town of Basin OU1 RI (CDM 200a), which concluded that groundwater was not a media of concern. Although data from selected areas within the AOC suggest minor, if any, impacts to groundwater, no conclusion can be made regarding the nature and extent of COCs in groundwater and associated impact from mining activities in this AOC.

5.7 Boulder River AOC Loads

Total and dissolved COC loads were calculated for low- and high-flow conditions at each location for each COC (Table 5.7-1, and Figures 5.7-1 through 5.7-4). Loading, discussed in the following paragraphs, refers to combined COC load. In general, zinc loads were several orders of magnitude larger than the remaining COC loads and, thus, zinc dominates the makeup of the combined COC load.

Boulder River Loading Summary:

- Combined COC load dominated by zinc
- Loads increased downstream
- Cataract Creek is the largest contributor of load, followed by Basin Creek, then High Ore Creek
- Streamside tailings partially responsible for COC loading contribution to Boulder River

The combined COC load in Boulder River progressively increased downstream at all mainstem locations throughout the year (Figures 5.7-1,

5.7-2, 5.7-3, and 5.7-4). No winter samples were collected during 2001, however based on historical data, the combined COC loads also increase downstream in the winter months (Figures 5.7-1 and 5.7-2).

During the Fall 2001 RI, the combined dissolved and total COC loads increased from upstream to downstream in Boulder River by 7 and 8 pounds per day (lbs/day), respectively (Figures 5.7-3 and 5.7-4). The dissolved and total loads from Basin, Cataract and High Ore Creeks combined accounted for 78 and 74 percent of the combined COC loads increase, respectively. Cataract Creek, at 4 lbs/day (total and dissolved) contributes the most COC load, four times Basin and High Ore Creek loads. The largest change in dissolved and total loads in Boulder River occurred in Reaches 2 and 5 and, therefore, are the two reaches discussed. Throughout Reach 2, both total and dissolved combined COCs increased by 3 lbs/day, while throughout Reach 5, the loads increased by 3 and 4 lbs/day for the dissolved and total combined COCs, respectively.

In Reach 2, Kleinsmith Gulch is the sole tributary, and it generally only flows during spring/summer runoff. Historically, Kleinsmith Gulch contributes on average 0.02 lbs/day. Since Kleinsmith Gulch was not flowing under the base flow conditions of Fall 2001, this increase in load can be attributed to non-point sources such as COC desorption from river bed sediments and/or contaminated groundwater discharging into the river. Historical combined COCs loading in Reach 2 could not be evaluated because no simultaneous concentration and flow results were available for a location upstream of Basin Creek.

Reach 5 is the longest reach in the Boulder River AOC, and there are at least nine tributaries that discharge into Reach 5. However only High Ore Creek was sampled in 2001. This tributary contributed approximately 20 percent (1 lb/day) of the load presently in the Boulder River, but it is not believed to be the sole source of COC load in the reach. Historically, Galena Gulch (the only other tributary sampled) contributed an insignificant 0.01 and 0.03 lb/day in the Fall 2001 low-flow period. The increase in calculated loads throughout Reach 5 in 2001 solely reflects the increase in flow measured at station 06032300 in September.

Cataract Creek typically contributes the most load to Boulder River followed generally by Basin Creek, then High Ore Creek. There is attributable loading, albeit small, from unmeasured tributaries in the AOC, and possibly from the resuspension of contaminated sediments.

During the September 6, 2001 storm event, Basin Creek, Cataract Creek and High Ore Creek combined contributed all of the increase in dissolved and total loads in the Boulder River. Cataract Creek contributed the most combined dissolved COC load, while Basin Creek contributed the most combined total load to the river. Reach 2 (including Jib tailings) had the largest increase in total combined COC load (79 lbs/day).

In summary, Cataract Creek contributed the most load to Boulder River, at loads anywhere from 2 to 5 times larger than Basin Creek. High Ore Creek contributes the least load, possibly as a result of lower flow or possibly completed removal actions. Most of the combined load under low flow is attributable to groundwater discharging into the tributary streams as surface runoff is minimal. The only flowing adit located during the Fall 2001 investigation was the Merry Widow adit. The adit was discharging only at a rate of 2 cfs. It was not apparent that the dischare reached the Boulder River before infiltrating the soil, which generally results in a very minor potential for COC load contribution to the Boulder River.

5.8 Radiological Conditions at Mine Sites

The only mine site with radiological results was the Basin Millsite. A number of the historical samples collected from Basin Millsite were screened for radioactivity using field screening instruments. Measured concentrations ranged from 0.03 millirems per hour (mR/hr) to 0.08 mR/hr , up to two times the reported background levels of 0.04 mR/hr, indicating an increased potential for radioactive materials in waste rock.

5.9 Summary and Conclusions

Concentrations of COCs and sulfate increased along the length of the Boulder River within the AOC. Figure 5.9-1 depicts the relative differences in dissolved zinc concentrations between the Boulder River reaches. Zinc is presented because it is a risk driver and it typically was present at the highest concentration of the COCs in both surface water and sediment. The water quality in the upper part of the river, upgradient from the confluence with Kleinsmith Gulch, was generally of acceptable quality with respect to human health and aquatic life benchmarks. Benchmarks were first exceeded in Reach 2, where concentrations of COCs in surface water under low flow increased to as much as 24 times the measured levels in Reach 1. The number of COCs as well as their concentrations progressively increased throughout the remaining reaches of the AOC.

The largest increase in sulfate and COC concentrations occurred downstream of the confluence with High Ore Creek. High Ore Creek contributed COCs at concentrations up to 298 times the values seen in Reach 1 of Boulder River. Cataract Creek contributed COCs at concentrations as much as 117 times the values seen in Reach 1, and up to 16 times the concentrations seen in Basin Creek.

The largest sulfate and combined COCs loads contributed by the tributaries came from Cataract Creek. Cataract Creek contributed loads up to six times the loads contributed by Basin and High Ore Creeks. In Reach 2, 60 to 70 percent of the load could not be attributed to surface inflows, indicating that the load source is discharging groundwater or other unknown inputs.

Contaminated sediments in the Boulder River come from the three major tributaries and from the Old Basin Millsite, the Jib tailings, and the Attwater tailings (i.e.,

unnamed tailings) area in Reaches 2 and 3, that have streamside in close proximity to the river. The mine wastes at these sites may also leach trace metals into the groundwater.

The water quality degradation in the Boulder River during the low-flow months was predominantly attributable to the tributaries. Water quality impacts to the river are greatest during high flows of the spring/summer months and during storm events, when the total contaminant load to the river increase. Higher flows during the spring/summer months and storm events result in the resuspension and mobilization of contaminated sediments, contributing to an increase of the total contaminant concentrations in the Boulder River. Based on the current benchmarks, surface water and sediment contribute to risk to human and environmental receptors in the Boulder River AOC.

This page intentionally left blank.

6 Section Six

Section 6
Nature and Extent of COCs in the Basin Creek AOC

The following subsections present flow conditions and the nature and extent of COCs in the Basin Creek AOC of the Basin Watershed OU2 (Figure 1.2-2).

6.1 Overview

Basin Creek is one of the three major tributaries (Cataract Creek and High Ore Creek are the other two) to the portion of the Boulder River that is within Basin Watershed OU2. Basin Creek contributes the most flow to the Boulder River, and the second most total combined COC load as discussed in Section 5.7. To evaluate the nature and extent of COC contamination and evaluate the risk to human and ecological health in the Basin Creek AOC, as well as identify the major sources of COC contamination to Basin Creek, the AOC was subdivided into subareas, and the creek itself was divided into reaches (Plate 2-1). The locations for all soil, surface water, and sediment samples used in this RI are presented in Plates 2-1 and 2-2.

6.2 Basin Creek Flow Characteristics

Basin Creek is a gaining stream with flow characteristics that are consistent with typical mountain stream flows. Although portions of the creek may lose surface water to groundwater, stream flow (measured historically) over the length of the Basin Creek increased by 10 to 20 fold during low-flow periods, and by 15 fold during high-flow periods (Table 6.2-1).

Flow during the Fall 2001 RI sampling was generally consistent with base flow conditions. Historically, fall low-flows ranged from 0.4 to 4 cfs. In 2001, however, the lowest flow in Basin Creek was 0.11 cfs, near its headwaters, while the highest flows were near the mouth of the creek (in Reaches 6 and 7) at 2 cfs and 3 cfs, respectively. Historically, flow in Basin Creek during the spring/summer months increased to as much as 30 times the fall and winter low flows. In 2001, spring/summer high flows were only 32 times higher than fall low flows.

Basin Creek Flow Characteristics:

- Basin Creek flow increases 10 to 20 fold from its headwaters to its confluence with Boulder River
- High flow is typically an order of magnitude higher than low flow (0.1 to 4 cfs versus 1 to 230 cfs)
- Jack Creek and South Fork Basin Creek contribute the most volume to Basin Creek
- Overall, Basin Creek is a gaining stream, but it likely loses and gains in different segments of the creek

Of the more than 30 tributaries to Basin Creek, only 4 were sampled in 2001, including Lady Leith, Clear Creek, Jack Creek, and South Fork Basin Creek (Plate 2-2).

Historical data exist for the Buckeye Mine, Grub Gulch, Jimmy's Creek, Joe Bowers Creek, an unnamed creek, and Saul Haggerty Gulch tributaries. Lady Leith, Clear Creek, Jack Creek, and South Fork Basin Creek combined accounted for about 50 percent (1 of 2 cfs) of the total surface inflows to Basin Creek during the fall 2001 low-flow. Of these tributaries, Jack Creek and South Fork Basin Creek had the highest flows (0.3 and 0.4 cfs, respectively). During the September 6, 2001 storm event, Basin Creek flow at the mouth increased to about 20 times the pre-storm low-flow, a total increase in flow of almost 48 cfs (Table 6.2-1). Only Lady Leith and Jack Creek tributaries were sampled during the storm event, and they accounted for about 25 percent of the total storm water flow increase.

Generally, flow in Basin Creek is highest during spring/summer months, while flow during the remainder of the year are orders of magnitude lower. Flow measured in Basin Creek during the Fall 2001 sampling was well below historical averages and reflects the low of base flow conditions. Of the individual tributaries in the AOC, Jack Creek and South Fork Creek contribute the most flow to Basin Creek.

6.3 Basin Creek Surface Water Quality

Table 6.3-1 presents the Fall 2001 RI and average historical concentrations for the COCs and selected physical parameters in Basin Creek and its tributaries during high and low-flow conditions. Results above benchmark concentrations (section 4.1) are identified in bold underline font.

Figures 6.3-1 and 6.3-2 present the historical concentration data for COCs that exceeded the benchmark levels in Basin Creek during the different flow regimes. The data are presented by station and reach for mainstem and tributary locations. Figure 6.3-3 presents the COCs exceeding the benchmark levels at stations sampled during the Fall 2001. Figures 6.3-4 and 6.3-5 depict sulfate changes and inputs along the creek.

A discussion of non-storm and storm water quality in Basin Creek follows.

6.3.1 Non-Storm Surface Water Quality

Concentrations of most of the COCs in Basin Creek headwaters were below benchmark levels during the Fall 2001 RI (Table 6.3-1). A change in water quality was first detected in Reach 2, where arsenic, cadmium, lead, and zinc exceeded benchmarks. Measured concentrations were as much as 5 times the concentrations in Reach

Basin Creek Surface Water Quality Highlights:

- Surface water in Basin Creek headwaters is generally of good quality
- Water quality degrades in Reach 2 above benchmarks with the introduction of As, Cd, Pb and Zn
- COC concentrations in Reach 4 of Basin Creek decrease to below benchmarks
- COCs increase in number (addition of Cd, As, and Pb) and concentration in Reach 5
- South Fork Basin Creek contributes the least amount of COC concentrations, while Jack

1. The Lady Leith tributary had arsenic, cadmium, copper, and zinc at levels greater than the concentrations in Reach 1.

By the end of Reach 3 in 2001, concentration levels of all COCs decreased, but arsenic, remained above benchmarks (Table 6.3-1 and Figure 6.3-3). Of the tributaries in Reach 3, only Grub Gulch and Clear Creek were sampled. Grub Gulch was sampled just below the Basin Creek Mine property boundary, and although it had high sulfate concentrations, it had no COCs above benchmarks (Table 6.3-1). Clear Creek was sampled just below the Josephine mine and again at the mouth. Just below the Josephine, all COCs exceeded benchmarks at concentrations 2 to 36 times levels in Reach 1, indicating a significant source area. At its mouth, Clear Creek discharged water with zinc above benchmarks, with the remaining COCs at concentrations up to seven times the levels seen at S001. Historically in Reach 3, under high flow conditions, arsenic, cadmium, copper, lead, and zinc exceeded benchmarks.

During 2001 in Reach 4, Joe Bowers Creek and Weasel Gulch discharge to the Basin Creek. By the end of this reach, the water quality in Basin Creek improved to the point that there were no exceedences of COCs, indicating possible dilution from clean water inflows. COC reductions is also reflected by the historical data (Table 6.3-1).

Basin Creek receives flow from South Fork Creek, Jack Creek, Wood Gulch, Vacchiou Gulch, and three unnamed tributaries in Reach 5. Within this reach, the Fall 2001 data show the water quality again degrades with arsenic, cadmium, copper, and zinc exceeding benchmarks. South Fork Creek had the lowest COCs and sulfate concentrations among the tributaries in the Basin Creek AOC, while Jack Creek had the highest number and concentrations of COCs and sulfate levels (Table 6.3-1 and Figure 6.3-3). Jack Creek contributes arsenic, cadmium, copper, and zinc above benchmarks year round. In 2001, Jack Creek under low-flow contributed arsenic, cadmium, copper, and zinc at concentrations as much as 500 times benchmarks, and 73 times the concentrations in Reach 1. Under high spring/summer flow, the concentrations were as much as 100 times the concentrations under low flow in Reach 1. Historically, although still the largest contributor, average concentrations are lower compared to the Fall 2001 sample results. (Figures 6.3-1 and 6.3-2)

Fall 2001 data for Reach 6 show arsenic, cadmium, and zinc decreased in concentration relative to Reach 5, but under high-flow conditions remained above benchmarks. Historically under high flow, copper also exceeded its benchmark in Reach 6 (Table 6.3-1 and Figure 6.3-3).

In Reach 7, Basin Creek receives flow from Lilly of the West, Meyers Gulch, Spring Gulch, and three unnamed tributaries. The Fall 2001 data show COC concentrations remained similar to Reach 6. Arsenic and cadmium remained above their respective benchmark values, which discharge to Boulder River. During the 2001 spring/summer high flow conditions, arsenic, copper, and zinc were above benchmarks (Table 6.3-1).

The field-measured pH levels were all near neutral and within surface water standards, and remained relatively unchanged along the length of Basin Creek. Sulfate generally increased in concentration from upstream to downstream in Basin Creek, except for during high-flow when its believed to be diluted. Of the tributaries, Jack Creek discharged the highest sulfate concentrations and South Fork Creek the lowest (Table 6.3-1; Figures 6.3-4 and 6.3-5). Sulfate and COCs values at the mouth of Basin Creek were 3, and 2 to 13 times higher, respectively, than sulfate levels near the headwaters at Station S001. These conditions indicate impact from ARD/AMD.

Surface water quality in the Basin Creek AOC is best with respect to human health and aquatic life benchmarks near Basin Creek headwaters and in South Fork Basin Creek. The first indications of water quality deterioration occurs in Reach 2, with the worst deterioration occurring in Reach 5, due to Jack Creek. Basin Creek discharges arsenic, cadmium, copper, and zinc at concentrations above benchmarks to Boulder River during both high- and low-flow conditions (Table 6.3-1 and Figure 6.3-3).

6.3.2 Storm Surface Water Quality

During the September 6, 2001 storm event, flow in Basin Creek increased by as much as 32 times the Fall 2001 low-flow, and about 11 times the historical low-flow average (Table 6.2-1). Water quality with respect to the COCs in the dissolved phase (comparison to ecological benchmarks) remained relatively similar to conditions under low flow, while total COC concentrations (comparison to human health benchmarks) increased dramatically (Table 6.3-1 and Figure 6.3-6). Concentrations of the COCs in the creek during this storm event, increased to levels as much as 120 times the concentrations near the headwaters under low-flow conditions (Table 6.3-1).

Fall 2001 Storm Water Summary:

- Flow increased to as much as 32 times base flow
- Reach 1 not sampled versus on exceedences
- COCs (As, Cd, Cu, PB, Zn) were measured at higher concentrations
- Dissolved concentrations were similar to low flow, while total concentrations increased significantly
- Hg was detected in Reach 5 at one station
- Exceedence patterns mimicked base flow, but with higher concentrations
- Surface water pH remained neutral from upstream to downstream
- Increased in concentrations mostly due to COC resuspension

Arsenic, copper, lead, and zinc storm-flow concentrations were as much as three times the ecological benchmarks and as much as 4000 times the human heath benchmarks compared to 5 times during low flow. Mercury exceeded the human health benchmark during the storm at one station (S011; below jack Creek) in Reach 5.

The field-measured pH levels were all within surface water standards and remained unchanged along Basin Creek (Table 6.3-1). Sulfate concentrations in Basin Creek remained similar to low-low conditions and increased along the length of Basin Creek (Table 6.3-1 and Figure 6.3-7), indicating impacts from ARD/AMD. The TDS concentrations remained within 10 percent of values seen under low-flow, however the TSS were up to 15 times the low-flow values (Table 6.3-1).

The increased flow from the storm event resuspended contaminated sediments, leading to further deterioration of water quality, as described below

6.4 Basin Creek Sediment Quality

Sediment samples collected historically from Basin Creek included instream sediment samples, stream terrace gravel deposits, overbank sediments, and fluvial tailings cores. In 2001, only instream sediments samples were collected and evaluated. The samples were analyzed either as minus 10-mesh, or sieved to minus 80 and 260-mesh size for analysis

Sediment Quality Highlights:

- Sediment COC distribution mimicked surface water COCs with many benchmark level exceedences
- Impacted sediment first occur in Reach 2 with identification As, Cd, Cu, Pb, and Zn
- Reach 5 has the highest COC concentrations
- South Fork Creek contributes the least amount of contaminated sediments, while Jack Creek contributes the most

Historically, COC concentrations generally increased along the length of the Basin Creek. During Fall 2001, sediments in Reach 1 had COC concentrations below benchmarks, except for arsenic, which slightly exceeded its benchmark. Concentrations of the COC in Reach 1 sediments were similar to levels detected in South Fork Basin Creek, a subarea considered to be representative of baseline conditions, since it has the least amount of abandoned mine lands and the lowest COC concentrations in the Basin Creek AOC. The number of COCs exceeding benchmarks increased in Reach 2 to arsenic, cadmium, copper, lead, and zinc. The Lady Leith tributary had all of these COCs at concentrations 2 to 60 times values detected in Reach 1.

Downstream of the Clear Creek confluence in Reach 3, all COCs remained at concentrations exceeding benchmarks, however, the concentrations were up to 5 times lower compared to Reach 2 (Table 6.4-1 and Figure 6.4-1). Sediment quality in Basin Creek continued to improve evidenced by further decrease in the concentrations of arsenic, cadmium, copper, lead, and zinc in Reach 4.

In Reach 5, after the confluence with Jack Creek, the COC concentrations increased again. Sediment in Jack Creek had COCs at concentrations that were as much as

60 times greater than the benchmark values, and as much as 6 times values seen in Reach 4 (Table 6.4-1), and were a substantial contribution to and impact on Basin Creek sediments.

In Reaches 6 and 7, the Fall 2001 COC concentrations in sediments decreased again, but remained above benchmarks. Arsenic and cadmium increased slightly in concentration in Reach 7, relative to Reach 6. Basin Creek at its mouth had COCs concentrations in sediment ranging from 1 to 7 times the benchmarks, compared to COCs concentrations at or below benchmarks in Reach 1 (Figure 6.4-1).

The highest COC concentrations were detected in the minus 260-mesh size fraction, followed by the minus 80-mesh. COC concentrations in the minus 260-mesh samples were about two to four times the concentrations detected in the minus 10-mesh size samples, and as much as twice the concentrations detected in the minus 80-mesh size samples (Table 6.4-1).

In summary, the frequency of COCs exceeding sediment screening levels and their concentrations increased downstream in Basin Creek. Reach 2, below Lady Leith and Reach 5, below Jack Creek had the most COCs at the highest concentrations in Basin Creek sediment.

6.5 COCs at Mine Sites in Basin Creek AOC

There are 86 mine sites that were identified in the Basin Creek AOC (Table 2.3-1). Physical and chemical data are available for 42 of these mine sites. The USFS is addressing 8 of these mine sites, namely the Bullion Smelter, Daily West, Hector, Lady Leith, Lower Hector, Morning, North Ada, and the Vindicator mines. Grub Creek Station (Upper Basin Creek subarea) had the lowest COC concentrations in waste rock among the mine sites and, therefore, is used as the baseline for COC concentrations at mine sites in the Basin Creek AOC. This subsection discusses the extent of COCs and acid production potential among the remaining 34 mine sites (USFS did not analyze for ABA) relative to Grub Creek Station to identify the major contaminant sources in the Basin Creek AOC. Adit discharge/seeps are also discussed.

6.5.1 Waste Material Characterization

Table 6.5-1 presents ranges for COC and ABA results for waste material samples collected at abandoned mine sites in the Basin Creek AOC. Mine sites with a NP/AP ratio of less than 1, and a percent sulfide of greater than 0.3 percent are considered to have a high potential of producing AMD/ARD (ICARD 2000). Mine sites with a NP/AP ratio of less than 1, and less than 0.3 percent sulfide are considered to have a moderate potential of producing AMD/ARD, while mine sites with a NP/AP ratio of greater than 1 are considered to have a low potential for AMD/ARD.

All of the mine sites in Basin Creek AOC were ranked based on their maximum zinc concentration differences relative to zinc values measured in samples from Grub Creek Station mine, since zinc makes up the largest metals/metalliods percentage of the waste composition.

Upper Basin Creek Subarea
There are 51 mine sites identified in the Upper Basin Creek Subarea, with 32 mine sites within 500 ft of a stream or drainage. Because of access limitations or vein groupings, not all mine sites were visited and/or sampled. Chemical and physical data are available for 16 of these mine sites. None of these mine sites had high AMD/ARD production potentials, however, the Buckeye, Dorothy Snow, Double Shaft, Enterprise, and Adit, Mine, Waste Rock Dump mines have a moderate (NP/AP ratio of less than 1, and less than 0.3 percent sulfide) potential to produce AMD/ARD (Table 6.5-1). The Buckeye, Lady Leith, SE SE Section 35, Neptune, and Dorothy Snow mines had the five highest total zinc concentrations in this subarea, with values ranging from 16 to 960 times the zinc concentration at the Grub Creek Gulch mine. The Buckeye mine was reclaimed by EPA in 2001/2002.

Jack Creek Subarea
There are 27 mine sites identified in the Jack Creek Subarea, with 14 mine sites within 500 ft of a stream or drainage. Chemical and physical data are available for 11 of these mine sites for reasons noted above. Two of these mine sites have high AMD/ARD production potentials, namely the Bullion and the North Ada (Table 6.5-1). The Bullion was reclaimed in 2001/2002 by the USFS and EPA. The Bullion Smelter (also partially reclaimed by the USFS in 2001), First Shot/Last Shot, and the Dew Drop have a moderate potential to produce AMD/ARD. The Hawkeye and Jack Creek Tailings sites have a low potential to produce AMD/ARD. The Bullion, Bullion Smelter, Vindicator, North Ada, and First Shot/Last Shot mine sites had the five highest total zinc concentrations in this subarea, with values ranging from 40 to 600 times the zinc concentration at Grub Creek Gulch mine.

Middle Basin Creek and South Fork Basin Creek Subareas
There are four mine sites identified in Middle Basin Creek Subarea, and none in the South Fork Basin Creek Subarea. All of the four mine sites in the Middle Basin Creek Subarea are former placer mines and are located within 500 ft of Basin Creek, however, there are no chemical or physical data are available for these sites.

Lower Basin Creek Subarea
There are 37 mine sites identified in the Lower Basin Creek Subarea, with 27 mine sites within 500 ft of a stream or drainage. Chemical and physical data are available for 14 of these mine sites. Five of these mine sites have high AMD/ARD production potentials, namely the Aurora, Doris, Basin Belle, Adelaide, and the Basin Creek Placer mines (Table 6.5-1). In addition, a high potential for AMD/ARD was also noted for sample BM-SO-004. Daily West, 24JF0524, and Columbus have moderate potentials to produce AMD/ARD. The Hector, Lower Hector, and Jessie have low

potentials to produce AMD/ARD. The Hector, Aurora, Daily West, Doris, and RTI Recon R mine sites had the five highest total zinc concentrations in this subarea, with values ranging from 50 to 400 times the zinc concentration at Grub Creek Gulch mine (baseline conditions). According to the USFS, remedial measures are planned for the Hector, Lower Hector, and Doris mines.

In summary, all mine sites within the Basin Creek AOC had COC concentrations that exceeded ecological and human health benchmarks. The concentrations of arsenic, cadmium, copper, lead, and zinc were as much as 9,673, 813, 225, 1,860, 560 times the ecological benchmarks, and 225,000, 17, 3, 93, and 2 times the human health benchmarks, respectively.

Metals and ABA analytical results were used for relative comparisons of concentrations to the lowest measured values in the AOC (at Grub Creek mine) to evaluate their potential to produce AMD/ARD, and estimate waste volumes. The proximity of mines to Basin Creek and the magnitude of the COC concentrations in the waste material indicate that under the right geochemical and climatic conditions the mines noted above (and on Table 6.5-1) with a NP/AP ratio of less than 1, and a percent sulfide of greater than 0.3 percent have a high potential of producing AMD/ARD and, thus, immediate adverse impacts to Basin Creek.

6.5.2 COC Concentrations in Groundwater Discharges

Eighteen mine sites with adits and seeps have been identified in the Basin Creek AOC (Table 6.5-2). Adits and seeps at only twelve of these mine sites have been sampled, and all had COCs at concentrations exceeding human health and ecological benchmarks. A brief description of these point sources at the mine sites with available flow data follows.

Mine Sites with Groundwater Discharges:

- Vindicator
- Lady Leith
- Josephine
- Morning Star
- RTI Recon P
- All discharges had COC concentrations that exceeded ecological and human health benchmarks

Vindicator

Three adits are associated with the Vindicator mine, with only two adits flowing at the time of investigation. Both adits had concentrations of cadmium, copper, and zinc above benchmarks (Table 6.5-2). The adit discharges ranged between 1 and 7 gpm with the pHs ranging from 7 to 7.8. Vindicator has the highest flowing adit in the Basin Creek AOC.

Lady Leith

Five adits are associated with the Lady Leith, with only two adits actively flowing at the time of investigation. Both adits had concentrations of cadmium, copper, lead, and zinc above benchmarks (Table 6.5-2). Historically, the upper adit discharged at a

rate of 1 gpm at a pH of 3.4, and the lower adit discharged water at a rate of 6 gpm at a pH of 6.8.

Josephine
The Josephine has two adits as well as one waste rock seep. Discharge samples collected at the Josephine mine indicated that cadmium, copper, lead, and zinc were above benchmarks (Table 6.5-2). Flow from the adit ranged from less than 0.5 to approximately 1 gpm with the pH ranging from 3 to 5.

Morning Star
The Morning Star has one adit that was flowing at less than 1 gpm during Fall 2001. The discharge had a pH of 6.3, and did not exceed any of the benchmarks.

RTI Recon-P
The RTI-Recon-P mine has one adit that was flowing at less than 1 gpm during 2001. The discharge had a pH of 6.6, and exceeded the arsenic and zinc benchmarks.

6.6 COCs in Groundwater in Basin Creek AOC

Groundwater data evaluated for the Basin Creek AOC in this RI included historical data from spring water samples, sample data from mine shafts located at the Josephine, and Dorothy Snow, and groundwater well data from two domestic wells in the Lower Basin Creek Subarea (Table 6.6-1). A spring located in Upper Basin Creek Subarea, about 3000 feet upgradient of the Basin Creek and Jack Creek confluence on the east bank of Basin Creek, had the lowest COC concentrations and only arsenic exceeded its respective benchmark. Jack Creek spring samples had COC concentrations as much as 70 times the concentrations in the Upper Basin Creek spring. Because of the limited data available, no conclusion can be made regarding the nature and extent of the groundwater impact from mining activities throughout this AOC. It should be noted that many groundwater samples were collected within the Town of Basin during the OU1 RI/FS that indicated localized contamination exists. However, it was determined that isolated impacts did not warrant groundwater being a media of concern for OU1 (CDM 2001c).

6.7 Basin Creek Loads

Basin Creek Loading Summary:

- Combined COC load is dominated by zinc
- Loads increased between the headwaters and confluence with Basin Creek
- Jack Creek is the largest contributor of COC load

Total and dissolved COC loads were calculated for low- and high-flow conditions at each location for each COC (Table 6.7-1). Loading is discussed as a combined COC load. Zinc loads were generally several orders of magnitude larger than the remaining COC loads, and thus zinc dominates the makeup of the combined COC load. The combined COC load in Basin Creek increased

along the length of the creek year round (Figures 6.7-1, 6.7-2, 6.7-3, and 6.7-4). No winter samples were available for 2001, however, based on historical data the combined COC loads also increase along the length of the Basin Creek in the winter months.

During the Fall 2001 RI, the combined dissolved and total COC loads near the headwaters were 0.01 lb/day, and near the mouth they were 0.6 lb/day respectively, a 60-fold increase. The first significant increase in combined loads in Basin Creek occurred in Reach 2, where dissolved and total loads increased by 0.09 lbs/day each, and the Lady Leith tributary contributed dissolved and total loads of 0.03 and 0.04 lbs/day, respectively.

By the end of Reach 3, the total and dissolved combined COC loads were 20 times higher than the total and dissolved combined COC loads in Reach 1. The dissolved and total combined loads in Reach 4 remained the same as in Reach 3, indicating that Joe Bowers Creek and Weasel Gulch do not contribute any significant loads Basin Creek.

In Reach 5, there was an increase in dissolved and total combined COC loads of 1.2 lbs/day. Jack Creek at the mouth, had dissolved and total combined COCs loads of 0.7 and 0.8 lbs/day respectively, the highest load among the tributaries in the Basin Creek AOC. Dissolved and total loads at the mouth of Jack Creek were calculated as high as 3 lbs/day during the Fall 2001, while historically it has been as high as 4 lbs/day. South Fork Basin Creek contributed 0.02 and 0.01 lbs/day of dissolved and total combined COCs loads, the lowest loads among the tributaries sampled during the Fall 2001 RI. The total and dissolved combined COCs loads in the Jack Creek Subarea were as much as 800 times higher than the loads in South Fork Basin Creek AOC.

By the end of Reach 6, dissolved and total combined COC loads were 0.8 and 0.7 lbs/day, respectively, indicating that Clay Creek, Saul Haggerty Gulch and the other minor tributaries do not contribute any significant loads Basin Creek. By the end of Reach 7, near the mouth of Basin Creek, the dissolved and total combined COC loads were 0.6 lbs/day each, also indicating that there are no additional significant COC loading sources in Reach 7, still 60 times higher than in Reach 1. Historically, dissolved and total combined COCs loads have been as high as 2 lbs/day each.

No winter samples were available for 2001, however Jack Creek historically contributed about 2 lbs/day of dissolved and total combined COCs each, accounting for the total increase in loads calculated for Basin Creek. Further, during the spring/summer months, dissolved and total loads calculated for Basin Creek at the mouth, were almost 50 times higher than calculated loads for low-flows based on historical data. Samples collected by the USGS in the spring/summer months of 2001 indicate that the dissolved and total combined COC loads during spring/summer high flows increased by as much as 34-fold compared to the fall low-flow loads.

Dissolved and total combined COCs loads in Jack Creek during spring/summer high-flow increased by as much as 10-fold relative to the fall low-flow loads.

During the September 6, 2001 storm event, the dissolved and total combined COC load in Basin Creek increased to 24 and 120 lbs/day, respectively. Almost all of the increase in dissolved load can be attributed to Jack Creek, which contributed 22 lbs/day. The total combined COC load increased by 120 lbs/day, with Jack Creek at 38 lbs/day accounting for 32 percent of the increase in total load.

In summary, Jack Creek contributed the most load to Basin Creek, at loads anywhere from 17 to 80 times the loads contributed by other tributaries in the Basin Creek AOC. South Fork Basin Creek contributes the least load. Flowing adits were located at five mine sites within the AOC. All adits were typified by low flow (less than 2 gpm) and neutral pH (near 7), except the Josephine mine where the adit discharge pH was 3. Only the Josephine is contributed significant load to Basin Creek (Table 6.7-1).

6.8 Radiological Conditions at Mine Sites

Twenty-eight mine sites in the Basin Creek AOC were screened for radioactivity. Radiation measurements in the Basin Creek AOC ranged between 0.01 and 0.52 mR/hr. The Josephine mine had the highest field measurement results, up to 52 times the lowest background concentration of 0.01 mR/hr (Table 6.8-1). None of the mine sites had concentrations that were greater than three times their respective background measurements taken near the mine sites.

6.9 Summary and Conclusions

Surface water quality in the Basin Creek AOC is best with respect to human health and aquatic life benchmarks near Basin Creek headwaters upgradient from the confluence with the Lady Leith tributary and in South Fork Basin Creek. Concentrations of COCs and sulfate increased downstream throughout the length of Basin Creek. Human health and ecological benchmarks are first exceeded in Reach 2 near the Buckeye and Enterprise mines, with the most quality degradation occurring in Reach 5, as a result of Jack Creek inflow. Plate 6-1 depicts the relative differences (using concentration ratios at each station compared to the baseline concentration) in dissolved zinc concentrations (in surface water) within Basin Creek. As noted previously, zinc is used as an indicator of COC occurrences in OU2.

South Fork Basin Creek had the lowest COC and sulfate concentrations among the tributaries in the Basin Creek AOC, while Jack Creek had the highest COCs and sulfate levels. Jack Creek contributed COC at concentrations up to 73 times the values seen in Reach 1 (upgradient) of Basin Creek. Jack Creek contributes arsenic, cadmium, copper, and zinc above benchmark concentrations year round, with the highest concentrations as much as 500 times the benchmarks. Basin Creek at the mouth discharges arsenic, cadmium, copper, and zinc above their respective benchmarks to

Boulder River. Sulfate and COC concentrations at the mouth of Basin Creek were 3, and 2 to 13 times higher, respectively, than sulfate levels near the headwaters at Station S001, indicating impact from ARD/AMD.

Contaminated sediments (Plate 6-1) in Basin Creek originate from two primary sources; the Buckeye-Enterprise mine complex in Reach 2 and Jack Creek. The mine wastes at these sites may also contribute elevated levels of trace metal concentrations to groundwater via leaching.

The water quality degradation in the Basin Creek during the low-flow months was predominantly attributable to the tributaries. Water quality impacts to the creek are greatest during high flows of the spring/summer months and during storm events, when the total contaminant loads to the creek increase. Higher flows during the spring/summer months and storm events result in the resuspension and mobilization of contaminated sediments, contributing to an increase of the total contaminant concentrations in Basin Creek.

Based on the current benchmarks, surface water and sediment contribute to risk to human and environmental receptors in the Basin Creek AOC, and further contribute to receptor risk in the Boulder River (Plate 6-1).

7

Section Seven

Section 7
Nature and Extent of COCs in the Cataract Creek AOC

The following subsections present the surface water flow characteristics and nature and extent of COCs in the Cataract Creek AOC of the Basin Watershed OU2 (Figure 1.2-3).

7.1 Overview

Cataract Creek is one of the three major tributaries (Basin Creek and High Ore Creek are the other two) to the Boulder River within the Basin Watershed OU2. To identify the major sources of COC contamination to Cataract Creek, the Cataract Creek AOC was subdivided into subareas, and the creek was divided into reaches (Plate 2-1). The locations for each soil, surface water, and sediment sample used in this RI are presented in Plates 2-1 and 2-2. USGS data collected in 2001 are only used as provisional results, because they have not yet been formally published. The following subsections present flow data and nature and extent of COCs in the Cataract Creek AOC.

7.2 Cataract Creek Flow Characteristics

Cataract Creek is a gaining stream, with flow characteristics that are consistent with typical mountain stream. Stream flow from headwaters to confluence with the Boulder River increased by 1 to 12 fold during low-flow, and by 4 fold during high-flows (historically) (Table 7.2-1).

Cataract Creek Flow Characteristics:

- Cataract Creek flow increases 20 fold from its headwaters to its confluence with Boulder River
- High flow is typically an order of magnitude higher than low flow (0.1 to 2 cfs versus 1 to 86 cfs)
- Uncle Sam and Snowdrift Creek contribute the most volume to Cataract Creek during Fall 2001
- Rocker Creek historically has the highest flow to Cataract Creek
- Overall, Cataract Creek is a gaining stream, but it likely loses and gains in different segments of the creek

Conditions during the Fall 2001 RI sampling were consistent with baseline flow. The lowest flow in Cataract Creek was 0.1 cfs, near its headwaters, while the highest flows were measured in Reach 5 and Reach 7 at 2 cfs (Table 7.2-1). Three Cataract Creek tributaries were sampled in 2001, including Unnamed 1, Snowdrift Creek, and Uncle Sam Gulch. These tributaries combined accounted for about 70 percent of the total surface inflows to Cataract Creek during the Fall 2001 RI. Of these tributaries, Uncle Sam Gulch and Snowdrift Creek had the highest flow.

Historical flow data exist for Unnamed 2, Nellie Grant Creek, Overland Creek, Rocker Creek, Snowdrift Creek, Hoodoo Creek, Unnamed 5, Unnamed 6, Uncle Sam Gulch,

Deer Creek, and Big Limber Gulch tributaries. These data show that Rocker Creek typically is tributary with the highest flow.

During the September 6, 2001 storm event, Cataract Creek flow at the mouth was about 15 times the pre-storm low-flow, and the total increase in flow from Reach 4 to Reach 7 was almost 19 cfs (Table 7.2-1). Only Snowdrift Creek and Uncle Sam Gulch tributaries were sampled during the storm event, and they accounted for about 50 percent of the total storm water flow measured in Reach 7.

Generally, flows in Cataract Creek are highest during spring/summer months, while flows during the remainder of the year are one to two orders of magnitude lower. Flow measured in Cataract Creek during the Fall 2001 sampling reflect base flow conditions. Flows in the creek increased along the length of the river relative to the headwaters, with Uncle Sam Gulch contributing the most flow.

7.3 Cataract Creek Surface Water Quality

Table 7.3-1 presents the Fall 2001 RI and average historical concentrations for the COCs and selected physical parameters in Cataract Creek and its tributaries during high- and low-flow conditions. Results above benchmark concentrations (Section 4.1) are identified in bold underlined font.

Figures 7.3-1 and 7.3-2 present the historical concentration data for COCs that exceeded the benchmark levels in Cataract Creek during the different flow regimes. The data are presented by station and reach for mainstem and tributary locations. Figures 7.3-3 and 7.3-4 present the COCs exceeding the benchmark levels in 2001. Figures 7.3-5 and 7.3-6 depict sulfate inputs and changes from upstream to downstream. Discussion of non-storm and storm water quality in Cataract Creek follow.

7.3.1 Non-Storm Surface Water Quality

Cataract Creek headwaters had no COCs at concentrations above benchmark levels (Table 7.3-1, and Figures 7.3-1 through 7.3-4). A change in water quality was first detected in Reach 3 (Plates 2-1 and 2-2), where cadmium, copper, and zinc exceeded benchmarks. Concentrations of COCs in Reach 3 ranged from 13 to 45 times the concentrations in Reach 1. The Nellie Grant Creek and Rocker Creek tributaries were not sampled,

Cataract Creek Surface Water Quality Highlights:

- Surface water in Cataract Creek headwaters is generally of good quality
- Water quality degrades in Reach 3 with the introduction of Cd, Cu and Zn above benchmarks
- COC concentrations in Reach 4 decrease to at or below benchmarks
- COCs increase in number (addition of As, and Pb) and concentration in Reach 5
- Snowdrift Creek contributes the lowest COC concentrations, while Uncle Sam Gulch contributes the most

but historically contributed most of the COCs above benchmarks in Reaches 1 through 3 (Table 7.3-1, and Figure 7.3-1 and 7.3-2).

At the downstream end of Reach 4 during Fall 2001, the COCs concentrations were at or below their respective benchmark levels. The concentrations of COC in this reach at low flow were equal to or lower than those in Reach 1 (arsenic, cadmium, mercury), but up to 25 times greater than the copper and zinc concentrations in Reach 1 (Table 7.3-1, and Figures 7.3-1 and 7.3-4). Historically within Reach 4, during both low- or high- flow, arsenic, cadmium, copper, lead, and zinc exceeded the benchmarks (Table 7.3-1, and Figures 7.3-1 and 7.3-2). No tributaries were sampled in Reach 4 during 2001, but historical data for Unnamed Tributary 6 showed concentrations of cadmium, copper, and zinc above benchmarks during high- and low-flow periods.

In Reach 5, measured COCs from Uncle Sam Gulch tributary exceeded benchmarks for arsenic, cadmium, copper, lead, and zinc by up to 300 times during 2001 (Table 7.3-1, and Figure 7.3.3 and Figure 7.3.4). These concentrations significantly deteriorated water quality in Reach 5. By the end Reach 5, cadmium, copper, and zinc concentrations were lower, but still exceeded benchmark levels. The concentrations of all COCs at the end of Reach 5 were as high as 47 times the levels measured in Reach 4. These patterns are also confirmed by the historical data (Table 7.3-1, and Figures 7.3-1 through Figure 7.3-2).

In Reach 6, inflow from Deer Creek tributary increased concentrations of arsenic, cadmium, copper, lead, and zinc in Cataract Creek as much as 1,317 times above benchmark levels and 22 times the concentrations in Reach 5. Historically, Big Limber Gulch tributary also contributed levels of arsenic and zinc above benchmark levels. Big Limber was not sampled during 2001. By the end of Reach 6, however, concentrations of all COCs decreased. Arsenic and lead were below benchmark levels and concentrations of cadmium, copper, and zinc only exceeded benchmark levels up to 7 times.

During 2001 in Reach 7, copper, cadmium, and zinc decreased in concentration relative to Reach 6, but remained above benchmarks, and arsenic increased in concentration (Figure 7.3-3 and Figure 7.3-4). Under spring/summer high-flow conditions, lead concentrations also exceeded benchmarks in Reach 7, historically and in 2001 (Figure 7.3-3). Relative to Cataract Creek headwaters, low-flow concentrations of arsenic, cadmium, copper, and zinc were up to 165 times levels greater by the end of Reach 7. Lead and mercury concentrations in Reach 7 were equivalent to concentrations in Reach 1.

The field-measured pH levels were all near neutral and within surface water standards, ranging from 6.2 to 8.2 along the length of the creek. Sulfate generally increased in concentration from upstream to downstream, except for during high-flow when it became diluted (Figures 7.3-5 and 7.3-6). Sulfate values at the mouth of Cataract Creek were 4 times higher than sulfate levels near the headwaters, indicating

impact from AMD/ARD. Of the tributaries, Uncle Sam Gulch discharged on average the highest sulfate concentrations (Table 7.3-1, and Figures 7.3-5 and 7.3-6).

In summary, Cataract Creek surface water quality is best with respect to human health and aquatic life benchmarks near its headwaters. Although historically Reaches 1 and 2 have had minor mining-related impacts, the first indications of regular water quality deterioration occur in Reach 3, with the worst deterioration occurring in Reach 5 form Uncle Sam Gulch (Figures 7.3-1 through 7.3-4). Cataract Creek discharges arsenic, cadmium, copper, and zinc at concentrations above benchmark values to Boulder River.

7.3.2 Storm Surface Water Quality

During the September 6, 2001 storm event, flow in Cataract Creek increased by as much as 15 times the Fall 2001 low-flow, and about 10 times the historical low-flow average (Tables 7.2-1). Water quality with respect to the dissolved COC phase remained relatively similar to conditions under low flow while total COC concentrations increased drastically (Table 7.3-1 and Figure 7.3-7). Concentrations of the COCs in the creek during this storm event increased to levels as much as 1,175 times the concentrations near the headwaters under low-flow.

Fall 2001 Storm Water Summary:

- Flow increased to as much as 15 times base flow
- Reach 1 was not sampled during the storm event
- Total COC concentrations increased significantly compared to low-flow, while dissolved concentrations remained similar
- Exceedence patterns mimicked base flow, but with higher concentrations
- Surface water pH remained neutral from upstream to downstream
- Sulfate concentrations increased along the length of the creek
- COCs Increased in concentrations mostly due to sediment resuspension

Concentrations of COCs were as much as 141 times the ecological benchmarks, and as much as 6,917 times the human health benchmarks (Figure 7.3-7). Arsenic, copper, lead, and zinc concentrations in Cataract Creek remained above screening levels and increased further in concentration along the remaining length of the stream during this storm event.

The field-measured pH levels were all within surface water standards, and remained unchanged along Cataract Creek (Table 7.3-1). Sulfate concentrations increased from headwaters to mouth (Table 7.3-1, and Figure 7.3-8), with significant contributions from Uncle Sam Gulch tributary. The TDS concentration increased up to 2.2 times low-flow conditions, and TSS was up to 4 times the low-flow values (Table 7.3-1). The increased flow from the storm event resuspended contaminated sediments, leading to further deterioration of water quality.

7.4 Cataract Creek Sediment Quality

Sediment samples collected historically from Cataract Creek included instream sediment samples, stream terrace gravel deposits, overbank sediments, and fluvial tailings cores. In 2001, only instream sediment samples were collected and evaluated. The samples were analyzed as either minus 10-mesh, minus 80-mesh and/or minus 260-mesh. In general, the highest COC concentrations were detected in the minus 260-mesh size fraction, followed by the minus 80-mesh (Table 7.4-1).

Sediment Quality Highlights:

- Sediment COC distribution mimicked surface water COCs with many benchmark level exceedences
- Impacted sediment first occur in Reach 2 with identification As, Cd, Cu, Pb, and Zn
- Reach 5 has the highest COC concentrations
- Snowdrift Creek contributes the least amount of contaminated sediments, while Uncle Sam Gulch contributes the most

Historically, arsenic, cadmium, copper, lead, and zinc were measured at concentrations exceeding ecological benchmark levels at most stations and generally increased along the length of Cataract Creek (Table 7.4-1 and Figure 7.4-1). Reach 1 had low levels of COCs with no benchmark exceedences, while Reach 7 had COC concentrations up to 58 times greater than benchmarks.

The Fall 2001, sediments in Reach 1 had the least number of COCs above ecological benchmark levels and lowest COC concentrations of all reaches (Figure 7.4-2). Reach 1 receives inflow from Unnamed Tributary 1 and the COCs exceeding benchmarks in this reach included arsenic, cadmium, and copper. The number of COCs above screening levels increased in Reach 2 (arsenic, cadmium, copper, lead, and zinc), with significant contributions of these COCs from Rocker Creek. Relative to Reach 1, COC concentrations in this reach were up to 40 times greater.

Downstream of the Snowdrift Creek tributary in Reach 3 during 2001, sediment quality continued to degrade; arsenic, cadmium, copper, lead, and zinc concentrations remained above benchmark levels (Figure 7.4-2). Concentration of arsenic in Snowdrift Creek exceeded the benchmark by 11 times. By the end of Reach 3, arsenic concentrations exceeded the benchmark by 22 times and represented a three fold increase from Reach 2. The concentrations of COCs exceeding ecological benchmarks in Cataract Creek sediment also continued to increase in Reach 4, although the number of COCs (arsenic, copper, cadmium, lead, zinc) remained the same. Sediment from Unnamed Tributary 6 included high levels of mercury, but the inflows from this tributary did not increase mercury levels in Reach 4. Historically, the greatest concentrations of zinc in the Cataract Creek AOC occurred in this tributary.

The highest concentrations of COCs in Cataract Creek in 2001 occurred in sediments from Uncle Sam Gulch (Figure 7.4-2). Arsenic, cadmium, copper, lead, mercury, and

zinc exceeded benchmarks 500 fold and were more than 3,500 times greater than headwater conditions. As a result, COC concentrations at the end of Reach 5 were about 2.5 times the levels in Reach 4.

Despite these high inputs and contributions from Deer Creek and Big Limber Gulch tributaries, COCs in the sediments in Reaches 6 and 7 decreased relative to Reach 5 (Figure 7.4-2). However, COC concentrations remained above ecological benchmarks in these reaches. By the end of Reach 7 at the outlet to Boulder River, the concentrations of the five COCs (arsenic, cadmium, copper, lead, and zinc) ranged from 3 to 475 times the levels in the headwaters and exceeded benchmarks up to 37 times.

In summary, the frequency of COCs exceeding sediment screening levels and their concentrations increase along the length of the creek. Reach 5 had the most COCs at the highest concentrations in Cataract Creek, followed by Reach 4. Unnamed Tributary 6 and Uncle Sam Gulch were the biggest sources of contaminated sediment to the creek, both historically and in 2001.

7.5 COCs at Mine Sites in Cataract Creek AOC

There are over 200 mine sites that have been identified in the Cataract Creek AOC (Table 2.3-1). Physical and chemical data are available for 67 of these mine sites. The USFS is addressing 6 of these mine sites, namely the Black Bear, Cracker, Grey Lead, Morning Glory Tailings, Phantom, and the Sirius. Vogel mine had the lowest COC concentrations among the mine sites in the AOC. This subsection discusses the extent of COCs and acid production potential among the mine sites relative to Vogel to identify the major contaminant sources in the Cataract Creek AOC.

7.5.1 Waste Material Characterization

Table 7.5-1 presents ranges for COC and ABA results for waste material samples collected at abandoned mine lands in the Cataract Creek AOC. Mine sites with a NP/AP ratio of less than 1, and a percent sulfide of greater than 0.3 percent are considered to have a high potential of producing AMD/ARD (ICARD 2000). Mine sites with a NP/AP ratio of less than 1, and less than 0.3 percent sulfide are considered to have a moderate potential of producing AMD/ARD, while mine sites with a NP/AP ratio of greater than 1 are considered to have a low potential for AMD/ARD. All the mine sites were ranked based on their maximum total zinc concentration relative to total zinc values at Vogel, since zinc makes up the largest metals/metalloid percentage of the waste composition.

Upper Cataract Creek Subarea

There are 26 mine sites identified in the Upper Cataract Creek Subarea, with 8 mine sites within 500 ft proximity to a stream or drainage. Chemical and physical data are available for 10 of these mine sites. Of these 8 mines, the Corbitt and the Eldorado and Plateau have high AMD/ARD production potentials, while the North Ada-

Piermont has a moderate potential to produce AMD/ARD. The Ida May, North Ada-Piermont, Eldorado Plateau, Crescent, and Corbitt have total zinc concentrations ranging from 34 to 820 times the total zinc concentration at the Vogel site.

Middle Cataract Creek Subarea

There are 91 mine sites identified in the Middle Cataract Creek Subarea, with 35 mine sites within 500 feet of a stream or drainage. Chemical and physical data are available for 46 of these mine sites. Eight of these mine sites have high AMD/ARD production potentials, namely the Hattie Fergusson, Lizzie Osborne, Mary Anne, Middle Snowdrift Creek, NE SE Section 14, Sirius, Timberline, and the Unnamed 001. Alpine, Bleak Bear, Blue Diamond/Occidental, Cataract Tails, Cracker, Eva May, Gray Lead, Morning Glory, NE SW Section 17, Unnamed 002, and the Vera and Marie mines have a moderate potential to produce AMD/ARD. The Morning Glory, Gray Lead, Hattie Fergusson, Eva May, and Boulder Chief mines had the five highest total zinc concentrations in this subarea, with values ranging from 284 to 1,440 times the zinc concentration at the Vogel mine site.

Uncle Sam Gulch Subarea

There are 20 mine sites identified in Uncle Sam Gulch Subarea, with 11 mine sites located within 500 ft of Uncle Sam Gulch. Chemical and physical data are available for 6 of these mine sites. There are no mine sites with available data with high AMD/ARD potentials. Evening Star was the only mine site with moderate AMD/ARD production potential. No ABA data are available for SW NW Section 29, Uncle Sam, Snowbird, Garfield, and the Crystal. Uncle Sam, Snowbird, Garfield, and the Crystal had the five highest total zinc concentrations in this subarea, with values ranging from 5 to 485 times the zinc concentration at the Vogel site.

Lower Cataract Creek Subarea

There are 75 mine sites identified in the Lower Cataract Creek Subarea, with 32 mine sites with in 500 ft proximity to a stream or drainage. Chemical and physical data are available for 15 of these mine sites. Silvan is the only mine site with a high AMD/ARD production potential. Big Medicine, Gold Flake, Manhattan, Phantom, Ruth, Saturday Night, Seattle and Vogel have moderate potentials to produce AMD/ARD. The Boulder Vestal is the only mine site with a low potential to produce AMD/ARD. The Seattle, Saturday Night, Phantom, Sylvan and Boston mine sites had the five highest total zinc concentrations in this subarea, with values ranging from 77 to 150 times the zinc concentration at Vogel.

All mine sites within the Cataract Creek AOC had COC concentrations that exceeded ecological and human health benchmarks. The concentrations of arsenic, cadmium, copper, lead and zinc were as much as 9,250, 123, 109, 584, 474 times the ecological benchmarks, and 215,000, 3, 3,100, 1,000, and 23,000 times the human health benchmarks, respectively.

The proximity of 86 mines to Cataract Creek, its tributaries and other drainages and the magnitude of the COC concentrations in the waste material indicate that under the right geochemical and climatic conditions these mines can have immediate adverse impacts to the creek.

7.5.2 COCs Concentrations in Groundwater Discharges

Fifty-seven mine sites with adit discharge or seeps have been identified in the Cataract Creek AOC (Table 7.5-2). Adit and seep samples were collected from 53 of these mine sites, and all had COCs at concentrations exceeding human and ecological health benchmarks. A brief description of these point sources at the mine sites with available flow data follows.

Mine Sites with Groundwater Discharges:

- Crystal
- NE SE Section14
- Cracker
- Eva May
- Cresent
- Rocker Extension
- Cartright Cabins
- Hattie Fergusson
- Waldy
- All discharges had COCs that exceeded ecological and human health benchmarks

Crystal

Four adits were sampled at the Crystal mine in Uncle Sam Gulch. All four samples exceeded ecological and human health benchmarks. Adit discharge from the Crystal mine reportedly flowed at a maximum rate of 25 gpm and a pH of 3.41 . Crystal had the highest adit discharge rate measured within the Cataract Creek AOC.

NE SE Section 14

One adit was sampled at NE SE Section 14. Flow and COC concentrations from this adit were significantly lower than the Crystal mine adit. The pH was in the neutral range, and only arsenic and zinc exceeded ecological and human health benchmarks.

Cracker

One adit was sampled at the Cracker mine, and it exceeded the ecological and human health benchmarks for all COCs. The adit discharged a rate of 6 gpm with a pH near 7.

Eva May

One adit was sampled at the Eva May mine, which exceeded the ecological and human health benchmarks for all COCs. The adit discharge flowed across the waste pile at a rate of approximately 4 gpm with a pH near 7. The surface flow infiltrated before reaching Cataract Creek.

Crescent

One adit was sampled at the Crescent mine, which exceeded the ecological and human health benchmarks. Discharge from the a single caved adit was flowing at a rate of about 3 gpm with a pH of 4 . The flow discharged to an adjacent wetland area.

Rocker Extension
One adit and one waste rock seep sample was collected at the Rocker Extension. Both samples exceeded ecological and human health benchmarks for all COCs. The adit seep was flowing at about 2 gpm with a pH near 7. The waste rock seeps discharged at a combined rate of about 5 gpm with a pH near 9.

Cartwright Cabins
One adit was sampled at the Cartwright Cabins mine, which only had arsenic and lead above human health benchmarks. Discharge from the a single caved adit was flowing at a rate of about 2 gpm with a pH near neutral.

Hattie Ferguson (Lower/Main)
Three adits were sampled from the Hattie Fergusson, one from the Lower Hattie Ferguson , and two from the Upper Hattie Ferguson. Discharge flow rates ranged between 2 and 3 gpm. All COCs exceeded either ecological or human health benchmarks. The pH of the discharges ranged from 4 to 9.

Waldy
One adit was sampled at the Waldy mine, with only mercury above ecological benchmarks. The adit discharged at an estimated flow rate of 2 gpm, and the pH was neutral to basic.

Of the remaining 47 mines, Boulder Chief had the highest COC concentrations with the lowest pH, followed by the Corbitt, Ida M, New Cottage, and Seattle mines.

7.6 COCs in Groundwater in Cataract Creek AOC

Groundwater data evaluated for the Cataract Creek AOC in this RI included historical data from a pond located at the Alsace, shafts located at the California, Corbitt, Eldorado and Plateau, Klondyke and Overland Creek, and groundwater well data from wells located at NE NW Section 17, and near the Boulder Vestal mine (Table 7.6-1). The shaft at California had the lowest COC concentrations, while the highest concentrations were detected in the Klondyke and Eldorado and Plateau shafts, and the NE NW Section 17 groundwater well. Because of the limited data available, no conclusion can be made regarding the nature and extent of the groundwater impact from mining activities in this AOC. Water from the sahft at the California mine is used as-needed for firefighting, because recharge in the shaft is reportedly very good.

7.7 Cataract Creek Loads

Total and dissolved COC loads were calculated for low- and high-flow conditions at each location for each COC (Table 7.7-1). Loading is discussed as a combined COC

load, since remedial activities cannot address individual COCs during cleanup. Zinc loads were generally several orders of magnitude larger than the remaining COC loads, and thus zinc dominates the makeup of the combined COC load. The combined COC load in Cataract Creek increased along the length of the creek year round (Figures 7.7-1, 7.7-2, 7.7-3, and 7.7-4). No winter samples were available for 2001, however, based on historical data the combined COC loads also increase along the length of the creek in the winter months too.

Cataract Creek Loading Summary:

- Combined COC load dominated by zinc
- Loading increased significantly between the headwaters and confluence with Boulder River (0.001 to 4 lbs/day) during 2001
- First significant laoad increase occurs in Reach 3
- Uncle Sam Gulch is the largest contributor of load (up to 10 lbs/day low flow; over 100 lbs/day storm flow)

During Fall 2001 RI, the combined dissolved and total COC loads near the headwaters were less than 0.001 lb/day, and near the mouth they were 4 lbs/day respectively, a 400 fold increase in load. The first significant increase in combined loads in Cataract Creek occurred downgradient of the Apollo mine in Reach 3, where dissolved and total loads increased by 0.8 lbs/day each. By the end of Reach 4, the total and dissolved combined COCs dropped to 0.3 lbs/day each, indicating that no significant loads are contributed in this reach.

In Reach 5, there was an increase in dissolved and total combined COC loads of almost 11 lbs/day. Uncle Sam Gulch at the mouth, had dissolved and total combined COCs loads of 9 and 10 lbs/day respectively, the highest load among the tributaries in the Cataract Creek AOC. Historically, Uncle Sam Gulch contributes loads as high 16 lbs/day during fall low-flow. Snowdrift Creek contributed the lowest loads among the tributaries sampled during the fall 2001 RI, at 0.01 Lbs/day of dissolved and total combined COCs loads each. The total and dissolved combined COCs loads in the Uncle Sam Gulch were as much as 1,500 times higher than the loads in Snowdrift Creek.

By the end of Reach 6, dissolved and total combined COC loads dropped to 6 lbs/day each during fall low-flow. Deer Creek contributes the second highest of the measured loads in the AOC, at 0.5 lbs/day dissolved and total each. By the end of Reach 7, near the mouth of Cataract Creek the dissolved and total combined COC loads were 5 lbs/day each, indicating that there are no additional significant COC loading sources in Reach 7. However, the load at the mouth of Cataract Creek was still 50,000 times higher than in Reach 1. Historically, dissolved and total combined COCs loads have been as high as 9 lbs/day each during the fall low-flow period.

No winter samples were available for 2001, however, Uncle Sam Gulch historically contributed about 7 lbs/day of dissolved and total combined COCs each, accounting for the total increase in loads calculated for Cataract Creek (Figure 7.7-1).

Historically, during the spring/summer months, dissolved and total loads calculated for Cataract Creek at the mouth, were about 10 times higher than calculated loads for low-flows. Samples collected by the USGS in the spring/summer months of 2001 indicate that the dissolved and total combined COC loads during spring/summer high flows increased by as much as 9 fold compared to the fall low-flow loads. Dissolved and total combined COCs loads in Uncle Sam Gulch during spring/summer high-flow increased by as much as 4 fold relative to the fall low-flow loads.

During the September 6, 2001 storm event, the dissolved and total combined COC load in Cataract Creek increased to 56 and 105 lbs/day, respectively. All of the increase in dissolved load can be attributed to Uncle Sam Gulch, which contributed 104 and 156 lbs/day dissolved and total combined COC respectively. The total combined COC load increased by 100 lbs/day relative to the low-flow load.

In summary, Uncle Sam Gulch contributed the most load to Cataract Creek, at loads as much as 15,000 times the loads from other tributaries in the Cataract Creek AOC. Snowdrift Creek contributed the least load. The Crystal adit had the highest combined COC load in the AOC, with the Hattie Fergusson, Crescent, Cracker, and Ada Mines also contributing significant loads (Table 7.7-2).

7.8 Radiological Conditions at Mine Sites

Fifty-one mine sites in the Cataract Creek AOC were screened for radioactivity. Radiation measurements in the Cataract Creek AOC ranged between 0.01 and 2.9 mR/hr. Four of the mine sites had concentrations that were greater than 3 times their respective background measurements. The Morning Marie mine had the highest field measurement results, up to 290 times the lowest background concentration of 0.01 mR/hr (Table 7.8-1).

7.9 Summary and Conclusions

Surface water quality in the Cataract Creek AOC is best with respect to human health and aquatic life benchmarks in Reaches 1 and 2 and in Snowdrift Creek. Concentrations of COCs and sulfate increased along the length of the Cataract Creek. Benchmarks are first exceeded in Reach 3 near the Apollo mine, with the worst deterioration occurring in Reach 5 due to Uncle Sam Gulch. Plate 7-1 depicts the relative differences in dissolved zinc concentrations between the Cataract Creek reaches.

Snowdrift Creek had the lowest COCs and sulfate levels among the tributaries in Cataract Creek AOC while Uncle Sam Gulch had the highest COCs and sulfate levels. Uncle Sam Gulch exceeded benchmarks for arsenic, cadmium, copper, lead, and zinc by up to 300 times. Of the tributaries, Uncle Sam Gulch discharged on average the highest sulfate concentrations .

The water quality degradation in Cataract Creek during the low-flow months was predominantly attributable to the tributaries. Water quality impacts to the creek are greatest during high flows of the spring/summer months and during storm events, when the total contaminant loads to the creek increase. Higher flows during the spring/summer months and storm events result in the resuspension and mobilization of contaminated sediments, contributing to an increase of the total contaminant concentrations in the creek.

The frequency of COCs exceeding sediment screening levels and their concentrations increase along the length of Cataract Creek. Reach 5 had the most COCs at the highest concentrations in the creek, followed by Reach 4. Unnamed Tributary 6 and Uncle Sam Gulch were the biggest sources of contaminated sediment to the river, both historically and in 2001. At the mouth of Cataract Creek the concentrations of the COCs in sediment exceeded benchmarks up to 37 times.

The field-measured pH levels were all near neutral and within surface water standards, ranging from 6.2 to 8.2 along the length of the creek. Sulfate generally increased in concentration along the length of the creek, and becomes diluted during high-flows. Sulfate values at the mouth of Cataract Creek were four times higher than sulfate levels near the headwaters, indicating impact from acid rock drainage. Sulfate and COCs values at the mouth of Cataract Creek were higher than sulfate levels near the headwaters at Station S014, indicating impact from AMD/ARD.

Based on the current benchmarks, surface water and sediment contribute to risk to human and environmental receptors in the Cataract Creek AOC.

8

Section Eight

Section 8
Additional Groundwater and Wetland Investigation

This section discusses the sampling methodology and results of the additional groundwater and wetland investigation performed in the Basin Watershed OU2 for this RI. This portion of the RI investigation was completed near the end of the sampling program to obtain additional information on potential impacts to wetlands and groundwater/surface water interactions. Because of time and access constraints, very few samples were collected. No site-wide conclusions were made based on these few samples, however, these data do reflect tendencies of surface to groundwater interactions.

8.1 Groundwater Investigation

The groundwater investigations performed included the collection of groundwater/surface water interface (GSI) samples, as well as waste material pore water, and wetland pore water samples. The GSI sampling was completed to establish the quality of the groundwater discharging into the surface water systems near mine sites during base flow conditions. The GSI was evaluated at the contact of the Eva May (Figure 8.1-1) and the Cataract tailings with Cataract Creek, at the Upper Hattie Fergusson wetland, and at a location downgradient of the Eva May site on the opposite (east) bank of Cataract Creek. The sample collected from the east bank of Cataract Creek, downgradient of Eva May is considered representative of baseline groundwater conditions, because the area on the east side of Cataract Creek near Eva May has not been extensively mined. Mine waste pore water samples were collected to establish the quality of water leached to the groundwater at mine sites, and were collected from the Apollo and the Cartwright Cabins waste piles located along Cataract and Deer Creek, respectively (Plate 2-2).

8.2 Wetland Investigation

The wetland investigation included the collection of surface water and sediment samples at both upgradient and downgradient locations in the wetland, as well as GSI and pore water samples. The selected locations included the wetland at the Upper Hattie Fergusson and a wetland on Rocker Creek. These locations were selected based on their close proximity to historical mine sites. Wetland pore water samples were collected to evaluate the pore water quality in wetlands impacted by the historical mining. Figures 8.2-1 and 8.2-2 present a schematic of the wetland sample locations at Upper Hattie Fergusson and Rocker wetlands, respectively.

8.3 GSI and Pore Water Sampling Methods

A Mark Henry Equipment (MHE) Pushpoint Sampler (patent pending) was used to collect the GSI and pore water samples. The MHE Pushpoint Sampler is a 27-inch long tubular device constructed of 316 stainless steel with a 1.5-inch long screened-bottom end and a sampling port at the top end. The screened zone is approximately 20 percent open area. To obtain a sample, the MHE Pushpoint Sampler was pushed

into the subsurface at the edge of the stream bank or in the waste material. Subsurface water was extracted using a syringe or peristaltic pump (Figure 8.3-1). To determine the groundwater head, the probe was inserted into the subsurface materials to a point where the screen was below the watertable and the top (sampling port) was above the surface water level. Water was evacuated from the probe and tubing. The tubing was then bent into a U-shape to view the water level. The water level (groundwater level) in the clear tubing was compared to the static surface water level to determine the potential vertical groundwater flow direction (Figure 8.3-1).

The sampler was further purged using the syringe (imparts low suction) or peristaltic pump (imparts higher suction) prior to sampling. Groundwater samples were collected when it was established that the subsurface water (purge water) was different from the surface water by comparing surface and subsurface water temperature, conductivity, and oxidation reduction potential measurements.

8.4 GSI and Pore Water Sampling Results

This section discusses the results of each GSI and pore water investigation. Table 8.4-1 presents a summary of the GSI and pore water sampling results.

8.4.1 GSI Sampling Result Interpretation

GSI samples were collected at the contact of the Eva May and the Cataract Tails tailings with Cataract Creek, at the Upper Hattie Fergusson wetland, and at a location downgradient of the Eva May site on the opposite bank of Cataract Creek. The GSI sample collected at the location downgradient of the Eva May site on the east bank (unimpacted side) of Cataract Creek had the lowest COC concentrations, at levels below the ecological benchmarks, suggesting limited, if any impact of groundwater. The GSI sample collected at the Upper Hattie Fergusson wetland, just downgradient of a waste rock pile had the highest COC concentrations (Table 8.4-1). The COCs were as much as 1300 times the ecological benchmarks, as much as 5200 times the concentrations measured in Cataract Creek upgradient from the Apollo mine, and as much as 4800 times the baseline groundwater sample, indicating a significant potential for groundwater impact from these waste materials. Upper Hattie Fergusson has a high potential to produce ARD. This indicates that at least the 23 other mine sites in the Basin Watershed OU2 (Tables 6.5-1 and 7.5-1) with a high ARD/AMD potential can have similar impacts to the groundwater and the surface water in areas of groundwater discharge.

8.4.2 Pore Water Sampling Result Interpretation

Pore water samples were collected from the Apollo, Cartwright Cabins, and a waste pile located in the Rocker Creek wetland. Rocker Creek wetland and Apollo combine accounted for the highest pore water COCs concentrations (Table 8.4-1). The COCs were as much as 2 times the ecological benchmarks, and as much as 4 times the baseline groundwater sample. Apollo and Cartwright Cabins had the highest potential to produce ARD.

8.5 Wetland Sampling Results

Wetland areas that were sampled included the Upper Hattie Fergusson wetland and a wetland on Rocker Creek. Both wetlands showed higher COC concentrations in the surface waters exiting the wetland areas than flowing into the wetlands (Table 8.4-1). Of these two wetlands, Rocker Creek wetland had the highest COC sediment concentrations, indicating impacts from mining activities.

The study did not evaluate the abundance and diversity of the biota community, but this is an aspect of future wetland evaluation, and is needed to understand impacts to wetland receptors.

This Page Intentionally Left Blank

9

Section Nine

Section 9
Contaminant Fate and Transport

An understanding of the fate and transport processes acting on the COCs in the Basin Watershed OU2 is critical when predicting the distribution of the COCs between different media in the environment (i.e. sediment, water, soil, and air) under various conditions (pH, conductivity, etc.). As the conditions change in the environment, the distribution of the COCs in the media and the form of the COCs can change (i.e., the oxidation state, molecular configuration, ionic charge, aqueous species), which can affect the mobility and toxicity of the compounds. This section discusses the theoretical aspects of fate and transport processes in the environment that define and/or control these processes. This section has been divided into three subsections, including:

- Physical and chemical properties that may affect the fate of a chemical
- Mechanisms that may affect the transport of a chemical
- Physical and chemical properties of surface water, sediment, COCs and groundwater

9.1 Fate Processes

Fate processes consist of physical and chemical transformations of COCs in the environment.

Physical processes are defined, for this RI, as processes that do not change the chemical state of a substance (e.g., the molecular structure or oxidation state). The predominately physical processes of solubility, speciation, complexation, precipitation/dissolution, soil-water partitioning, and air-water, and air-soil partitioning are briefly described in Appendix E. Chemical processes are defined, for this RI, as processes that change the chemical state of a substance (e.g., the molecular structure or oxidation state). Brief explanations of chemical, photochemical, and biological transformation and oxidation/reduction are presented in Appendix E.

9.2 Transport Mechanisms

Transport mechanisms, for this RI, are described as those processes that convey possible contaminants from one location to another. Brief explanations of infiltration/percolation, advection, dispersion, and diffusion, all of which occur in OU2, are provided in Appendix E.

9.3 Physical and Chemical Properties of the Site COCs

The following sections discuss the fate and transport mechanisms effecting the indicator COCs (i.e., cadmium, copper, mercury, lead, and zinc) in this RI.

9.3.1 Physical and Chemical Properties of Cadmium

Stability of Solid and Aqueous Species

Cadmium is more mobile in aquatic environments than most other heavy metals (Callahan et al. 1979), primarily because of its minimal ability to sorb to soil. In natural water, cadmium primarily exists as the cadmium $^{2+}$ ion, and its concentration in water is inversely related to pH and the concentration of organic material in the water (Callahan et al. 1979). Eh/pH diagrams are presented in Appendix E for both low-flow (higher concentrations) and high-flow (lower concentrations) conditions, respectively. Because cadmium exists only in the +2 oxidation state, it is not strongly influenced by the oxidation or reduction potential of the stream.

Precipitation/Dissolution

Precipitation and sorption to mineral surfaces and organic materials are the most important removal processes for cadmium compounds. Sediment bacteria may also assist in the partitioning of cadmium from water to sediments (Burke and Pfister 1988). Cadmium in sediment may redissolve from the sediment under varying ambient conditions.

Adsorption/Desorption

The tendency for cadmium to sorb mainly depends on the CEC and pH of the soil. The most important factor in reducing the cadmium load in water is sorption. Cadmium is more mobile in acidic water than in alkaline water (Callahan and Slimak 1979).

9.3.2 Physical and Chemical Properties of Copper

Stability of Solid and Aqueous Species

Copper is found in most natural water. Eh/pH diagrams are presented in Appendix E for both low-flow (higher concentrations) and high-flow (lower concentrations) conditions, respectively. Decreased water hardness enhances the toxicity of copper (EPA 1988). In solution, copper exists in two oxidation states: copper (I) predominated in reducing conditions while copper (II) dominates in oxidizing conditions. As a result, the solubility of the solid phases of copper (I) and copper (II) depends upon the redox potential (Rai et al. 1986). Copper is only slightly soluble in the pH range of most natural water (Boyd and Frobish 1990).

Precipitation/Dissolution

The retention of copper by montmorillinite clay (Bingham et al. 1964) and some soil (Abd-Elfattah and Wada 1981) have been observed to be consistent with the formation of a copper solid phase such as $Cu(OH)_2$ (Rai et al. 1986). Precipitation is

an important removal mechanism at pH values greater than 6.5 when copper containing leachate contacts clay minerals (Frost and Griffin 1977).

Adsorption/Desorption
Copper is strongly adsorbed in soil by three prominent retention mechanisms: complexation by soil organic matter, specific adsorption, and ion exchange (Rai et al. 1986). The dominant factor controlling copper adsorption in surface soil is soil organic matter (McLaren and Crawford 1973; Pertuzelli et al. 1978; Ramamoorthy and Rust 1978). At low aqueous concentrations of copper and in soil or subsoil low in organic material, specific adsorption to soil iron, aluminum, and manganese oxides may be the prominent retention mechanism (McLaren and Crawford 1973; Oakley et al. 1981; Davis and Leckie 1978; McKenzie 1980; McBride 1982). Soil pH has an important effect on copper adsorption (Sadiq 1981), in that it controls copper solution speciation and hydrolysis and surface charge distribution on amphoteric soil hydrous oxides (Rai et al. 1986).

9.3.3 Physical and Chemical Properties of Mercury

Stability of Solid and Aqueous Species
Mercury is a multivalent element and in aqueous environments can exist in 0, $^{+}1$, and $^{+}2$ oxidation states. The stable form of mercury in most natural water systems is the free metal. Eh/pH diagrams are presented in Appendix E for both low-flow (higher concentrations) and high-flow (lower concentrations) conditions, respectively. The amount of mercury present in water open to the atmosphere is likely to be low, owing to its tendency to escape as vapor (low boiling point) (Rai et al. 1986).

Precipitation/Dissolution
The solubility of mercury compounds in oxidized environments is predicted to be very high. Mercury sulfide (cinnabar), metacinnabar, or liquid elemental mercury may control mercury solution levels in reduced environments (Rai et al. 1986).

Adsorption/Desorption
Organic material is the most important factor controlling mercury adsorption in soil (Hogg et al. 1978; John et al. 1975) and on sediment (Ramamoorthy and Rust 1978I Rogers et al. 1981; Ramamoorthy and Rust 1976; Miller 1975). Mercury (II) forms strong complexes with many ligands including halides. Under oxidizing conditions where mercury (II) compounds are fairly soluble, the primary attenuation mechanism of mercury is expected to be adsorption/desorption. Mercury may form chloride or hydroxide complexes depending on pH and total chloride concentrations (Rai et al. 1986). The fate of mercury in natural water is controlled by its strong affinity for adsorption onto inorganic and organic particulates (Callahan and Slimak 1979). Organic complexes such as methyl mercury and other similar forms can be produced by methane-generating bacteria in contact with metallic mercury in lake or stream sediments (Wood et al. 1968). Sediments are the major sink for mercury in the aquatic environment. Dissolved mercury is removed from the water within a short time, generally near its source. Mercury is bound strongly with sediment in river water

and can be transported through sedimentary mobilization (Callahan and Slimak 1979).

9.3.4 Physical and Chemical Properties of Lead

Stability of Solid and Aqueous Species

Naturally occurring lead has three oxidation states: 0, +2, and +4. In natural aqueous environments, lead primarily exists as lead (II); it exists as lead (IV) only in extremely oxidizing conditions that are outside the natural pH and Eh range (Rai et al. 1986). Eh/pH diagrams are presented in Figures 9.3-13 and 9.3-14 for both low-flow (higher concentrations) and high-flow (lower concentrations) conditions, respectively. The shaded areas in these diagrams denote solid phases. Lead is more mobile in acidic water. In alkaline water, lead is removed from the dissolve phase very quickly. Above pH 7, most of the lead is in the solid phase. A significant fraction of lead carried by river water is expected to be in an undissolved form, which can consist of colloidal particles or larger undissolved particles of lead carbonate, lead oxide, lead hydroxide, or other lead compounds incorporated in other components of surface particulate matter from runoff (Getz et al. 1977). Some of the lead (II) compounds with relatively low solubility include lead carbonates, lead phosphates, and lead phosphate halides (Lindsay 1979). Lead may be converted to lead sulfate in the soil surface which is relatively soluble compared with lead carbonate or phosphate

Precipitation/Dissolution

Nriagu (1974) pointed out that lead phosphate can readily precipitate and could be a major factor in the biochemistry of lead. However, no direct identification of lead phosphate precipitates in natural aqueous systems have been made. Solution concentrations of lead in soils appear to be regulated by solid phases that include phosphates (Santillan-Medrano and Juriank 1975). Several lead compounds [$Pb(OH)_2$, $Pb_3(PO_4)_2$, $Pb_4O(PO_4)_2$, and $Pb_5(PO_4)_3OH$], depending upon pH, appear to be controlling the solubility of lead in noncalcareous soils. Depending on the pH, cerussite ($PbCO_3$) was found to be the controlling phase in calcareous soils (Rai et al. 1986).

Adsorption/Desorption

Lead is strongly retained in soil by ion exchange and specific adsorption. The soil properties, which most often correlate with lead adsorption, are soil organic matter and clay content (Singh and Sekhon 1977a; Soldatini et al. 1976; Riffaldi et al. 1976; Abd-Elfattah and Wada 1981). Lead is strongly sorbed to organic matter in soil, and although not subject to leaching, it may enter surface waters as a result of erosion of lead-containing soil particulates. Lead may also be immobilized by ion exchange with hydrous oxides or clays or by chelation with humic or fulvic acids in the soil (Olson and Skogerboe 1975). Lead may occur either as sorbed ions or surface coatings on sediment mineral particles, or it may be carried as a part of suspended living or nonliving organic matter in water. The ratio of lead in suspended solids to lead in dissolved form has been found to vary form 4:1 in rural streams to 27:1 in urban streams (Getz et al. 1977).

9.3.5 Physical and Chemical Properties of Zinc

Stability of Solid and Aqueous Species

Zinc in natural aqueous environments exists exclusively in the +2 valence state. Eh/pH diagrams are presented in Appendix E for both low-flow (higher concentrations) and high flow (lower concentrations) conditions, respectively. Franklinte ($ZnFe_2O_4$) and willeminte (Zn_2SiO_4) are the two least soluble zinc compounds (Lindsay 1979). Other zinc minerals such as $Zn(OH)_2$, smithsonite ($ZnCO_3$), and zincite (ZnO) are relatively more soluble than willemite and franklinite (Rai et al. 1986).

Precipitation/Dissolution

Limited information is available on solubility controlling solids in natural soil and sediment (Jenne et al. 1980) modeled waters and reported that the concentration of zinc appeared to be controlled by $ZnCO_3 \cdot H_2O$ or smithsonite. Jenne et al. 1980 also suggests that willemite may be the solubility controlling phase of zinc (Rai et al. 1986). In reducing environments, precipitation of zinc sulfide will control its mobility (Callahan and Slimak 1979).

Adsorption/Desorption

Like other cationic heavy metals, zinc is adsorbed specifically by ion exchange. The predominant absorbents controlling the adsorption behavior of zinc in soil are manganese and zinc oxides (Takematsu 1979), with lesser contribution from soil organic matter (Kuo and Mikkelsen 1979; Bunzl et al. 1974) and clay minerals (Farrah and Pickering 1977). Of the heavy metals, zinc is one of the most mobile. The zinc ion and compounds of zinc formed with the ligands of surface water are soluble in acidic or neutral water. If Su pH exceeds 7 Su, zinc will generally be removed from solution. Below pH 6, little zinc will be adsorbed (Callahan and Slimak 1979).

This page intentionally left blank.

10

Section Ten

Section 10
Summary of Risk Assessment in OU2

This section summarizes the evaluation of the risks to ecological (Section 10.1) and human receptors (Section 10.2) posed by exposure to environmental media (i.e., surface water, sediment, or soil/mining waste) in the Basin Watershed OU2 (Figure 1.2-2; Plate 1-1). The ERA evaluates the likelihood that adverse effects are occurring or may occur to ecological receptors as a result of exposure to physical and chemical stressors within OU2. It consists of two major components, a screening-level ecological risk assessment (SERA) and a baseline ecological risk assessment (BERA). The ERA was streamlined, pulling from the assumptions and risk calculations from the Upper Tenmile Creek Superfund site BERA (CDM 2001d); however, maintained consistent with EPA ecological risk assessment for superfund (ERAGS) guidance (EPA 1997). Data used in the ERA was exclusively from Basin Watershed OU2.

The human health risk assessment (HHRA) for the Basin Watershed OU2 is a unique combination of two HHRAs performed on two adjacent Superfund sites; Upper Tenmile Creek and Town of Basin OU1. Both the Upper Tenmile Creek and Town of Basin OU1 HHRAs quantify potential carcinogenic and noncarcinogenic health risks from exposure to contaminants in the mining areas adjacent to Basin Watershed OU2 following EPA's Risk Assessment Guidance for Superfund (RAGS) (EPA 1997). Both assessments evaluate current and future risks to individuals living, working, and recreating within the respective sites based on the assumption of no remediation or institutional controls (i.e., baseline conditions).

The BERA and HHRA documents have not received final approval by EPA at the time this RI report was issued. Findings presented in these documents have bearing on the findings presented in the RI and, therefore, the RI conclusions must be reviewed if there are changes in the BERA and/or HHRA documents.

10.1 Ecological Risk Assessment Summary

The ERA was initiated with the SERA to provide a gross estimation of risk to ecological receptors and determine if a more focused and comprehensive BERA was needed for OU2. The SERA fulfills Steps 1 and 2 of EPA's 8-step risk assessment evaluation process.

10.1.1 Components of the SERA

The following subsections describe the components of the SERA, including the environmental setting, contaminants of concern, contaminant fate and transport mechanisms, ecotoxicity of site-related contaminants, ecological receptors, and exposure pathways to receptors.

Environmental Setting and Contaminants of Concern

The environmental setting has been previously discussed in this RI (Section 2) and is not repeated. COPCs- within OU2 were identified through comparison of maximum

detected concentrations to relevant ecological screening values, or appropriate surrogates where screening values were unavailable. For surface water COPCs selection, dissolved metals concentrations were used to compare against screening values, since the dissolved fraction is generally considered most bioavailable and, therefore, potentially more toxic to aquatic biota.

Screening values for surface water, sediment, and solid media were selected from state and federal standards and guidance, as well as accepted national guidance. These initial screening values are considered conservative to ensure that all possible COPCs are retained for consideration in the risk assessment. When necessary, hardness was used to adjust toxicity values or criteria for hardness-dependent metals. The average hardness for OU2 is 55 mg calcium carbonate per liter ($CaCO_3$/L), which is considered representative of the Site. The chemicals whose associated maximum detected concentration did not exceed screening values were automatically eliminated from consideration. Those chemicals lacking accepted screening values were retained. Detected chemicals were only eliminated as COPCs if they were detected at a low frequency (i.e., <5 percent), an essential nutrient or electrolyte, or minimally toxic. Chemicals that were retained as surface water, sediment, and solid media COPCs for the BERA are presented in Tables 10.1-1 through 10.1-3, respectively.

Fate and Transport Mechanisms

Fate and transport mechanisms potentially impacting these chemicals within OU2 include chemical, physical, and biological processes. These processes or mechanisms include hydrolysis/complexation, oxidation-reduction, proteolysis, volatilization, adsorption/desorption, dissolution/precipitation, and biodegradation. The importance of each of these processes depends upon the specific chemical and the environmental conditions. Each of these fate and transport mechanisms is discussed in detail in Section 9 of this RI and the BERA.

Ecotoxicity

A review of the most recent ecological risk and toxicity assessment literature identified ecotoxicity data (i.e., toxicity reference values [TRVs]) for each of the retained COPCs identified above. The selection of TRVs is presented in Tables 10.1-4 through 10.1-6 for each media. Chemical-specific information on the aquatic ecotoxicity of the COPCs is presented in the BERA (CDM 2002).

Potential Receptors

Potential ecological receptors for OU2 are plants, algae, and animals (i.e., soil and aquatic invertebrates, fish, amphibians, reptiles, birds, and mammals) that inhabit or use the aquatic, riparian/wetland, and terrestrial habitats of the Basin Watershed OU2.

The number of potential receptor species identified or expected in OU2 obviously precludes an assessment of risks for every aquatic and terrestrial species onsite. Several species or groups of organisms have, therefore, been selected to serve as representative receptors for a detailed evaluation of ecological risks. The selection of these receptors is based on their importance to local ecosystems, population status, human use potential, the exposure medium, metals sensitivity, and data availability.

Using these criteria, the following groups of organisms were selected as primary ecological receptors for the screening-level ERA.

- Aquatic plants and algae
- Water column and benthic macroinvertebrates
- Salmonid fish (e.g., trout)
- Piscivorous birds (e.g., belted kingfisher)
- Piscivorous mammals (e.g., mink)
- Terrestrial macrophytes (e.g., agricultural crops, grasses, shrubs)
- Soil invertebrates (e.g., earthworm)
- Soil microbes

Exposure Pathways

Several pathways related to the migration of COPCs were identified. These include windblown dust, surface water runoff, erosion, instream transport of contaminated water and sediment, and food chain transfer. Minor and major complete exposure pathways, organized by contaminant source, are described in Table 10.1-7. Exposure pathways that are complete include those with a contaminant source, a route of exposure, and contact with or uptake by a receptor. Incomplete exposure pathways cannot cause adverse effects because one or more critical components (e.g., contaminant source, exposure route, or receptor) are lacking. Minor complete and incomplete exposure pathways are not included in the SERA.

The assessment endpoints identified under the SERA are presented in Table 10.1-8, and are compared to exposure data to estimate risk. Assessment endpoints include any adverse effects on ecological receptors. More often, assessment endpoints are defined as the ecological attribute, value, or resource that requires protection (e.g., a self-reproducing trout population).

The SERA assessed risk at a population or community level, using toxicity data at the organism level as surrogate data. Site-specific assessment and measurement endpoints directly related to the important complete exposure pathways include:

- Benthic macroinvertebrate population, community structure, and function
- Fish population and community structure and function
- Wetland function
- Terrestrial macrophytes, small mammals, and birds

10.1.2 Screening-level Exposure Estimate and Risk Estimation

Maximum detected concentrations (Table 10.1-9, 10.1-10, and 10.1-11) were used for exposure point concentrations, and were used to estimate risks. Although this is a conservative approach, it both follows regulatory guidance and assures that potentially important contaminants are not eliminated at this stage of the ERA.

Screening-level hazard quotients (HQs) for each of the identified COPCs were calculated by subarea are presented in Tables 10.1-12 (surface water), 10.1-13 (sediment), and 10.1-14 (surface soil and other solid media). Ranges of HQ values are presented when TRVs ranges were selected for a particular COPC. HQs were calculated as follows:

$$HQ = \frac{\text{Exposure Concentration}}{TRV}$$

The 95 percent upper confidence limit (95 UCL) was preferably used to calculate the HQs. In instances where the 95 UCL value lacked confidence (i.e., 95 UCL was lower than or equal to the mean, or equal to or higher than the maximum concentration), the mean and maximum concentrations were used as the exposure concentration to calculate a HQ range. Chemicals with HQs below 1.0 have no hazardous effect on ecological receptors, and were eliminated from further consideration. Many COPCs in the various site media had HQs greater than 1.0, which indicates that risk to ecological receptors exists throughout OU2 in all media.

Surface water trace metals had the highest HQs, ranging from less than 1 to 7,235 with the highest HQs associated with aluminum, cadmium, copper, iron, lead, and zinc (Table 10.1-12). Sediment COPCs had HQs that ranged from less than 1 to 466. The most prevalent sediment COPCs with the highest associated HQs were arsenic, cadmium, copper, lead, silver, and zinc (Table 10.1-13). Soil COPCs, consisting primarily of inorganic chemicals within waste rock, had HQs that ranged from less than 1 to 2,128 (Table 10.1 -14). The most prevalent soil COPCs with the highest associated HQs were aluminum, arsenic, iron, and lead.

Achieving scientific proof is often difficult. The scientific method is instead based on stating hypotheses, testing these hypotheses, and either accepting or rejecting the hypotheses based on the weight-of-evidence provided by test data. Cause and effect relationships can be inferred and evidence can support hypotheses, but cause and

effect relationships can rarely be proven. In this screening-level ERA, the primary null hypothesis is:

- Basin Creek, Cataract Creek, Boulder River and their tributaries, as well as associated aquatic, riparian, and terrestrial habitats have not been and are not being adversely affected, directly or indirectly, by mining-related contaminants.

Reviewing the SERA data, hazard quotient calculations indicate that many COPCs in surface water, sediment, and soil greatly (i.e., >10 to >100 times) exceed the 1.0 threshold HQ for unacceptable ecological risk. Based on the magnitude of the calculated HQs, aquatic toxicity, and direct association with adverse effects at other similar sites, it is expected that a subset of the COPCs with HQs greater than 1.0 are of most concern. These include:

- Aluminum, barium, beryllium, cadmium, copper, iron, lead, manganese, selenium, silver, thallium, and zinc in surface water
- Arsenic, cadmium, copper, lead, silver, and zinc in sediment
- Aluminum, arsenic, iron, manganese, mercury, and zinc in surface soil

Therefore, the number and magnitude of the HQs based on maximum detected COPC concentrations demand that the above null hypothesis be rejected.

At this stage of the SERA, there is adequate information to conclude that ecological risks exist in OU2 and, thus, a BERA is warranted. A summary of the BERA follows. The BERA was conducted using a weight-of-evidence approach that is more robust and less conservative than that used to perform the SERA.

10.1.3 Baseline Ecological Risk Assessment Summary

10.1.3.1 BERA Rationale

Based on the SERA, EPA requirements, and recommendations by EPA Region 8 and FWS ecotoxicologists, a streamlined risk evaluation (i.e., a BERA) was completed for OU2. The BERA comprises Steps 3 through 8 of EPA's risk assessment process and was completed using a focused approach. The BERA also builds on the structure and findings of the adjacent Upper Tenmile Creek Superfund site BERA (CDM 2001d); however, uses OU2-specific data. This focused approach is a conservative, yet sufficiently comprehensive approach for estimating the potential for unacceptable ecological risk within the Basin Watershed OU2. At some point, an addendum to the BERA may be warranted to address future site-specific ecological concerns.

10.1.3.2 BERA Problem Formulation

The BERA (CDM 2002) quantifies ecological risks identified in the SERA and uses risk estimations and assumption from Upper Tenmile Creek to evaluate the need for remedial strategies within OU2. BERA problem formulation includes the following activities:

Refining COPCs Identified in the SERA
The data used was the most recent site data, thus no refinement of COPCs were needed. All COPCs identified in the SERA (Tables 10.1-1 through 10.1-3) are retained and evaluated as COCs in the BERA. With the exception of molybdenum, all of the COCs retained for Upper Tenmile Creek site were also retained in the Basin Watershed OU2 ERA. In addition, up to seven additional analytes were retained for Basin Watershed OU2 media, indicating a higher potential incidence of ecological risk in OU2 compared to Upper Tenmile Creek.

Refining Contaminant Fate and Transport
No additional fate and transport mechanisms were identified from the SERA. A detailed discussion of these mechanisms and general conclusions concerning their importance in affecting the fate and transport of the COCs in OU2 is presented in the BERA (CDM 2002).

Identifying Ecosystems at Risk and Ecological Receptors
From the SERA, ecosystems at risk include terrestrial and aquatic ecosystems. At risk are terrestrial habitats consisting of wood, scrub/shrub, and open grass field habitats that sustain species of concern like the boreal owl (*Aegolius funereus*) and lynx (*Lynx canadensis*); and plant species like the muskroot (*Adoxa moschatellina*), peculiar moonwort (*Botrychium paradoxum*), and Hall's rush (*Juncus halli*). Aquatic ecosystems at risk consist of natural ponds, surface water streams, intermittent creeks, and wetlands that sustain species of concern like the westslope cutthroat trout (*Oncorhyhchus clarkii lewisi*), aquatic plants and algae, water column and benthic macroinvertebrates, and piscivorous birds like the belted kingfisher.

The BERA revised the list of representative receptors for OU2. An insectivorous avian receptor was added to the list of representative receptors. As in Upper Tenmile Creek and because of it occurrence, diet, and natural history (for modeling), the marsh wren (*Cistothorus palustris*) was selected. This BERA also assumes the specific exposure concerns for Canada lynx. Therefore, the final list of representative receptors for OU2 include the following:

- Aquatic plants and algae
- Water column and benthic mcroinvertebrates
- Salmonid fish (e.g., trout)
- Piscivorous birds (e.g., belted kingfisher)
- Piscivorous mammals (e.g., mink)
- Insectivorous birds (e.g., marsh wren)
- Terrestrial macrophytes (e.g., agricultural crops, grasses, shrubs)

- Soil invertebrates (e.g., earthworm)
- Soil microbes

Identifying Complete Exposure Pathways
Figure 10.1-1 presents an evaluation of the completeness of identified exposure pathways for the selected representative receptor groups. Complete exposure pathways include a primary or secondary contaminant or stressor source (e.g., metals-contaminated surface water) connected to a receptor (e.g., trout) by a likely exposure mechanism (e.g., ingestion of metals-contaminated surface water). Lack of any one of these components (i.e., stressors, receptors, or exposure mechanisms) results in an incomplete exposure pathway and, thus, no potential for adverse effects. Only complete exposure pathways are evaluated in the BERA.

Selecting Assessment and Measurement Endpoints
Assessment endpoints were derived from management goals, and represent specific environmental values that should be protected in OU2. Assessment endpoints for this BERA include the following:

- Protection of a self-reproducing salmonid fishery
- Protection of a diverse and abundant benthic macroinvertebrate community
- Protection of a diverse community of aquatic macrophytes and algae
- Protection of a diverse and abundant terrestrial vegetative community
- Protection of piscivorous mammal and piscivorous and insectivorous bird populations such that ingestion of surface water and prey causes no measurable adverse effects
- Protection of a diverse and abundant terrestrial invertebrate/soil microbial community such that nutrient cycling in soils is not measurably impaired

Wetland function as an assessment endpoint was dropped from the SERA because of a lack of data to evaluate. Recognizing this may be an important element of the risk evaluation, wetland function evaluation will be included in the long-term biomonitoring program proposed for OU2. Conversely, terrestrial-based assessment endpoints were added after the SERA because it is assumed that waste rock, tailings, and contaminated surface soil have potential to adversely affect certain ecological receptors. Although such risks are believed to be lower than those associated with aquatic environments.

The identified assessment endpoints are mutually inclusive. Further, multiple expressions of assessment endpoints are included. The assessment endpoints

described above are directly related to the measurement endpoints (discussed below) and corresponding TRVs used in this BERA to assess risk.

Measurement endpoints are quantitative expressions of observed or measured biological responses to stressors relevant to selected assessment endpoints. Measurement endpoints are commonly expressed in terms of changes in community structure, changes in community function, or impaired survival, growth, or reproduction at the individual level. Impaired survival, growth, or reproduction at the individual level is commonly expressed in terms of toxicity to specific receptors or receptor groups. Measurement endpoints selected for use in this BERA are summarized below, along with corresponding assessment endpoints.

- Chronic effect (survival, growth, or reproduction endpoints) concentrations of COCs in surface water for trout
- No adverse effect concentration (NOAEC)- and low adverse effect concentration (LOAEC)- based COC concentrations in sediment for trout
- Chronic effects (survival, growth, or reproduction endpoints) concentrations of COCs in surface water for daphnids or other freshwater invertebrates
- NOAEC- and LOAEC-based COC concentrations in sediment for benthic macroinvertebrates such as amphipods
- NOAEC- and LOAEC- based COC concentrations in surface water and sediment for representative piscivorous birds and mammals and insectivorous birds
- NOAEC- and LOAEC-based COC concentrations in soil for representative terrestrial macrophytes, small mammals, and birds

Models Used in the BERA

A simple food chain model developed in the Upper Tenmile Creek BERA (CDM 2001d) is incorporated by reference. This model used literature-based bioaccumulation factors (BAFs) for invertebrates and aquatic plants that serve as potential food items for waterfowl. Because of the potential for some COCs to accumulate in biological tissues and exert adverse effects on piscivorous and insectivorous predators, this BERA evaluates the effects of ingestion of contaminated water, sediment, and food items.

Site Conceptual Exposure Model (SCEM) and Testable Hypotheses

The SECM (Figure 10.1-1) is discussed above. In addition, an important goal of the BERA is to answer important risk-based questions about OU2. Test hypotheses are used to frame the important questions, primarily those regarding potential exposure scenarios and the relationship between selected assessment and measurement endpoints. The hypotheses for OU2 are defined as follows:

- Are the levels of mining-related contaminants in water, sediment, and biota sufficiently elevated to adversely affect the survival, growth, or reproduction of salmonid fish in OU2?

- Are the levels of mining-related contaminants in water, sediment, and biota sufficiently elevated to adversely affect the survival, growth, or reproduction of aquatic plants and aquatic invertebrates in OU2 surface waters?

- Are the levels of mining-related contaminants in surface soils, mine tailings, and waste rock sufficiently elevated to adversely affect the survival, growth, or reproduction of terrestrial macrophytes, soil invertebrates and microbes, piscivorous and insectivorous birds, and piscivorous mammals in OU2?

This BERA assumes that population-level effects are most important and that the loss of a single individual is not critical to the population or community. This is not true for threatened or endangered species. Adverse effects or a loss of even one individual is considered important.

10.1.3.3 Exposure Characterization

The assessment of exposures to ecological receptors is the evaluation of co-occurrence or contact between a receptor and a contaminant (stressor). The objective of the exposure assessment is to quantify the exposure of an organism to a contaminant, so that the potential for harm can be assessed. Exposures can be direct (i.e., where the stressor acts directly on the ecological component of interest, not through other components of the ecosystem) or indirect (i.e., where the stressor acts on supporting components of the ecosystem, which in turn have an effect on the ecological component of interest).

Direct Exposures to COCs in Site Media

Direct exposures occur when the ecological receptor is directly exposed to a contaminant in an environmental medium, through ingestion, inhalation, or dermal exposure. Adverse effects to ecological receptors can occur from a combination of exposure frequency, exposure duration, and COC concentration in exposure media. Piscivorous birds, insectivorous birds, and piscivorous mammals were selected as the representative species because they are likely to be directly or indirectly exposed to site-related stressors (i.e., COCs) in surface water, sediment, soil, or prey.

Tables 10.1-9 through 10.1-11 present the mean, maximum, and 95 UCL values for the COC concentrations for each media in each of the 11 subareas within OU2. As noted previously, the 95 UCL is used to represent reasonable maximum exposures. It is believed that means and maximums bracket the reasonable upper range of concentrations to which ecological receptors are likely to be exposed. The values presented on the tables are compared to ecotoxicological benchmark values in the risk

characterizations to estimate risks to fish, benthic macroinvertebrates, terrestrial plants, and soil invertebrates and microbes.

Indirect Exposures Through the Food Chain

In addition to direct exposure to site contaminants, ingestion of contaminated water and prey can also adversely affect ecological receptors through food chain exposures. Generally, piscivorous and insectivorous predators are at most risk if the COCs present in surface water and sediments accumulate to a significant level in fish and aquatic invertebrates. This BERA estimates dose-based risks to piscivorous and insectivorous birds and piscivorous mammals using belted kingfisher, marsh wren, and mink, respectively using the Upper Tenmile Creek BERA food chain exposure model (CDM 2001d). The model calculates daily dose via drinking water (directly) and in the calculation of dose via ingestion of prey (indirectly, using bioaccumulation). The resulting estimated total daily doses are compared to dietary thresholds or TRVs to estimate risk to the receptors.

Specific Issues Related to Canada Lynx Exposures

Although lynx have not been confirmed within OU2, they are known to occur in the area. With existing suitable habitat for this species, they were considered for this BERA. The Upper Tenmile Creek BERA presented an exposure profile for potential risks to Canada lynx (listed as threatened by FWS), and it was extended to OU2. The information suggests that lynx is a potential receptor that may be exposed to mining-related contaminants. Of specific concern for OU2 is the exposure pathway that includes willows growing in cadmium-contaminated soils, herbivorous predators on willows, and lynx preying on such herbivores (CDM 2002). However, the assumption that a direct pathway from willow to lynx does not currently exist in OU2, and further suggests that such data collections are not warranted at this time.

Exposure Characterization Summary

The 95 UCL values presented in this section are compared to ecotoxicological benchmark values in the risk characterization evaluation (Section 10.1.3.5) to characterize risks to fish, benthic macroinvertebrates, terrestrial plants, and soil invertebrates and microbes as a result of potential direct exposure to contaminated media. In addition, the estimated total daily ingestion doses of representative piscivorous and insectivorous birds and piscivorous mammals are compared to dietary thresholds or TRVs in to evaluate risks to these receptors.

10.1.3.4 Ecological Effects Assessment

Published literature indicates that most of the COCs identified for OU2 have substantial potential to adversely affect exposed ecological receptors. Several different types of data are used to assess the toxicity of COCs or the potential of COCs to cause adverse effects in exposed receptors. These different types of data are used in a weight-of-evidence approach to assess risk.

Lines-of-Evidence Approach

The approach used to conduct this BERA is based on multiple lines of evidence. One line of evidence is the HQ method where comparisons are made between COC concentrations in various media and COC- and media-specific measurement endpoints that are applicable to representative receptors. Other lines of evidence include quantitative and qualitative site-specific information and studies on key receptor groups such as benthic macroinvertebrates, periphyton, and fish. The various lines of evidence will be evaluated for each assessment endpoint in the risk characterization.

Effects Characterization

The list of effects data was refined by replacing screening-level values with TRVs specifically related to key receptors, receptor groups, or assessment endpoints. Tables 10.1-4, 10.1-5, and 10.1-6 summarize the TRVs. Most of these TRVs were obtained from the the EPA-approved Upper Tenmile Creek site ERA (CDM 2001d). Additional TRVs for COCs not in this document were obtained from the same sources used for Upper Tenmile Creek ERA. All TRVs were selected from state and federal guidance. When these sources lacked TRVs for specific COCs, generally accepted industry standards were used (CDM 2002).

Site-Specific Exposure-Response Studies

In addition to TRVs, three site-specific studies were performed in Basin Watershed OU2 between 1999 and 2001 that focused on evaluating impacts to aquatic ecological receptors. The three studies (described below) are used to support the risk evaluation by characterizing exposure effects. These studies also provide additional lines-of-evidence. Additional details are provided in the BERA (CDM 2002).

- Macroinvertebrate Sampling Summary During Fall 1999, Basin Watershed OU2 (CDM 2001g)

This study documents that habitat and macroinvertebrate diversity is generally good within OU2, with a few exceptions (e.g., Jack Creek, Uncle Sam Gulch). Although screening-level sampling duration precludes assessment of benthic macroinvertebrate abundance, the low numbers of organisms in good habitat suggest poor water quality or poor sediment quality. Comparison of relative abundance (i.e., between stations) suggests that actual abundance is lower in Jack Creek and Uncle Sam Gulch than throughout the rest of OU2.

- Characterizing Aquatic Health Using Fish Mortality, Physiology, and Population Estimates in the Boulder River Watershed, Montana (USGS 2000)

This study evaluated inorganic chemicals in environmental media in the Basin Watershed OU2 and their affect on fish tissue and populations. The absence of fish and conditions that lend to fish mortality were documented in upper Basin Creek and Cataract Creek, while improved habitat and diversity exists in the lower reaches near

and in Boulder River. Macroinvertebrate densities were greater in Basin Creek as opposed to Cataract Creek. Cadmium, copper, and zinc were the primary contributors of degraded water quality and are believed to be responsible for stress, poor habitat, and poor fish diversity, with contributing affects from lead and arsenic. Degraded water quality and habitat are especially pervasive in Bullion Mine tributary, Jack Creek, Uncle Sam Gulch. The USGS concluded that increased survival of fish in these waters requires metals concentrations reduced to at least 3 ug/l Cd, 33 ug/l Cu, and 400 ug/l Zn (USGS 2000).

- Focused Fish Survivability Evaluation in Cataract Creek of the Basin Watershed OU2 (MDFWP 2001; unpublished)

MDFWP personnel studied trout in lower Cataract Creek between Uncle Sam Gulch (a major contributor of metals) and Boulder River during 2001 (personal communication; D. Skaar 2002). The focused study was follow up work to the 1998/1999 USGS study described above. Survivability of trout in elevated metals-load conditions, population counts, and *in situ* bioassay tests were included in the study.

Cutthroat trout exist above the confluence with Uncle Sam Gulch, while very few fish were documented between Uncle Sam Gulch and waterfall downstream of Uncle Sam Gulch (due to poor water quality). Only rainbow trout capable of tolerating poor quality water existed downstream of the waterfall. Also significant was the population structure of the trout at each location. Below the waterfall, the rainbow trout were reproducing successfully in the mainstem of Cataract Creek (judged by the lack of spawning tributaries but the presence of young-of-the-year [YOY] fish). Above Uncle Sam Gulch, all age classes of cutthroat trout were found.

Survivability testing initially consisted of 2-inch, hatchery-raised, rainbow trout (younger fish than used by USGS) placed at 4 locations downstream of Uncle Sam Gulch. All test fish died within 48 hours (consistent with USGS findings). To evaluate acclamation, YOY rainbow trout living below the waterfall were captured, caged, and placed in Cataract Creek between Uncle Sam Gulch and the waterfall (i.e., the area lacking living fish). These fish survived a 96-hour test. Similar tests with adult and YOY cutthroats from upstream of Uncle Sam Gulch revealed that all YOY and 30 percent of the adults died within 96 hours.

During the fish population surveys, all trout were fin-clipped at each location. The rainbow trout were documented to stay in the area (six-week study), while the few cutthroat trout that were fin-clipped below Uncle Sam Gulch were never recaptured. These results suggest that the rainbow trout have acclimated to the waters of Cataract Creek and are capable of longer-term survival there. Their absence from the stream above the waterfall is more likely a result of the waterfall physical barrier, rather than an inability to tolerate the poor water quality. In contrast, the cutthroat trout do not appear to have acclimated to the poor water quality below Uncle Sam Gulch, and only larger fish can tolerate the conditions for short periods of time.

In addition to these studies, several site-specific studies (e.g., trout survivability and willow sampling) were performed in Upper Tenmile Creek site (CDM 2001d).

10.1.3.5 Risk Characterization

This risk characterization integrates exposure and effects information to determine or estimate risk to representative ecological receptors in OU2. It also incorporates site-specific information, such as macroinvertebrate community studies, and fish population and toxicity data, as well as risk assumptions and conclusions identified in the Upper Tenmile Creek ERA.

Several lines of evidence were used to evaluate exposure risks to the assessment endpoints. The method varied depending on the receptor group or primary exposure pathway. Risks to benthic macroinvertebrates, aquatic plants, and fish were evaluated by comparison of site-specific sediment and surface water COC concentrations to literature-derived benchmark values (i.e., TRVs), which results in a range of HQs as risk estimates. In addition, site risks to benthic macroinvertebrates and fish were evaluated using site-specific community abundance and diversity assessments. For terrestrial organisms, risks were evaluated by comparison of solid media COC concentrations to literature-derived TRVs for soil invertebrates, soil microbes, and terrestrial macrophytes. Risks to piscivorous birds, insectivorous birds, and piscivorous mammals were assessed using the Upper Tenmile Creek food chain model. Daily doses were estimated based on ingestion of COC-contaminated surface water and aquatic prey and these doses were compared to dose-based NOAECs and LOAECs from the literature. Another approach was based on the calculation of a single exposure point in surface water or sediment, for direct comparisons of risk estimates between COCs. This approach was based on the hazard index or HQ method of risk estimation discussed in the SERA. Estimates of risk are presented below for each assessment endpoint.

For the BERA, each HQ was based on a single exposure concentration, preferably 95 UCL, divided by a single selected TRV. Tables 10.1-12, 10.1-13, and 10.1-14 summarize the HQ calculations for COCs in site media by subarea. A HQ range is presented when a range of TRVs were identified for a particular chemical. HQs greater than 1.0 are considered significant, HQs greater than 10.0 are presented in yellow-highlighted type, and HQs greater than 500 are presented in pink-highlighted type.

Risks for representative piscivorous mammalian (mink) and piscivorous/ insectivorous avian (belted kingfisher/marsh wren) predators were estimated based on total (diet + water) daily doses divided by appropriate TRVs - analogous to the HQ approach, and are summarized in Table 10.1-15. An HQ of greater than 1.0

indicates significant risks to the types of organisms represented by the selected receptors. HQs in several of the subareas exceed 1.0 for the modeled receptors.

10.1.3.6 Risk Summary

Summary of HQs Determinations

Many COCs in surface water, sediment, and soil at the site had HQs greater than 1.0. Surface water COCs had the highest HQs, which ranged from less than 1 to 7,235. A subset of the COCs contribute the most risks associated with surface water exposures to aquatic ecological receptors, such as aquatic plants, invertebrates and vertebrates. These COCs include dissolved aluminum, cadmium, copper, iron, lead, and zinc. All subareas had HQ values above 10 for one or more COCs except South Fork Basin Creek.

Surface water-based risks to piscivorous mammalian and piscivorous/insectivorous avian predators include HQs for mink, belted kingfisher and marsh wren exposed to cadmium, copper, lead, and zinc. Fish and aquatic invertebrates consumed by piscivorous/insectivorous predators are most likely to be contaminated with COCs that bioaccumulate, including cadmium, copper, lead, and zinc. The other surface water COCs identified are unlikely to bioaccumulate to the same degree as these four COCs. Cadmium HQs exceeded 1.0 for the belted kingfisher and mink in only one subarea (Uncle Sam Gulch). The HQs for copper, lead, and zinc were below 1.0 in all subareas for these two species. Piscivorous birds and mammals, represented by kingfisher and mink, do not appear to be at risk from consumption of metal-contaminated prey in most subareas, excluding Uncle Sam Gulch. In contrast, HQs ranged from 1.1 to 138.9 for cadmium, copper, lead, and zinc for the marsh wren in eight subareas. These HQs above 1.0 suggest that consumption of insects estimated to be contaminated with copper, cadmium, lead, and zinc has potential to adversely affect insectivorous birds, such as those represented by the marsh wren.

Sediment COCs had HQs that ranged from less than 1 to 466. Similar to the surface water findings, a subset of COCs contribute the most risks to aquatic invertebrates and vertebrates associated with sediment exposures. These COCs include arsenic, cadmium, copper, lead, silver, and zinc. Other sediment COCs also contribute to sediment toxicity at some locations, but generally to a lesser degree than arsenic, cadmium, copper, lead, silver, and zinc. All subareas had HQ values above 10 for one or more COCs except South Fork Basin Creek and Upper Cataract Creek (upgradient of significant mining-related impacts). Jack Creek and Uncle Sam Gulch subareas had the most COCs and the highest associated HQs.

Solid media COCs, consisting primarily of inorganic chemicals within waste rock, had HQs that ranged from less than 1 to 2,128. The most prevalent solid media COCs with the highest associated HQs are aluminum, arsenic, iron, and lead.

All the soil HQs are based on limited TRVs and on the assumption that soil-based receptors (e.g., terrestrial plants, soil invertebrates, or soil microbes) are in direct contact with the contaminated surface material. In fact, mine waste, tailings, and other similar surface material are not expected to support viable plant and invertebrate communities for a variety of reasons; toxic condition, reduced moisture retention, and lack of cover. Therefore, the surface soil HQs likely overestimate risk. The average risks to terrestrial receptors is also expected to be lower because of low frequency and duration of exposure to contaminated locations. Finally, many terrestrial species avoid unsuitable habitats regardless of toxicity. Most of the surface soil/solid media samples came from barren or mostly unvegetated waste piles that may be or may not be toxic.

All subareas with data had associated COCs with HQs greater than 1; three subareas had no soil/waste rock samples collected and, therefore, no data.

The Upper Tenmile Creek BERA documented the low potential exposure for the lynx terrestrial predator. Terrestrial biota are not expected to significantly accumulate the major surface soil COCs in OU2, because of their wide home and foraging ranges. Of the surface soil COCs identified, only mercury readily bioaccumulates and is biomagnified in food webs, however, the risks associated with exposure to mercury in solid media are probably overestimated because of the uncertainties with the mercury TRVs. The Clark Fork River ERA (EPA 1999) came to similar conclusions for terrestrial carnivores exposed to mining-related contaminants. That ERA concluded that metals other than mercury in terrestrial environments posed little or no risk to top predators such as red fox. Risks to lynx would be different, based on dietary differences, however these COCs are not expected to bioaccumulate to significant amounts in likely prey of the lynx (e.g., snowshoe hare, red squirrel, etc.). These prey species are mostly herbivorous, and significant accumulation of soil COCs via the terrestrial plant to herbivore pathway is unexpected.

Summary of Site-Specific Exposure-Response Studies

Biological surveys or toxicity studies conducted within or near the site were important components of the weight-of-evidence approach used to conduct this BERA. The results of these studies were used as independent lines of evidence for the BERA.

The macroinvertebrate study concluded that habitat and macroinvertebrate diversity is generally good within OU2, with a few exceptions (e.g., Jack Creek, Uncle Sam Gulch). However, low numbers of organisms in good habitat suggest poor water quality or poor sediment quality. Comparison of relative abundance (i.e., between stations) suggests that actual abundance is lowest in Jack Creek and Uncle Sam Gulch.

Fish studies concluded that inorganic chemicals in environmental media in the Basin Watershed OU2 affect fish tissue and populations. The absence of fish and conditions

that lend to fish mortality were documented in Basin Creek and Cataract Creek, while improved habitat and diversity exists in the lowermost reaches near and in Boulder River. Also, macroinvertebrate densities were determined to be greater in Basin Creek as opposed to Cataract Creek.

Additional results from fish population studies suggest that rainbow trout have acclimated to the waters of Cataract Creek and are capable of longer-term survival there. Their absence from middle and upper Cataract Creek is likely a result of a physical barrier rather than an inability to tolerate poor water quality. In contrast, the cutthroat trout have not acclimated to the poor water quality below Uncle Sam Gulch, and only larger fish can tolerate the conditions for short periods of time.

10.1.3.7 Uncertainty Analysis

Uncertainties at any point in the ERA can affect confidence in the acceptance or rejection of hypotheses and overall conclusions reached in the ERA. Important areas of potential uncertainty are discussed briefly below. Additional details are presented in the BERA (CDM 2002).

By definition, uncertainties in risk characterization are influenced by uncertainties in exposure assessment and effects assessment. Uncertainties in exposure assessment are minimized by the adequate sampling and analysis of surface water, sediment, and surface soil and, for the most part, the availability of other supporting data related to specific receptor groups. Descriptions of the magnitude and distribution of COCs within the site are considered to be generally representative of current conditions within OU2.

The degree of uncertainty associated with the soil TRVs varies depending on the amount of data available in the literature and considered when evaluating the effects data. There are more toxicity data and, therefore, more confidence in estimating risk from exposure to arsenic, cadmium, copper, lead, and zinc in soil than other COCs. Therefore, risks from COCs with limited toxicity data (e.g., antimony, manganese, and silver) should be viewed with caution. Further, there is some uncertainty in using soil TRVs to calculate HQs for mine waste.

Effects data can also contribute to overall uncertainty in risk characterization. Accepting or rejecting testable hypothesis beyond doubt is difficult, especially using a weight-of-evidence approach. No data are conclusive.

Site-specific biological and chemical data are subject to concerns of representativeness and availability and the sensitivity of sampled species used to derive such data. Conclusions from food chain modeling for Upper Tenmile Creek ERA were extended to Basin because the sites have similar receptors, environmental settings, and contaminants. There are concerns about laboratory-to-field extrapolation of effects data. Taxa-to-taxa extrapolations are a concern as well. All effects data are, therefore, subject to some degree of uncertainty. For the most part, there is higher confidence in

effects data for the major surface water COCs, followed by less confidence in sediment, then in surface soil.

Another potential source of uncertainty is the relatively small amount of biological or ecological survey data conducted over time to support this ecological risk assessment. Although data are insufficient for making conclusions relating cause and effect of possible population level effects on fish and macroinvertebrates, the abundances are correlated with concentrations of dissolved metals in surface water.

Finally, the risk characterization method itself can contribute to uncertainty. This type of uncertainty is minimized by not relying on a single exposure point concentration (e.g., mean or maximum value) or on a single effects concentration (e.g., AWQC or LC_{50}). The weight-of-evidence approach used here provides a more meaningful approach that minimizes the effects associated with the inherent uncertainty in any particular exposure or effects data value.

10.1.3.8 ERA Conclusions

Risks to ecological receptors within the Basin Watershed OU2 were evaluated using multiple lines of evidence. Unacceptable risk to ecological receptors exists in OU2, which is supported by the following evidence:

1. The number and concentrations of COCs in surface water and sediment in Basin Watershed OU2 were higher (i.e., demonstrated more potential risk) than those documented in the adjacent Upper Tenmile Creek site, which also showed unacceptable risk to ecological receptors. These COCs are stressors for sensitive aquatic ecological receptors, such as benthic invertebrates and fish.

2. The HQs of many COCs exceed 1.0 in most of the subareas in multiple media. HQs between 500 and nearly 8,000 were calculated for several COCs in environmental media in multiple subareas. The primary drivers of risk include arsenic and lead in soil; arsenic, cadmium, copper, lead, silver, and zinc in sediment; and cadmium, copper, and zinc in surface water. Although other metals had elevated HQs, their prevalent natural occurrence and generally lower toxic effects reduced their priority of consideration.

3. For aquatic environments, site-specific studies using fish and benthic macroinvertebrates demonstrate that these sensitive receptors are currently being impacted by elevated concentrations of metals. Fish and macroinvertebrate abundance and survivability have been detrimentally affected by poor habitat and poor water quality. Areas of reduced aquatic populations and areas devoid of fish have been documented.

4. The Uncle Sam drainage is impacted to the extent that fish and vegetation cannot survive in the water.

5. Insectivorous birds, represented by marsh wren, may be at risk from copper, cadmium, lead, and zinc in several of the most contaminated areas. Piscivorous mammalian and piscivorous avian predators, represented by mink and belted kingfisher, are at risk from consumption of fish and aquatic invertebrates contaminated with cadmium, copper, lead, or zinc in only one subarea.

6. Carnivorous mammals, represented by lynx, do not appear to be at risk from ingestion of contaminated prey based on (1) expected low bioaccumulation of major site COCs, (2) limited use of disturbed habitat, (3) assumption of incomplete exposure pathway associated with large home and foraging ranges and low cadmium in soil, willows, and cadmium-contaminated prey, and (4) the results of dose estimations for predator species identified as being at the greatest risk (e.g., mink).

This evidence adequately demonstrates unacceptable risk to ecological receptors. Plate 10-1 presents areas of unacceptable risk based on surface water and sediment HQ results, represented by color-coding on surface water conveyances. Throughout much of OU2, reduced concentrations of metals in surface water, sediment, and surface soils are needed to protect sensitive organisms inhabiting or using these media.

The previously-defined hypotheses or risk questions for this BERA are repeated below. Responses to the questions asked follow each risk question, and these responses are used to help summarize the results of this BERA.

- Are the levels of mining-related contaminants in water, sediment, and biota sufficiently elevated to adversely affect the survival, growth, or reproduction of salmonid fish in the Basin Watershed OU2?

Data indicate that salmonid fish are at risk from metals-contaminated surface water. Survival, growth, and reproduction are likely impaired at the most contaminated locations. Although not quantitatively assessed, metals-contaminated sediments and prey are also expected to contribute to risks to salmonid fish.

- Are the levels of mining-related contaminants in water, sediment, and biota sufficiently elevated to adversely affect the survival, growth, and reproduction of aquatic plants and aquatic invertebrates in OU2 surface waters?

Data indicate that sensitive aquatic invertebrates and some forms of aquatic plants are at risk from mining-related metals contamination of surface water and sediments.

- Are the levels of mining-related contaminants in surface soils, mine tailings, and waste rock sufficiently elevated to adversely affect the survival, growth, and reproduction of terrestrial macrophytes, soil invertebrates and microbes, piscivorous/insectivorous birds, and piscivorous mammals in OU2?

Data indicate that sensitive terrestrial macrophytes and some forms of soil invertebrates are at risk from metals-contaminated surface soils and other solids media. Data also indicate that piscivorous birds and mammals are at risk from ingestion of metals-contaminated water, fish, or aquatic invertebrates in one subarea. Finally, data indicate that in several of the most contaminated subareas, insectivorous birds may be at risk from ingestion of insects contaminated with cadmium, lead, and zinc.

Cadmium, copper, and zinc were the primary contributors of degraded water quality and are likely responsible for stress, poor habitat, and poor fish diversity. Degraded water quality and habitat are especially pervasive in Bullion Mine tributary, Jack Creek, Uncle Sam Gulch.

10.1.3.9 Biomonitoring Program to Support the ERA

Consistent with efforts to mitigate risk in Basin Watershed OU2, an ecological monitoring program should be developed to evaluate environmental media and ecological receptors over time. The goal of biomonitoring is to develop a data set to for time-trend analysis of surface water, sediment, and aquatic life community relative to mine cleanup in both impacted and non-impacted streams. Biomonitoring should include, but not be limited to, the following components:

- Monitor exposure concentrations at strategic locations for all media against acute and chronic criteria
- Monitor macroinvertebrate abundance, diversity and evaluate changes
- Monitor macrophyte and algae abundance, diversity and evaluate changes
- Monitor piscivorous community for abundance, diversity and evaluate changes
- Monitor bird population for bioaccumulation, abundance, diversity and evaluate changes
- Monitor fish populations, including tissue metal burden and toxicity testing
- Monitor wetland function, as a comparison between impacted and unimpacted

These monitoring stations should be selected at stream and wetland locations. This monitoring would provide site-specific data on surface water, sediment, and biota that would facilitate evaluation of remedial strategies and techniques, as well as support needed risk assessment addenda or risk-reduction efforts. Biomonitoring program specifics will be prior to the forthcoming record of decision (ROD).

10.2 Human Health Risk Assessment Summary

As noted above, a unique approach to the HHRA has been implemented for the Baisn Watershed OU2. As a result of focusing and streamlining efforts and recent relevant HHRA quantification efforts in the immediate vicinity, the HHRA for the Basin Watershed OU2 integrates the findings of two risk assessments quantify risk to human receptors and develop PRGs for remedial activities. The approach considers current EPA regulation and guidance and the bounds of technical feasibility.

This alternative approach to the baseline risk assessment for human health for OU2 considers that the approach for HHRAs performed for both the Town of Basin OU1 (CDM 2000b) and the Upper Tenmile Creek site (CDM 20001e) is also applicable for use in risk assessment for the Basin Watershed OU2. Key aspects of this approach are listed below:

- Use both default and regional data on bioavailability of arsenic and lead in mine wastes to develop reasonable maximum exposure (RME) and central tendanciy exposure (CTE) estimates of risk and hazard
- Use both default and regional data on soil-to-dust transfer coefficients for arsenic and lead to develop RME and CTE estimates of risk and hazard
- Evaluate residential exposures for private land holdings within the national forest
- Evaluate recreational exposures using regional data from the Anaconda Smelter NPL site
- Evaluate residential, commercial/industrial and recreational exposures in large "exposure units" (subareas within the watershed)
- Focus on preliminary remediation goals (PRGs) for use in the feasibility study

All of these aspects of risk assessment developed for the Town of Basin and for Upper Tenmile Creek appear to apply equally well to the Basin Watershed OU2.

- Mines within the Upper Tenmile Creek and OU2 access the same geologic formations and regional data for bioavailability of arsenic and lead in mines wastes seems equally applicable for each site
- Lifestyles and land conditions in the two watersheds appear similar and use of regional data for soil-to-dust transfer of arsenic and lead also seems equally applicable in each site
- Residential exposures within the national forest are possible in both watersheds since private land holdings are found in both areas
- Given the similar uses of land within the two watersheds, exposure assumptions

for residents, commercial/industrial workers and recreational exposures seem equally applicable to both areas

- A focus on PRGs, which was predicted on the lack of a viable PRP(s), is apparently still applicable to Basin Watershed OU2

Given the above considerations, PRGs calculated for the Town of Basin OU1 and Upper Tenmile Creek site should be directly applicable to Basin Watershed OU2. This focused and streamlined approach, based on extrapolation of risk assessment information from several nearby and similar sites will adequately support risk management decisions for the forthcoming ROD.

10.2.1 Summary of Risk Caracterization in Town of Basin OU1

This section presents a summary of the HHRA for the Town of Basin OU1. The HHRA quantitatively evaluates potential human health risks associated with exposure to COPCs associated with historical mining activities in soil, groundwater, sediment, interior dust, airborne particulates (i.e., respirable dust), and surface water.

The basis of risk assessment for OU1 was modified from standard EPA guidance to take advantage of regional data on bioavailability of arsenic and lead in soils contaminated with mine wastes and efficiency of transfer of contaminants in outdoor soil to indoor dust. Further, the risk assessment was streamlined through use of a screening-level approach and that focused primarily on development of PRGs. The HHRA also redefined the usual interpretation of average CTE to allow appropriate use of regional exposure data from nearby mining and ore processing sites. CTE used conservative estimates of bioavailability and soil to indoor dust transfer factors taken from regional data from Butte and Anaconda mining sites. As a result of these modifications, PRGs calculated based on both RME, which used EPA default parameters for bioavailability and soil to dust transfer, and CTE are intended to fall within the range of PRGs that could be selected to guide risk management decisions at the site.

10.2.1.1 Site Data Evaluation

Historical chemical data for the site were reviewed to determine overall quality, usability, and relevance to assessing potential human health risks resulting from exposure to mining-related material. The primary goal during the data usability evaluation process was to use historical site data to the maximum extent possible. Data that were identified as usable were incorporated into the Town of Basin chemical database. In the data evaluation step of the HHRA, COPCs were selected using previously collected data for the site. COPCs for each medium are summarized in 10.2-1.

10.2.1.2 Exposure Assessment

Exposure is defined as human contact with a chemical or physical agent (EPA 1989). Exposure assessment consists of three steps:

- Characterization of exposure setting
- Identification of exposure pathways for human receptors
- Quantification of exposure

The first step involves identifying physical characteristics of a site (i.e., climate) and the current and potential future human populations on and near the site. The second step of the exposure assessment identifies pathways by which human populations might be exposed to site-related chemicals.

The final step, exposure quantification, has two components: estimation of exposure point concentrations and calculation of chemical intake. Exposure point concentrations are estimated chemical concentrations a receptor will contact over an exposure period. Exposure point concentrations were estimated for COPCs for each medium using data from previous investigations.

Chemical intake is the amount of chemical contacted per unit of body weight per unit of time, and is calculated by combining pathway-specific exposure assumptions, such as frequency and duration of exposure, with exposure point concentrations. Pathway-specific exposure assumptions, and chemical intake calculations are presented in the exposure assessment section of this report.

For the evaluation of human health risks, sites are usually segregated into exposure units. EPA guidance indicates that differences in land use, population characteristics, type of contaminant, and variability of contaminant distribution may require the establishment of multiple exposure units within a site. The Town of Basin is evaluated as one exposure unit to minimize the amount of effort used in refining risk estimates for the town and to allow rapid calculation of PRGs that can be used to develop the feasibility study in parallel to the HHRA. Evaluation of exposure units will be performed during the remedial design and/or implementation using the HHRA as a basis and in consultation with EPA.

Town of Basin receptors of concern consist of residents (adults and children), recreational users, and workers. A site conceptual exposure model (SCEM) is presented in Table 10.2-2 present potentially important exposure pathways for these receptors.

Medium-specific exposure point concentrations were calculated using previously collected data. Review of chemical summary statistics for the site indicates that average chemical concentrations (e.g., arsenic) are very close to the 95th percent upper confidence limits (95UCL) of the arithmetic mean concentrations, providing a great degree of confidence that chemical concentrations were adequately characterized.

Because of the uncertainty associated with estimates of exposure, 95UCL of the arithmetic mean are generally used in HHRAs as the exposure point concentration. As described above, assessing the town as a single exposure unit was one means employed to streamline the process. Although the Town of Basin OU1 is small, smaller exposure units probably exist within the town. In such case, 95UCL of the arithmetic mean would probably not represent the possible range of exposures for potential smaller exposure units within the town. As a means of expressing the potential range of possible exposure point concentrations, the 95 percentile of the entire data set is used to represent RME estimates. The 95UCL is used to represent CTE estimates.

Pathway-specific exposure assumptions used to calculate intake are based on regional data (when available) and EPA default exposure assumptions. Regional data from mining sites as well as data from non-regional mining sites indicate that the arsenic bioavailability estimates used in this exposure assessment are overly conservative, especially those used for RME. Studies performed by the University of Missouri showed arsenic bioavailability of 10 to 60 percent in mining wastes (EPA 1997a). Other studies have shown arsenic bioavailability of approximately 20 percent in mining wastes (EPA 1996, 1997b). Based on this information, CTE estimates are more representative (and probably still overestimate) arsenic bioavailability. Regional studies of urinary arsenic levels indicate that measured levels are in reasonable agreement with levels predicted based on CTE assumptions and site-specific bioavailability estimates (EPA 1996).

10.2.1.3 Toxicity Assessment

Risk characterization combines chemical exposure estimates with toxicity values to produce quantitative health risk estimates for exposure to chemicals associated with the Town of Basin OU1. Carcinogenic risks from exposure to COPCs at OU1 are estimated by multiplying chemical intake estimates by cancer slope factors. Noncancer health effects are estimated by comparing chemical exposures to reference doses (RfDs) to determine if exposures are within a range that is likely to cause adverse health effects for potential receptors in the Town of Basin OU1. If the ratio of exposure to RfD for an exposure pathway or a combination of pathways is less than one, it is unlikely that even sensitive populations will experience adverse health effects. If the ratio exceeds one, a potential for adverse health effects may exist.

10.2.1.4 Risk Characterization

In the risk characterization, chemical intake, and toxicity estimates are combined to develop cancer and noncancer health effects estimates. Risk estimates were developed using site-wide concentrations for COPCs. Cancer risk estimates for residents, commercial workers, and recreationists and noncancer health effects estimates are summarized in 10.2-3.

Target cancer risks defined by EPA as an acceptable range from 1 in one million (1×10^{-6}) to one in ten thousand (1×10^{-4}). Cancer risks due to exposure to arsenic in soils

in the Town of Basin OU1 could be as high as 2 in ten thousand (2×10^{-4}) for residents in contact with the most contaminated mine wastes and surface soils (10.2-3). If surface water were used as a source of drinking water, cancer risks due to exposure to arsenic could be as high as 5 in ten thousand (5×10^{-4}) for residents in the town. Since no one is known using Basin Creek as a source of drinking water, this risk is only hypothetical.

A target hazard index for evaluation of non-cancer hazards defined by EPA as the upper limit for acceptable exposure is 1.0. Most possible exposures for people living, working, or recreating in town are at or below this target. However, use of water in Basin Creek as drinking water, or inhalation of dusts generated during dirt bike riding on some mine waste deposits could result in hazards that exceed the target by a factor of about 20 (10.2-3).

10.2.1.5 Risk-Based PRGs

Risk-based PRGs are also presented herein. PRGs are calculated using the same regional and EPA default exposure assumptions used in intake calculations, as well as ranges for target cancer risks and noncancer hazards commonly used by EPA. PRGs are presented in Tables 10.2-4 through 10.2-8. PRGs do not automatically represent remediation levels nor do they establish that cleanup action to meet these risk-based PRGs is warranted (EPA 1991a).

PRGs are presented for a range of cancer risks from 1×10^{-6} to 1×10^{-4}. This range covers that considered acceptable by EPA. For contact with contamination in waste piles and surface soils, residential PRGs for arsenic ranged from 0.6 to 1,200 mg/kg depending on exposure scenario and target cancer risk (CDM 2000b). These PRGs are generally lower than those associated with residential PRGs based on noncancer hazards. For example, the lowest PRG for noncancer hazards (120 mg/kg) is about the same as the PRG for a target risk of 1×10^{-5} for CTE exposure assumptions (124 mg/kg) (10.2-4).

PRGs for use of surface water as a drinking water source were also calculated, only for future town residents (10.2-5). These values are low, but because no one is known to currently use the water as a drinking source, the low values do not necessarily mean that residents in town are currently at risk.

Potential exposures for workers in the town result in PRGs considerably higher that those based on residential exposure. For example, the lowest and highest PRGs for exposure to arsenic in contaminated mine wastes and surface soils are 0.6 and 1,200 mg/kg for residents and 2.9 and 4,900 mg/kg workers. Use of residential PRGs would be protective for workers, but the reverse may not be true.

PRGs for recreational exposure were calculated for incidental exposure to contaminated surface water (10.2-6), contaminated sediments (10.2-5) and dust raised from contaminated soils (10.2-7). PRGs for recreational exposures are generally higher

than those based on residential exposure. For exposure to arsenic in wastes and soils, PRGs for recreationists range from 7.2 and 14,400 mg/kg.

Recreational exposure during dirt biking activities could result in substantial exposure to manganese in mine wastes (10.2-8). This PRG, based on potential non-cancer hazards, is the only case where residential PRGs are not the lowest among those calculated for the site.

Remediation levels to be used in cleanup activities are selected by the EPA after consideration of results of the risk assessment, the distribution of contamination in the town, size of areas with elevated contaminant levels, community concerns, regional information, possible future site uses and other issues.

10.2.2 Summary of Risk Characterization in Upper Tenmile Creek

This section presents a summary of the HHRA for the Upper Tenmile Creek site. Like Town of Basin OU1 (Section 10.2.1), the HHRA quantitatively evaluates potential human health risks associated with exposure to COPCs associated with historical mining activities in soil, groundwater, sediment, interior dust, airborne particulates (i.e., respirable dust), and surface water. This HHRA also used the same modifications to the typical approach for Superfund risk assessment as the Town of Basin OU1 (i.e., several large exposure units and redefining the use of CTE), as described in Section 10.2.1. The one exception to large exposure areas is the area around the community of Remini, where a smaller exposure unit was used. This particular exposure unit is not applicable to present conditions in Basin Watershed OU2, but is possible from a future land use stand point. Appropriate interpretation of risks and hazards within large exposure units is discussed in detail in the report.

10.2.2.1 Site Data Evaluation

Historical chemical data for the site were reviewed to determine overall quality, usability, and relevance to assessing potential human health risks resulting from exposure to mining-related material at the site. EPA's primary goal during the data usability evaluation process was to use historical site data to the maximum extent possible. Data that were identified as usable were incorporated into the Upper Tenmile Creek Database Management System (UTCDMS). To date, twenty-six separate data surveys containing approximately 41,000 analytical results have been imported into the UTCDMS from historical and current data sources. The site database includes data from EPA's RI effort in 2000, which included samples of soil and waste rock, groundwater, surface water (including adit discharges and seeps), and sediment, to complement historical data. The RI data filled significant data gaps, and included data from samples taken from residential yards and roadways in the community of Rimini, from a location selected to be unimpacted by mining activities, and from many additional mining sites identified in the area. Complete descriptions of methods, rationale, locations, and results are provided in the RI report (CDM Federal 2001e).

10.2.2.2 Chemicals of Potential Concern

COPCs are chemicals that are quantitatively evaluated in the risk characterization and for which PRGs are calculated. COPCs were selected for both site-wide and Rimini area exposure units by comparing maximum detected concentrations to EPA Region III PRGs for soil and tap water (CDM 2001d). Chemicals with maximum detected concentrations or maximum reporting limits less than the PRG were eliminated as COPCs in order to focus the assessment on those chemicals presenting the greatest potential for human health effects. Additional COPC screening was performed using the database supplemented with data from the RI to ensure that all chemicals of concern were addressed. COPCs are listed in 10.2-1.

10.2.2.3 Exposure Pathways

The receptors are the same as Town of Basin OU1 (Section 10.1.2.), and include residents (adult and children), recreational visitor, and workers. Complete exposure pathways for these receptors are described in 10.2-2.

Chemical-specific chronic daily intakes (CDIs) were estimated for each exposure pathway based on estimates regarding the extent, frequency, and duration of exposures, and exposure point concentrations for each COPC. Separate risk calculations were performed for each exposure unit. Exposure assumptions for selected exposure pathways were developed from regional or site-specific data when available or selected from EPA default values. Regional exposure assumptions included estimates of arsenic and lead bioavailability in soil, and soil-to-indoor dust transfer for these two contaminants.

10.2.2.4 Summary of Risks and Hazards

Risks and hazard assessment for the site was focused on providing order-of-magnitude estimates for relatively large subareas of the site. Both RME and CTE estimates were calculated to provide a range of possible risks for the site (Tables 10.2-9 through 10.2-13). Interpretation of risk and hazard estimates cannot be directly applied to any given mining site or other smaller area with significant historical mine waste. Decisions for risk management at specific sources within the site will be made in the site record of decision.

Cancer Risk

Arsenic is the only carcinogenic COPC for oral exposure to solid media, surface water, sediment, and groundwater. All cancer risk estimates are therefore based on potential exposure to arsenic. For site subareas other than Tenmile Creek Near Rimini, which includes the community of Rimini, all RME cancer risk estimates for residents and workers (i.e., cancer risks associated with ingestion of waste rock and surface soil, ingestion of surface water for domestic purposes, and ingestion of surface water or groundwater used for domestic purposes) are above EPA's acceptable 10^{-6} to 10^{-4} risk range.

Recreational exposure in many subareas is significantly less than either residential or worker exposure. Almost all cancer risk estimates for recreational exposure fall within or below the EPA acceptable risk range. When risk estimates exceed 1×10^{-4}, exceedances are relatively small (e.g., the highest RME risk estimated for recreationists is 7×10^{-4} for exposure to waste rock/tailings in the Beaver Creek Subarea). Since land use is expected to remain mainly recreational, much of the site may not present risks above the upper limit of the EPA acceptable risk range.

High cancer risks for surface soil and waste rock/tailings suggest that, in some locations within the site, frequent contact with source materials and/or soils contaminated with such materials may be associated with unacceptable levels of risk. Actual current or future risk, however, is likely to be highly dependent on the location of wastes, land ownership, and other local conditions. Actual risks for individual waste sources cannot be discerned readily from risk estimates based on data pooled from relatively large regions within the Upper Tenmile Creek watershed.

Risk estimates for exposure to other media (air, surface water, and groundwater) are likely to be more representative of actual risks throughout the site, since exposures are not as location specific, i.e., dust blown from waste piles can be carried to people living, working, or recreating in their general vicinity, even if people don't actually frequent source areas. Similarly, surface water quality data are likely to represent stream reaches rather than individual points along streams.

For the Rimini area data set, RME residential and worker cancer risks associated with ingestion of solid media, ingestion of groundwater, and ingestion of surface water for domestic purposes are also above EPA's acceptable range. Estimated risks from inhalation of particulates are within the acceptable risk range. For recreationalists RME cancer risks for recreational exposures from incidental ingestion of waste rock and sediments are above EPA's acceptable range.

Exposures and risks within the Tenmile Creek Near Rimini Subarea, which includes the community of Rimini, are of concern because:

- Data were collected in the RI specifically to provide a more complete characterization of possible exposure concentrations.
- Waste materials may have been redistributed in this subarea by human activities (e.g., use of waste materials for fill).
- Human activity and potential for human contact with waste materials, is probably greatest in this area.

CTE risk estimates for residents and workers from ingestion of solid media, ingestion of groundwater and ingestion of surface water are generally within EPA's acceptable range for site subareas, but are highest for the Rimini area exposure area. CTE cancer risks for recreationists are generally within or below EPA's acceptable cancer risk

range for ingestion, but do exceed the risk range for exposure to waste rock and adit discharge water in the Tenmile Creek Near Rimini Subarea.

Noncancer Hazard

Noncancer health effects estimates are primarily from exposure to arsenic. Hazard index (HI) estimates for RME and CTE are generally above unity for exposure to solid media by residents, workers and recreationists. RME and CTE HI estimates are also above unity for potential future use of surface water and groundwater for drinking water purposes by residents and workers. In addition, the HI for RME for incidental ingestion of sediment and adit discharge water by recreationists was greater than one within the Tenmile Creek Near Rimini Subarea. HIs above unity indicate a potential for adverse noncancer health effects.

The HI estimates for inhalation of particulates by residents, workers, and recreationists (for RME and CTE), incidental ingestion of surface water by recreationists (for RME and CTE), and the CTE HI estimate for incidental ingestion of sediment by recreationists were all less than unity. If the HI for an exposure pathway is less than unity, adverse health effects from exposure through the pathway are not expected.

Possible exposure to contaminants in air and surface water are not expected to be as sensitive to location. That is, dust blowing from waste piles might be inhaled by people in the general vicinity of waste materials, and surface water quality data are expected to represent stream reaches, not specific locations along the streams.

Estimates for Lead Impacts

EPA has established a goal of no more than 5 percent of children potentially having blood lead levels greater than 10 µg/dL. Conservative estimates (i.e., using default rather than more site-specific assumptions and exposure point data from waste piles rather than yards) indicate that many children exposed to lead in all subareas would have a high probability of having blood lead levels greater than 10 µg/dL. Further, even adult exposure to lead in surface soils and waste piles could be significant if exposure was chronic. The key to interpretation of results of the analysis of possible lead exposure is understanding human activity on and near areas where lead levels

are high. Unacceptable lead exposure is likely only when children or adults contact contaminated media on a daily or almost daily basis.

No quantitative evaluation of recreational exposures to lead was performed. Sporadic exposure to lead for recreationist makes such evaluation difficult. Moreover, the considerations, such as ecological impacts or migration of lead from source areas, are often more important for risk management decisions than risk-based PRGs for recreational exposure to lead.

IEUBK modeling results also suggested that many children who might drink

contaminated surface water and groundwater may have a high probability of having blood lead levels greater than 10 μg/L. This conclusion holds true for all subareas. Again, lead exposures could be greatest in the Rimini area.

10.2.2.5 Risk Based Preliminary Remediation Goals

PRGs were calculated for COPCs using the same regional and EPA default exposure assumptions used in risk calculations, as well as ranges for target cancer risks and non-cancer hazards commonly used by EPA. PRGs are initial guidelines; they do not set remediation levels nor do they establish that cleanup action to meet these risk-based PRGs is warranted (EPA 1991a). Final remediation levels to be used in cleanup activities will be selected by EPA following review of site-specific data and information, and other considerations such as regional information, uncertainties, and future site use. PRGs are presented in Tables 10.2-9 through 10.2-13.

10.2.3 Summary of PRGs for Basin Watershed OU2

The PRGs developed for receptors of concern for Town of Basin OU1 and Upper Tenmile Creek are identical. The PRGs are only for arsenic for residential, recreational, and workers (Tables 10.2-4 through 10.2-8 and 10.2-9 through 10.2-13).

Most of the current risk is associated with recreationists and workers. Although full-time residents live in outside of the Town of Basin OU1 within OU2, they are atypical and for the ones visited, do not live directly on waste rock piles or tailings. Because of the wide range of measured concentrations in Town of Basin OU1 and Upper Tenmile Creek and the fact that the upper Tenmile Creek HHRA was constructed from the Town of Basin OU1 HHRA, these PRGs will also be used for Basin Watershed OU2.

Plate 10-2 shows a comparison of measured arsenic values in soil/waste materials within OU2 and the CTE values (i.e., PRGs) for 10^{-4} to 10^{-6} risk for residential receptors. The plates demonstrates that risk to human receptors exists within OU2 within the mine sites wastes, and risk reduction efforts are warranted in some areas.

This page intentionally left blank.

11

Section Eleven

Section 11
Summary and Conclusion

The Basin Mining Area Operable Unit 2 includes the Town of Basin (OU1), Montana and the surrounding watersheds of Basin Creek, Cataract Creek, and part of the upper Boulder River (Basin Watershed OU2). The Town of Basin OU1, however, was investigated as a separate operable unit and, therefore, excluded from OU2. The boundaries of OU2 are presented in Plate 1-1.

Historical mining that began in the late 1800s and continued through the 1960s left over 300 abandoned mine sites of varying size and characteristics throughout OU2. These historical mine sites are responsible for environmental impacts consisting of metals/metalloids contamination and low pH water in surface water, sediment, and soil within OU2. The nature and extent of mining-related contamination in Basin Watershed OU2 and their impacts on human and ecological health were evaluated in this RI using the most comprehensive data, both spatially and temporally. This section summarizes the findings and conclusions of this RI.

11.1 Data Interpretation

The conclusions presented in this RI are primarily based on data collected during 2001, which included the Fall 2001 RI data collected by EPA/CDM and USFS, and fall and spring/summer 2001 data collected by USGS. When possible, averages of older historical data were used to supplement these recent data. Often, there were fewer data points available then preferred to make interpretations, however, even in instances when the number data for a location were not sufficient to provide confidence in the minimum, maximum, mean values, the results were still used and assumed representative, and were used as basis for conclusions.

All data were either validated or evaluated for usability. Data qualified as rejected (R) were considered unusable. All other data were considered to be valid and acceptable including those analytes that have been qualified as estimated (J). The data interpretation considered all detected values and all nondetected values with reporting limits below human health and ecological benchmarks. For nondetects with reporting limits below their respective benchmark value, the reporting limit values were used as the measured concentration. Analytical results with reporting limits greater than benchmarks were not used in these discussions to prevent conclusions that suggest chemical concentrations are above the benchmarks or action levels, when, in fact, the actual concentrations the chemicals could be below theses levels.

Aqueous dissolved detected concentrations and dissolved nondetected values (that meet the criteria above) were compared against ecological risk-based benchmark standards, while total concentrations were compared against human risk-based benchmark standards. For solid media, total detected concentrations and total

nondetected values with reporting limits below benchmarks were compared against ecological and human health risk-based standards.

Benchmark standards were compiled from available state and federal guidance and adjacent Superfund sites, in addition to published and industry-acknowledged literature values, if needed. Generally, the lowest benchmark value was used for each chemical by media (Table 4.1-2 and 4.1-3).

To streamline the surface water and sediment quality interpretations, the mainstem streams were divided into reaches and the data were divided into seasons of low flow and high flow. The flow seasons were categorized as follows: (1) winter low-flow months (December, January, February, and March); (2) spring and summer high-flow months (April, May, June, and July); and (3) fall low-flow months (August, September, October, and November). Three flow seasons were created based on the calendar months and variations in low-flow data between winter and fall.

Not all of the mining-related COCs identified in OU2 are discussed. In conjunction with EPA guidance and experience at other mining sites, target COCs, including arsenic, cadmium, copper, lead, mercury, and zinc, were evaluated. Further, zinc was found to comprise the majority of load in surface water and, therefore, zinc was used as an indicator of the COCs in nature and extent discussions and graphical presentations.

In these evaluations, COC concentrations relative to background (average, mean, or otherwise) were not used. Instead, the results for zinc were compared relative to a baseline value that consisted of the lowest concentration of zinc in each media in each of the three AOCs (i.e., Basin Creek, Cataract Creek, and Boulder River) in the Basin Watershed OU2. Background values were not used because it is hard to determine acceptable background values for each COC since they occur naturally, and have a wide variability based on location and ore deposit compositions. The baseline approach was used because it is well understood that the process of exposing previously unexposed mined material typically results in some degree of ARD related contamination.

Lastly, it is unfeasible to address all of the 300-plus abandoned mine sites within OU2. Private property access authorization and funding limitations limited visitation and characterization of all sites. However, it is important to identify the relative extent of contamination or contamination potential associated with as many mine sites as possible. This was accomplished grouping mine sites, prioritizing mine sites investigated, and using existing historical data to the extent possible to characterize environmental contamination in OU2. As noted above, the locations with the lowest total zinc concentration per media in each AOC was used as a baseline to which the

rest of the data were compared. Table 4.3-1 presents the locations with the lowest zinc concentrations per media.

11.2 Basin Watershed OU2 Summary of COC Nature and Extent

Previous and current investigations have documented contamination and risk to human and ecological health throughout the Basin Watershed OU2. In general, Cataract Creek AOC has been impacted the most by contaminations associated with historical mining, followed by Basin Creek AOC. Although the Boulder River AOC has historical mines impacting site media, it is also the recipient of all surface water discharges and sediment transported form the Cataract Creek and Basin Creek AOCs. The following subsections summarize the conditions in each AOC.

11.2.1 Boulder River AOC Nature and Extent

The Boulder River AOC within the Basin Watershed OU2 is the culmination point of all surface water discharges and sediment transport within OU2. Boulder River averages the highest flow of the streams/creeks in the Basin Watershed OU2. The average base flow in the Boulder River during winter and fall low-flow months ranged from 17 to 29 cfs and 8 to 33 cfs, respectively. During the spring /summer months, the average flows were as much as 24 times the low flows, with a range of 265 to 694 cfs (Table 5.2-1).

The water quality in the upper part of the Boulder River, upgradient from the confluence with Kleinsmith Gulch, was generally of acceptable quality with respect to human health and aquatic life benchmarks. Surface water and sediment benchmarks were first exceeded in Reach 2, where Old Basin Millsite, the Jib, and the Attwater tailings area (i.e., unnamed golf course tailings along Boulder River) are located in close proximity to the river. The number of COCs as well as their concentrations progressively increased throughout the remaining reaches of the AOC (Figure 5.9-1).

The largest increase in sulfate and COC concentrations occurred downstream of the confluence with High Ore Creek. High Ore Creek contributed COCs at concentrations up to 298 times the measured concentrations in Reach 1 (most upstream) of Boulder River. Cataract Creek contributed COCs at concentrations as much as 117 times the values reported for Reach 1, and up to 16 times the concentrations measured in Basin Creek.

The largest sulfate and combined COCs loads contributed by the tributaries came from Cataract Creek. Cataract Creek contributed loads up to six times the loads contributed by Basin Creek and High Ore Creek. Based on comparison to conservative benchmarks, the surface water and sediment in the Boulder River AOC are adversely impacted by the remnants of historical mining operations, and pose risk to human and environmental receptors. Both dissolved and total concentrations of the

surface water and total concentration of sediment COCs occur above benchmarks throughout the AOC.

There were 18 mine sites previously identified in proximity to the Boulder River. During the Fall 2001 RI, it was estimated that eight of the 18 sites had been removed by Interstate Highway 15 construction, as there was no visual evidence of mine workings. Five of the remaining sites (24JF0183, Merry Widow, Montana Central Railroad Ore Bins, 24JF0517 and 24JF0178) were determined to pose little threat to the Boulder River, because of the minimal amount of waste that was present and/or the great distances between the mine and the Boulder River. Included in the mine sites are two streamside tailings areas; Jib tailings and unnamed tailings area near the former Attwater Mill (i.e., existing golf course). These two areas were sampled during the Town of Basin RI (CDM 2000a) were identified as sources of COCs to the Boulder River. Both areas are scheduled to be addressed as part of the Town of Basin ROD (CDM 2001f).

The only mine site near the Boulder River with available data for solid waste material is the Old Basin Millsite. This site is comprised of several mine waste piles that are located within 1000 feet of the Boulder River. Historical mean arsenic, lead, antimony, and thallium concentrations in tailings and mine waste materials at the Old Basin Millsite exceeded the ecological and human health benchmarks for soil. Historical mercury concentrations exceeded the soil ecological benchmarks. Further, the mine waste and tailings contain arsenic, cadmium, lead, mercury, and zinc at concentrations that would exceed their respective sediment screening level. If these materials were transported into the Boulder River, they would likely have an adverse affect on sediment quality. The ABA at the site ranged from -87 to 94.4 MT $CaCO_3$/1000 MT, indicating that there is the potential for leaching of COCs into the groundwater.

No historical information was available on adit or seep discharges for mine sites in this AOC . The only flowing adit located during the Fall 2001 investigation was the Merry Widow adit. Water quality at the Merry Widow adit was generally acceptable with respect to the COCs, although arsenic was above its human health screening level (Table 5.5-2). Historical groundwater data near the Boulder River evaluated in this RI included data from nine groundwater wells (Table 5.6-1). The groundwater data showed no exceedences of benchmarks.

11.2.2 Basin Creek AOC Nature and Extent

Basin Creek is a gaining stream with flow characteristics that are consistent with typical mountain stream flows. Although portions may lose surface water to groundwater, stream flow (measured historically) over the length of the creek

increased by 10 to 20 fold during low-flow periods, and by 15 fold during high-flow periods (Table 6.2-1).

Of the more than 30 tributaries to Basin Creek, only the Lady Leith, Clear Creek, Jack Creek, and South Fork Basin Creek were sampled in 2001. Historical data exist for the Buckeye Mine, Grub Gulch, Jimmy's Creek, Joe Bowers Creek, an unnamed creek, and Saul Haggerty Gulch tributaries. Lady Leith, Clear Creek, Jack Creek, and South Fork Basin Creek combined accounted for about 44 percent of the total surface inflows to Basin Creek during the fall 2001 low-flow. Of these tributaries, Jack Creek had the highest flow.

Surface water and sediment quality in the Basin Creek AOC are best with respect to human health and aquatic life benchmarks in the Basin Creek headwaters upgradient from the confluence with the Lady Leith Tributary and in South Fork Basin Creek. Concentrations of COCs and sulfate increased downstream throughout the length of Basin Creek. Benchmarks are first exceeded in Reach 2 near the Buckeye and Enterprise mines, with the most quality degradation occurring in Reach 5 as a result of Jack Creek inflow. South Fork Basin Creek had the lowest COCs and sulfate levels among the tributaries in the Basin Creek AOC, while Jack Creek had the highest COCs and sulfate levels.

Basin Creek, at its mouth discharges arsenic, cadmium, copper, and zinc above their respective benchmarks to Boulder River. Sulfate and COCs values at the mouth of Basin Creek were 3, and 2 to 13 times higher, respectively, than sulfate levels in the headwaters at Station S001, indicating impact from ARD/AMD. Based on the current benchmarks, surface water and sediment contribute to risk to human and environmental receptors in the Basin Creek AOC.

There are 86 mine sites that were identified in the Basin Creek AOC (Table 2.3-1). All of these mine sites had COC concentrations above ecological and human health benchmarks for soil. Grub Creek Station mine had the lowest COC concentrations, while the Magdelena Group, Morning Star, and Meyers Gulch had the highest COC concentrations. At least 19 of the mine sites in Basin Creek AOC had medium to high ARD/AMD potentials (Table 6.5-1). The Bullion, North Ada and the Aurora mines are the ones with the highest potential to produce ARD.

Eighteen mine sites with adits and seeps (i.e., groundwater discharges) have been identified in the Basin Creek AOC (Table 6.5-2). Twelve of these point sources have been sampled, and all had COCs at concentrations exceeding human health and ecological benchmarks. The Vindicator, Lady Leith, and Bullion mines had the highest adit discharge flow rates, as well as the highest COC concentrations.

Groundwater data evaluated for the Basin Creek AOC included historical data from spring water samples, sample data from mine shafts located at the Josephine, and Dorothy Snow, and groundwater well data from two residential wells in the Lower

Basin Creek Subarea (Table 6.6-1). A spring located in Upper Basin Creek Subarea , about 3000 feet upgradient of the Basin Creek and Jack Creek confluence on the east bank of Basin Creek, had the lowest COC concentrations and only arsenic exceeded its respective benchmark. Jack Creek spring samples had COC concentrations as much as 70 times the concentrations in the Upper Basin Creek spring. Town of Basin OU1 had isolated exceedences of groundwater standards, but concluded in the ROD that groundwater was not a media of concern for OU1. Town of Basin OU1 is at the downgradient boundary of the Basin Creek and Cataract Creek AOCs suggesting that groundwater is not a significant concern for OU2 until new data suggest otherwise .

11.2.3 Cataract Creek AOC Nature and Extent

Cataract Creek is a gaining stream, with flow characteristics that are consistent with typical mountain stream flows. During the Fall 2001 RI base flow sampling Cataract Creek had the lowest flow at 0.12 cfs, near its headwaters, while the highest flows were measured in Reach 5 (2.4 cfs) and Reach 7 (1.89 cfs) (Table 7.2-1). Three Cataract Creek tributaries were sampled in 2001, including Unnamed 1, Snowdrift Creek, and Uncle Sam Gulch. These tributaries combined accounted for about 70 percent of the total surface inflows to Cataract Creek, with Uncle Sam Gulch having the highest flow.

Surface water and sediment quality in the Cataract Creek AOC is best with respect to human health and aquatic life benchmarks in Reaches 1 and 2 and in Snowdrift Creek. Concentrations of the COCs and sulfate increased along the length of the Cataract Creek. Benchmarks are first exceeded in Reach 3 near the Apollo mine, with the worst deterioration occurring in Reach 5 due to Uncle Sam Gulch. Unnamed Tributary 6 and Uncle Sam Gulch were the biggest sources of contaminated sediment to the creek, both historically and in 2001. Snowdrift Creek had the lowest COCs and sulfate levels among the tributaries in Cataract Creek AOC while Uncle Sam Gulch had the highest COCs and sulfate levels. Uncle Sam Gulch tributary exceeded benchmarks for arsenic, cadmium, copper, lead, and zinc by up to 300 times. Vegetation within and along the banks of Uncle Sam Gulch are dead, evidence of fish and macroinvertebrates in the gulch is nil, and only limited aquatic life exists immediately below its confluence with Cataract Creek.

Sulfate values at the mouth of Cataract Creek were 4 times higher than sulfate levels near the headwaters, indicating impact from ARD/AMD. Based on the current benchmarks, surface water and sediment contribute to risk to human and environmental receptors in the Cataract Creek AOC.

There are over 200 mine sites that have been identified in the Cataract Creek AOC (Table 2.3-1). Physical and chemical data are available for 67 of these mine sites, and all of these mine sites had COC concentrations above ecological and human health benchmarks for soil. Vogel mine had the lowest COC concentrations among the mine sites in the AOC, and at least 38 of these mine sites had medium to high ARD/AMD

potentials (Table 7.5-1). The Apollo, Cartwright Cabins, and the Clipper/Edna mines are the ones with the highest potential to produce ARD.

Fifty-seven mine sites with adits and seeps (i.e., specific point sources) have been identified in the Basin Creek AOC (Table 7.5-2). Samples were collected from 53 of these mine sites, and all had COCs at concentrations exceeding human and ecological health benchmarks. The Crystal, NE SE Section 14, and the Cracker mines had the highest point source flow rates, as well as the highest COC concentrations.

Groundwater data evaluated for Cataract Creek AOC in this RI included data from a pond located at the Alsace, shafts located at the California, Corbitt, Eldorado and Plateau, Klondyke, and Overland Creek mines, and groundwater well data from wells located at NE NW Section 17 and near the Boulder Vestal mines (Table 7.6-1). The shaft at California had the lowest COC concentrations, while the highest concentrations were detected in the Klondyke and Eldorado and Plateau shafts, and the NE NW Section 17 groundwater well.

11.3 Basin Watershed OU2 COC Waste Source Ranking

Of the 300-plus mine sites in Basin Watershed OU2, there are approximately 130 mines with characterization data. An estimated 30 do not exist or were unlocatable during the RI. Based on the mine waste and soil chemical data, every existing mine sites in Basin Watershed OU2 has COC concentration in the waste rock, tailings, and/or adit dicharge and seeps that exceeded either ecological or human health screening levels. Because elevated COC concentrations exist at every mine site, as well as naturally throughout Basin Watershed OU2, it is likely unfeasible, and technically unnecessary to address all the mine sites.

Because the characterization effort followed a prioritization schedule, most of the mines designated high priority were evaluated. Therefore, all mine sites with usable data were categorized based potential impact relative to each other.

Mine sites with high ARD/AMD potentials were considered to have a high potential for adverse impact to primarily the environment in Basin Watershed OU2. Mine sites with no ABA information were ranked based on their total zinc concentrations relative to the baseline sites (Vogel and Grub Creek Station), and others were grouped based on similar ore veins mined. Table 11.3-1 presents the mine sites in order of relative potential to impact the environment at the Basin Watershed OU2. Plate 11-1 presents the mine site in order of relative potential to impact the environment combined with the surface water and sediment HQs. Plates 11-2 through 11-4 presents the mine sites in order of relative potential to impact the environment combined with the relative surface water and sediment quality in the streams. The proximity of the mine waste to surface water bodies, estimated waste volumes, and other site specifics concerns will be evaluated in the FS to select the final group of priority sites to address.

Basin Creek AOC

Of the 86 mines that have been identified in Basin Creek AOC, 16 are considered to have a high potential to contribute COCs to the environment and present risk to aquatic and human health (Table 11.3-1). The Buckeye, Lady Leith, Enterprise, Josephine, Bullion, Bullion Smelter, and Daily West mines had the most soil COCs that exceeded screening levels. Of these mines the Buckeye and the Bullion mines had the highest COC concentrations. There are at least 16 additional mines considered to have a medium potential to contribute COCs under the right geochemical and climatic conditions to Basin Creek or its tributaries. A total of 60 mines remain in the AOC with no COC data are available (Table 11.3-1).

Cataract Creek AOC

Of the more than 200 mines that have been identified in Cataract Creek AOC, all had COC concentrations that exceeded either ecological or human health benchmarks. In addition there are 29 mines that are considered to have a high potential to contribute COCs to the environment and present risk to aquatic and human life (Table 11.3-1). The Crystal mine had the highest COC concentrations among these mines. There are at least 22 additional mines considered to have a medium potential to contribute COCs under the right geochemical and climatic conditions to Cataract Creek or its tributaries. A total of 104 mines remain in the AOC that have no associated COC data (Table 11.3-1).

Boulder River AOC

Of the 11 mines that have been identified in the Boulder River AOC, one had results that exceeded either ecological or human health Benchmarks. The proximity of the Basin Quarry and Jib Mines, and their degree of metals concentrations at the mine indicate that under the right geochemical and climatic conditions these mine can contribute media high in metals concentration to the Boulder River and ground water. There are at least 4 additional mines that under the right geochemical and climatic conditions can contribute mine waste media to the Boulder River, however, no COC data are available for these mines.

11.4 Uncertainty

The RI program was structured to collect data that would allow conservative characterization of the Basin Watershed OU2. Although recent and historical data were used to evaluate the Basin Watershed OU2, neither all of the mines, nor all of the surface waters within OU2 were visited or characterized. The nature and extent of contamination in OU2 as presented in this RI is based available data points and interpolated between these points. In an effort to streamline characterization, mine groups were used. There is a potential that all mines in the group are not adequately represented by a single mine sites sample. Finally, because of time and funding limitations, mine site waste materials were typically characterized by one or two samples, when in fact, multiple piles and types of waste were present at a mine site.

Additional data may be collected and the characterization refined during the FS process.

11.5 Conclusions

Based on a weight-of-evidence approach, multiple lines of evidence support the conclusion that unacceptable risk exist to human and ecological receptors from mining-related wastes within the Basin Watershed OU2. Furthermore, site-specific ecological population diversity, survivability and mortality studies indicate that risks to ecological receptors, primarily aquatic receptors, is far greater than risk to humans, particular under current land uses in OU2. The risks primarily exists within the limits of the drainage channels and mine site boundaries, while impacts and therefore risk to receptors quickly decrease beyond the limits of the drainage channels and mine site boundaries.

Following are conclusions regarding impacts to the Basin Watershed OU2 media, presented in order of subarea priority (highest to lowest) with details that support the prioritization.

Uncle Sam Gulch Subarea

Uncle Sam Gulch has the highest degree of impact form historical mining, suggesting that the entire subarea warrants evaluation for remedial actions. This conclusion is supported by the following:

- High concentrations of COCs in surface water and sediment throughout its drainage channels
- High HQs in surface water and sediment throughout its drainage channels
- Six high and medium priority mine sites based on soil data result
- Extensive areas with unhealthy vegetation along the drainage channels
- No abundance of living fish and macroinvertebrates in the gulch
- Presence of large sources of surface water infiltration to groundwater

Jack Creek Subarea

The middle to lower portions of the drainage between Cataract Creek and Bullion mine tributary, including the Bullion mine tributary have the next highest degree on impacts from historical mining, and warrant evaluation for remedial actions. This is supported by the following:

- High concentrations of COCs in surface water and sediment
- Medium to high HQs in surface water and sediment
- Twelve high and medium priority mine sites based on soil data
- Reduced population and diversity of macroinvertebrates in sediment
- High fish mortality rates during 96-hour tests

The upper potion of this drainage is relatively unimpacted by mining-related wastes, as evidenced by low COC concentrations in surface water and sediment, low HQs, several low priority mine sites, and improved habitat and biodiversity.

Lower Cataract Creek Subarea

The upper portions of Cataract Creek between Uncle Sam Gulch and Saturday Night hill, including Deer Creek have high to medium degrees of impacts resulting from Uncle Sam Gulch and Deer Creek discharging in this portion of the subarea, and warrant evaluation for remedial actions. This is supported by the following:

- High COC concentrations in Uncle Sam Gulch surface water and sediment
- Medium to high HQs in surface water and sediment
- Nine high and medium priority mine sites based on soil data
- Reduced population and diversity of fish and macroinvertebrates in the creek
- High fish mortality rates during 96-hour tests

The middle to lower portions of Cataract Creek is improved relative to the upper portions, but still is considered impacted by historical mining, and warrants consideration for remedial actions. This conclusion is supported by poor water quality and moderately low sediment quality, as well as medium HQs in this portion of Cataract Creek. There are seven mine sites with high and medium priority rankings based on soil data, but they are not in close proximity to surface water.

Big Limber Gulch is considered low priority for remedial actions. Historically, water quality is acceptable, however, sediment quality is unknown. The mines along the drainage are typically low to medium priority based on soils data. The highest priority mine site is the Redwing/Waldy complex at the headwaters of the drainage, and these are reportedly scheduled for remediation by the USFS.

Middle Cataract Creek Subarea

This subarea has generally medium degrees of impacts resulting from historical mining, but warrants evaluation for remedial actions, primarily because of the number of high priority mine sites along this portion of Cataract Creek. This is supported by the following:

- Medium COC concentrations in surface water
- Medium to low COC concentrations in sediment
- Medium surface water HQs in tributaries in lower portions of the subarea
- Low surface water HQs throughout most of Cataract Creek and in the upper tributaries (e.g., Hoodoo and Snowdrift Creeks)
- Medium to low sediment HQs in the upper portions of the drainage (higher near Unnamed 001 and Apollo mines)
- Medium sediment HQs in the lower portions of Cataract Creek from several mine sites and streamside tailings (Cataract Tails and Eva May tailings)
- Approximately 50 high and medium priority mine sites based on soil data

- Improved population and diversity of fish and macroinvertebrates in the surface water up gradient of the confluence with Uncle Sam Gulch
- Impacts to wetland areas including the Upper Hattie Fergusson and Rocker wetlands.

Upper Basin Creek Subarea

This subarea warrants evaluation for remedial actions downstream of the Buckeye-Enterprise mine complex and in Clear Creek from the Josephine on, while the remainder of this subarea warrants remedial action considerations. This is supported by the following:

- Generally low COC concentrations in surface water (except for near the Buckeye, Lady Leith mines, and Clear Creek)
- Medium COC concentrations in sediment through the upper and middle portions of Basin Creek in this subarea
- Generally low surface water HQs throughout the subarea
- High sediment HQs at the Buckeye-Enterprise mine, including impacts from streamside tailings
- Medium sediment HQs in the lower portions of the subarea and below Lady Leith mine
- Low sediment HQs in the middle and upper portions of Basin Creek and headwater tributaries (except Clear Creek)
- Medium to low sediment HQs in the upper portions of the drainage (higher near Unnamed 001 and Apollo mines)
- Seventeen high and medium priority mine sites based on soil data
- Lower population and diversity of macroinvertebrates in the sediment than in downstream reaches of Basin Creek
- Suspected impacts to wetland areas around the Buckeye mine

Lower Basin Creek Subarea

This subarea showed lower impacts from historical mining, and warrants remedial considerations because of high and medium priority mine sites. This is supported by the following:

- Medium COC concentrations in surface water and sediment throughout the subarea
- Low HQs in surface water and sediment throughout the subarea
- Thirteen high and medium priority mine sites based on soil data, typically in close proximity to Basin Creek
- Highest population and diversity of macroinvertebrates in the sediment in Basin Creek
- High fish mortality rates during 96-hour tests

Middle Basin Creek Subarea

This subarea showed a lower degree of impact from historical mining because it receives flows from South Fork Creek and is considered a low priority are, but may warrant remedial considerations. This is supported by the following:

- Medium COC concentrations in surface water and sediment throughout the subarea suspected to source from Jack Creek
- Low surface water HQs throughout the subarea
- Medium sediment HQs in the upper portion of this subarea below Jack Creek
- Low sediment HQs in the lower portions of this subarea
- No priority mine sites in the subarea, as it is dominated by placer mining
- Moderate population and diversity of marcoinvertebrate in sediment in Basin Creek

Boulder River AOC

This subarea, as the culmination of all Basin Watershed OU2 surface water and sediment discharges warrants evaluation for remedial actions. However, after addressing priority areas in Basin and Cataract Creeks, as wells as the Jib and the golf course under OU1, there may be few remedial needs in this subarea. The portion of Boulder River below the confluence with High Ore Creek warrants monitoring for improvement since High Ore Creek has undergone remedial activities. This is supported by the following:

- Low COC concentrations in surface water and sediment prior to entering OU2
- Medium COC concentrations in surface water and sediment throughout this subarea, with increased degradation in quality at Basin Creek, Cataract Creek, and High Ore Creek
- Low surface water HQs throughout the subarea
- Medium sediment HQs throughout the subarea
- Impacts to surface water and sediment from the streamside Jib and golf course tailings
- Other than the Jib and golf course tailings there a no priority mine sites
- Best habitat and diversity in OU2 at upstream locations, with decreasing population and diversity of macroinvertebrates downstream.
- Highest fish population in OU2

Upper Cataract Creek Subarea

This subarea showed a little impact from historical mining, is considered a low priority area, however it may warrants remedial considerations, however, it may warrant remedial considerations. This is supported by the following:

- Low COC concentrations in surface water and sediment throughout the subarea
- Low surface water and sediment HQs throughout the subarea
- There are only six priority mine sites in the subarea, generally located on ridges away from surface water drainages

- Unknown impacts to the large Cataract Meadows wetland in the central potion of the subarea
- Highest population and diversity of macroinvertebrates in the sediment in Cataract Creek

South Fork Basin Creek Subarea

No remedial efforts are needed for this subarea. It is unimpacted by mining and COC concentrations are the lowest measured in OU2.

This page intentionally left blank.

12

Section Twelve

Section 12
References

Adb-Elfattah, A., and K. Wada. 1981. Adsorption of Lead, Copper, Zinc, Cobalt and Cadmium by Soils that Differ in Cation-Exchange Materials. *Journal of Soil Science* 32:271-283.

Abandoned Mine and Reclamation Bureau (AMRB)/Pioneer. 1997. *Final Adit Baseline Characterization Ivestigation Report.* By Pioneer Technical Services, Inc. February 1998.

AMRB/Pioneer. 1995. *Abandoned Hardrock Mine Priority Sites* (1995 Project Report). Prepared by Pioneer Technical Services, Inc.

AMRB. 1994. *Abandoned and Inactive Mines Scoring System (AIMSS).* March.

AMRB/Pioneer. 1994. *Abandoned Hardrock Mine Priority Sites* (1994 Project Report). Prepared by Pioneer Technical Services, Inc. June 1995.

AMRB/Pioneer. 1993. *Abandoned Hardrock Mine Priority Sites* (1993 Project Report). Prepared by Pioneer Technical Services, Inc.

Administrative Rules of Montana (ARM). 1996. Environmental Rules for Water. Available via www.deq.state.mt.us/wqinfo (1996 update).

Becraft, George, Darrell Pickney, and Sam Robinson. (Beacraft) 1963. *Geology and Mineral Deposits, Jefferson City Quadrangle, Jefferson and Lewis and Clark Counties, Montana.* United States Geological Survey Professional Paper 428.

Benes P, Sebesta F, Sedlacek J, et al. 1983. Particulate forms of radium and barium in uranium mine waste waters and receiving river waters. *Water Resources.* 17:619-624.

Bingham, F. T., and A. L. Page. 1964. Specific Character of Boron Adsorption by an Amorphous Soil. *Soil Sci. Soc. Am. Proc.* 35: 892-893.

Bodek I, Lyman WJ, Reehl WF, et al. Eds. 1988. *Environmental inorganic chemistry: Properties, processes, and estimation methods.* New York: Permagon Press.

Bowen HJM. 1966. *Trace elements in biochemistry.* New York: Academic Press, Inc.
Bowman, R. S., and G. A. O'Conner. 1982. Control of Nickel and Strontium Sorption by Free Metal Ion Activity. *Soil Sci. Soc. Am. J.* 46: 933-936.

Bowman, R. S., M.E. Essington, and G. A. O'Connor. 1981. Soil Sorption of Nickel: Influence of Solution Composition. *Soil Sci Soc. Am. J.* 45: 860-865.

Boyd, C. E. and L. T. Frobish. 1990. *Water Quality in Ponds for Aquaculture.* Birmingham, Alabama: Birmingham Publishing Co.

Bunzl, K., W. Schmidt, and B. Sansoni. 1974. Kinetics of Ion Exchange in Soil Organic Matter. IV. Adsorption and Desorption of Pb^{2+}, Cu^{2+}, Cd^{2+}, Zn^{2+}, and Ca^{2+} by Peat. *J. Soil Sci.* 27: 32-41.

Burke, B. E. and Pfister, R. M. 1988. The removal of cadmium from lake water by sediment bacteria. Proceedings of the Annual Meeting of the American Society for Microbiology, Miami Beach, Florida, May 8-13, 1988. 88: 312.

CDM Federal Programs Corporation. CDM. 2002. Draft Ecological Risk Evaluation, Basin Mining Area, Operable Unit 2, Jefferson County, Montana. November.

CDM. 2001a. Preliminary Remedial Investigation Report, Basin Mining Area Superfund Site Operable Unit 2, Jefferson County, Montana. May.

CDM. 2001b. Final Sampling and Analysis Plan, Basin Mining Area Superfund Site Operable Unit 2, Jefferson County, Montana. August.

CDM. 2001c. Draft Data Summary and Usability Report, Basin Watershed Operable Unit 2, Montana. November.

CDM. 2001d. Final Ecological Risk Assessment, Upper Tenmile Creek, Mining Area Site, Lewis and Clark County, Montana. March.

CDM. 2001e. Final Human Health Risk Assessment, Upper Tenmile Creek, Mining Area Site, Lewis and Clark County, Montana. March. October.

CDM. 2001f. Record of Decision, Town of Basin Mining Area Operable Unit 1, Jefferson County, Montana. September.

CDM. 2000a. Final Remedial Investigation Report for Basin Mining Area Superfund Site, Town of Basin Operable Unit 1, Jefferson County, Montana. October.

CDM. 2000b. Final Human Health Risk Assessment for the Town of Basin Mining Area Site, Operable Unit 1, Montana. October.

Davis, J. A. and J. O. Leckie. 1980. Surface Ionization and Complexation at the Oxide/Water Interface. 3. Adsorption of Anions. *Journal of Colloid Interface Science.* 74: 32-43.

Davis, J. A. and J. O. Leckie. 1978. Surface Ionization and Complexation at the Oxide/Water Interface. II. Surface Properties of Amorphous Iron Oxyhydroxide and Adsorption of Metal Ions. *J. Colloid & Interface Sci.* 67: 90-107.

Farrah, H. and W. F. Pickering. 1977. Influence of Clay-Solute Interactions on Aqueous Heavy Metal Ion Levels. *Water Air Soil Pollut.* 8: 189-197.

Faure, Gunter. 1991. *Inorganic Geochemistry*. New York: MacMillan Publishing Company.

Fordham, A. W. 1969. Sorption and Precipitation of Iron on Kaolinite. II. Sorption Isotherms and Their Interpretations in Terms of Iron (III) Ionic Equilibrium. *Aust. J. Soil Res.* 7: 199-212.

Francis A. J., and Doge C. J. 1990. Anaerobic microbial remobilization of toxic metals coprecipitated with iron oxide. *Environ. Sci Technol.* 24: 373-378.

Freeze, R. Allan and John A. Cherry. 1979. *Groundwater*. Englewood Cliffs, New Jersey: Prentice-Hall, Inc.

Frost, R. R. and R. A. Griffin. 1977. Effect of pH on Adsorption of Copper, Zinc, and Cadmium from Landfill Leachate by Clay Minerals. *J. Environ. Sci. Health.* A.12: 139-156.

Garrels, R. M. and C. L. Christ. 1965. *Solutions, Minerals, and Equilibria*. New York: Harper and Row.

Getz LL, Haney AW, Larimore RW, et al. 1977. *Transport and distribution in a watershed ecosystem. In: Boggess, WR, ed. Lead in the Environment.* Chapter 6. Washington, D. C.: National Science Foundation. Report No. NSF/RA-770214, 105-133.

Hem, John. 1992. Study and Interpretation of the Chemical Characteristics of Natural Water. 3rd Edition. United States Geological Survey Water-Supply Paper 2254.

International Conference on Acid Rock Drainage (ICARD). 2000. Proceedings from the Fifth international Conference, Volume I, pg. 552.

Hutchinson, G. E. 1957. *A Treatise on Limnology: Vol. I. Geography, Physics, and Chemistry*.

James, R. O. and T. W. Healy. 1972a. Adsorptoin of Hydrolyzable Metal Ions at the Oxide-Water Interface. I. Co (II) Adsorption on SiO_2 and TiO_2 as Model Systems. *Journal of Colloid Interface Science*. 40:42-52.

James, R. O. and T. W. Healy. 1972b. Adsorptoin of Hydrolyzable Metal Ions at the Oxide-Water Interface. III. A Thermodynamic Model of Adsorption. *Journal of Colloid Interface Science*. 40: 65-81.

Jenne, E. A. 1968. Controls on Mn, Fe, Co, Ni, Cu, and Zn Concentrations in Soil and Water: The Significant Role of Hydrous Mn and Fe Oxides. *Advanced Chemistry Service.* 73: 337-387.

Kabata-Pendias, A and H. Pendias. 1984. *Trace Elements in Soils and Plants.* Boca Raton, Florida: CRC Press, Inc.

Kerndorff, H. and M. Schnitzer. 1980. Sorption of Metals on Humic Acid. *Geochimical Cosmochimical Acta.* 44:1701-1708.

Knopf, Adolf. 1913. *Ore deposits of the Helena Mining Region, Montana.* United States Geological Survey Bulletin 527.

Kuo, S., and D. S. Mikkelsen. 1979. Zinc Adsorption by Two Alkaline Soils. *Soil Science.* 128: 274-279.
McBride, M. B. 1982. Cu^{2+} Adsorption Characteristics of Aluminum Hydroxide and Oxyhydroxides. *Clays Clay Min.* 30: 21-28.

McKenzie, R. M. 1980. The Adsorption of Lead and Other Heavy Metals on Oxides of Manganese and Iron. *Aust. J. Soil. Res.* 18: 61-73.

McLaren, R. G. and D. V. Crawford. 1973b. Studies on Soil Copper. I. Fractionation of Copper in Soils. *J. Soil Sci.* 24: 172-181.

McLaren, R. G. and D. V. Crawford. 1973. Studies on Soil Copper. II. The Specific Adsorption of Copper by Soils. *J. Soil Sci.* 24: 443-452.

Montana Bureau of Mines and Geology (MBMG). 1996. *Montana Bureau of Mines and Geology Open-File Report No. 348, Abandoned-Inactive Mines Program, U.S. Bureau of Land Management.* July.

MBMG. 1995. *Montana Bureau of Mines and Geology Open-File Report No. 321, Abandoned-Inactive Mines Program Deerlodge National Forest: Volume II Cataract Creek Drainage.* May.

MBMG. 1994. *Montana Bureau of Mines and Geology Open-File Report No. 321, Abandoned-Inactive Mines Program Deerlodge National Forest: Volume I Basin Creek Drainage.* April.

MBMG. 1960. *Bulletin 16, Mines and Mineral Deposits Except Fuels Jefferson County, Montana.* By R.N. Roby, W.C. Ackerman, F.B. Fulkerson, and F.A. Crowley.

MDFWP. 2001. Focused Fish Survivability Evaluation in Cataract Creek of the Basin Watershed. D. Skaar, unpublished.

O'Melia, C. R. and W. Stumm. 1967. Aggregation of Silica Dispersions by Iron (III). *Journal of Colloid and Interface Science*. 23: 437-447.

Oakley, S. M., P. O. Nelson, and K. J. Williamson. 1981. Model of Trace-Metal Partitioning in Marine Sediments. *Environ. Sci. Technol.* 15: 474-480.

Olson, KW, Skogerboe RK. 1975. Identification of soil lead compounds from automotive sources. *Environmental Science and Technology*. 9: 227-230.
Renewable Technologies, Inc. 2002. Historical Context Report, Basin/Cataract Mining District, Jefferson County, Montana. April.

Page, A. L. and L. D. Whittig. 1961. Iron Adsorption by Montmorollinite Systems. I. Preliminary Studies. *Journal of the Soil Science Society of America*. 25:278-286.

Perdue, E. M., K. C. Bek and J. N. Reuter. 1976. Organic Complexes of Iron and Aluminum in Natural Waters. *Nature*. 260: 418-420.

Personal Communication, C. French - Montana Department of Environmental Quality. 2001. Status of TMDL work by Montana for the Boulder River. April.

Personal Communication, M. Browne - BLM Butte Office. 2001/2002. Status of BLM remediation efforts for the Redwing/Waldy mine in Caratact Creek watershed.

Petruzelli, G., G. Guidi, and L. Lubrano. 1978. Organic Matter as a Influencing Factor of Copper and Cadmium Adsorption by Soils. *Water Air Soil Pollut*. 9: 263-268.

Ponnamperuma, F. N., T. A. Loy, and E. M. Tianco. 1969. Redox Equilibria in Flooded Soils: II. The Manganese Oxide Systems. *Soil Science*. 108: 48-57.

Rai, D. and J. M. Zachara, et al. 1986. *Chemical Attenuation Rates, Coefficients, and Constants in Leachate Migration, Volume 1: A Critical Review*. Palo Alto, California; Research Reports Center.

Ramamoorthy, S., and B. R. Rust. 1978. Heavy metal Exchange Processes in Sediment Water Systems. *Environ. Geology*. 2: 165-172.

Ramamoorthy, S., and B. R. Rust. 1976. Mercury Sorption and Desorption Characteristics of Some Ottawa River Sediments. *Can. J. Earth Sci.* 13: 530-536.

Reddy, M.R. and H. F. Perkins. 1976. Fixation of Manganese by Clay Minerals. *Soil Science*. 121:21-24.

Rengasamy, P., and J. M. Oades. 1977. Interaction of Monomeric and Polymeric Species of Metal Ions with Clay Surfaces. I. Adsorption of Iron(III) Species. *Aust. J. Soil Res.* 15: 221-233.

Riffaldi, R., R. Levi-Minzi, and G. F. Soldatini. 1976. Pb Adsorption by Soils. II. Specific Adsorption. *Water Air Soil Pollut.* 6: 119-128.

Rogers, J. S., P. M. Huang, and W. K. Liaw. Chemical Dynamics of Mercury Sorption and Desorption of Freshwater Sediments. *Verh. Internat. Verein. Limnol.* 21: 174-180.

Ruppel, Edward. 1963. *Geology of the Basin Quadrangle, Jefferson, Lewis and Clark, and Powell Counties, Montana.* United State Geological Survey Bulletin 1151.

Ruppel, Edward. 1962. *A Pleistocene Ice Sheet in the Northern Boulder Mountains Jefferson, Lewis and Clark, and Powell Counties, Montana.* United State Geological Survey Bulletin 1141-G.

Sadiq, M. 1981. The Adsorption Characteristics of Soils and Sorption of Copper, Manganese and Zinc. Commun. *Soil Sci. Plant Anal.* 12: 619-630.

Schaanning, M. K. Naes, P. K. Egeberg, et al. 1988. Cycling of Manganese in the Permanently Anoxic Drammens Fjord. *Marine Chemistry.* 23: 365-382.

Schindler, P. W., B. Furst, R. Dick, and P. V. Wolf. 1976. Ligand Properties of Surface Silanol Groups. Surface Complex Formation with Fe^{3+}, Cu^{2+}, Cd^{2+}, and Pb^{2+}. *Journal of Colloid and Interface Science.* 55: 469-475.

Schnitzer, M. 1969. Reaction Between Fulvic Acid, a Soil Humic Compound and Inorganic Soil Constituents. *Soil Science Society of American Proc.* 33: 75-80.

Schwab, A. P. and W. L. Lindsay. 1983. Effect of Redox on the Solubility and Availability of Iron. *Soil Science Society of America Journal.* 47: 217-220.

Schwarzenbach, Rend P., Philip M. Gschwend, and Dieter M. Imboden. 1993. Environmental Organic Chemistry.

Singh, B., and G. S. Sekhon. 1977. Adsorption, Desorption and Solubility Relationships of Lead and Cadmium in Some Alkaline Soils. *J. Soil Sci.* 28: 271-275.

Soldatini, G. F., R. Riffaldi and R. Levi-Minzi. 1976. Pb Adsorption by Soils. I. Adsorption as Measured by the Langmuir and Freundlich Isotherms. *Water Air Soil Pollu.* 6: 111-118.

Stumm, W., H. Hohl, and F. Dalang. 1976. Interaction of Metal Ions with Hydrous Oxide Surfaces. *Croatica Chem. Acta.* 48:491-504.

Stumm, Werner and James J. Morgan. 1996. *Aquatic Chemistry, Chemical Equilibria and Rates in Natural Waters.* Third Edition.

Stumm, W. and J. J. Morgan. 1981. *Aquatic Chemistry. 2nd Edition.*

Suter and Tsao. 1996.

Syracuse Research Corporation. 1991. *Toxicological Profile for Nickel.*

Takematsu, N. 1979. Sorption of Transition Metals on Manganese and Iron Oxide, and Silicate Minerals. *Journal of the Oceanography Society of Japan.* 35:36-42.

U.S. Department of Agriculture (USDA). 1989.

U.S. Environmental Protection Agency (EPA). 2001. Guidance for the Data Quality Objectives Process. EPA QA/G-4. September

EPA. 2000. Abandoned Mine Site Characterization and Cleanup Handbook. August.

EPA 1999. Corrective Action. Ecological Data Quality Levels. EPA Region V. Internet Access. URL: http://www.epa.gov/reg5oopa/rcra/edql.htm.

EPA. 1999. Clark Fork River Ecological Risk Assessment. December

EPA 1999. Hazard Ranking System. Basin Mining Area. July.

EPA. 1997a. Relative Bioavailability of Arsenic in Mining Wastes. December.

EPA. 1997b. *Final Risk Assessment Butte Priority Soils Operable Unit Baseline Human Health Risk Assessment For Arsenic.*

EPA. 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conduction Ecological Risk Assessments. Interim Final. EPA-540-R-97-006.

EPA. 1996. *Baseline Human Health Risk Assessment.* Anaconda Smelter NPL Site. Anaconda, Montana.

EPA. 1995. Subchronic Reference Dose for Arsenic . Letter from Robert Benson to Christopher Weiss. September 12.

EPA. 1994. National Functional Guidelines for Inorganic Data Review. February, with current revisions (Inroganic Guidelines).

EPA. 1993. *Baseline Risk Assessment for the Old Works/East Anaconda Development Area.* Prepared by Lifesystems. August.

EPA. 1991a. Risk Assessment Guidance for Superfund: Volume I. Human Health Evaluation Manual. Part B, Development of Risk-Based Preliminary Remediation Goals. Interim.

EPA. 1991b. Guidance Manual for Site-Specific Use of the U.S. Environmental Protection Agency Lead Model. Office of Emergency and Remedial Response. December.

EPA. 1989. *Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual. Interim Final. Office of Emergency and Remedial Response.* September.

EPA. 1988. *Water Quality Standards Criteria Summaries: A Compilation of State/Federal Criteria. EPA 440/5-88/014 for Cadmium; EPA 440/5-88/027 for Copper; EPA 440/5-88/030 for Lead; and EPA 440/5-88/019 for Zinc. Office of Water Regulations and Standards.* September.

EPA. 1986. *East Helena, Montana, Child Lead Study. Summer 1983. Final Report.* July.

EPA. 1984. *Health Assessment Document for Manganese.* Cincinnati, Ohio: U.S. Environmental Protection Agency, Office of Research and Development. EPA-600/8-83-013F.

EPA. 1984. *Health effects assessment for barium.* Prepared by Environmental Criteria and Assessment Office. Cincinnati, OH. Washington, DC: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. EPA/540/1-86/021.

United States Geological Survey (USGS). 2002. Stream Flow Data for Station 06033000, Boulder River Near Boulder MT. Available via World Wide Web http://water.usgs.gov/mt/nwis USGS. 2001. USGS Water Quality Data Base.

USGS. 2001. Stream Flow Data available via World Wide Web. Http://water.USGS.gov/nwis/discharge. USGS. 2001. USGS Water Quality Data Base.

USGS. 2000. Characterizing Aquatic Health Using fish Mortality, Physiology, and Population Estimates in the Boulder River Watershed. By A.M. Farag (USGS), D. Skar (MDFWP), and D. Nimick (USGS), and E. MacConnell (MDFWP). December.

WRCC. 2002. Period of Record Daily Climate Summary. Boulder, MT (Station 241008) www.wrcc.dri.edu/cgi-bin/climain.pl?mt

Bulletin 1141-G.

Sadiq, M. 1981. The Adsorption Characteristics of Soils and Sorption of Copper, Manganese and Zinc. Commun. *Soil Sci. Plant Anal.* 12: 619-630.

Schaanning, M. K. Naes, P. K. Egeberg, et al. 1988. Cycling of Manganese in the Permanently Anoxic Drammens Fjord. *Marine Chemistry.* 23: 365-382.

Schindler, P. W., B. Furst, R. Dick, and P. V. Wolf. 1976. Ligand Properties of Surface Silanol Groups. Surface Complex Formation with Fe^{3+}, Cu^{2+}, Cd^{2+}, and Pb^{2+}. *Journal of Colloid and Interface Science.* 55: 469-475.

Schnitzer, M. 1969. Reaction Between Fulvic Acid, a Soil Humic Compound and Inorganic Soil Constituents. *Soil Science Society of American Proc.* 33: 75-80.

Schwab, A. P. and W. L. Lindsay. 1983. Effect of Redox on the Solubility and Availability of Iron. *Soil Science Society of America Journal.* 47: 217-220.

Schwarzenbach, Rend P., Philip M. Gschwend, and Dieter M. Imboden. 1993. Environmental Organic Chemistry.

Singh, B., and G. S. Sekhon. 1977. Adsorption, Desorption and Solubility Relationships of Lead and Cadmium in Some Alkaline Soils. *J. Soil Sci.* 28: 271-275.

Soldatini, G. F., R. Riffaldi and R. Levi-Minzi. 1976. Pb Adsorption by Soils. I. Adsorption as Measured by the Langmuir and Freundlich Isotherms. *Water Air Soil Pollu.* 6: 111-118.

Stumm, W., H. Hohl, and F. Dalang. 1976. Interaction of Metal Ions with Hydrous Oxide Surfaces. *Croatica Chem. Acta.* 48:491-504.

Stumm, Werner and James J. Morgan. 1996. *Aquatic Chemistry, Chemical Equilibria and Rates in Natural Waters.* Third Edition.

Stumm, W. and J. J. Morgan. 1981. *Aquatic Chemistry. 2nd Edition.*

Suter and Tsao. 1996.

Syracuse Research Corporation. 1991. *Toxicological Profile for Nickel.*

Takematsu, N. 1979. Sorption of Transition Metals on Manganese and Iron Oxide, and Silicate Minerals. *Journal of the Oceanography Society of Japan.* 35:36-42.

U.S. Environmental Protection Agency (EPA). 2000. Abandoned Mine Site Characterization and Cleanup Handbook. August.

EPA 1999. Corrective Action. Ecological Data Quality Levels. EPA Region V. Internet Access. URL: http://www.epa.gov/reg5oopa/rcra/edql.htm.

EPA 1999. Hazard Ranking System. Basin Mining Area. July.

EPA. 1997. *Final Risk Assessment Butte Priority Soils Operable Unit Baseline Human Health Risk Assessment For Arsenic.*

EPA. 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conduction Ecological Risk Assessments. Interim Final. EPA-540-R-97-006. U.S. EPA. Environmental Response Team. Edison, N.J.

EPA. 1996. *Baseline Human Health Risk Assessment.* Anaconda Smelter NPL Site. Anaconda, Montana.

EPA. 1995. Subchronic Reference Dose for Arsenic . Letter from Robert Benson to Christopher Weiss. September 12.

EPA. 1994. *Final Risk Assessment Butte Priority Soils Operable Unit Baseline Human Health Risk Assessment For Lead.*

EPA. 1994. *Guidance for the Data Quality Objectives Process.* EPA QA/G-4. September.

EPA. 1993. *Baseline Risk Assessment for the Old Works/East Anaconda Development Area.* Prepared by Lifesystems. August.

EPA. 1989. *Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual. Interim Final. Office of Emergency and Remedial Response.* September.

EPA. 1986. *East Helena, Montana, Child Lead Study. Summer 1983. Final Report.* July.

EPA. 1984. *Health Assessment Document for Manganese.* Cincinnati, Ohio: U.S. Environmental Protection Agency, Office of Research and Development. EPA-600/8-83-013F.

EPA. 1984. *Health effects assessment for barium.* Prepared by Environmental Criteria and Assessment Office. Cincinnati, OH. Washington, DC: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. EPA/540/1-86/021.

USGS. 1997. Quantification of Metals Loads by Tracer-Injection and Synoptic-Sampling Methods in Cataract Creek Jefferson County, Montana, August 1997. Water

Resources Investigations Report 00-4237 By T. Cleasby (USGS), D. Nimick (USGS), and Briant Kimball (USGS). December 2000.

Wada, K. and N. Gunjigake. 1979. Active Aluminum and Iron and Phosphate Adsorption in Ando Soils. *Soil Science*. 128:331-336.

Wagman, D. D., W. H. Evans, V. B. Parker, I. Halow, S. M. Bailey, and R. H. Schumm. *Selected Values of Chemical Thermodynamic Properties*. Technical Note 270-4, National Bureau of Standards, U. S. Govt. Printing Office, Washington, D.C., 1969.

Wood, J. M., Kennedy, F. S., and Rosen, C. G., 1968. Synthesis of methyl-mercury compounds by extracts of a methanogenic bacterium. *Nature*. 220: 174.

This page intentionally left blank.

Figures

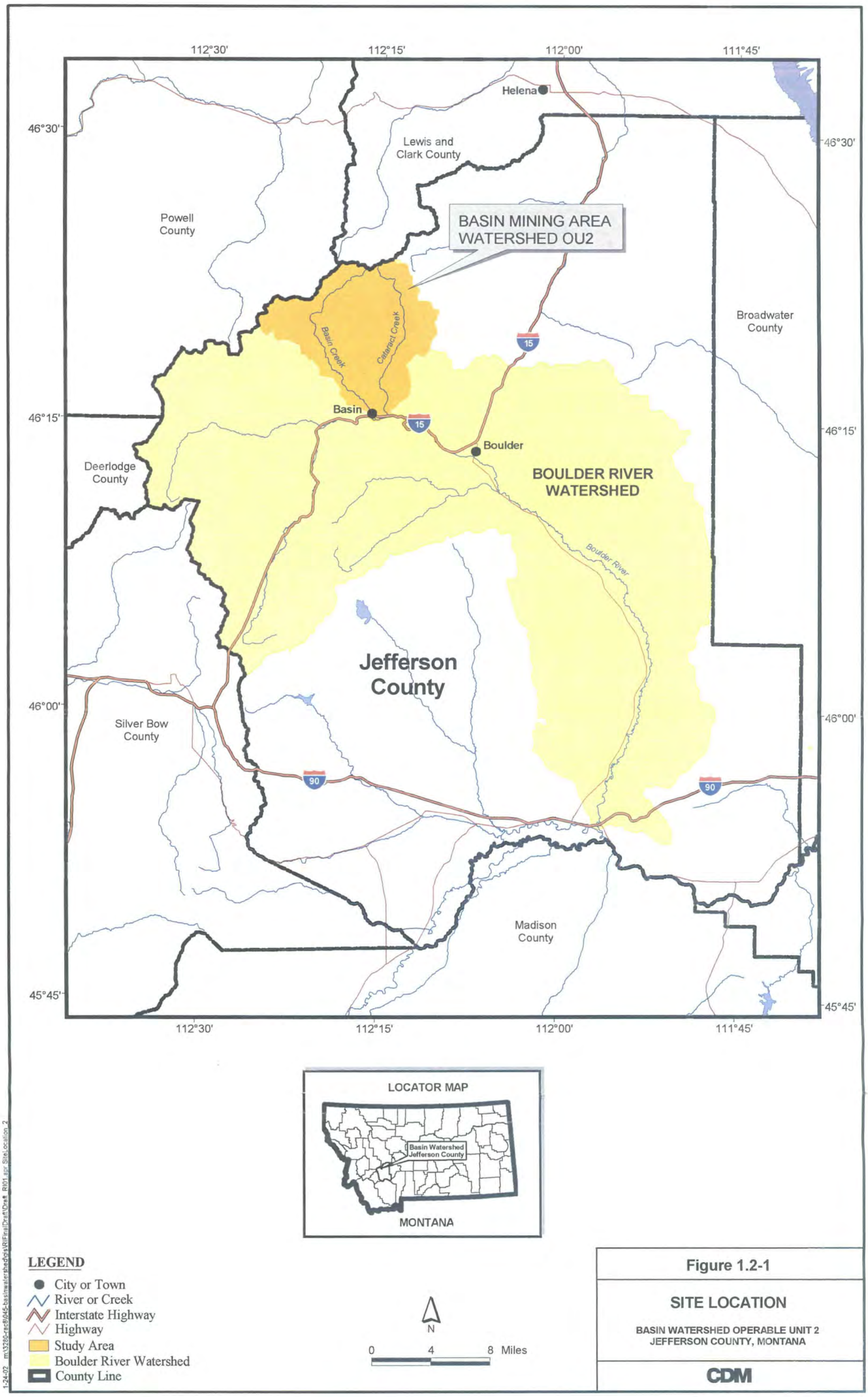


Figure 1.2-1

SITE LOCATION

BASIN WATERSHED OPERABLE UNIT 2
JEFFERSON COUNTY, MONTANA

CDM

1-24-02 m:\3280-rec8\045-basinwatershed\gis\RI\Final\Draft\Draft_RI01.apr SiteLocation_2

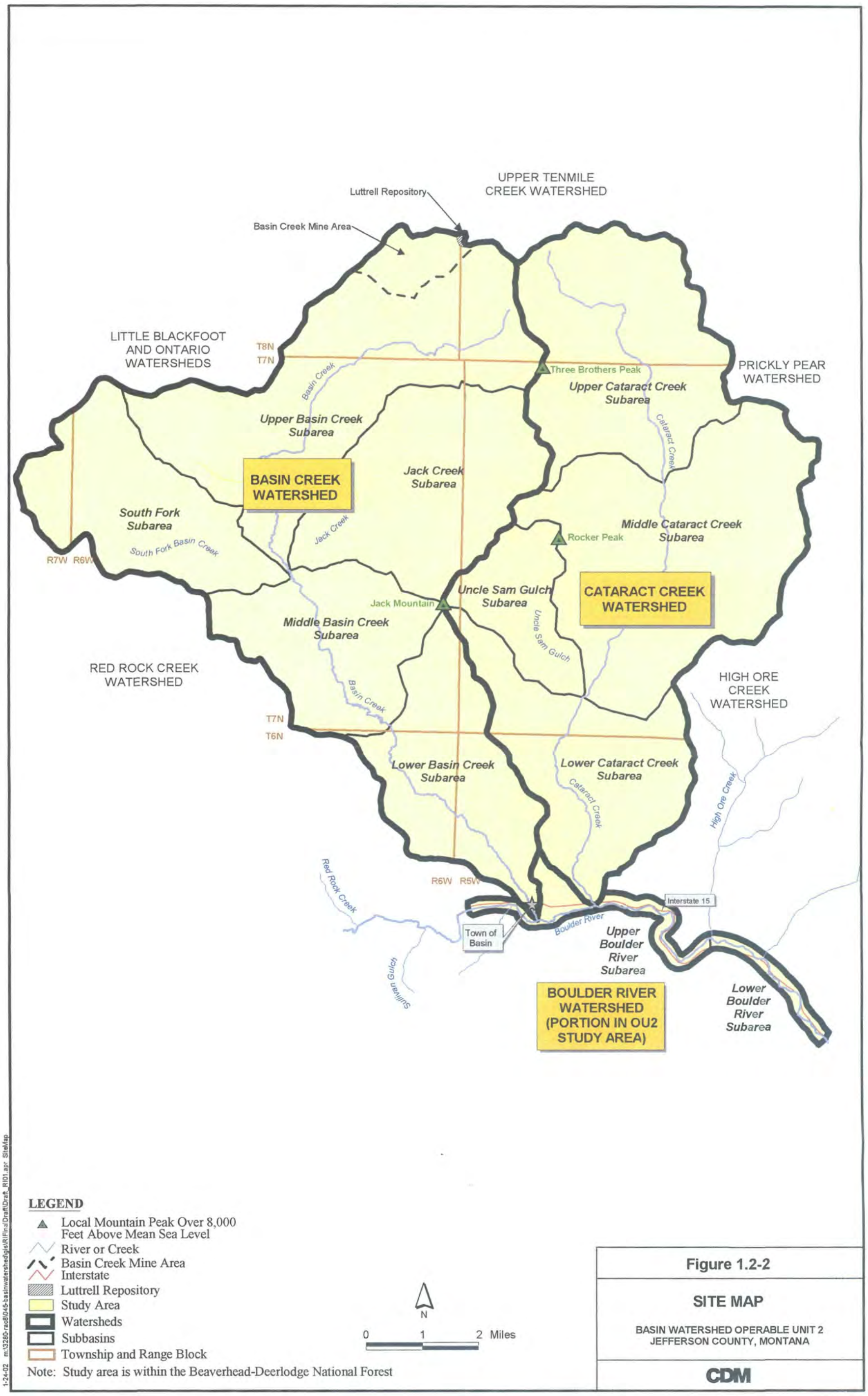


Figure 1.2-2

SITE MAP

BASIN WATERSHED OPERABLE UNIT 2
JEFFERSON COUNTY, MONTANA

CDM

1-24-02 m:\3280-rac8\045-basinwatershed\gis\RIFinal\Draft\Draft_RI01.apr SiteMap

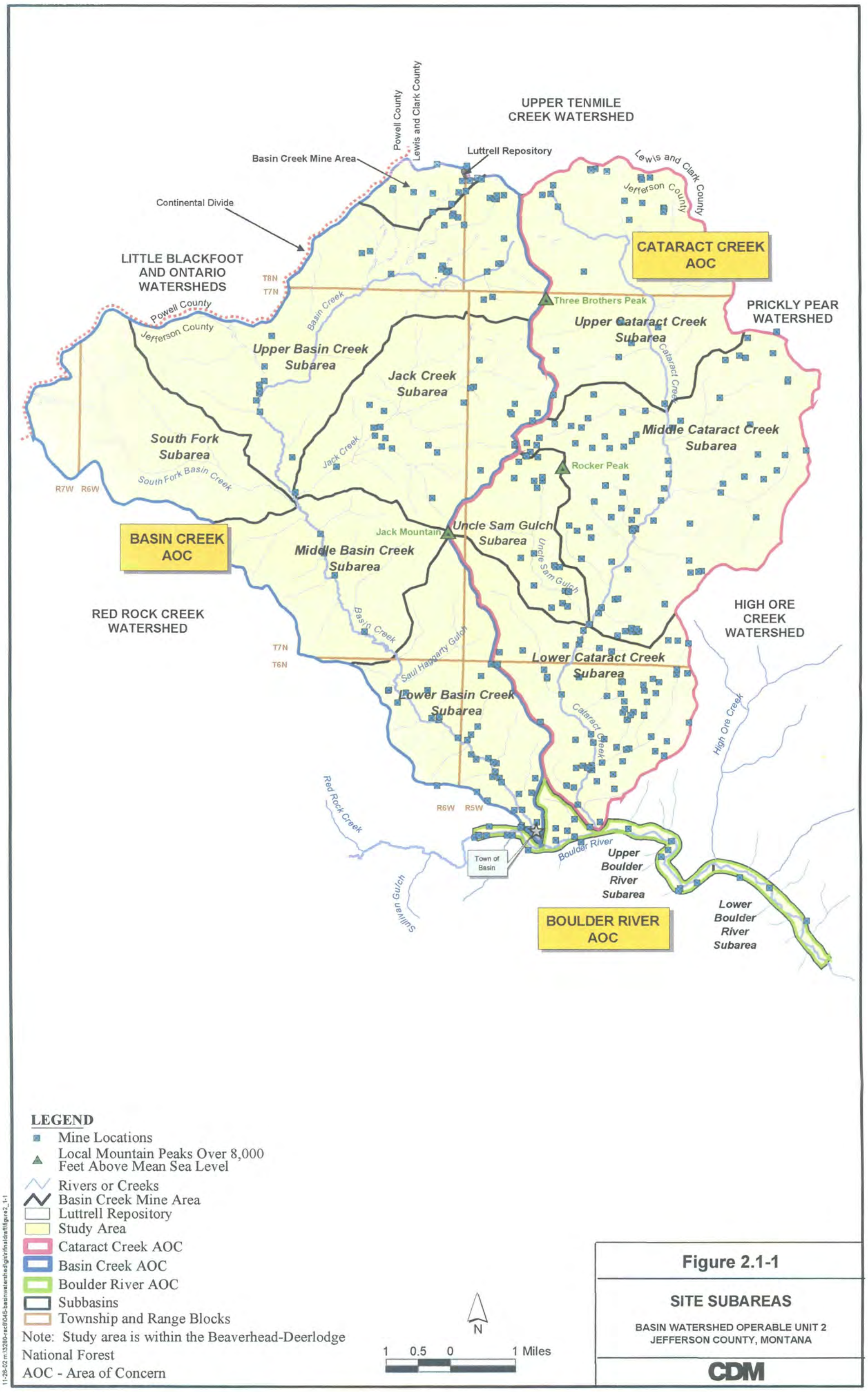


Figure 2.1-1

SITE SUBAREAS

BASIN WATERSHED OPERABLE UNIT 2
JEFFERSON COUNTY, MONTANA

CDM

11-28-02 m:\3280-rac\9045-basinwatershed\gis\final\draft\figure2_1-1

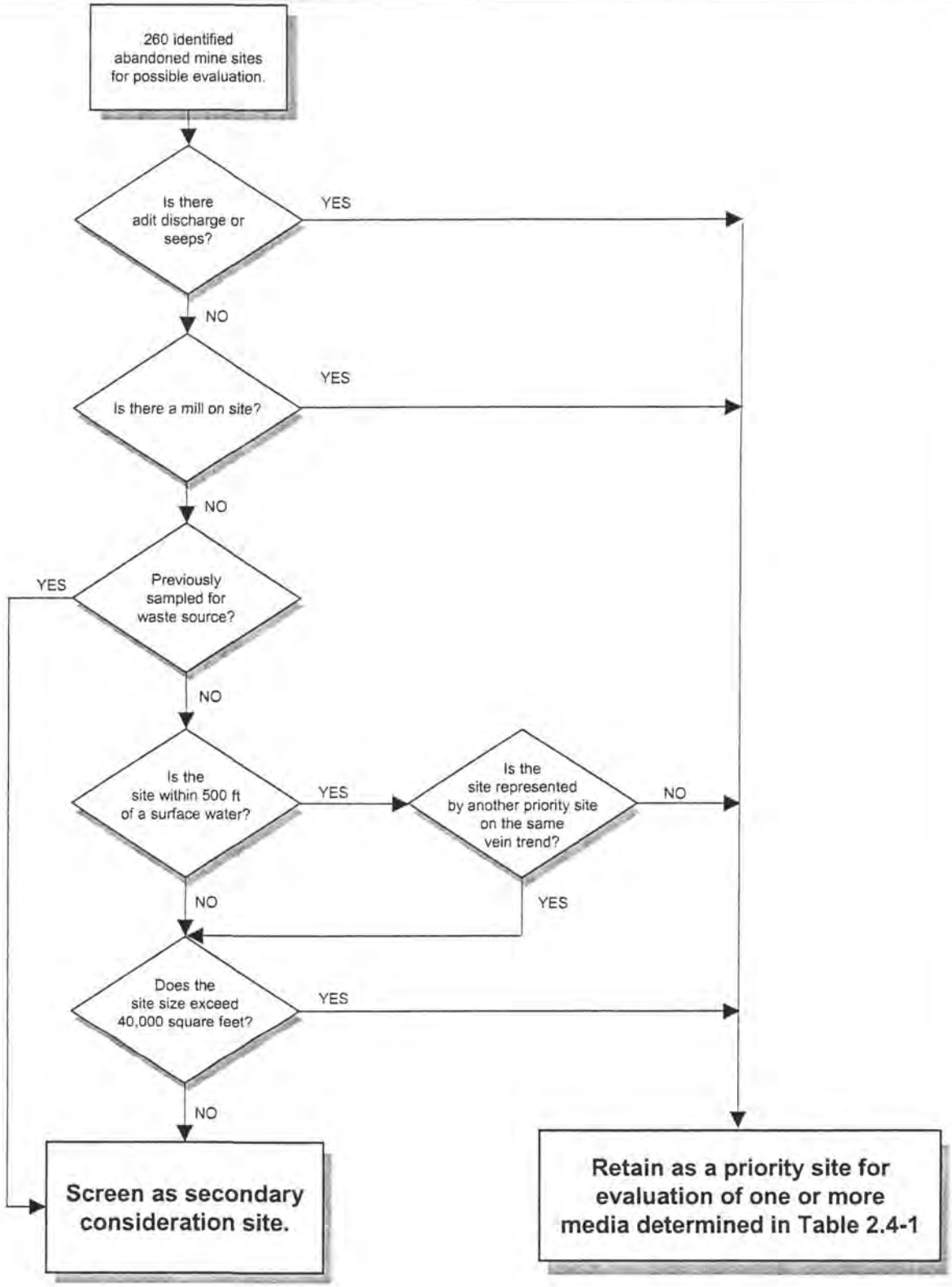


Figure 2.4-1

PRIORITY MINE SITE SELECTION SCHEME

BASIN WATERSHED OPERABLE UNIT 2
JEFFERSON COUNTY, MONTANA

CDM

P:\3280-RAC8\945\REPORTS\RI\DRAFTFIG&TABLES\FIG 2.4-1.ppt

This page intentionally left blank.

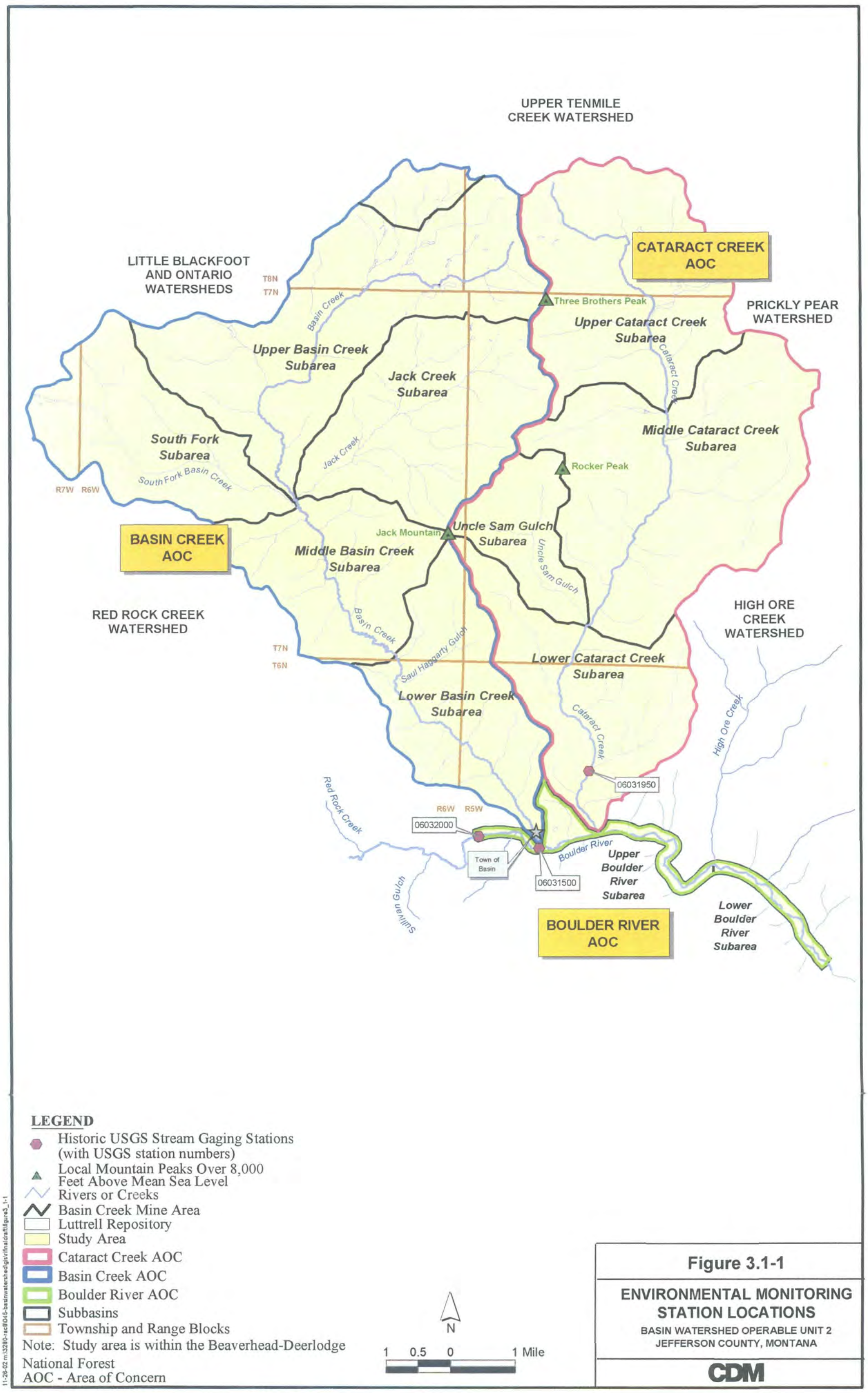


Figure 3.1-1

ENVIRONMENTAL MONITORING STATION LOCATIONS

BASIN WATERSHED OPERABLE UNIT 2
JEFFERSON COUNTY, MONTANA

CDM

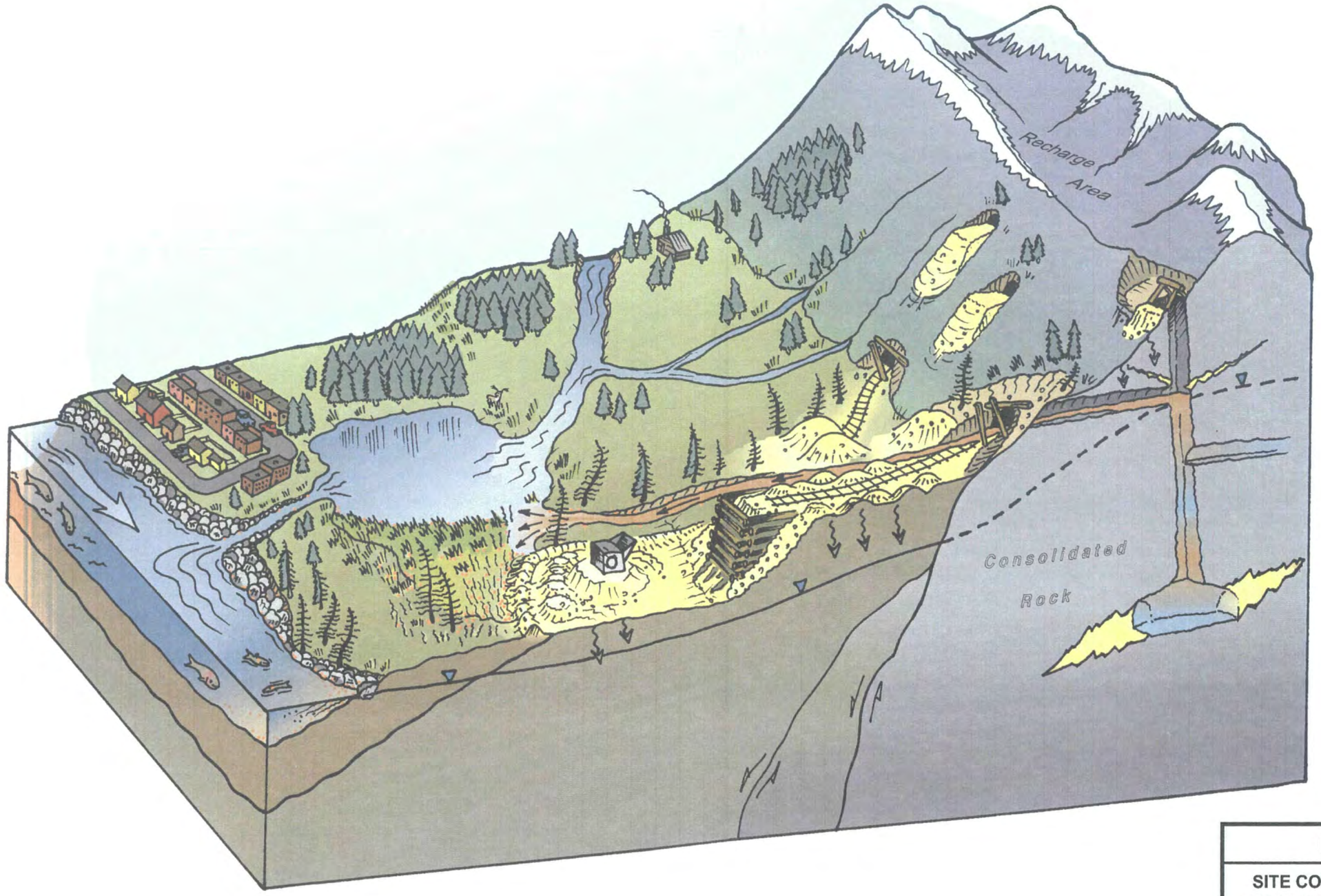


Figure 3.8-1

SITE CONCEPTUAL MODEL

BASIN WATERSHED OPERABLE UNIT 2
JEFFERSON COUNTY, MONTANA

CDM

Figure 3.8-2. Site Photo. Collapsed adit discharge over waste rock. Bullion mine, Basin Watershed OU2. Debris and iron hydroxide staining present. (Note: this mine was remediated in 2001/2002 by USFS/EPA).

Figure 3.8-3. Site Photo. Waste piles at the Mary Anne (or Marianne) mine site in Basin Watershed OU2.

Figure 3.8-4. Site Photo. Former ore loading structure on waste rock pile at the RTI Recon R mine site, Basin Watershed OU2.

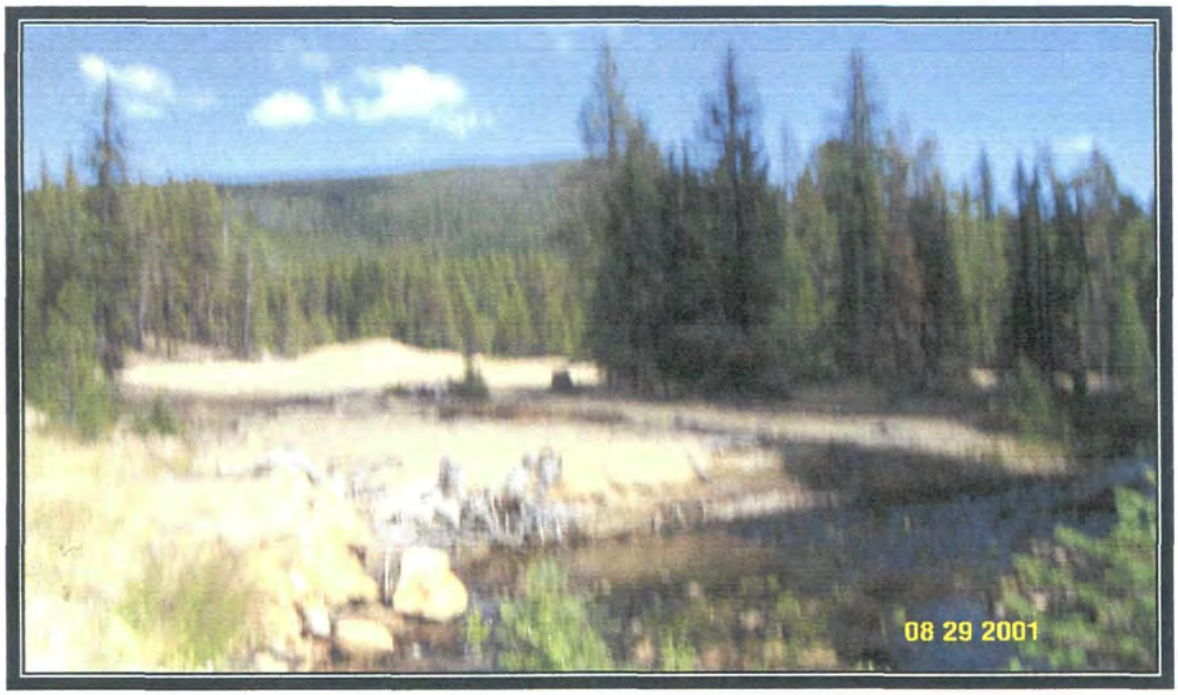
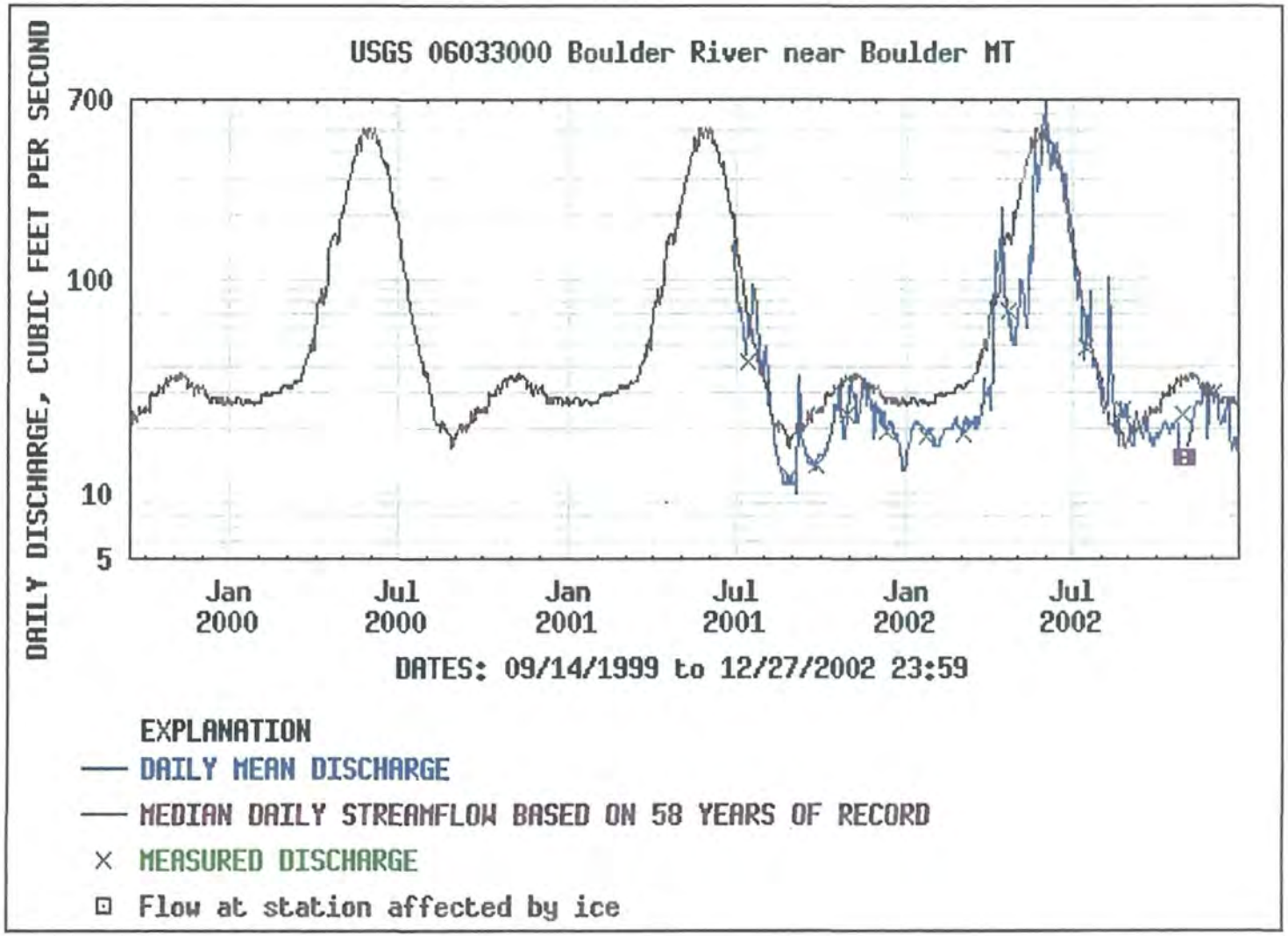


Figure 3.8-5. Site Photo. Stream-side tailings along Cataract Creek at the Eva May mine, Basin Watershed OU2.

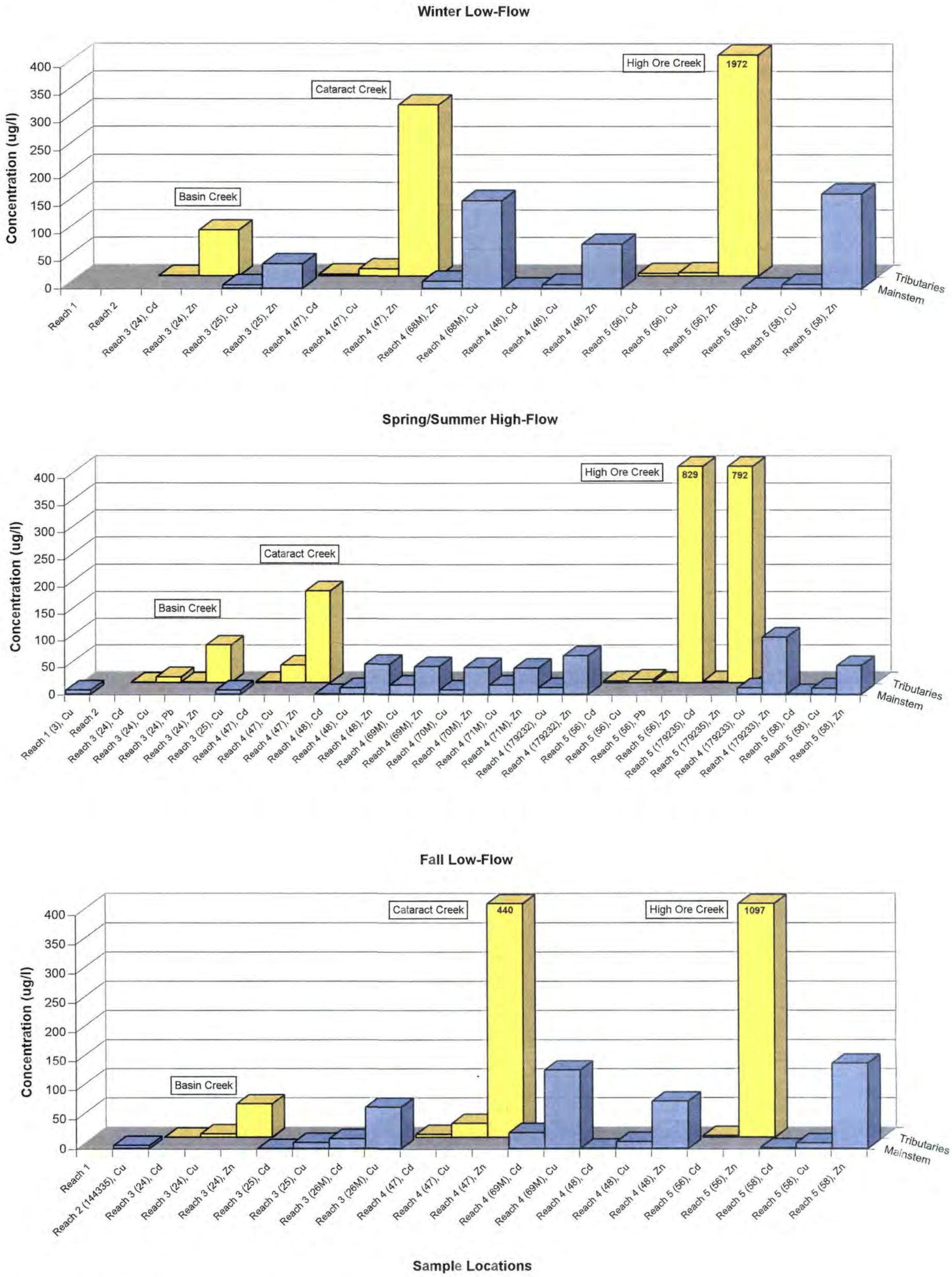
Figure 4.1-1 Historical Stream Flow Mean Daily Values - Boulder River Near Boulder, Montana, USGS Station 06033000, Basin Watershed OU2



CDM

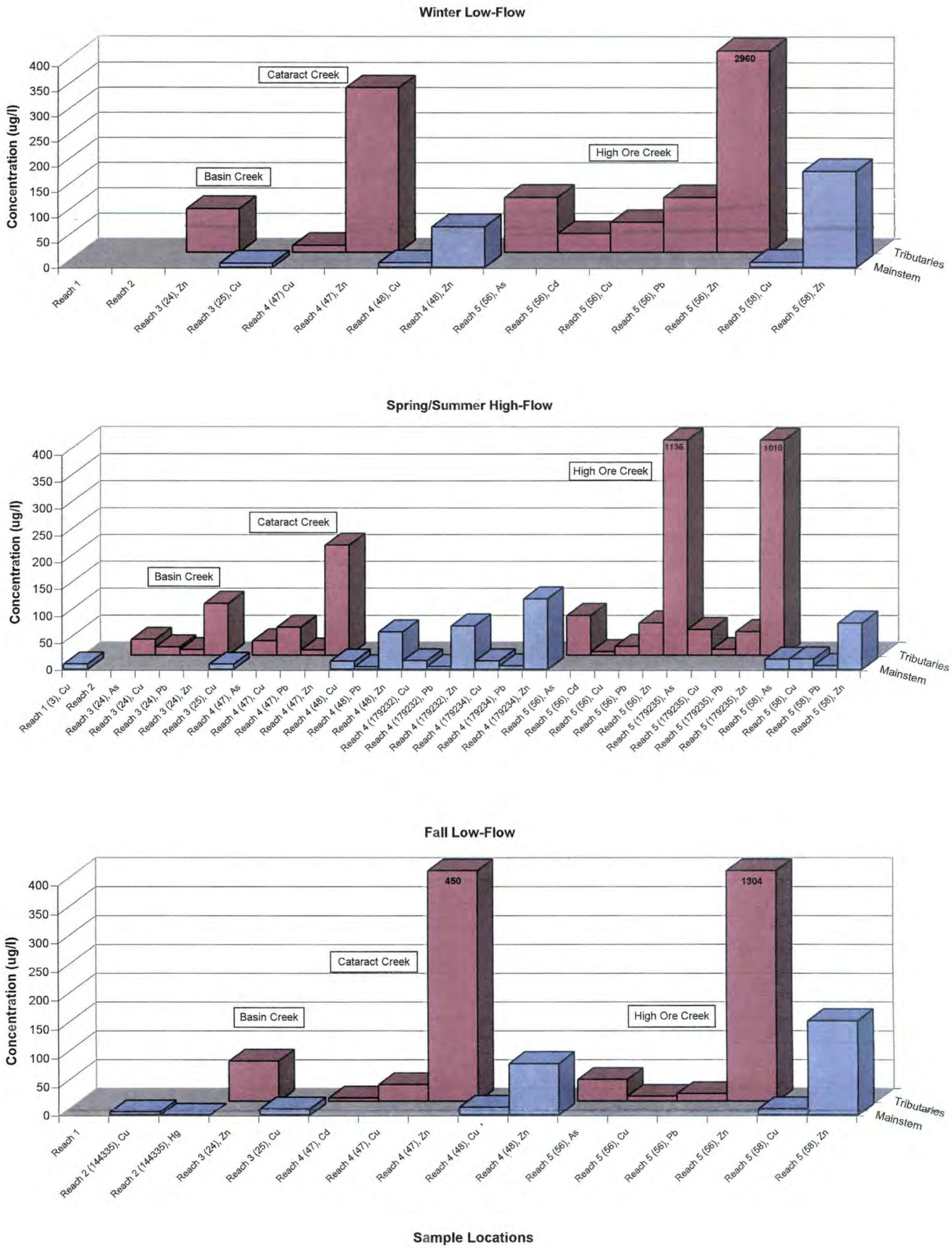
Figure 4.1-1

Figure 5.3-1 COCs that Exceeded Ecological Benchmarks in the Boulder River Historically, Basin Watershed OU2



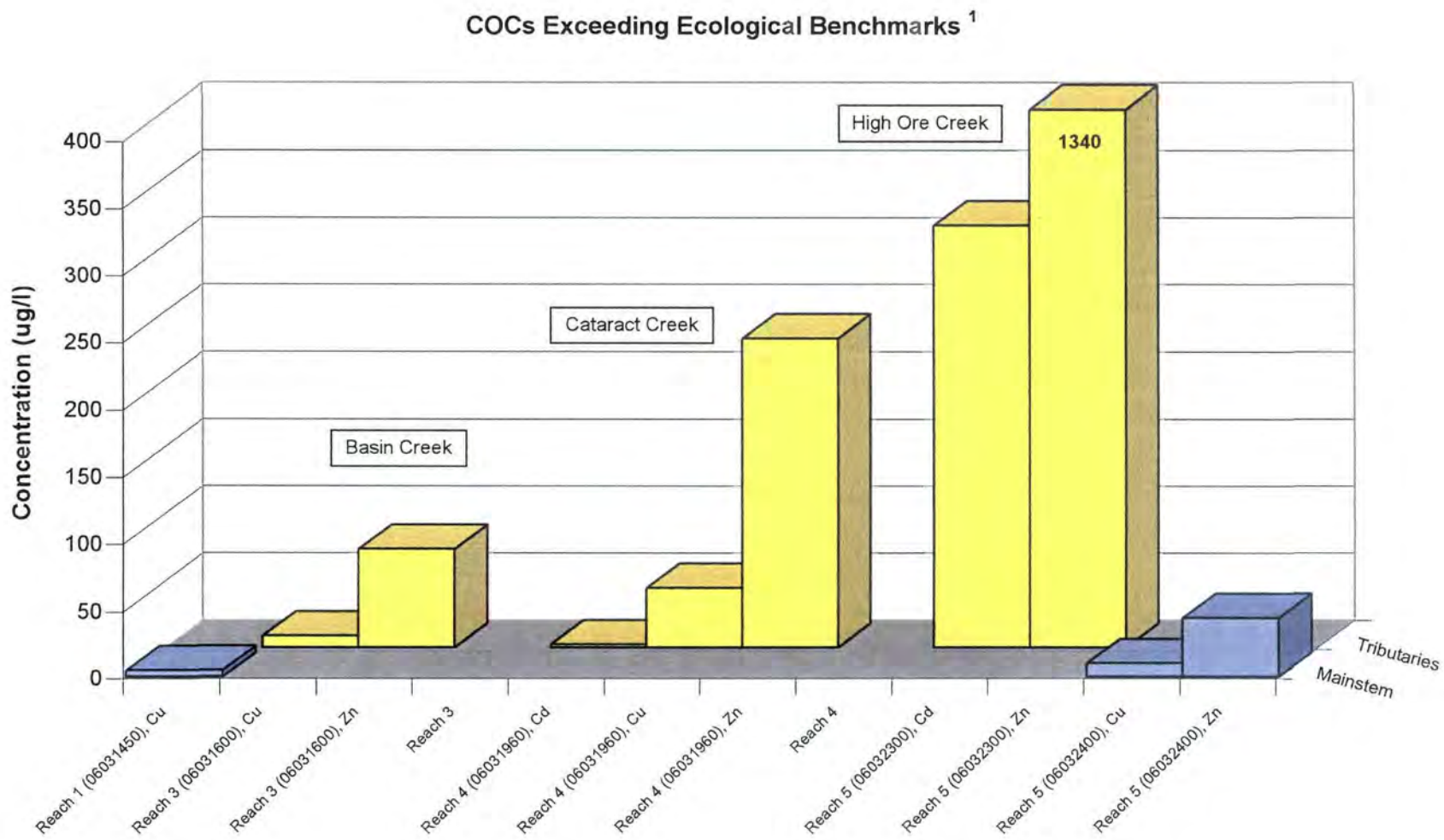
Notes:
Concentration values are mean detected concentrations exceeding benchmarks.
Concentration values greater than upper scale limits are presented on graph.
Sample locations appear in brackets.

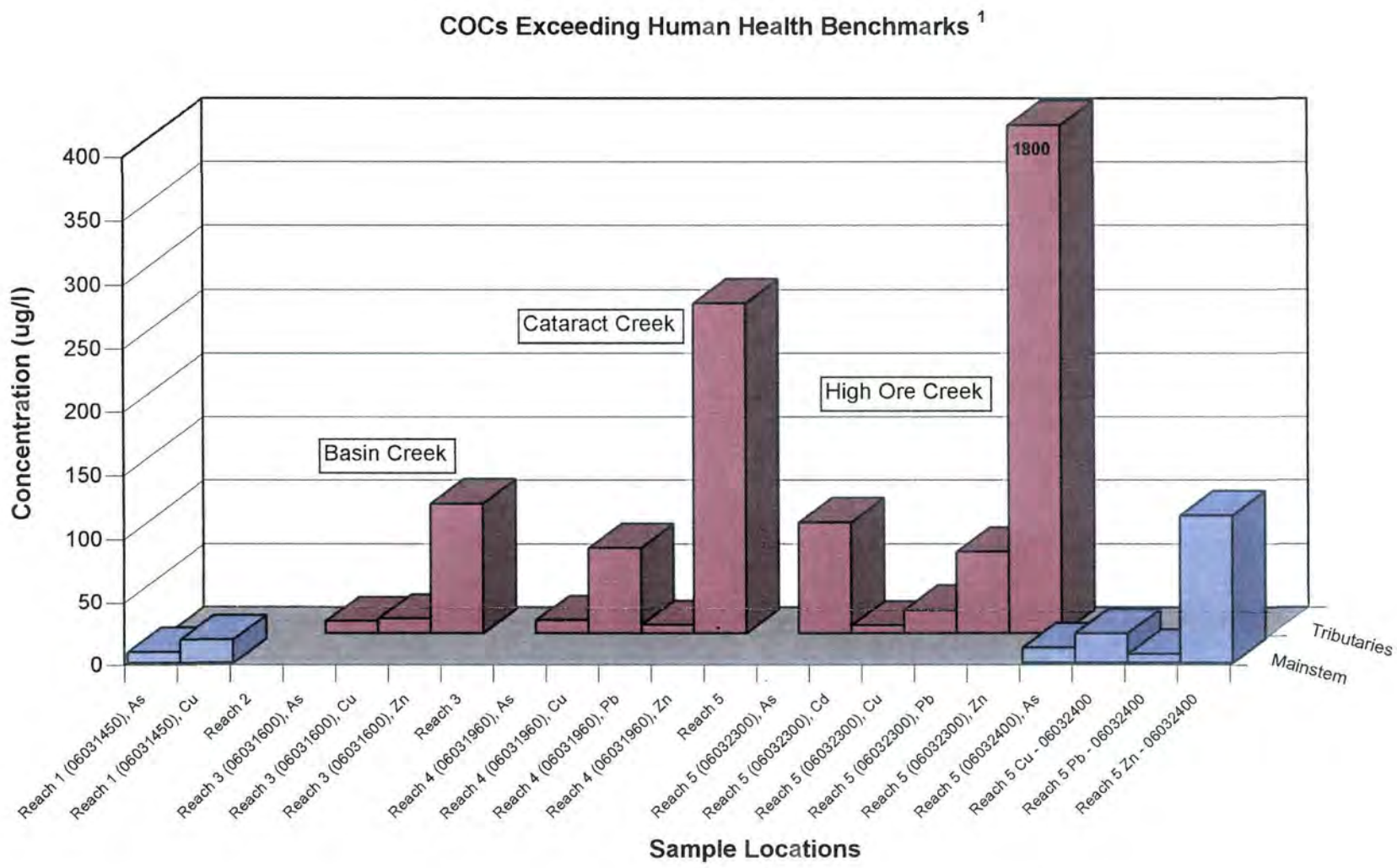
Figure 5.3-2 COCs that Exceeded Human Health Benchmarks in the Boulder River Historically, Basin Watershed OU2



Notes:
Concentration values are mean detected concentrations exceeding benchmarks.
Concentration values greater than upper scale limits are presented on graph.
Sample locations appear in brackets.

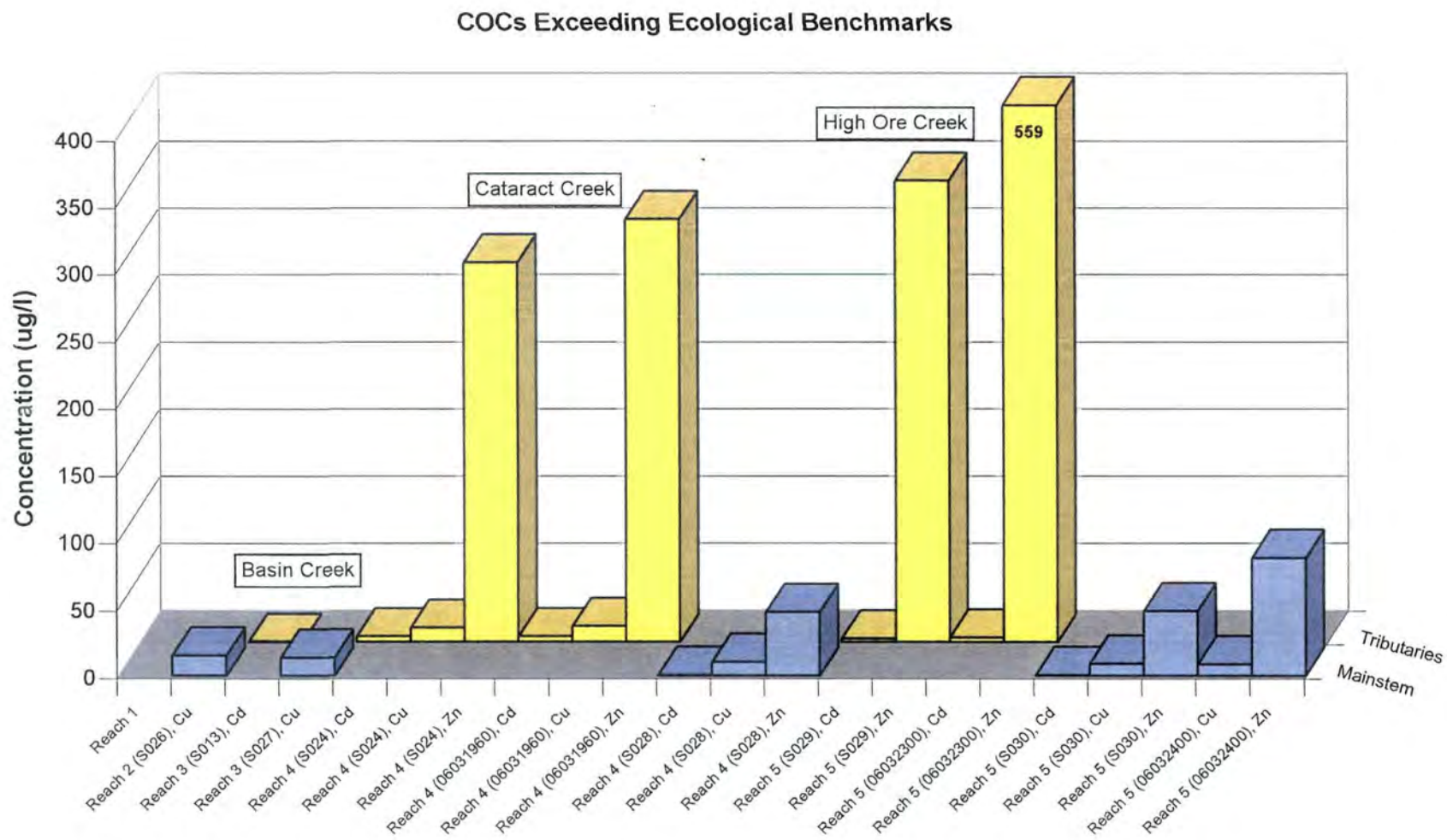
Figure 5.3-3 COCs that Exceeded Ecological and Human Health Benchmarks in the Boulder River in Spring/Summer of 2001, Basin Watershed OU2

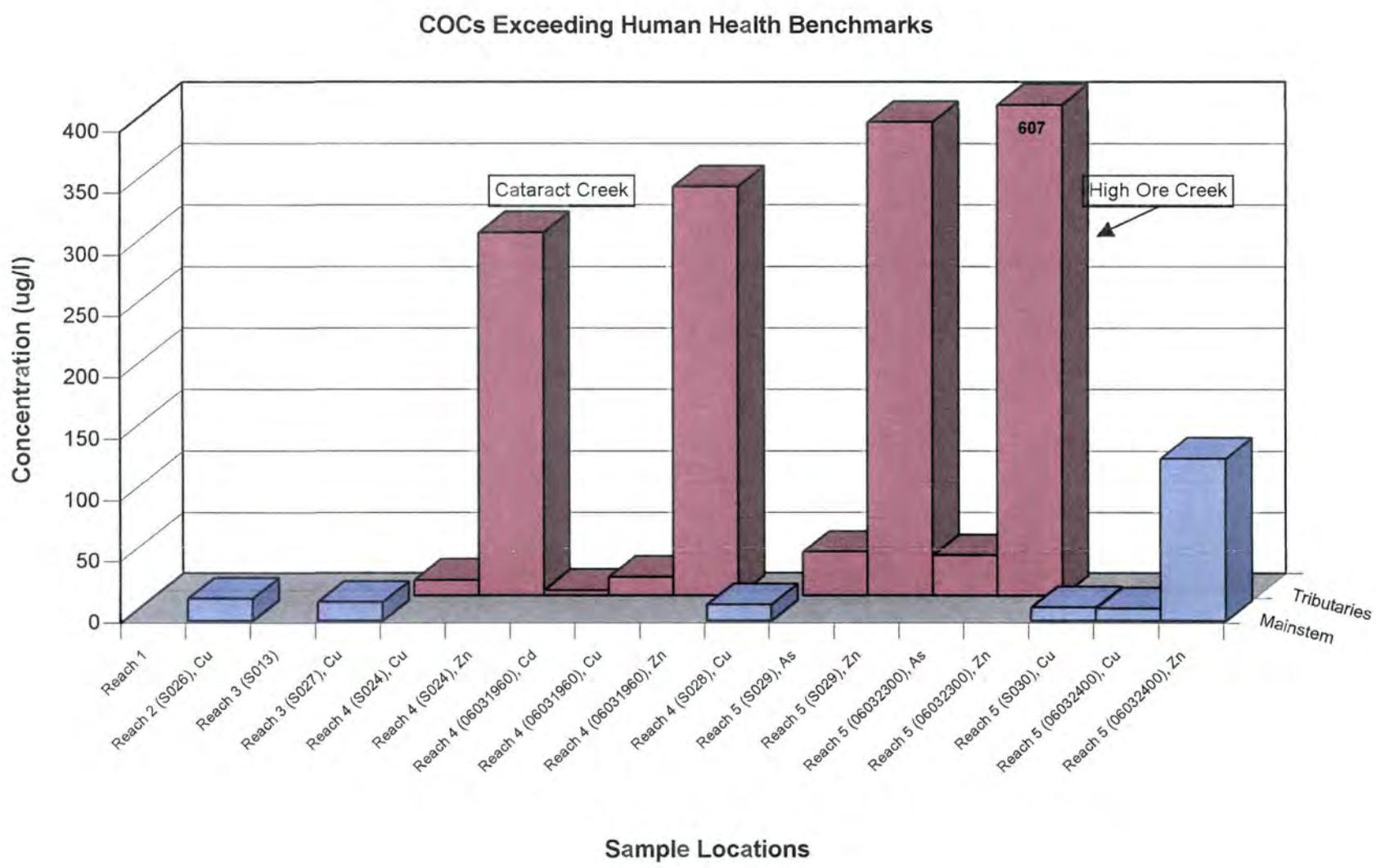




Notes:
1 - USGS provisional COPCs results from measurements taken in April and May 2001.
Concentration values are mean detected concentrations exceeding Benchmarks.
Concentration values greater than upper scale limits are presented on graph.
Sample locations appear in brackets.

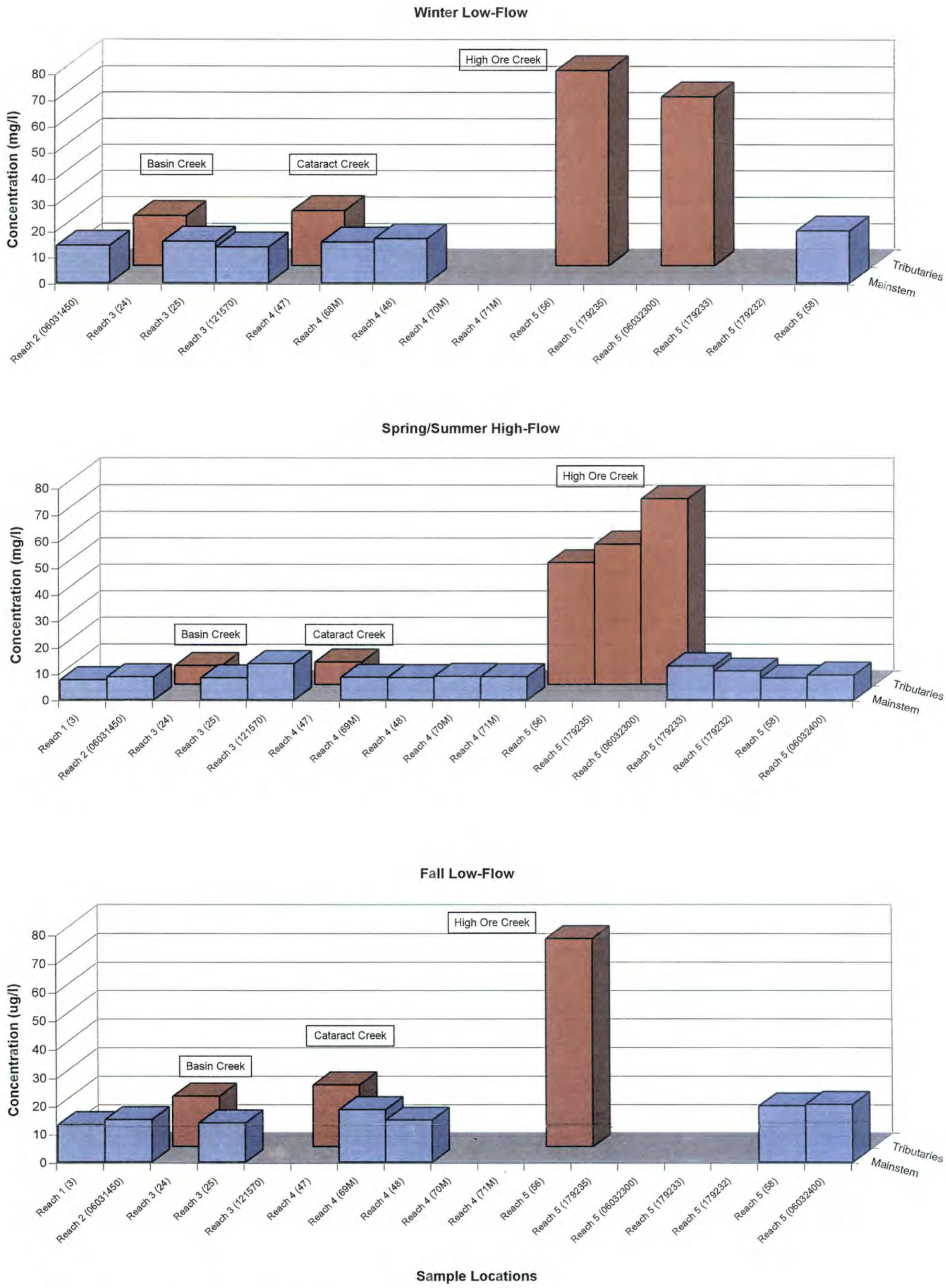
Figure 5.3-4 COCs that Exceeded Ecological and Human Health Benchmarks in the Boulder River in Fall of 2001, Basin Watershed OU2





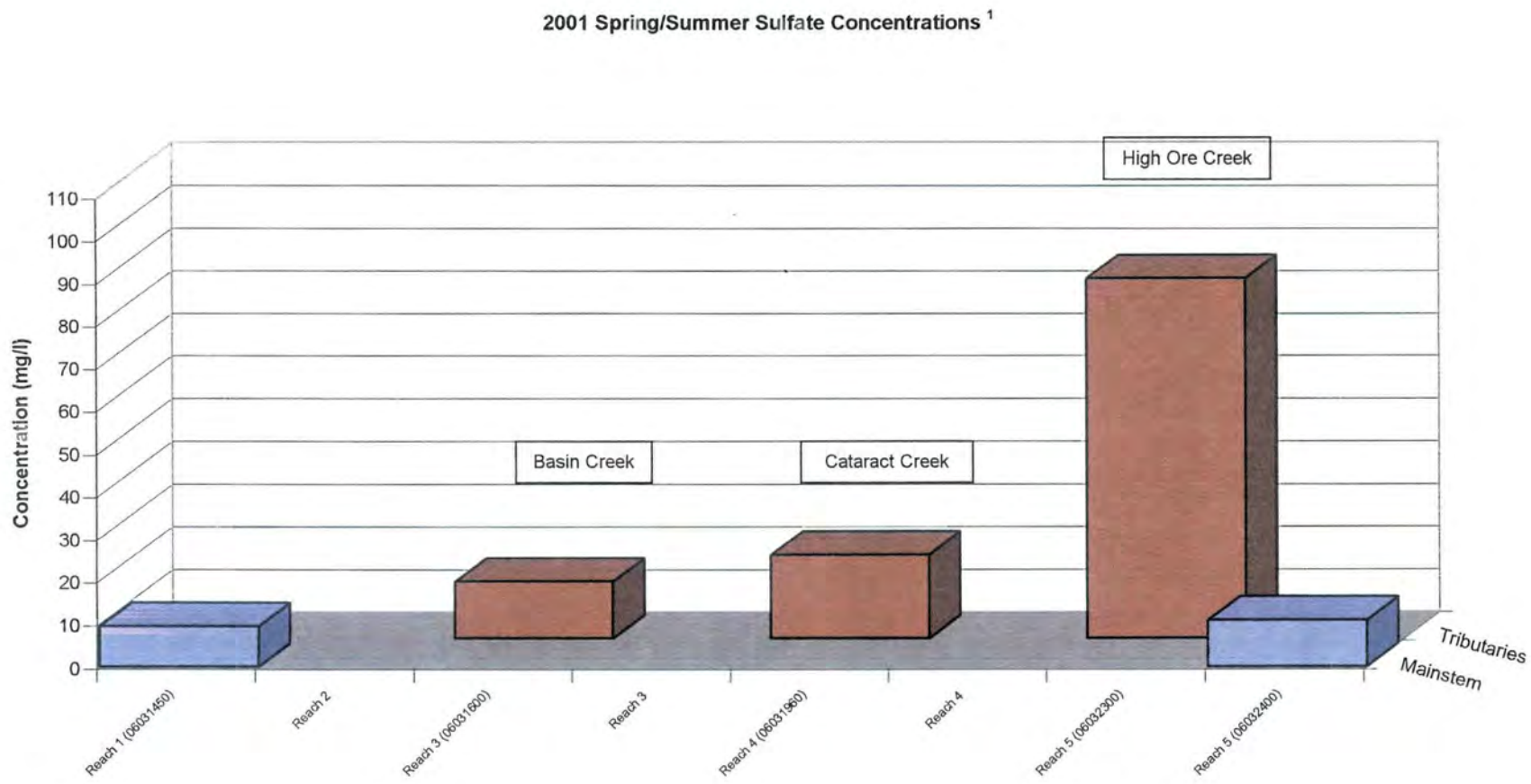
Notes:
Concentration values are mean detected concentrations exceeding Benchmarks.
Concentration values greater than upper scale limits are presented on graph.
Sample locations appear in brackets.

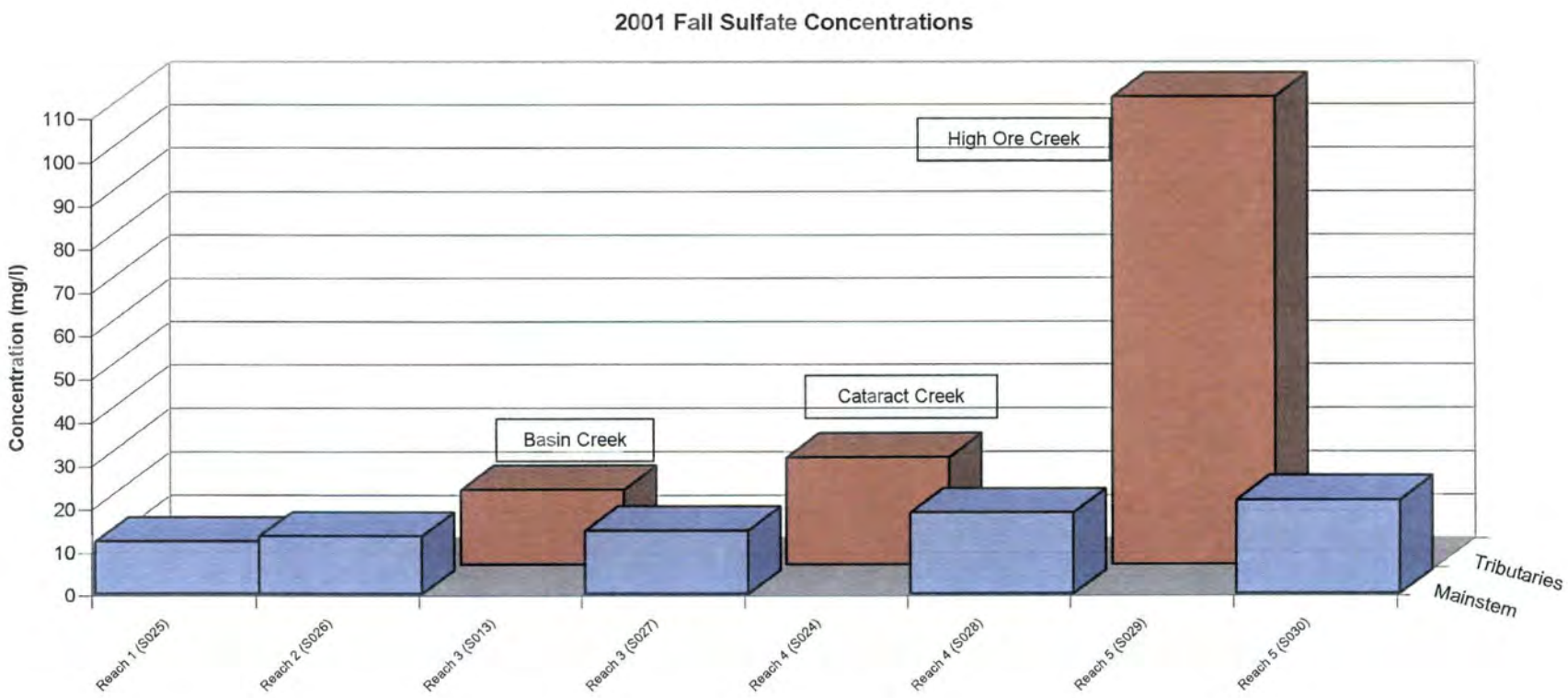
Figure 5.3-5 Sulfate Concentrations in the Boulder River Historically, Basin Watershed OU2



Notes:
Concentration values are mean detected concentrations.
Sample locations appear in brackets.

Figure 5.3-6 Sulfate Concentrations in the Boulder River in 2001, Basin Watershed OU2

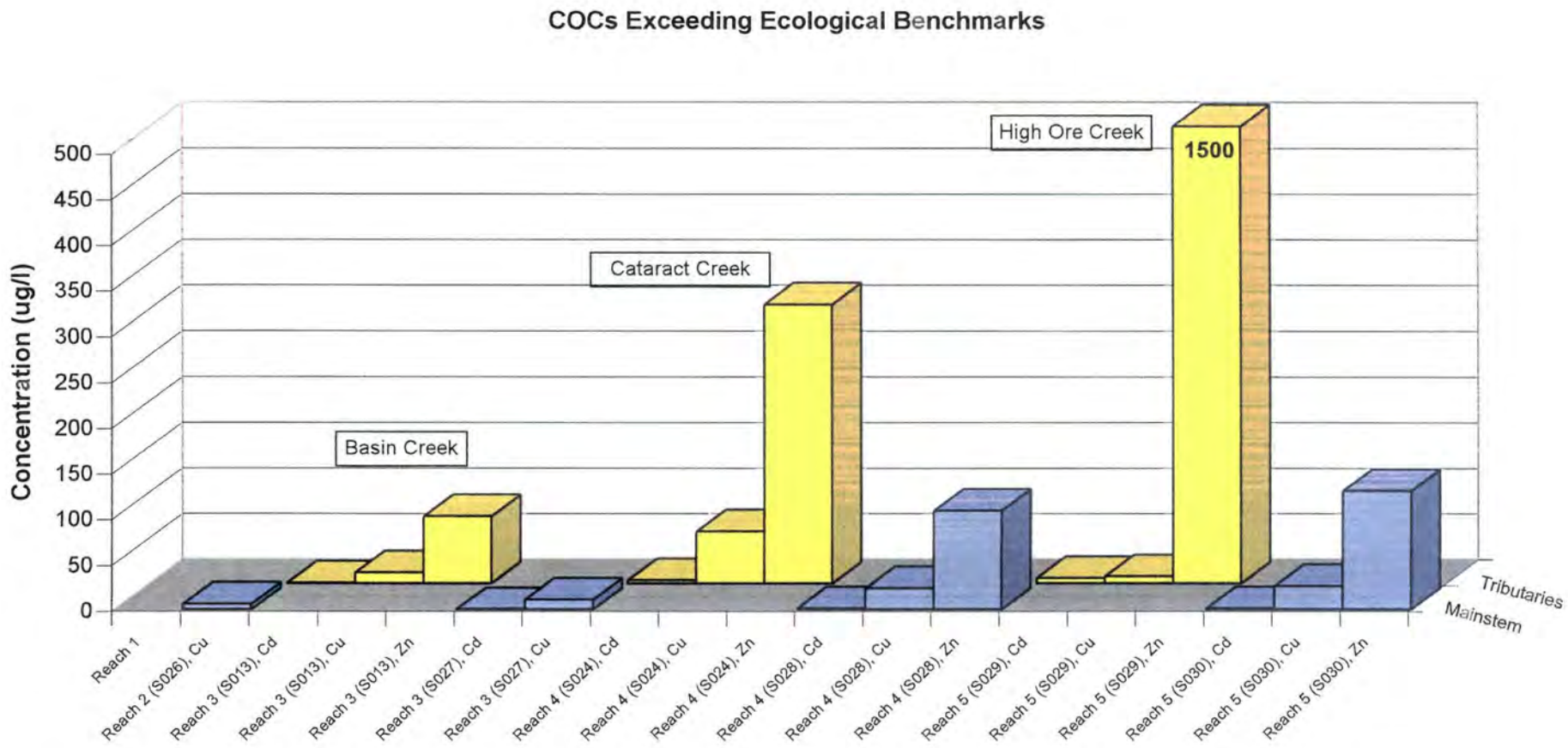


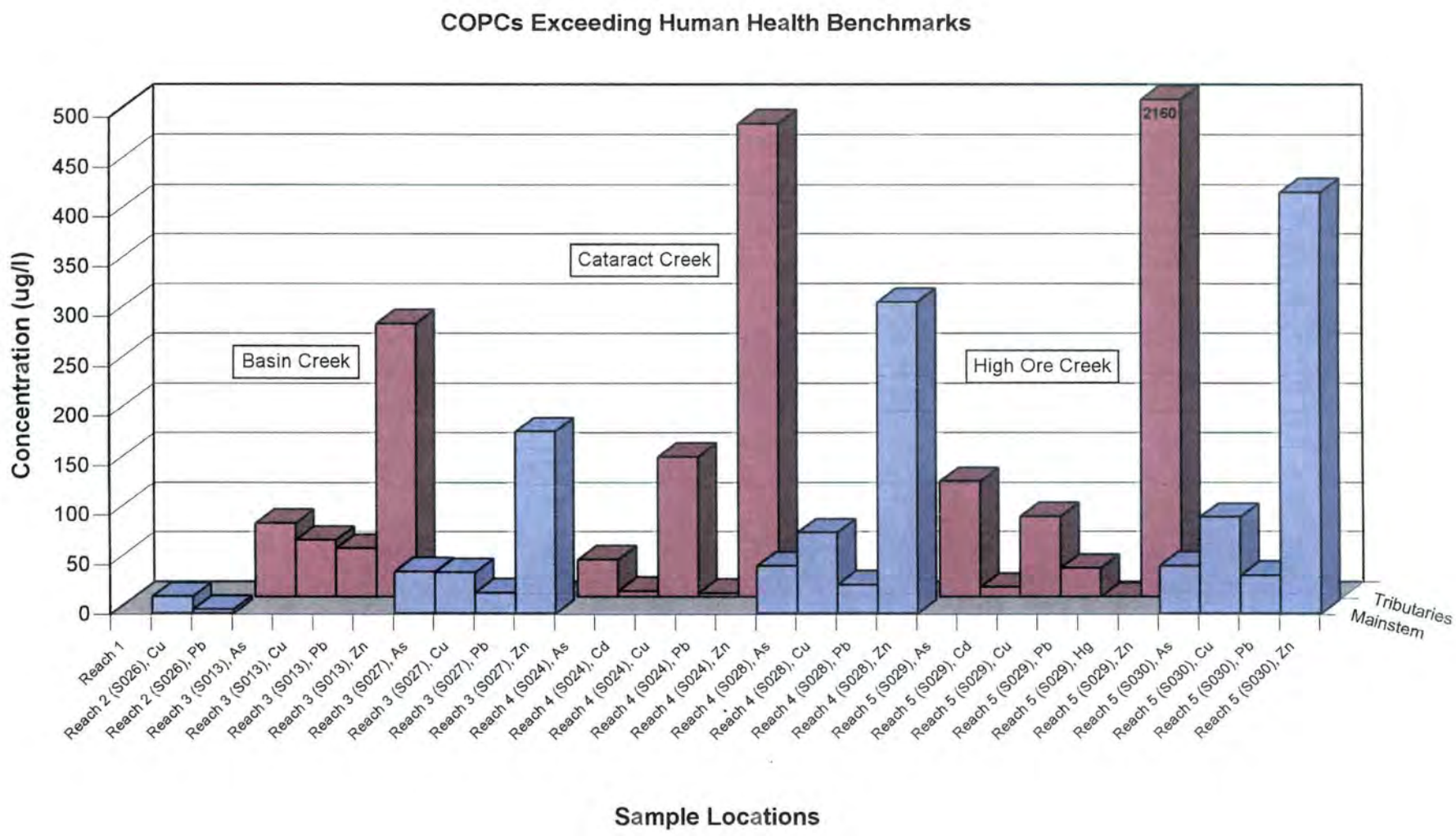


Sample Locations

Notes:
1 - USGS provisional COPCs results from measurements taken in April and May 2001.
Concentration values are mean detected concentrations.
Sample locations appear in brackets.

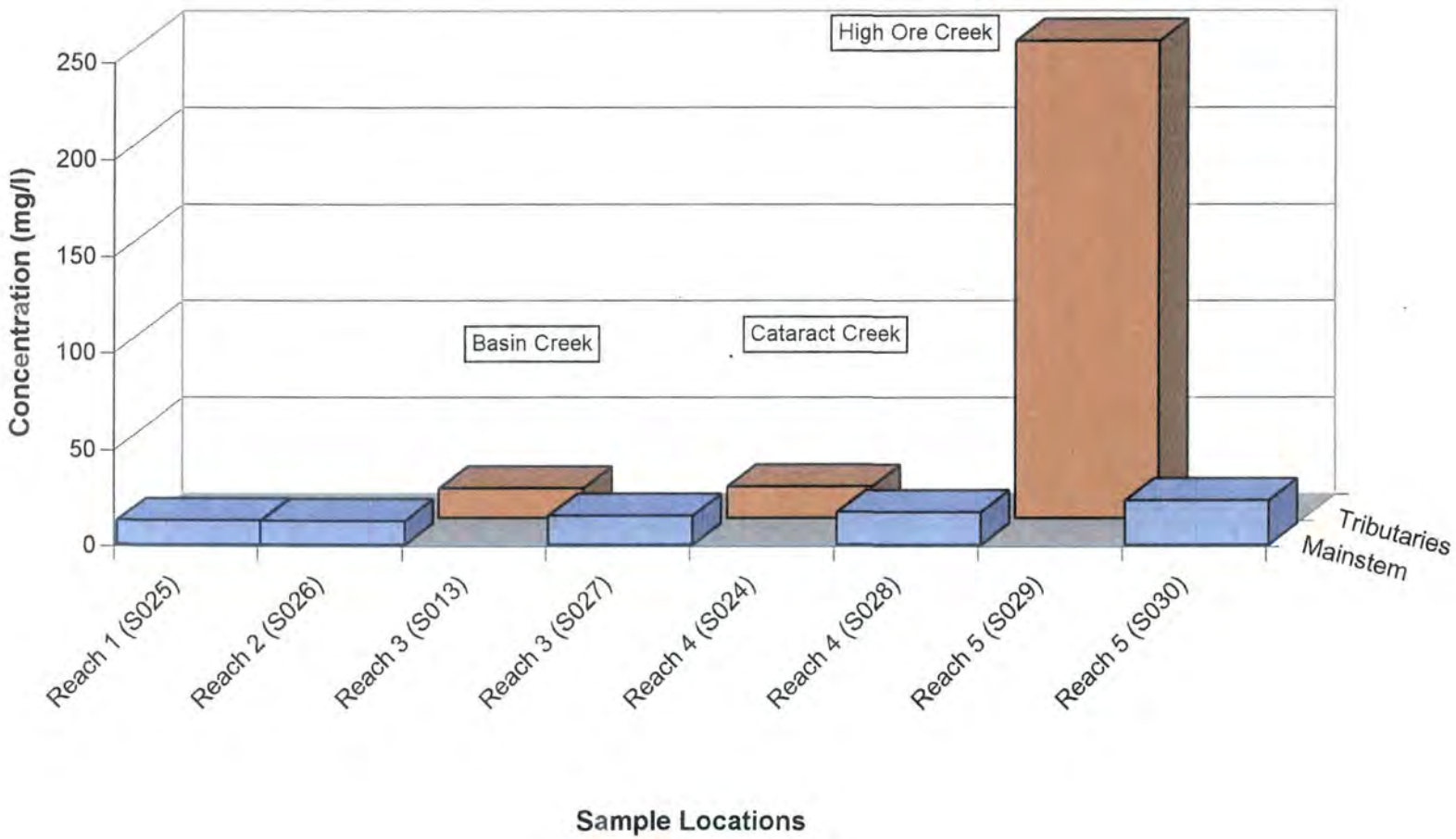
Figure 5.3-7 COCs that Exceeded Ecological and Human Health Benchmarks in the Boulder River During September 6, 2001 Storm, Basin Watershed OU2





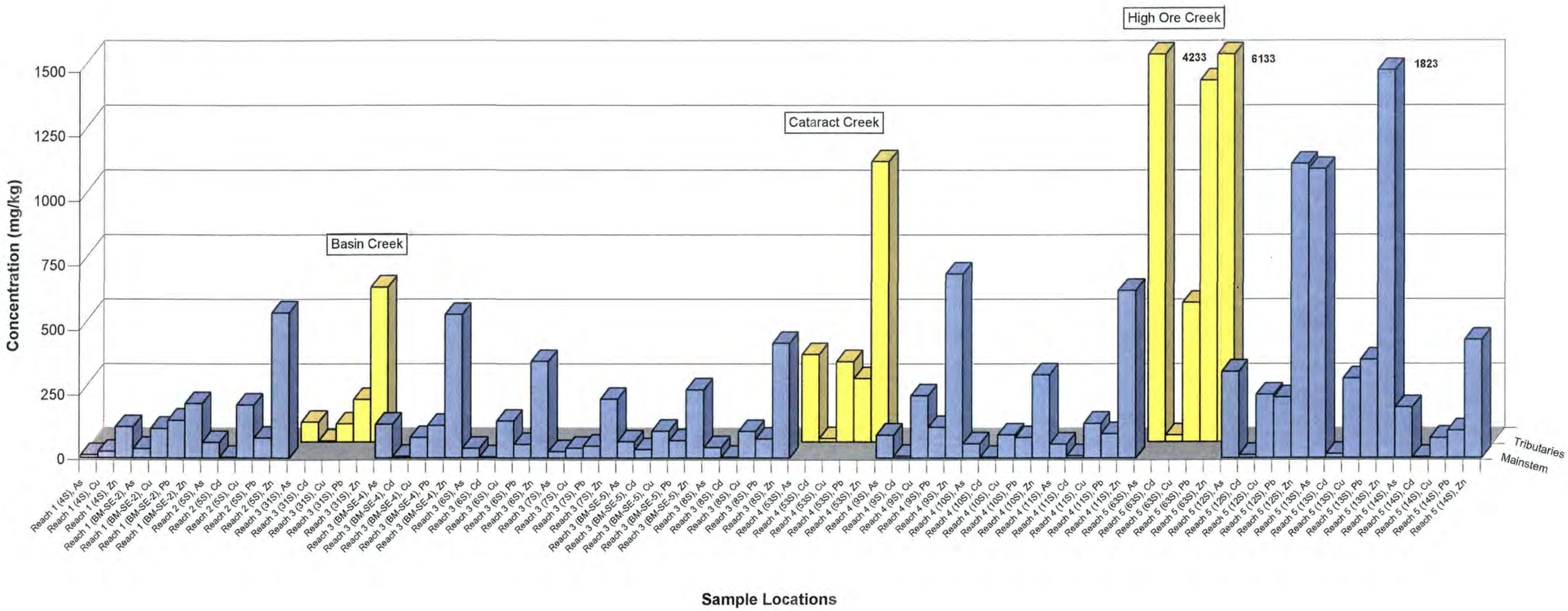
Notes:
Concentration values are mean detected concentrations exceeding Benchmarks.
Concentration values greater than upper scale limits are presented on graph.
Sample locations appear in brackets.

Figure 5.3-8 Sulfate Concentrations in the Boulder River During September 6, 2001 Storm, Basin Watershed OU2



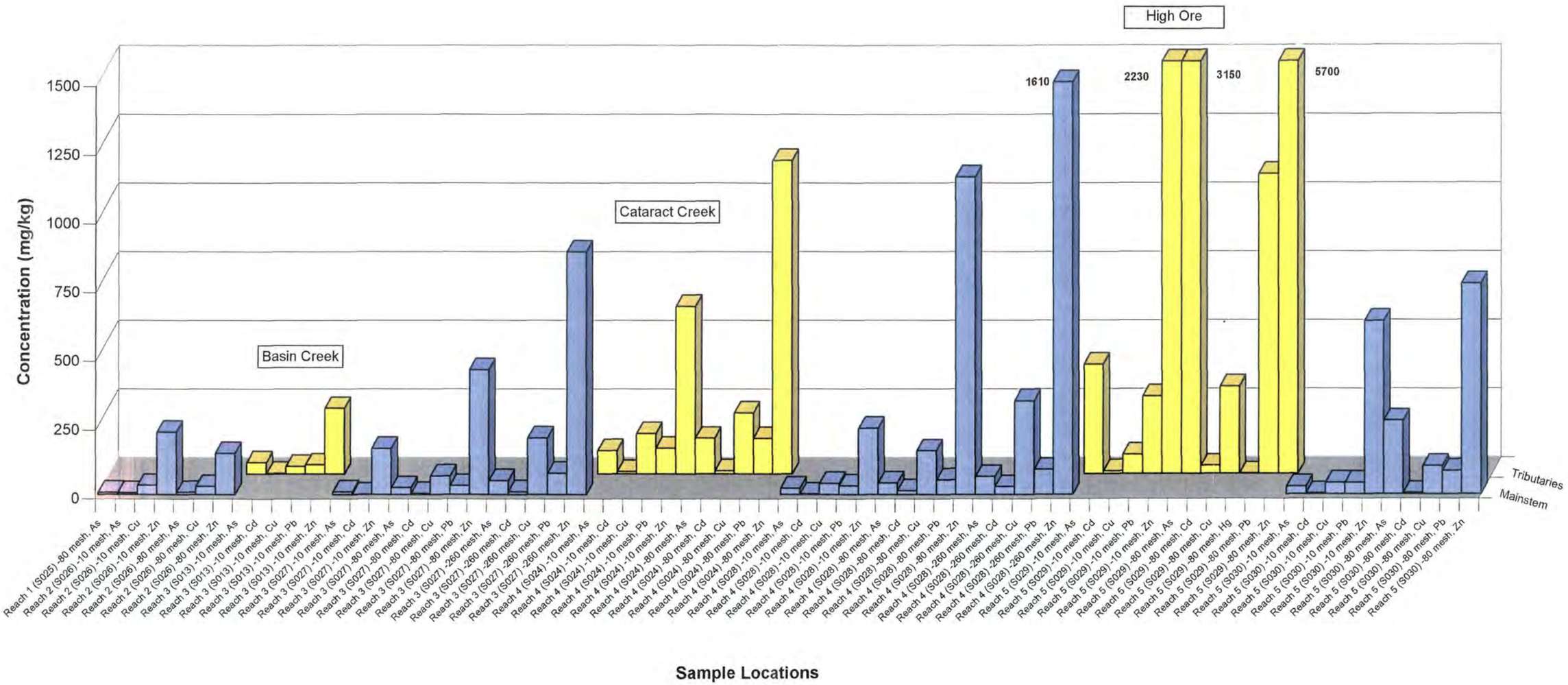
Notes: .
Concentration values are mean detected concentrations.
Sample locations appear in brackets.

Figure 5.4-1 COCS that Exceeded Ecological Benchmarks in the Boulder River Sediment Historically, Basin Watershed OU2



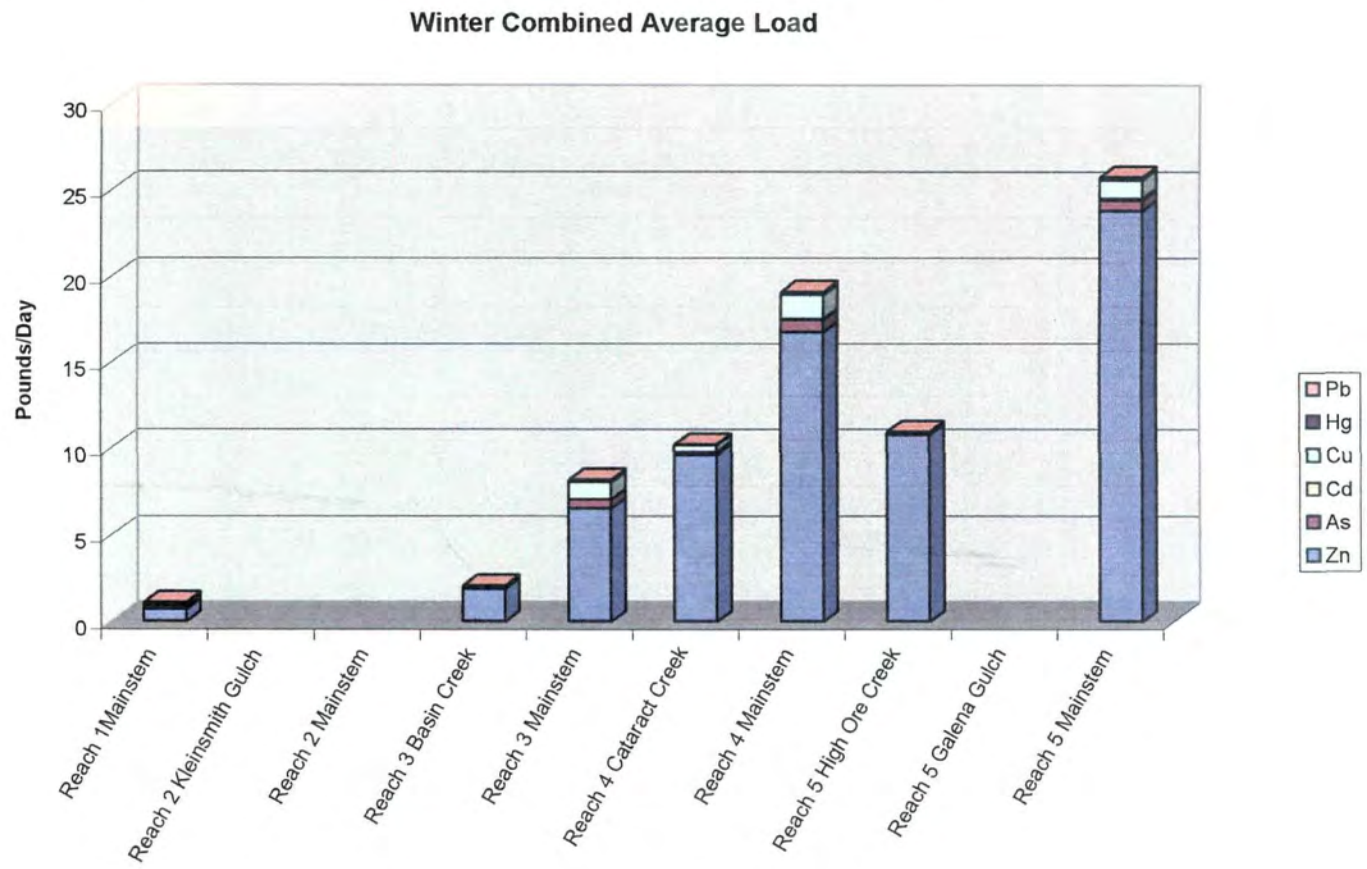
Notes:
Concentration values are mean detected concentrations exceeding benchmarks.
Concentration values greater than upper scale limit are presented on graph.
Sample locations appear in brackets.

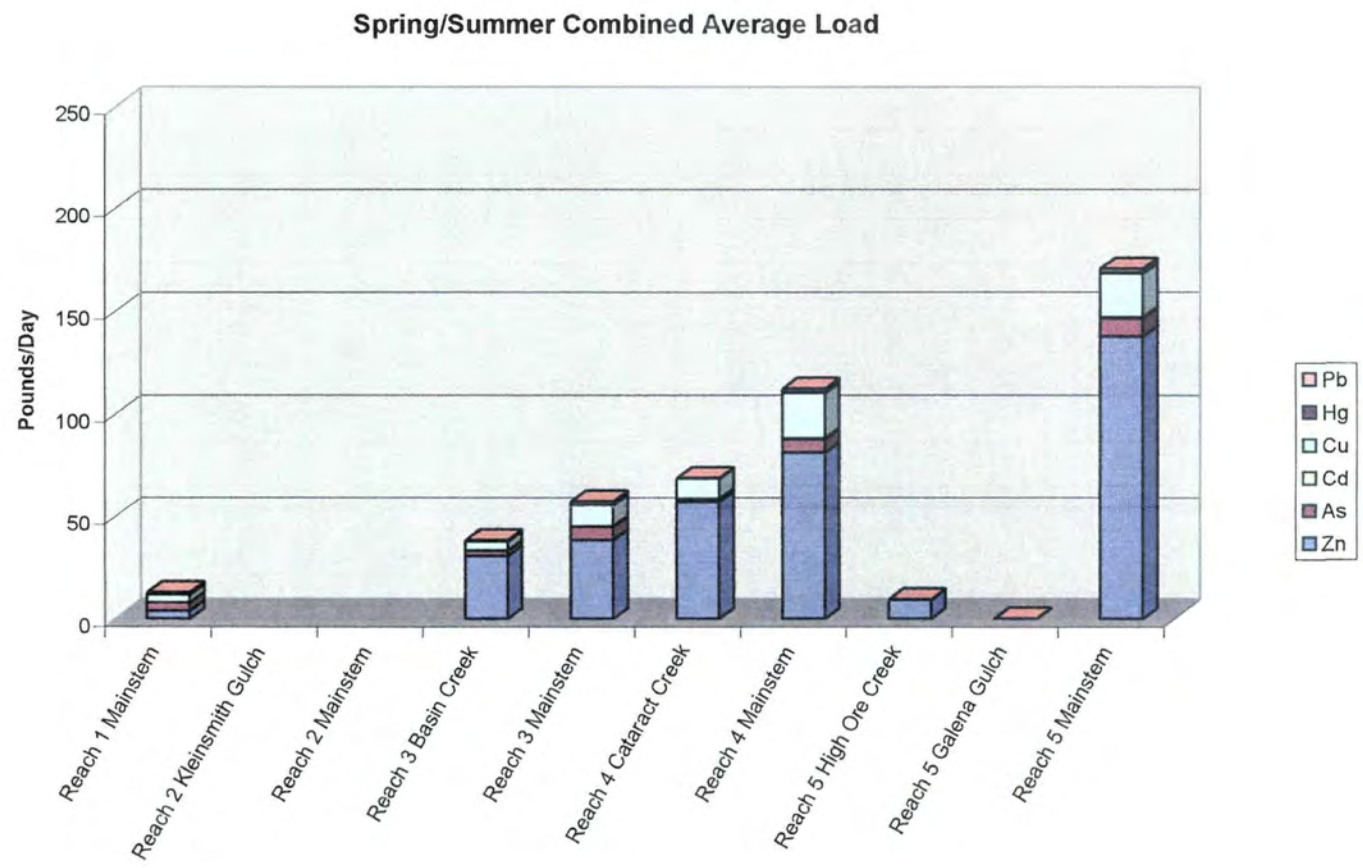
Figure 5.4-2 COCs that Exceeded Ecological Benchmarks in the Boulder River Sediments in 2001, Basin Watershed OU2



Notes:
Concentration values are mean detected concentrations exceeding benchmarks.
Concentration values greater than upper scale limit are presented on graph.
Sample locations appear in brackets.

Figure 5.7-1 Historical Combined Dissolved COCs Load in the Boulder River, Basin Watershed OU2





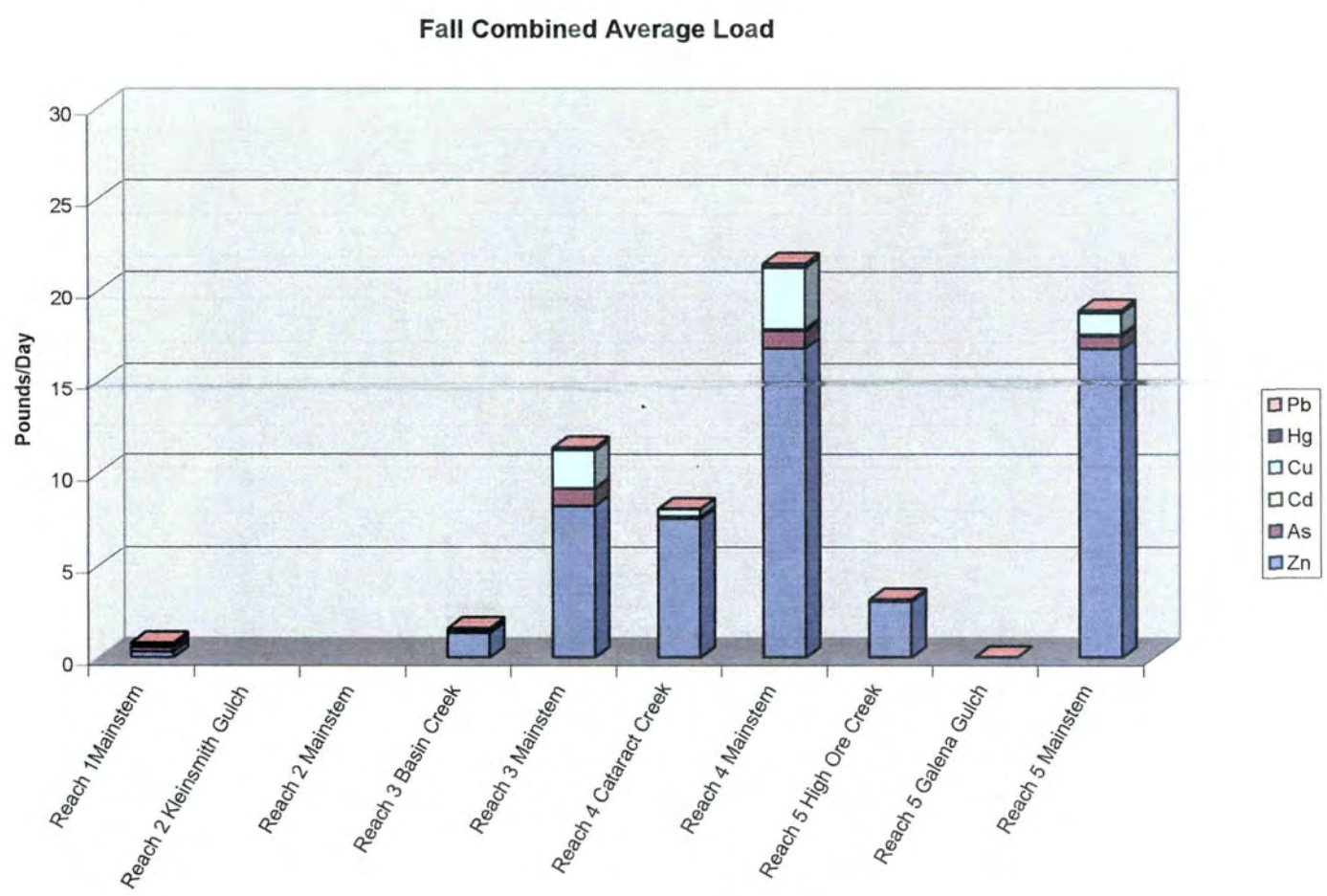
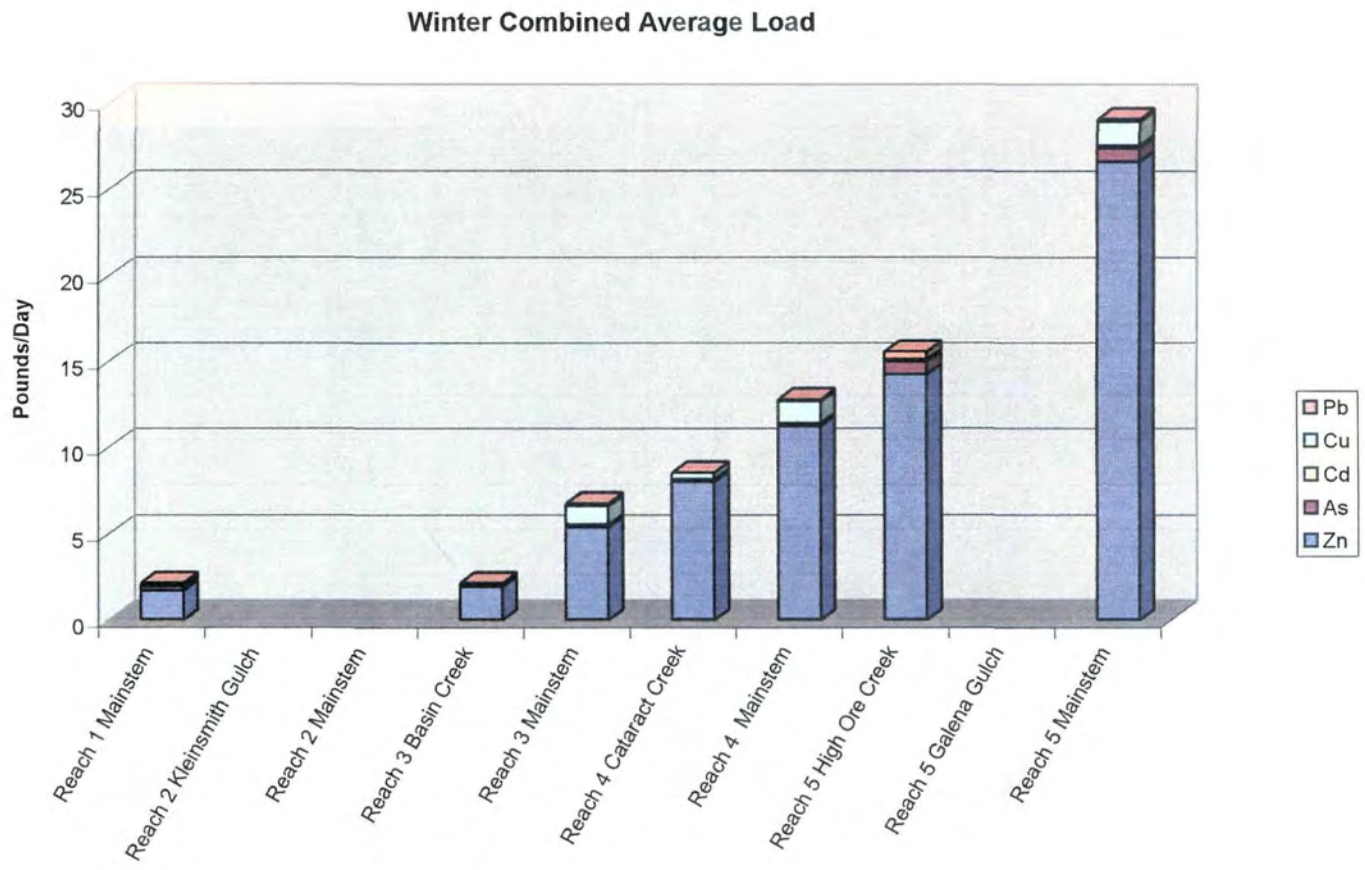
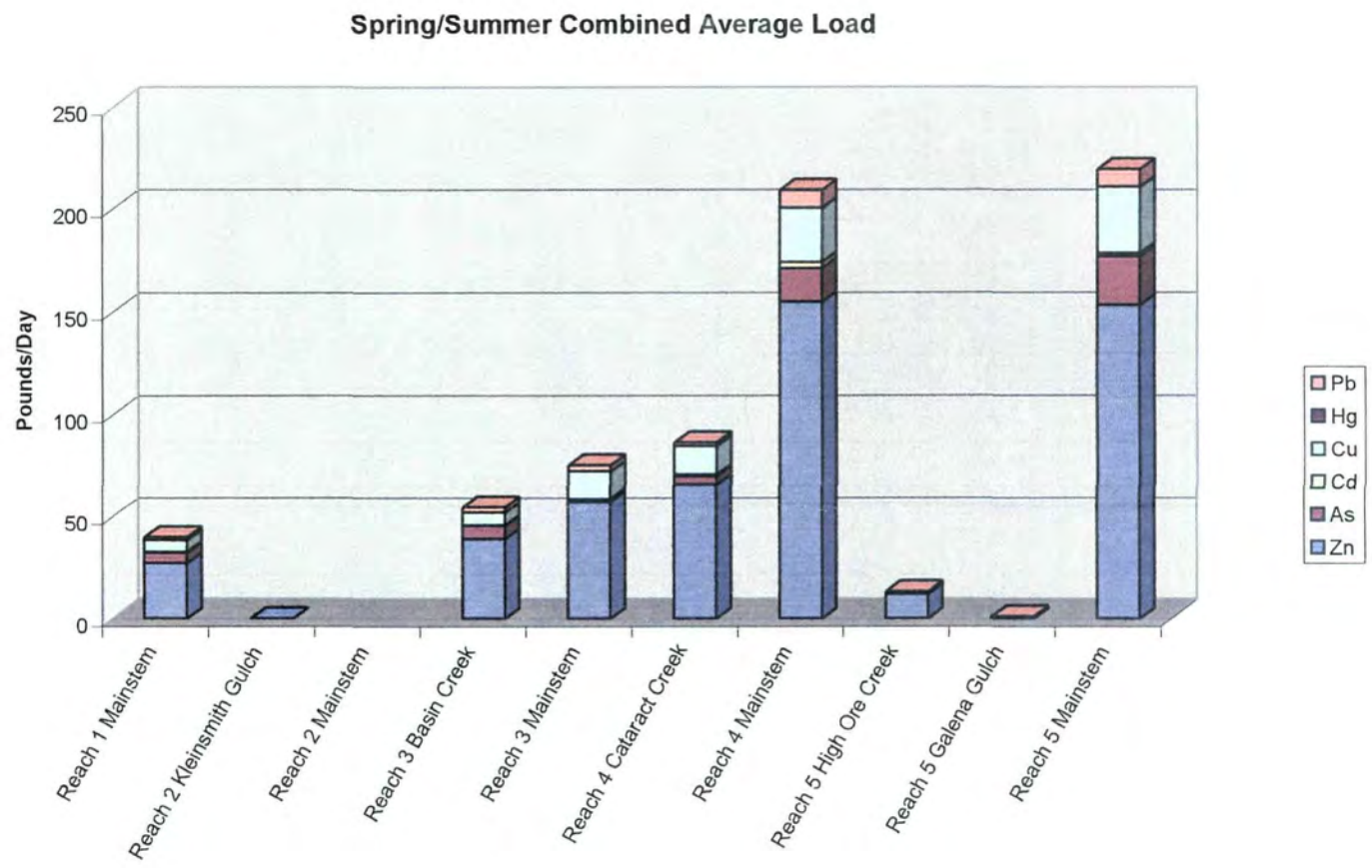


Figure 5.7-2 Historical Combined Total COCs Load in the Boulder River, Basin Watershed OU2





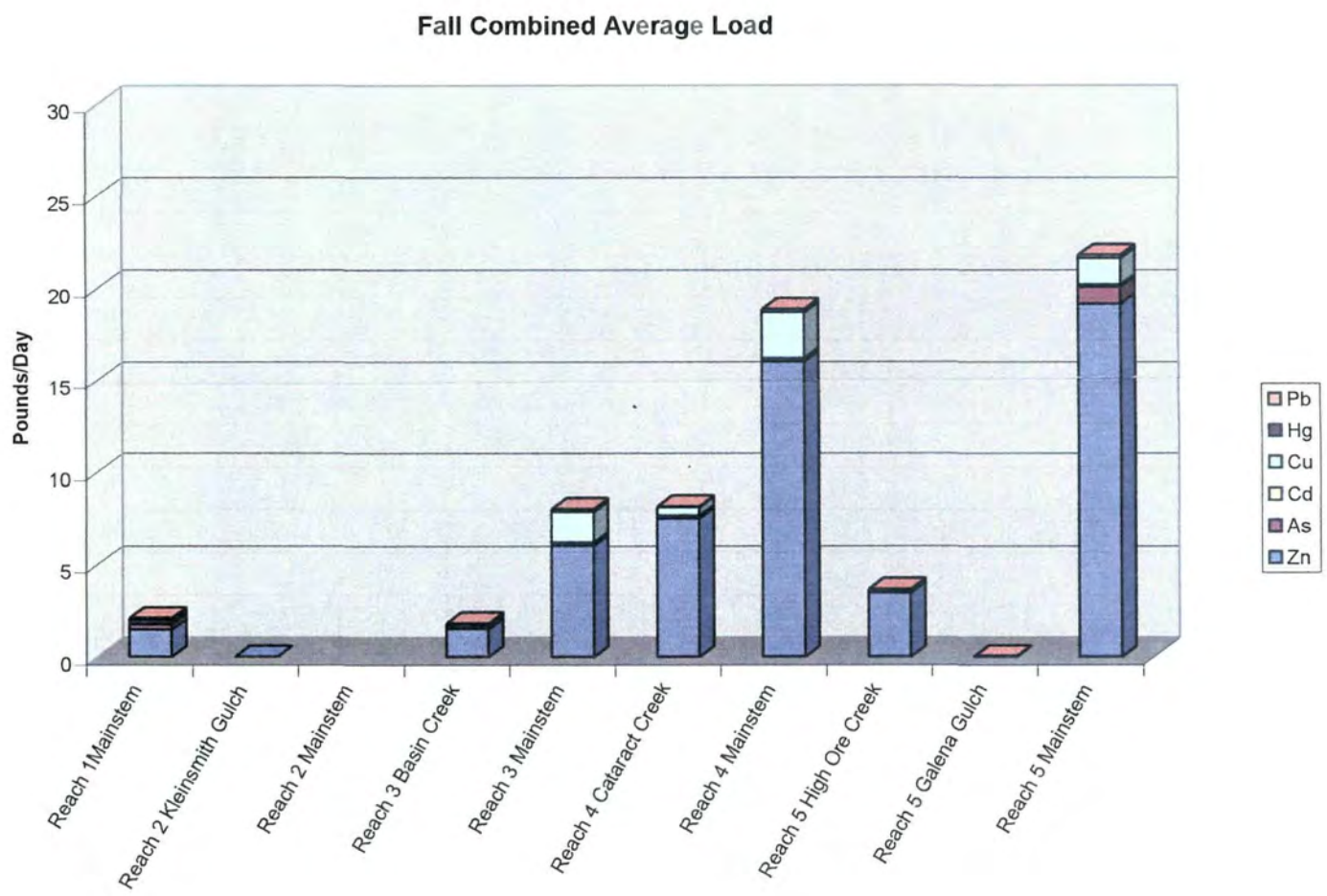
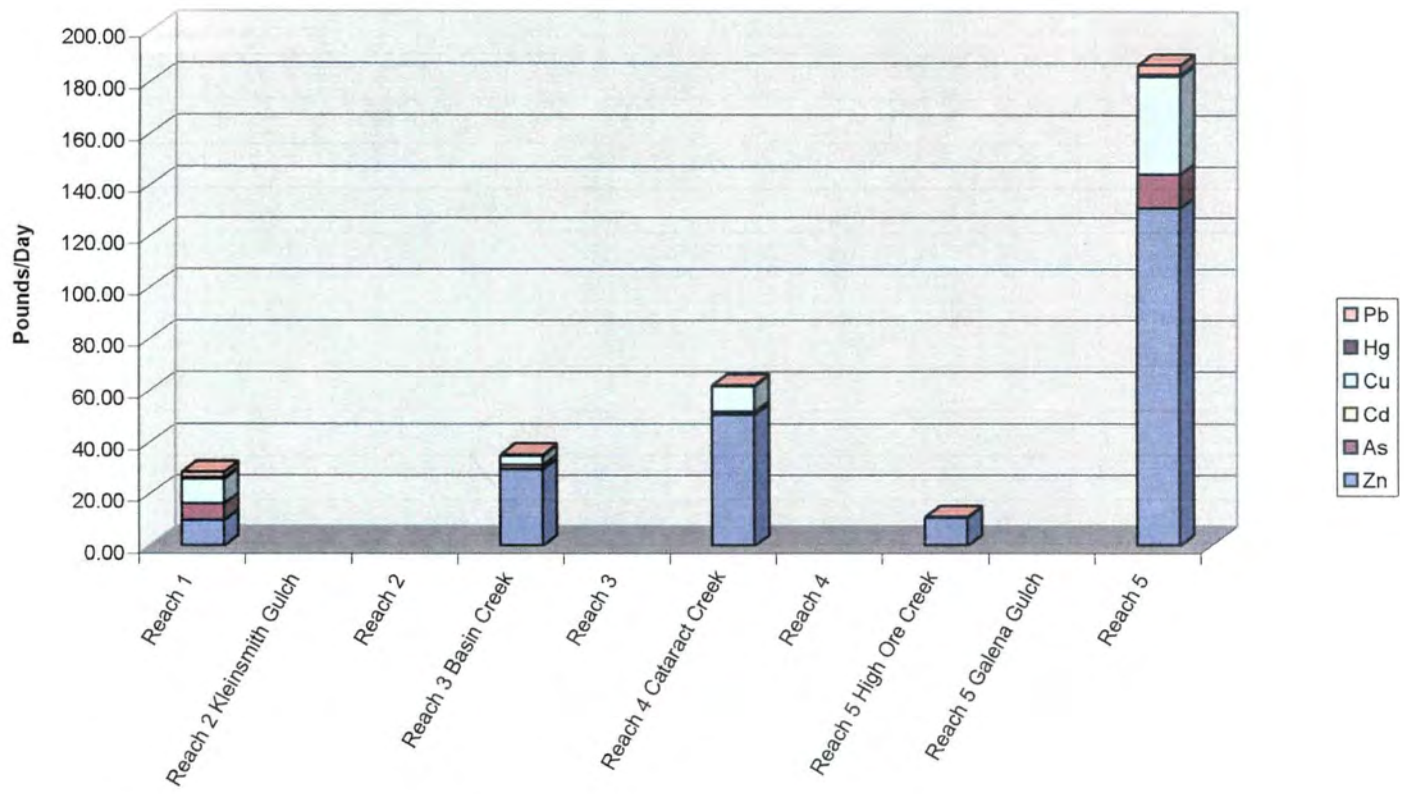
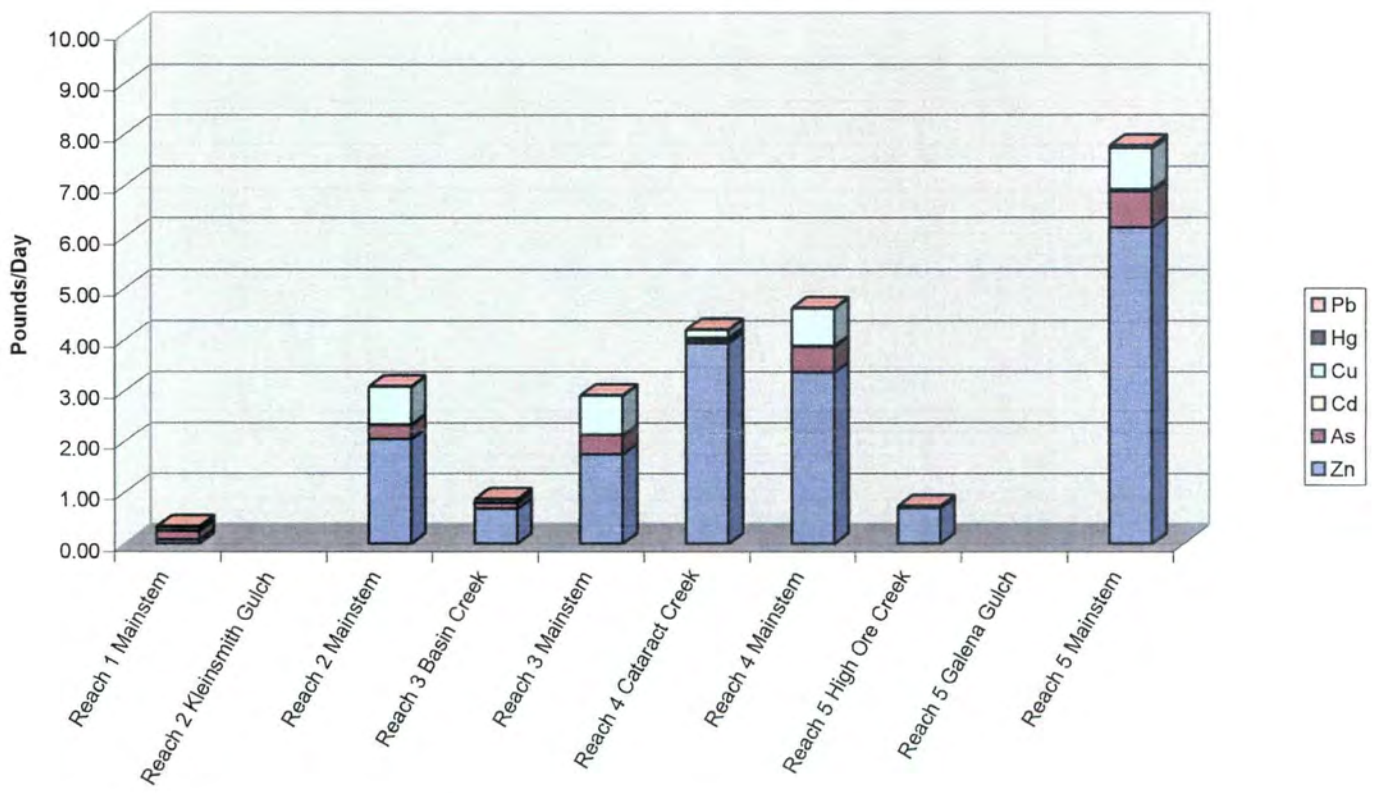


Figure 5.7-3 Spring/Summer and Fall 2001 Combined Dissolved COCs Load in the Boulder River, Basin Watershed OU2

Spring/Summer 2001 Combined Average Load



Fall 2001 Combined Average Load



Fall Storm 2001 Combined Average Load

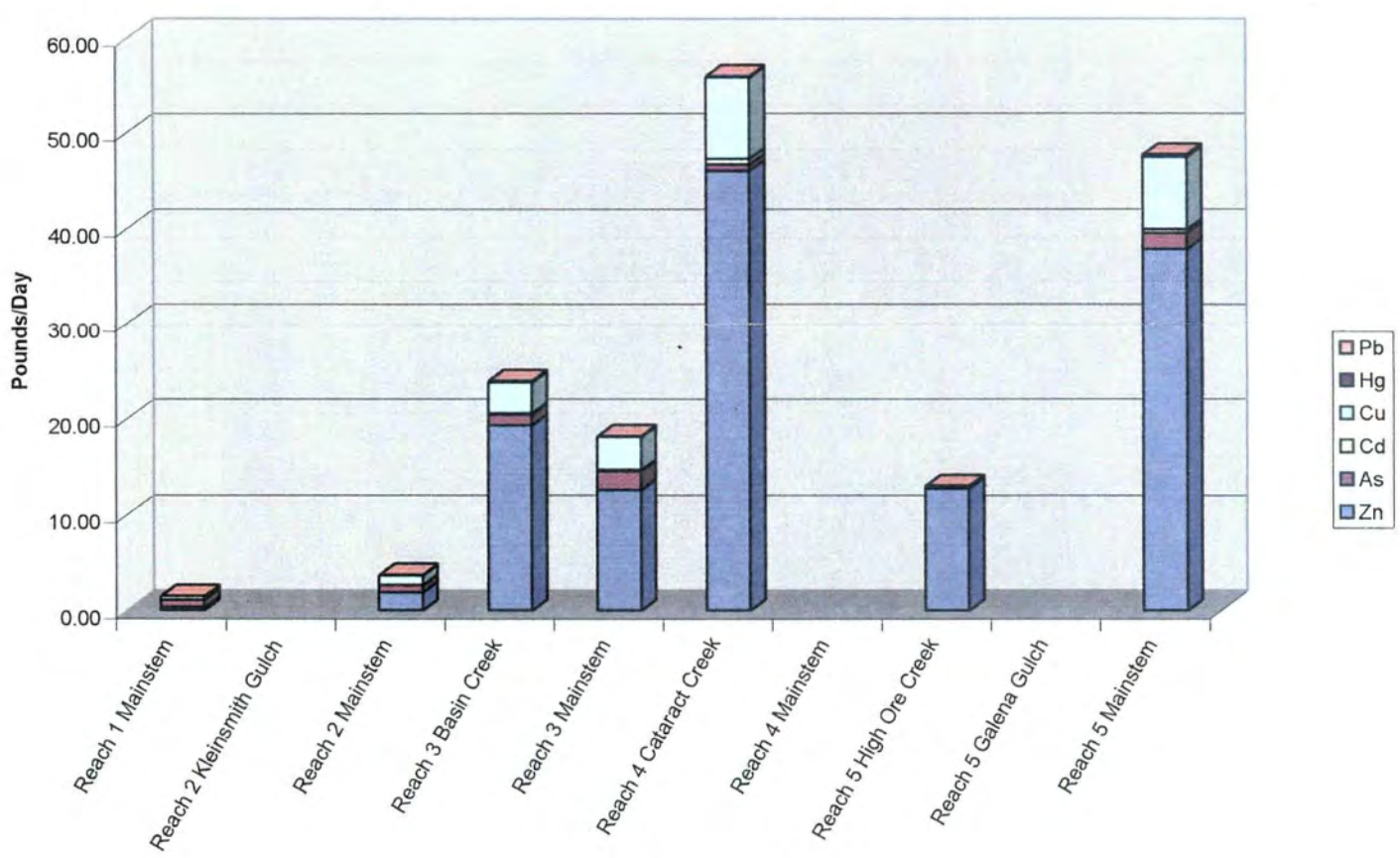
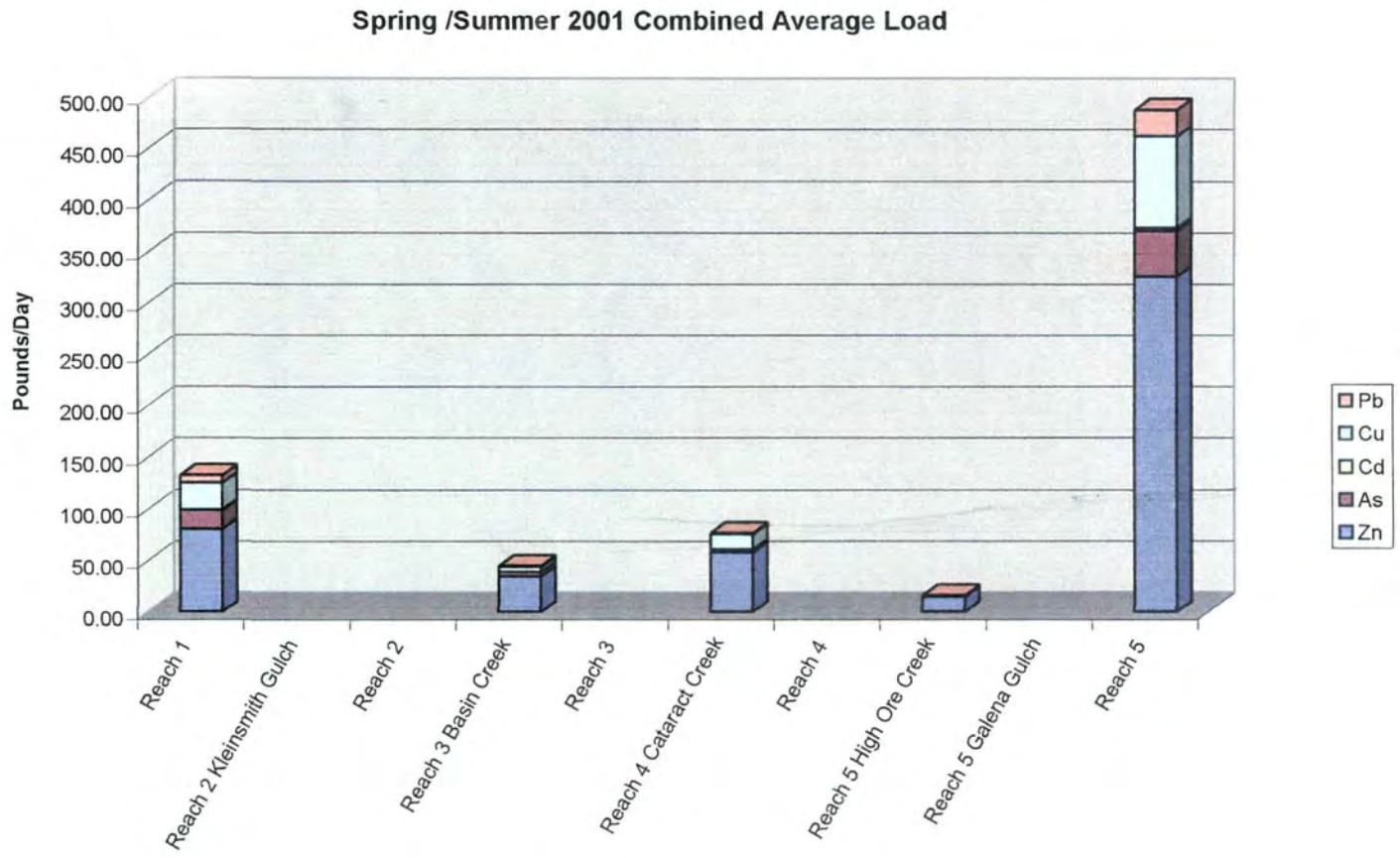
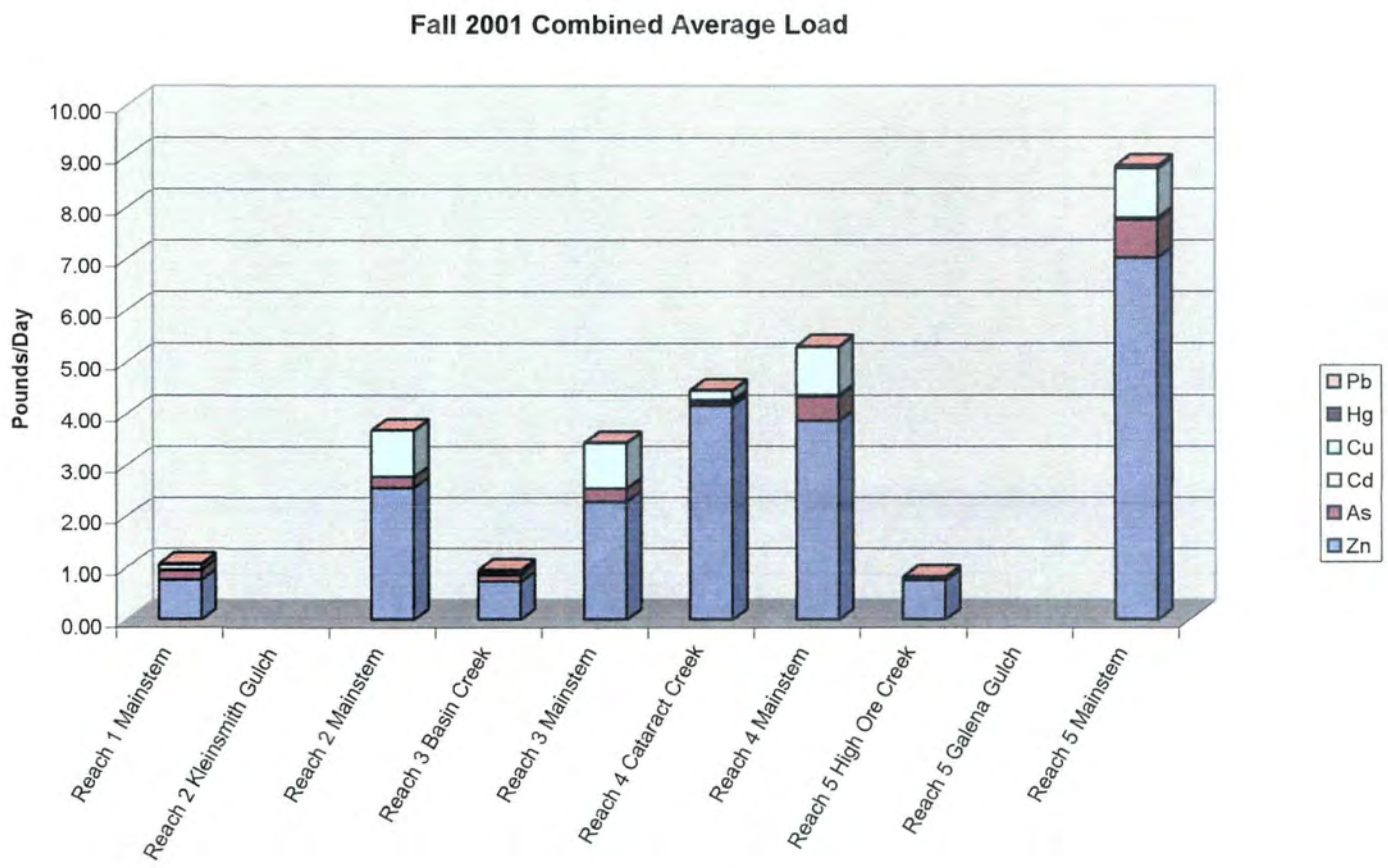
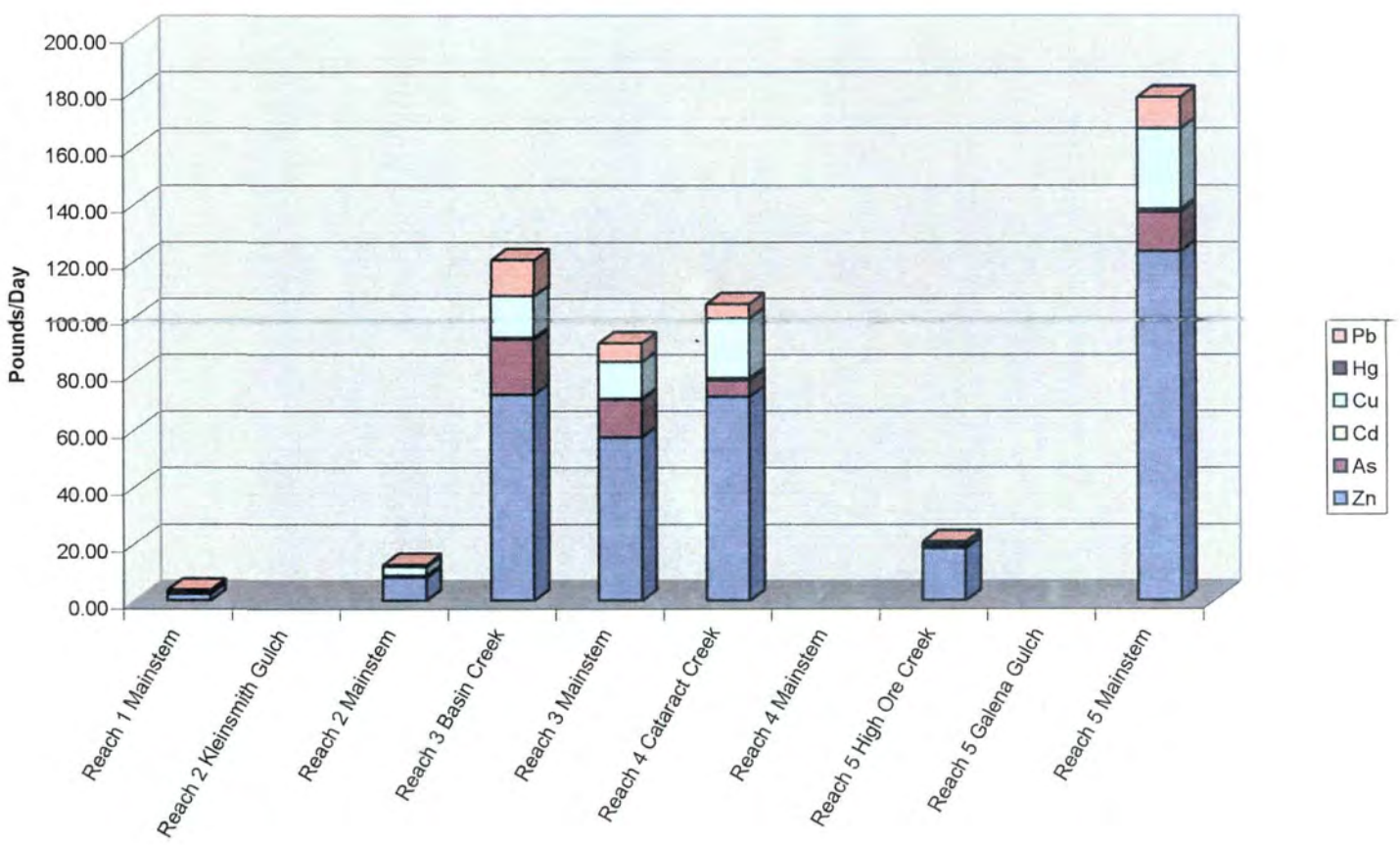
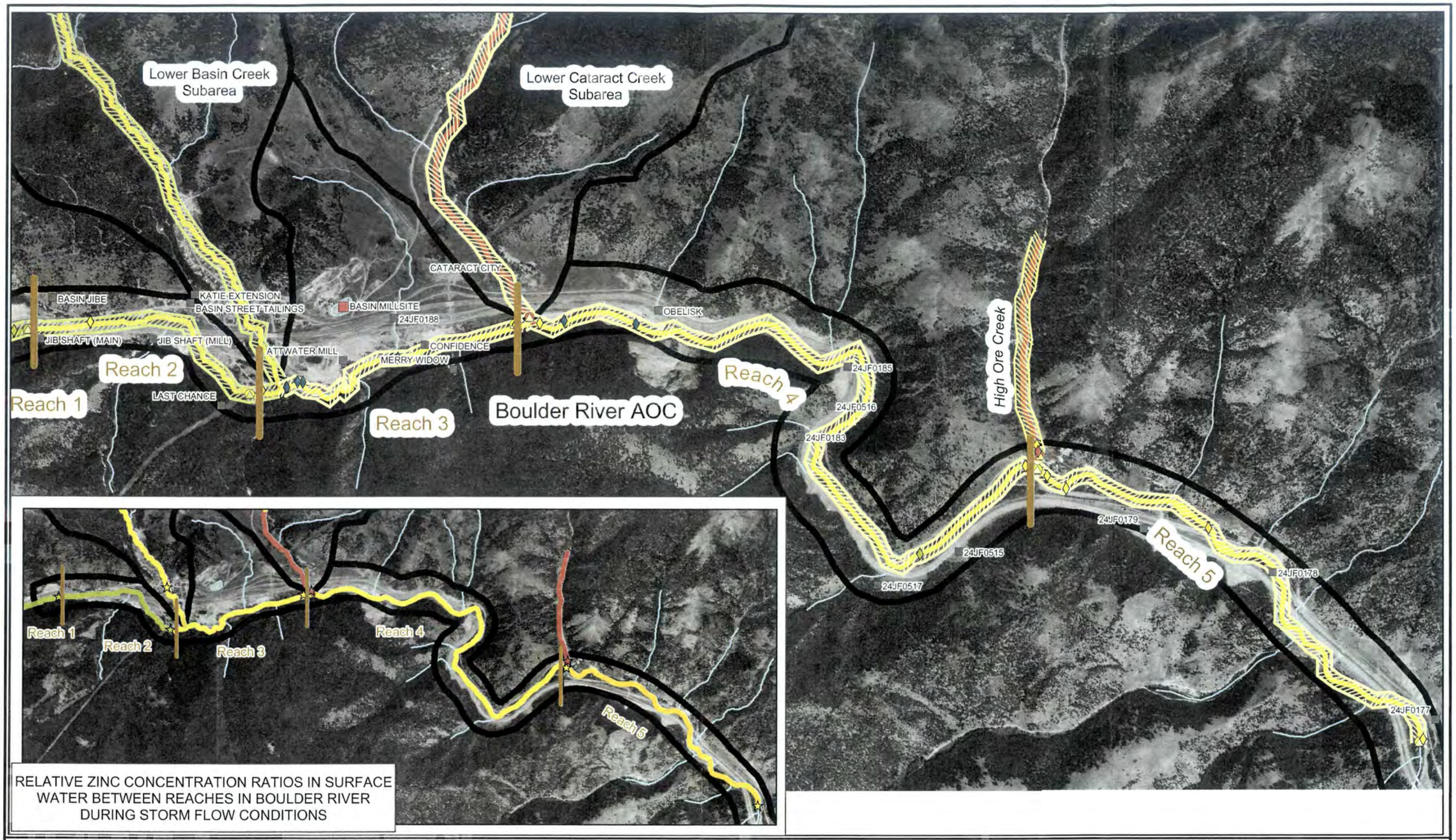


Figure 5.7-4 Spring/Summer and Fall 2001 Combined Total COCs Load in the Boulder River, Basin Watershed OU2









RELATIVE ZINC CONCENTRATION RATIOS IN SURFACE WATER BETWEEN REACHES IN BOULDER RIVER DURING STORM FLOW CONDITIONS

Note: Basin Creek and Cataract Creek RRs are relative to the most up-stream station on Boulder River.

LEGEND

- RR >= 100
- 50 <= RR <= 100
- 10 <= RR <= 50
- 5 <= RR <= 10
- 5 < RR
- No Data

Based on baseline zinc concentration of 2.5 ug/L.

- △ Sediment Station
- ○ Surface Water Station
- ☆ Stormwater Station
- □ Mine Site
- ◊ Historical Sediment Station

- Relative difference in surface water total zinc concentrations between reaches.
- Relative difference in sediment total zinc concentrations between reaches.

RR = ratio of concentration at station and baseline concentration
Baseline Concentration = lowest concentration in AOC

N W E S

Feet

0 1,000 2,000 4,000

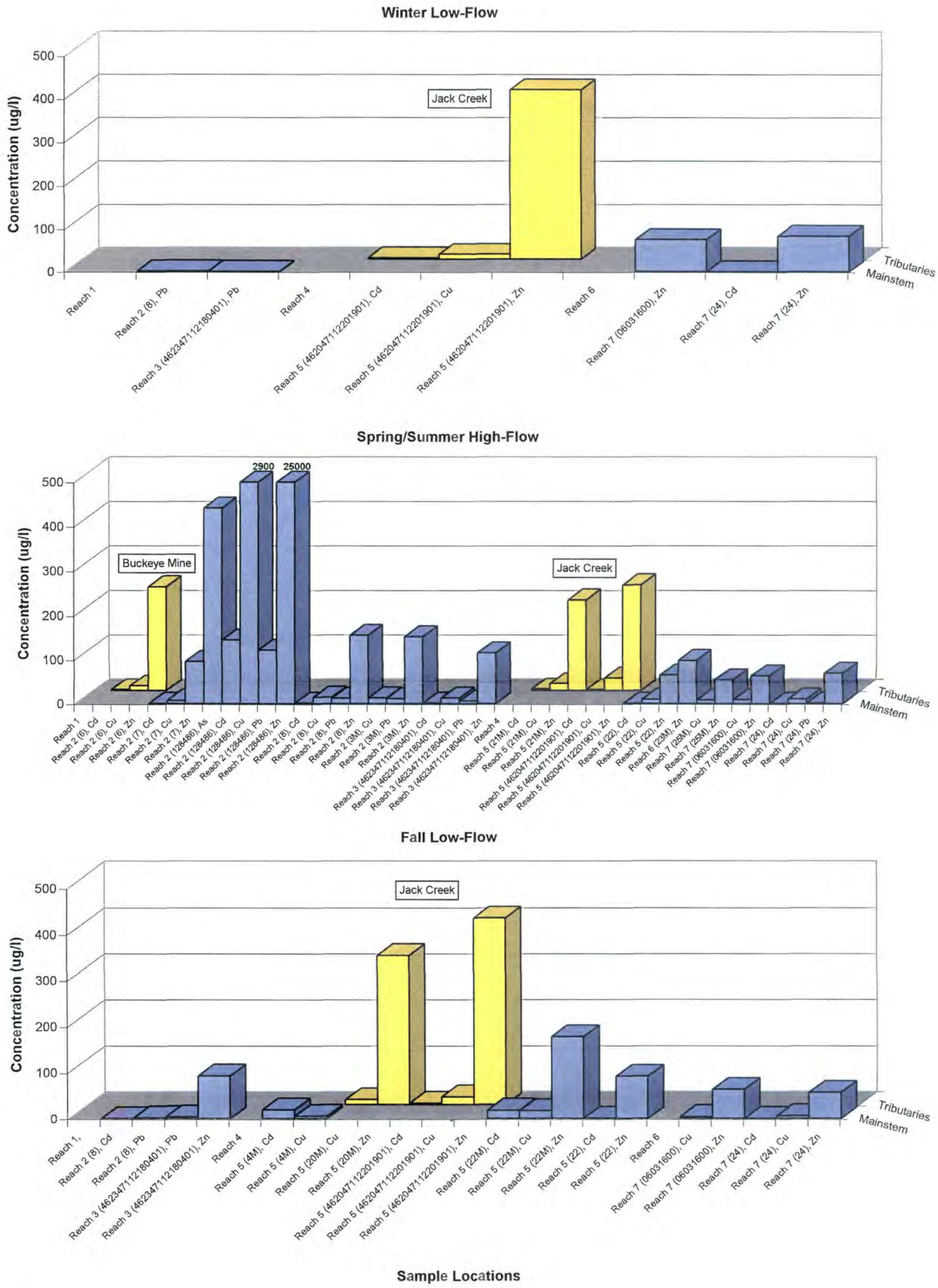
Figure 5.9-1
RELATIVE ZINC CONCENTRATION RATIOS IN SURFACE WATER AND SEDIMENT BETWEEN REACHES IN BOULDER RIVER DURING NON-STORM AND STORM FLOW CONDITIONS

Basin Watershed Operable Unit 2
Jefferson County, Montana

CDM

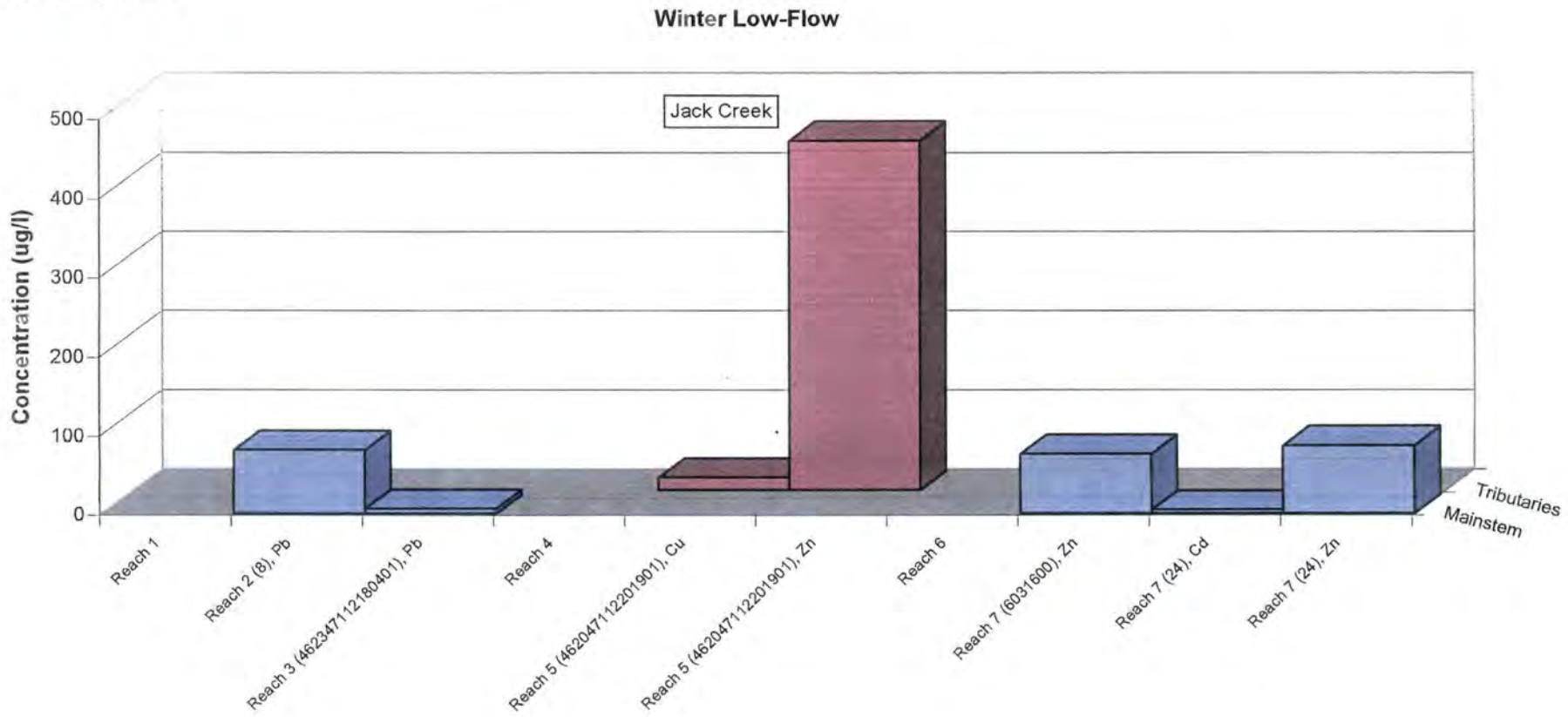
Map Filename: Figure5.9-1_11x17.mxd 11/20/2002

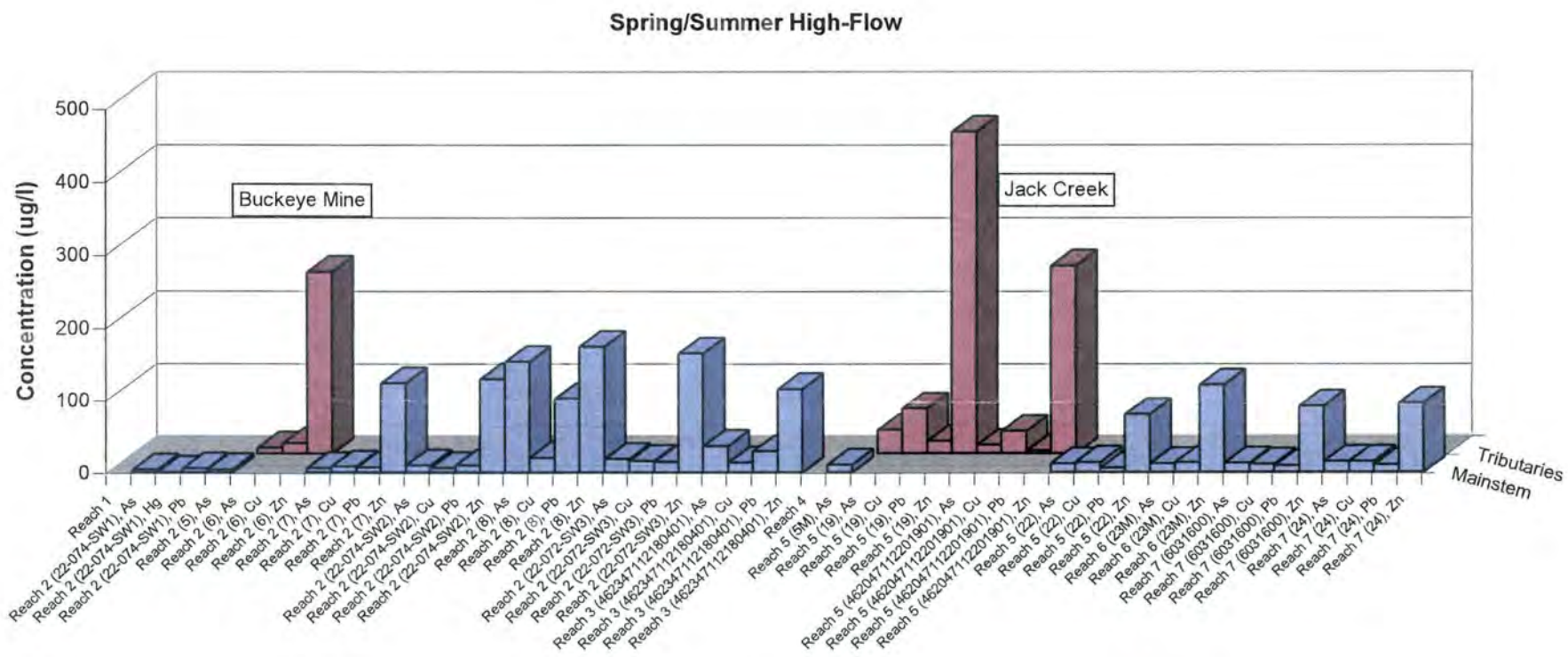
Figure 6.3-1 Historical Locations Along Basin Creek Where COCs Exceeded Ecological Benchmarks, Basin Watershed OU2

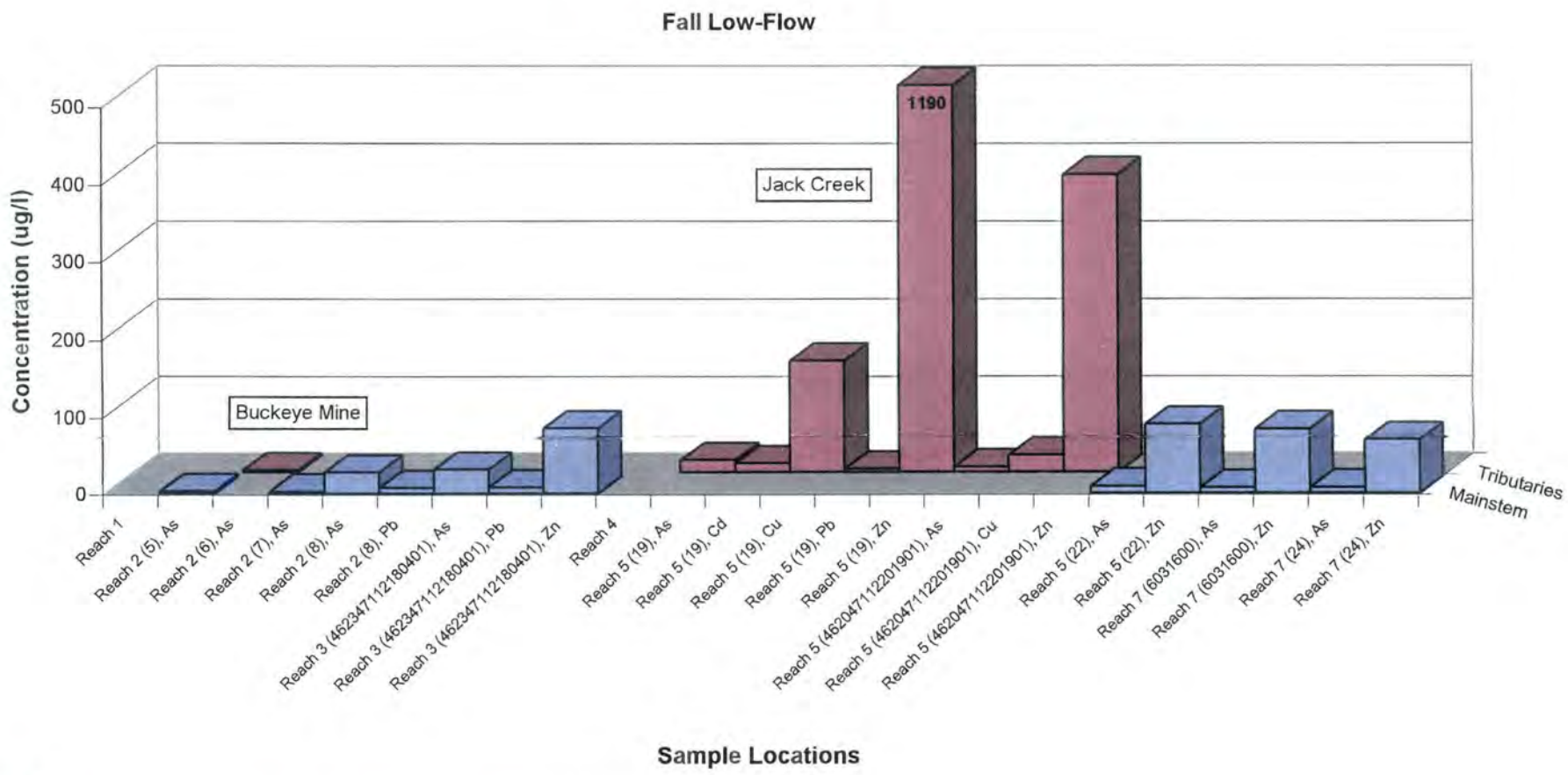


Notes:
Concentration values are mean detected concentrations exceeding benchmarks.
Concentration values greater than upper scale limits are presented on graph.
Sample locations appear in brackets.

Figure 6.3-2 Historical Locations Along Basin Creek Where COCs Exceeded Human Health Benchmarks, Basin Watershed OU2

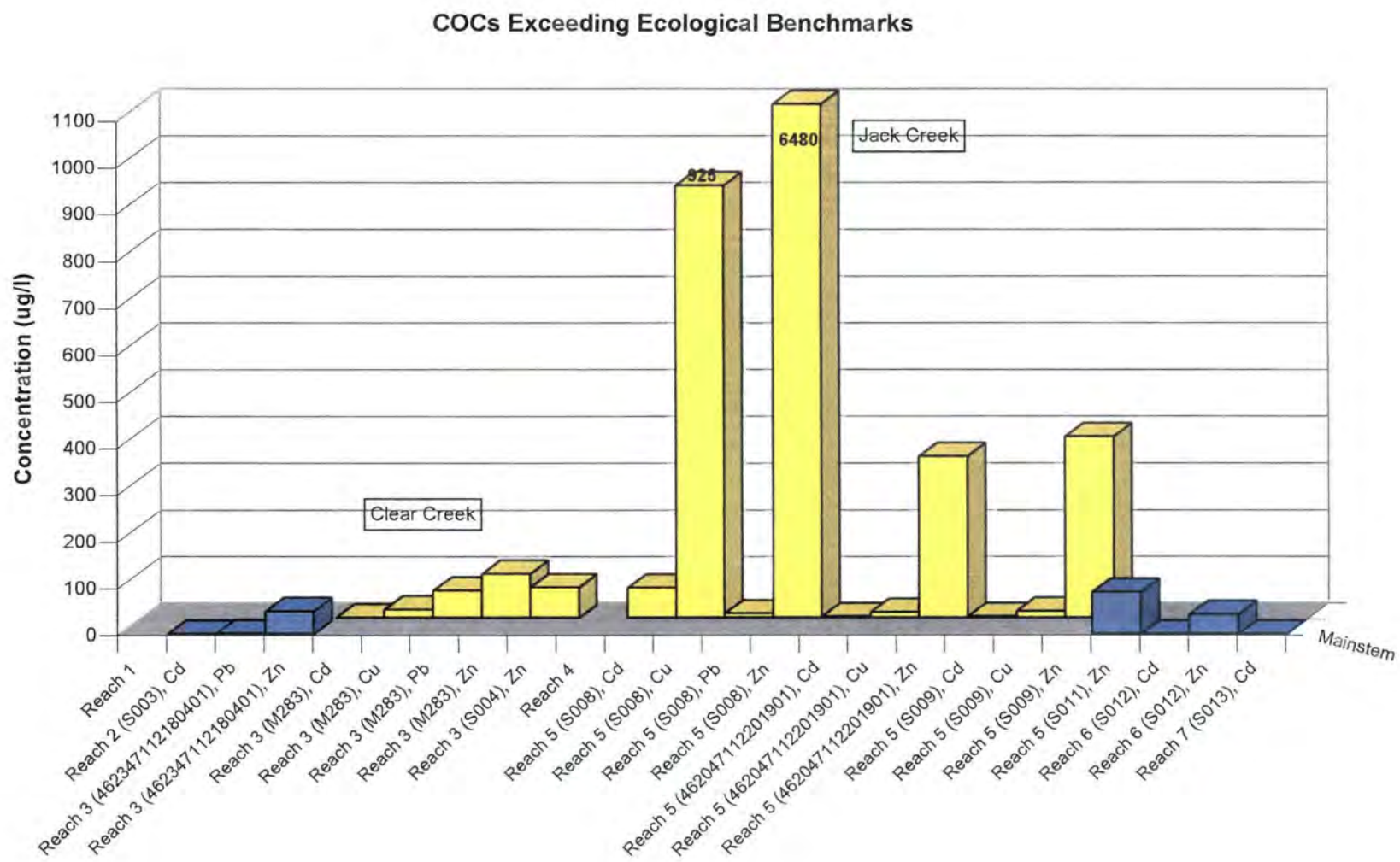


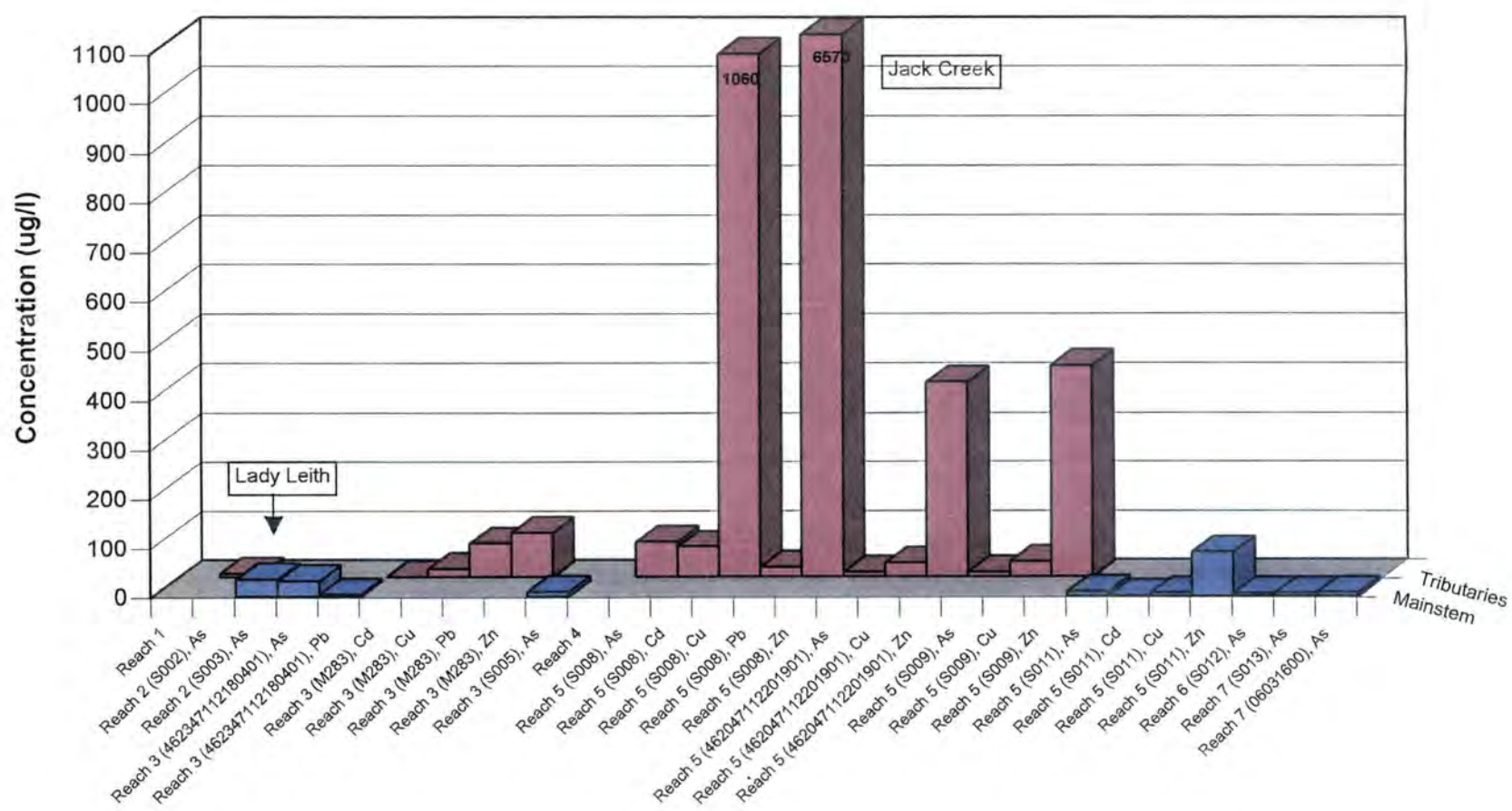




Notes:
Concentration values are mean detected concentrations exceeding benchmarks.
Concentration values greater than upper scale limits are presented on graph.
Sample locations appear in brackets.

Figure 6.3-3 Locations Along Basin Creek Where COCs Exceeded Ecological and Human Health Benchmarks Based on 2001 Fall Low-Flow, Basin Watershed OU2

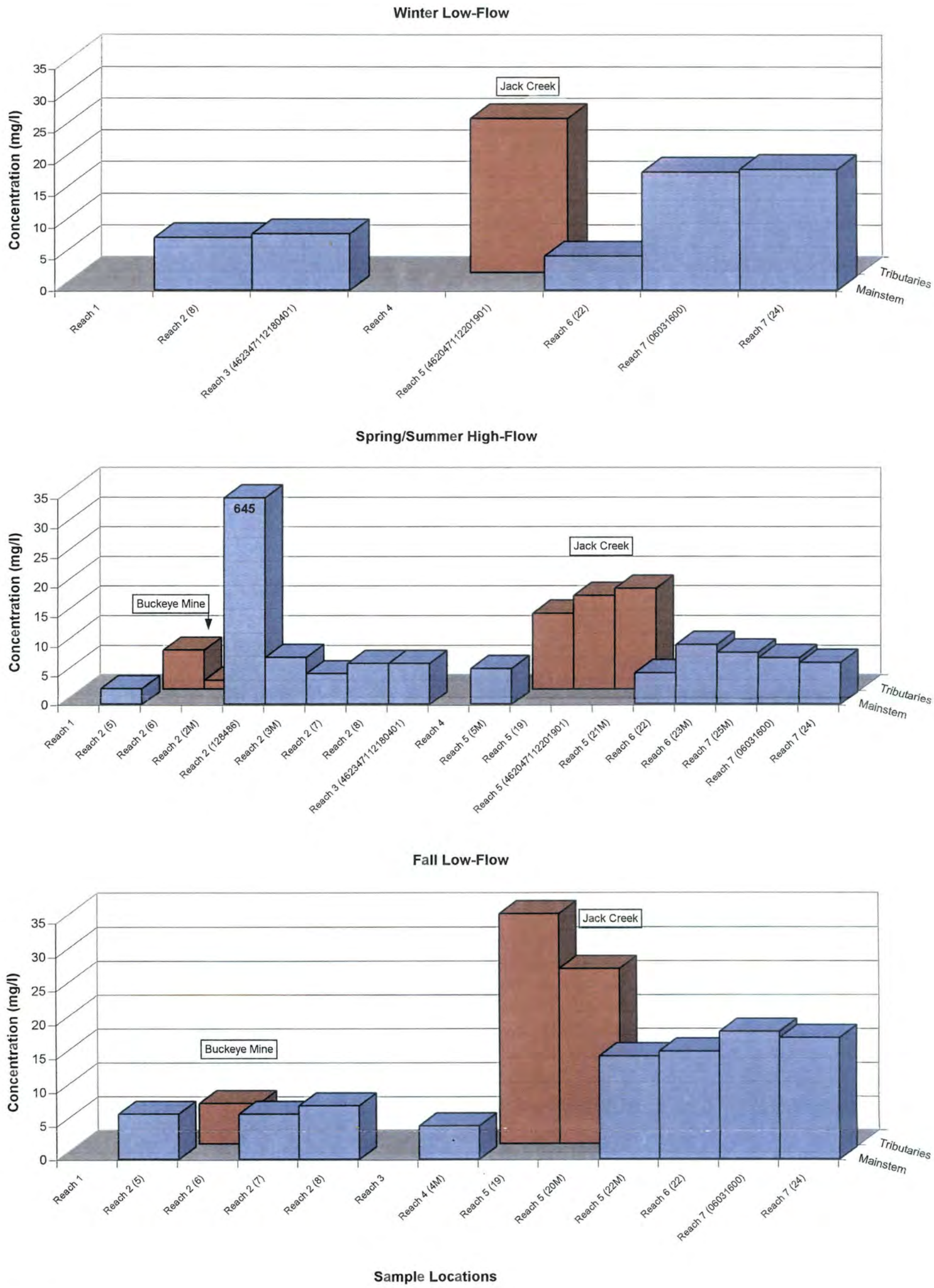




Sample Locations

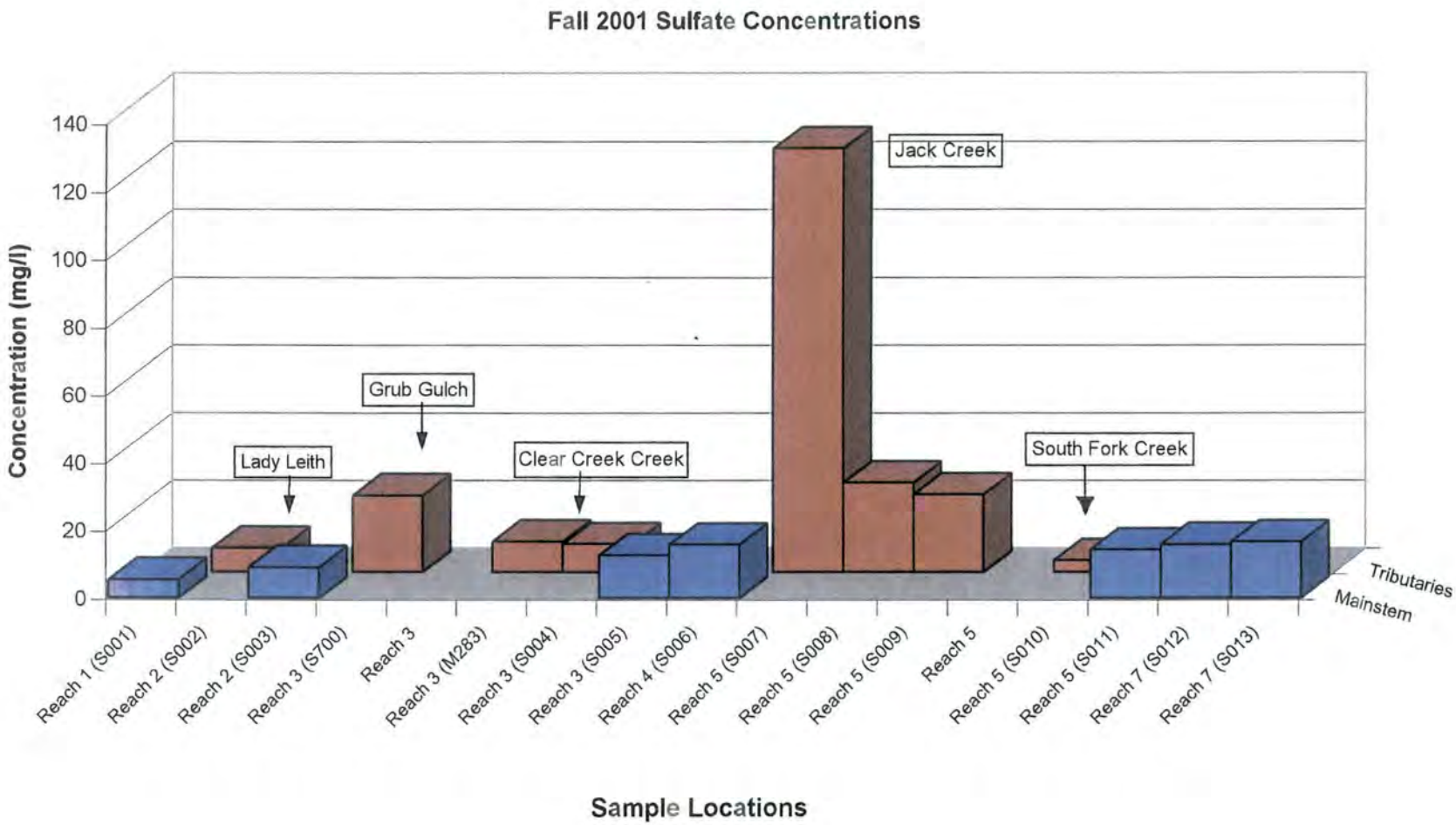
Notes:
Concentration values are mean detected concentrations exceeding benchmarks.
Concentration values greater than upper scale limits are presented on graph.
Sample locations appear in brackets.

Figure 6.3-4 Historical Sulfate Concentrations Along Basin Creek, Basin Watershed OU2



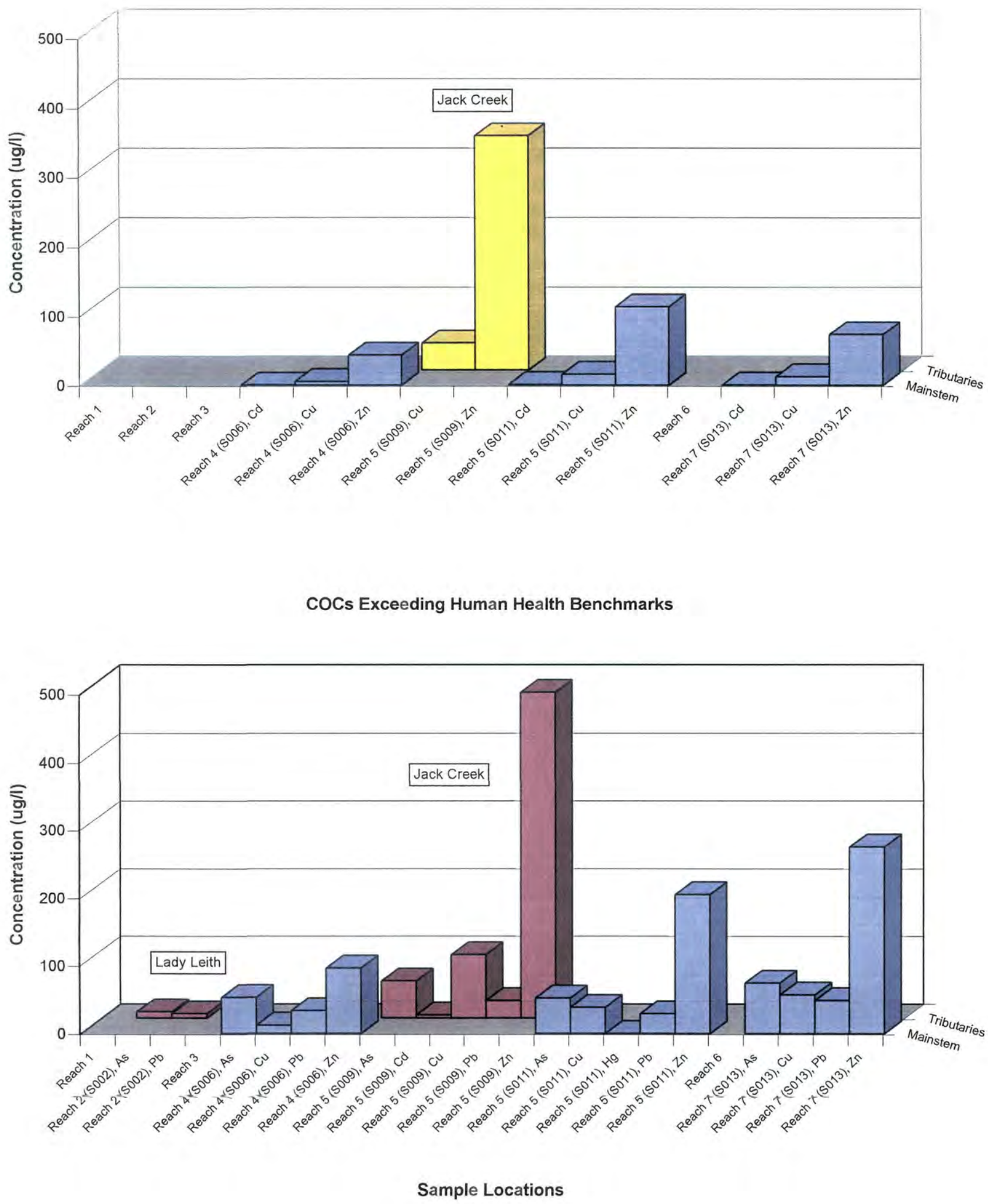
Notes:
Concentration values are mean detected concentrations.
Sample locations appear in brackets.

Figure 6.3-5 Fall 2001 Sulfate Concentrations Along Basin Creek, Basin Watershed OU2



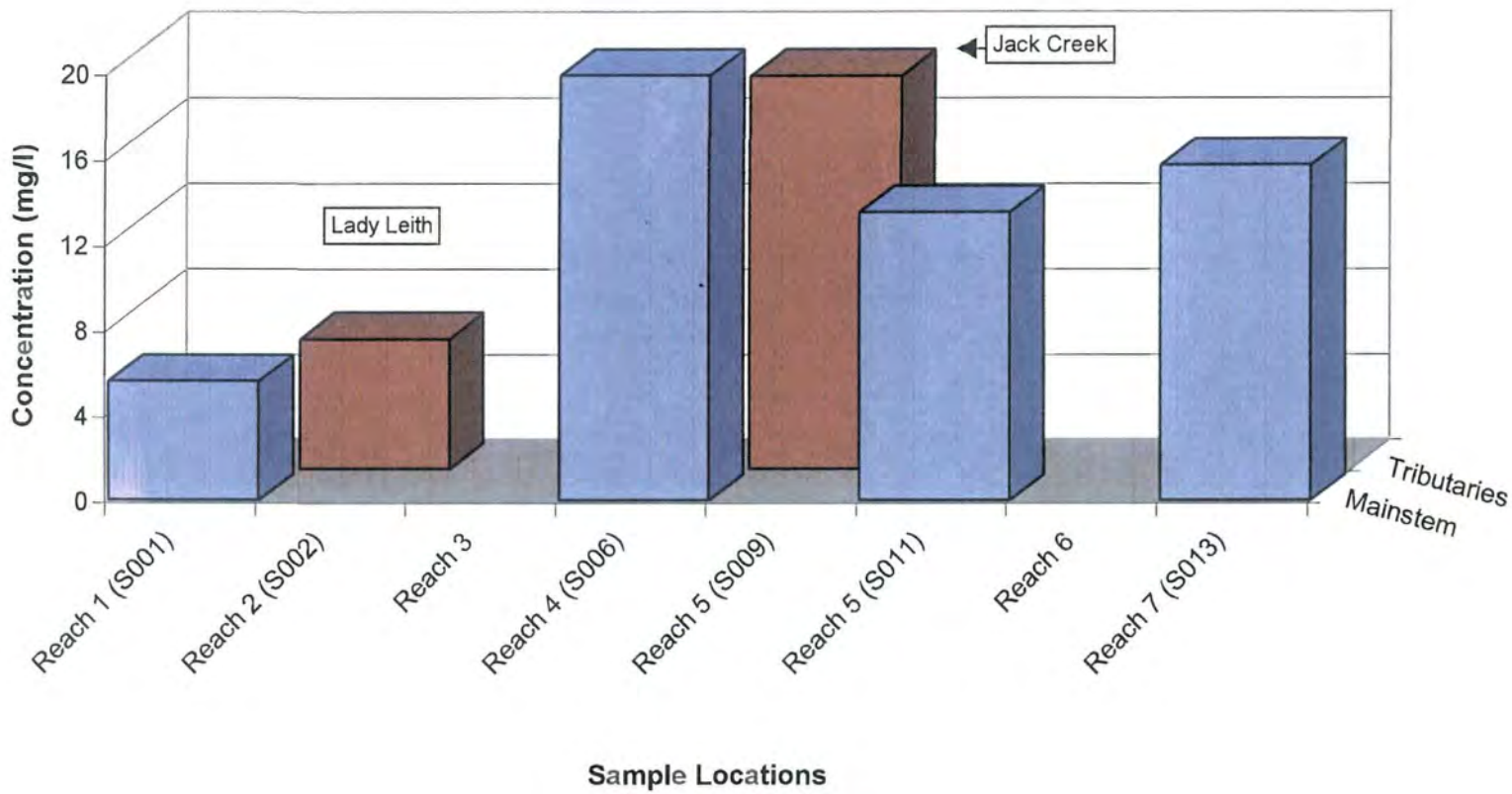
Notes:
Concentration values are mean detected concentrations.
Sample locations appear in brackets.

Figure 6.3-6 Locations Along Basin Creek Where COCs Exceeded Ecological and Human Health Benchmarks During Fall 2001 Storm High-Flow, Basin Watershed OU2



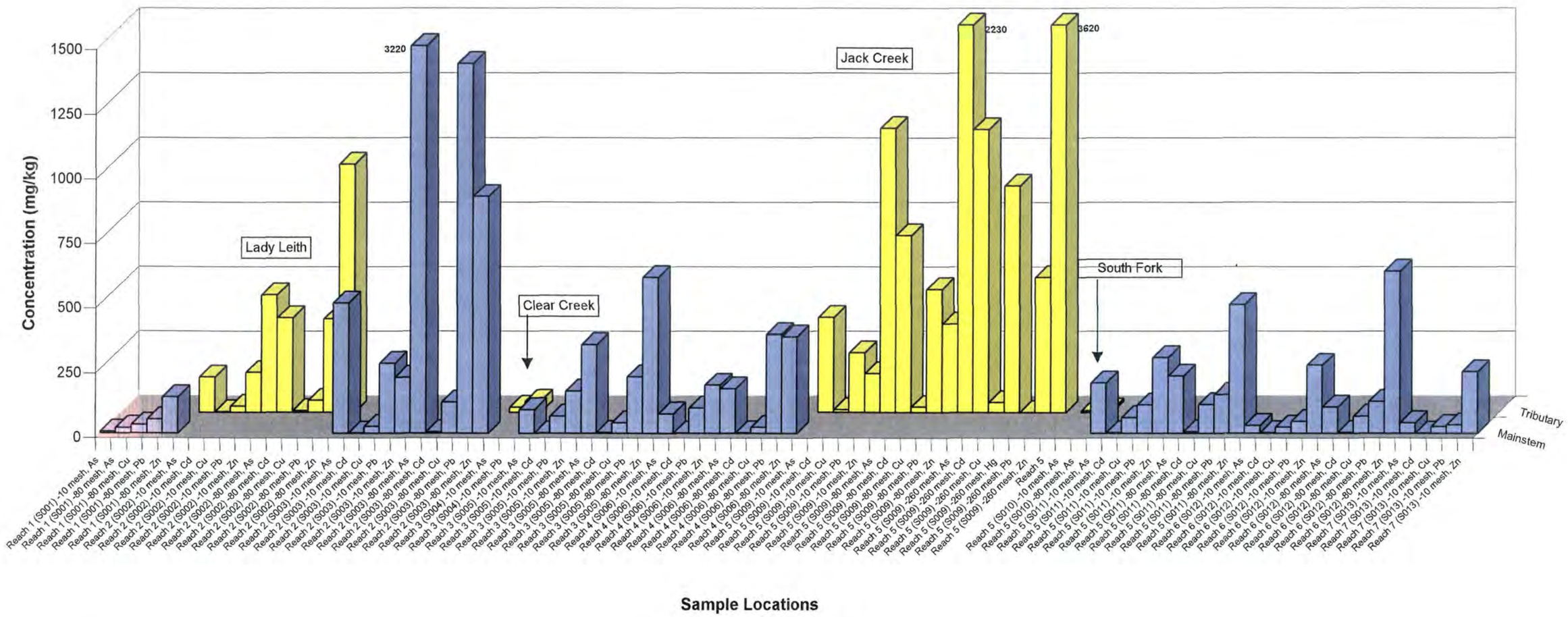
Notes:
Concentration values are mean detected concentrations exceeding benchmarks.
Sample locations appear in brackets.

Figure 6.3-7 Fall 2001 Storm High-Flow Sulfate Concentrations Along Basin Creek, Basin Watershed OU2



Notes:
Concentration values are mean detected concentrations.
Sample locations appear in brackets.

Figure 6.4-1 Fall 2001 Locations Along Basin Creek Where COCs in Sediment Exceeded Ecological Benchmarks, Basin Watershed OU2



Notes:
Concentration values are mean detected concentrations exceeding benchmarks.
Concentration values greater than upper scale limit are presented on graph.
Sample locations appear in brackets.

Figure 6.7-1 Historical Combined Dissolved COCs Load in the Basin Creek, Basin Watershed OU2

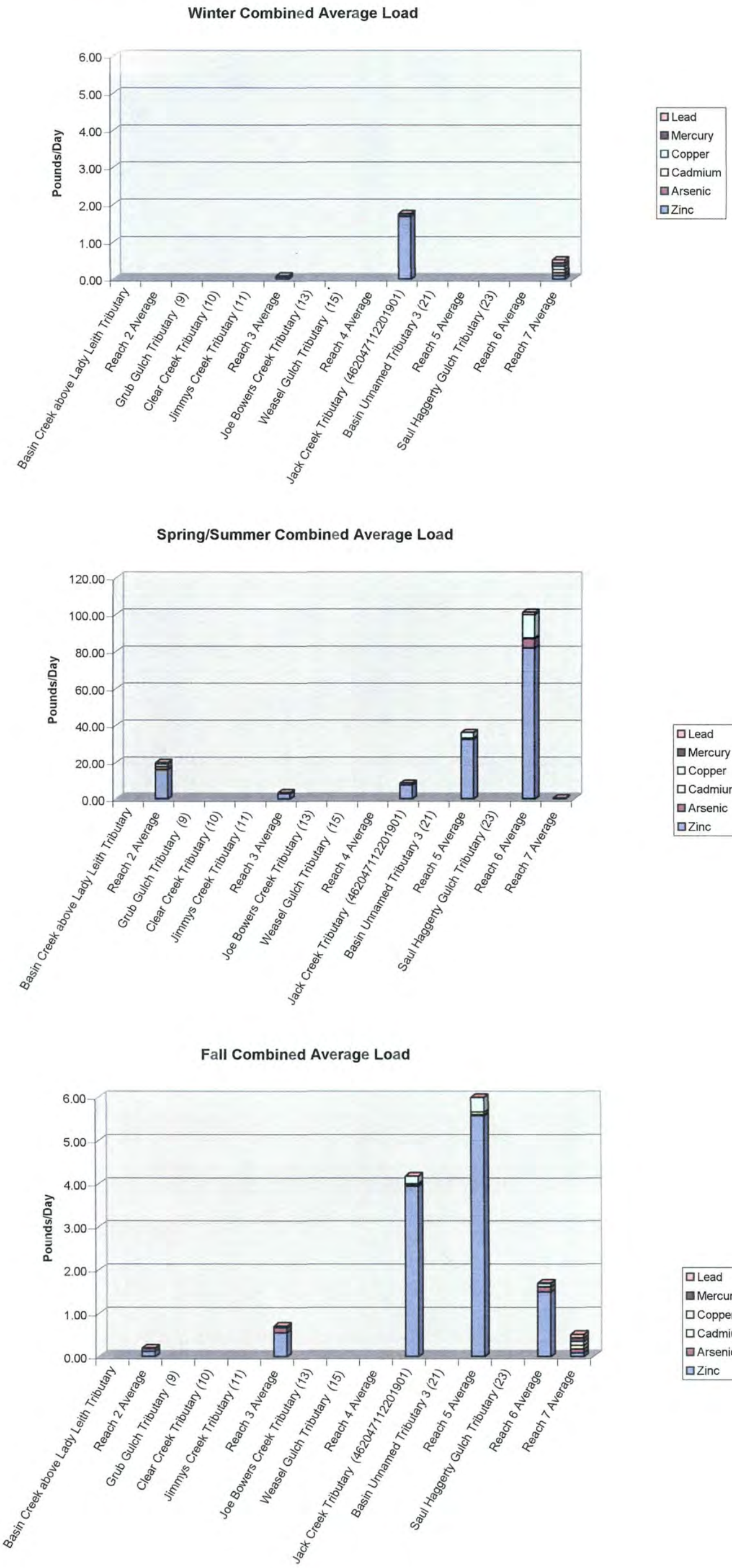
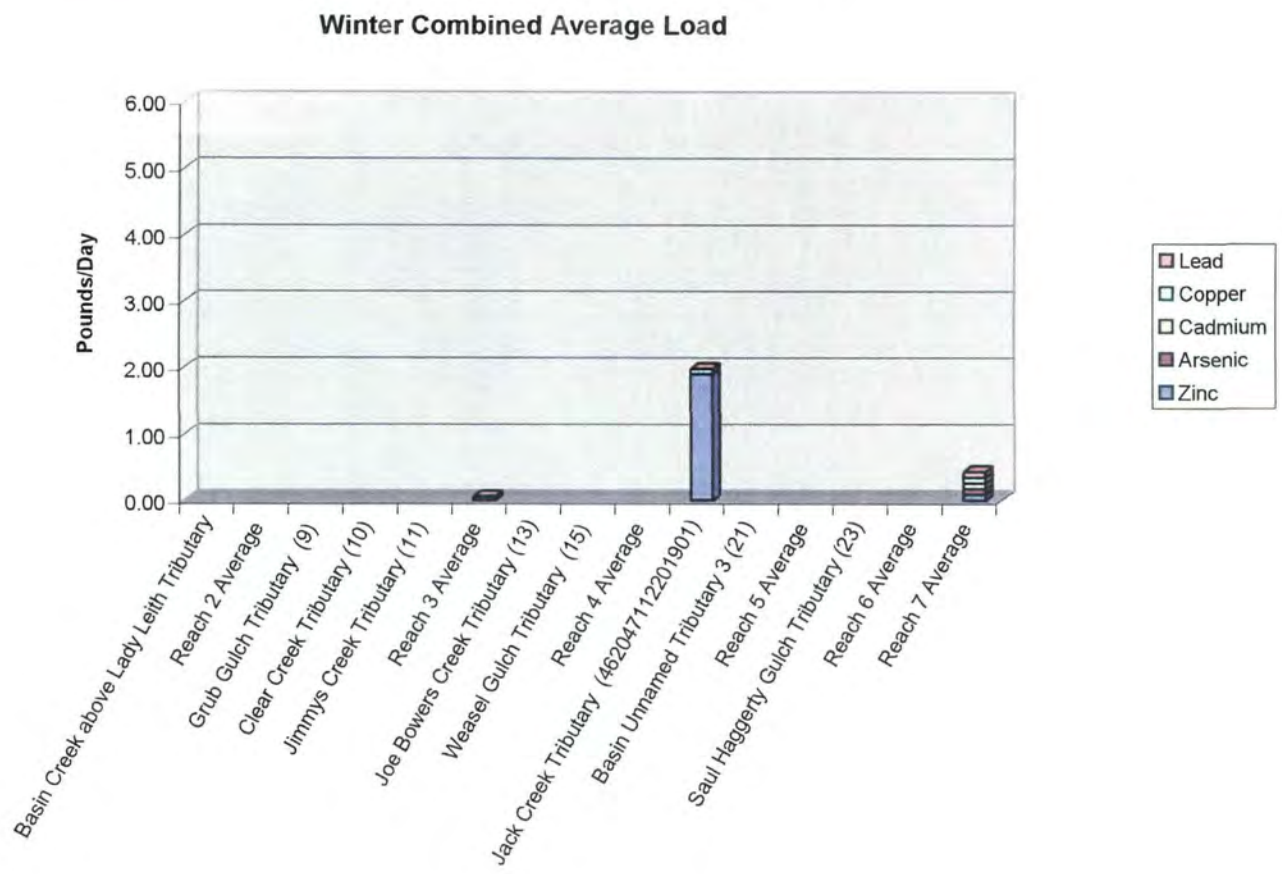
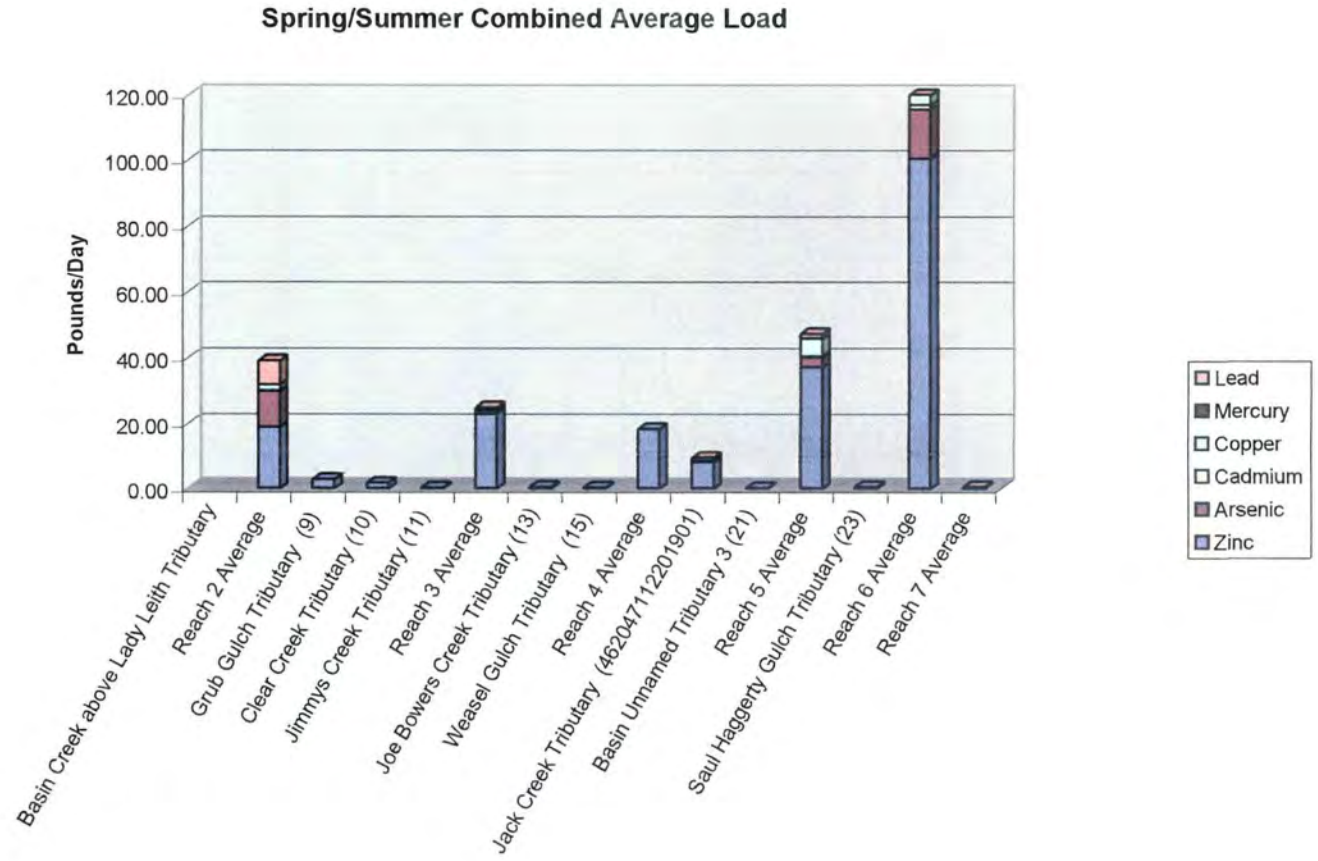


Figure 6.7-2 Historical Combined Total COCs Load in the Basin Creek, Basin Watershed OU2





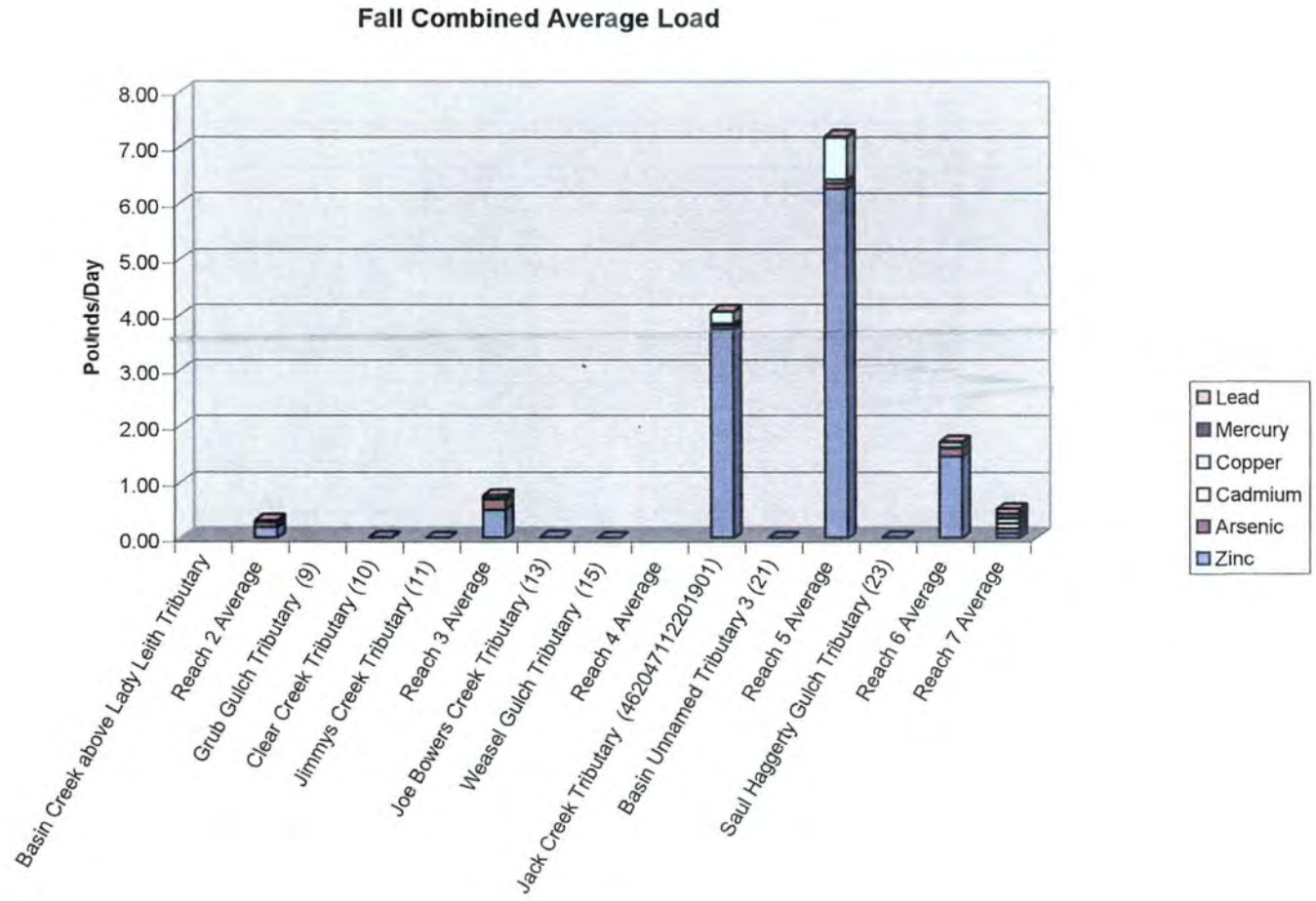
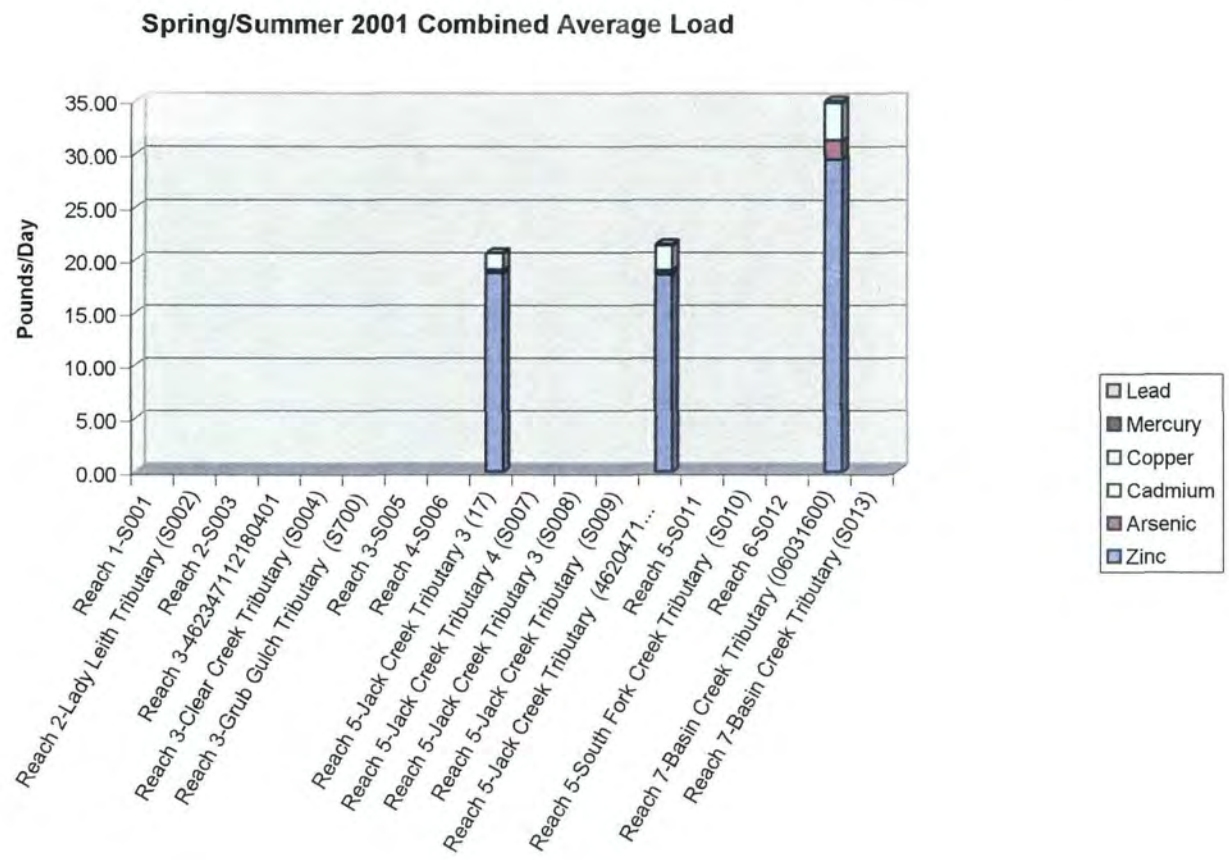
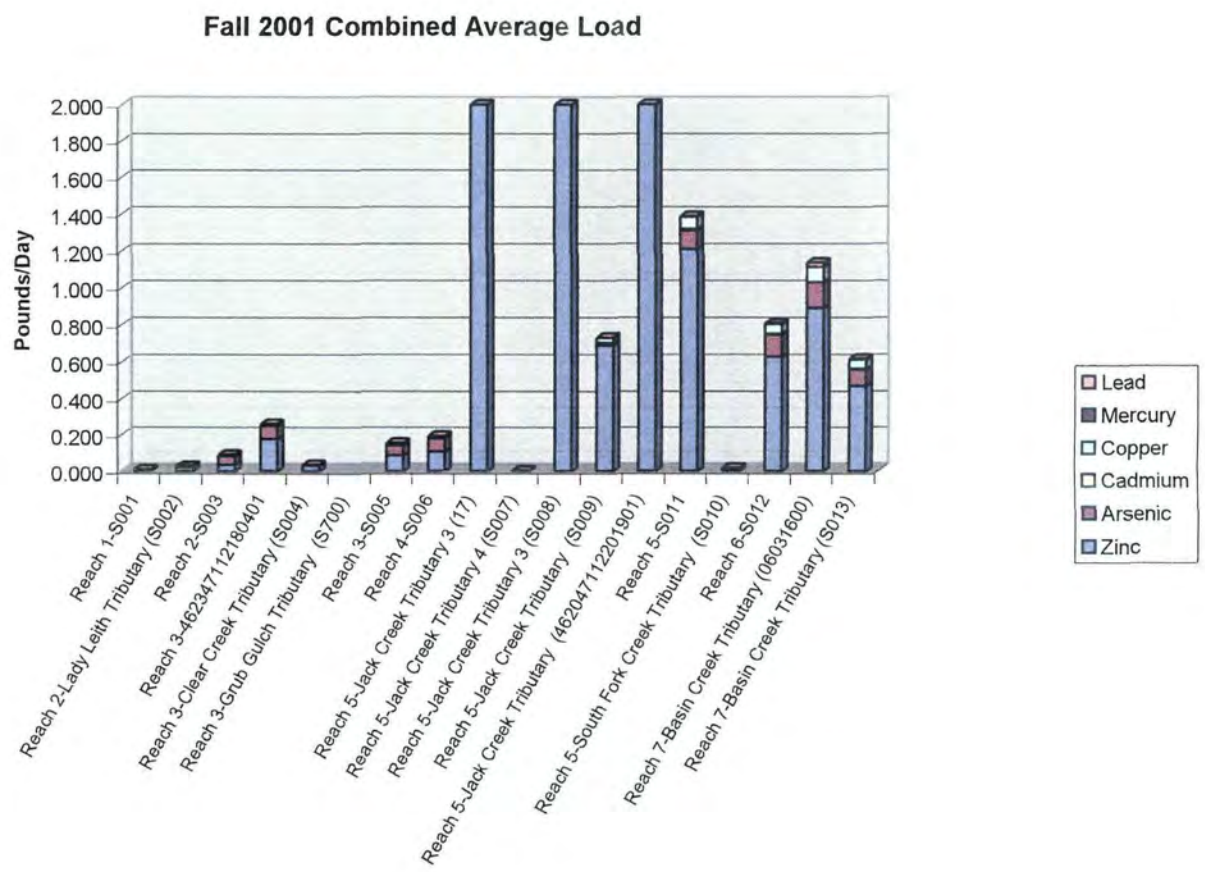


Figure 6.7-3 Spring/Summer and Fall 2001 Combined Dissolved COCs Load in the Cataract Creek, Basin Watershed OU2





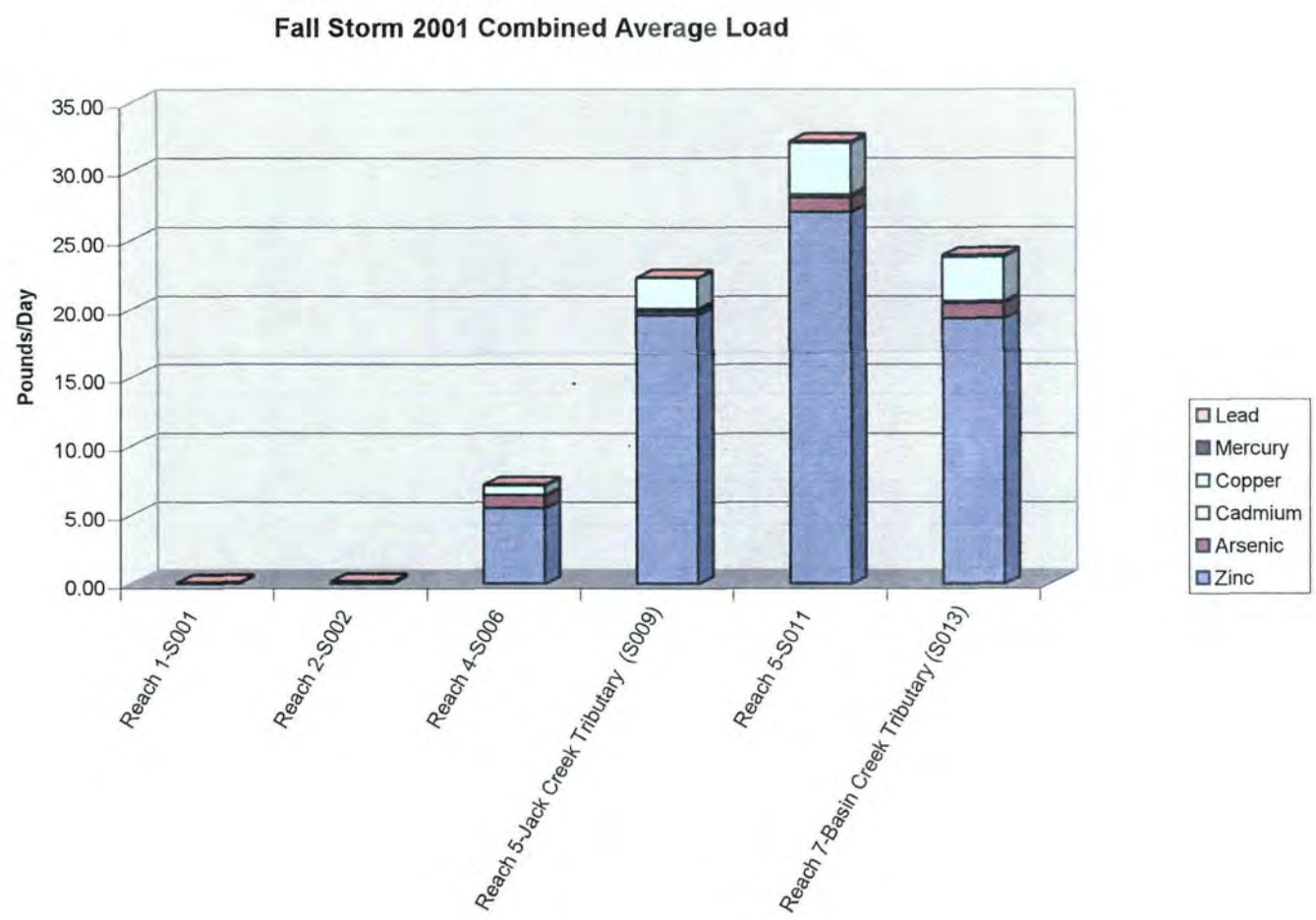
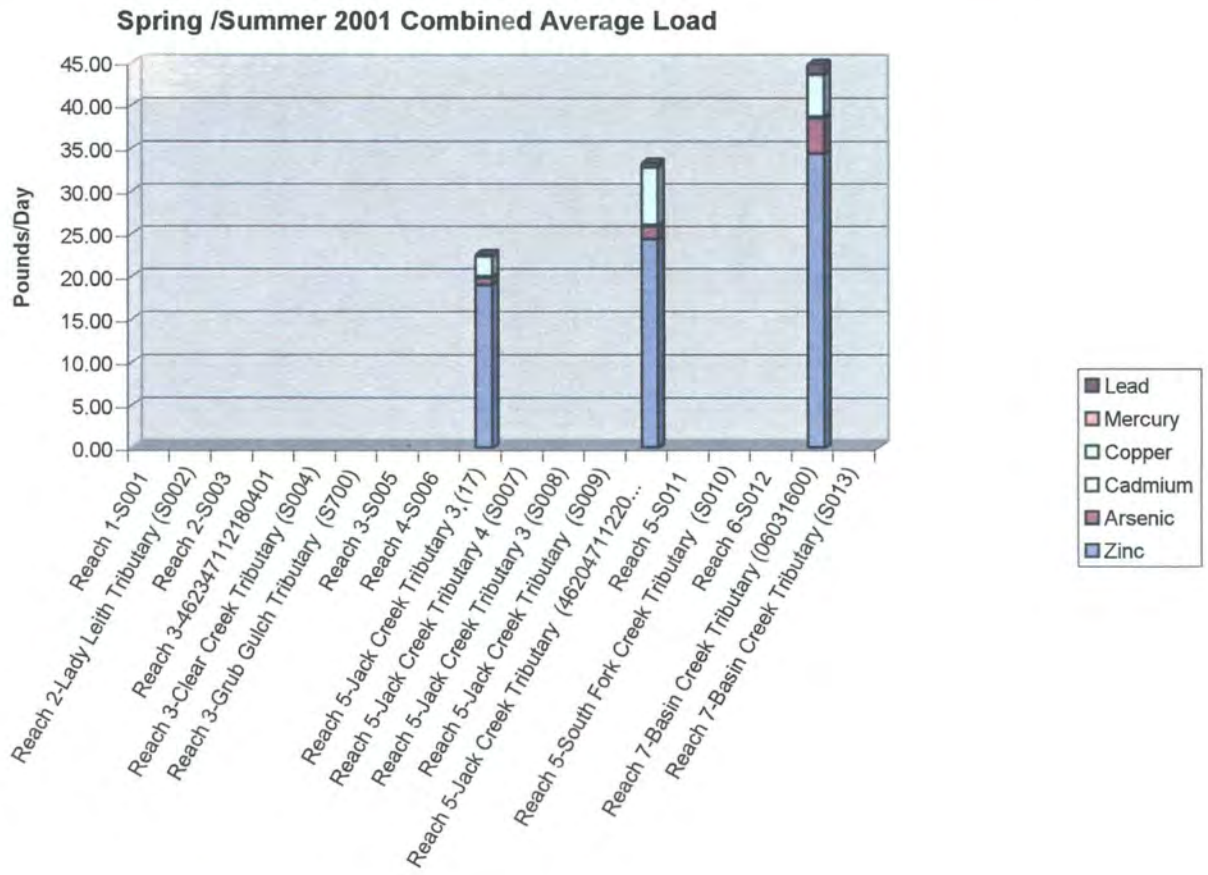
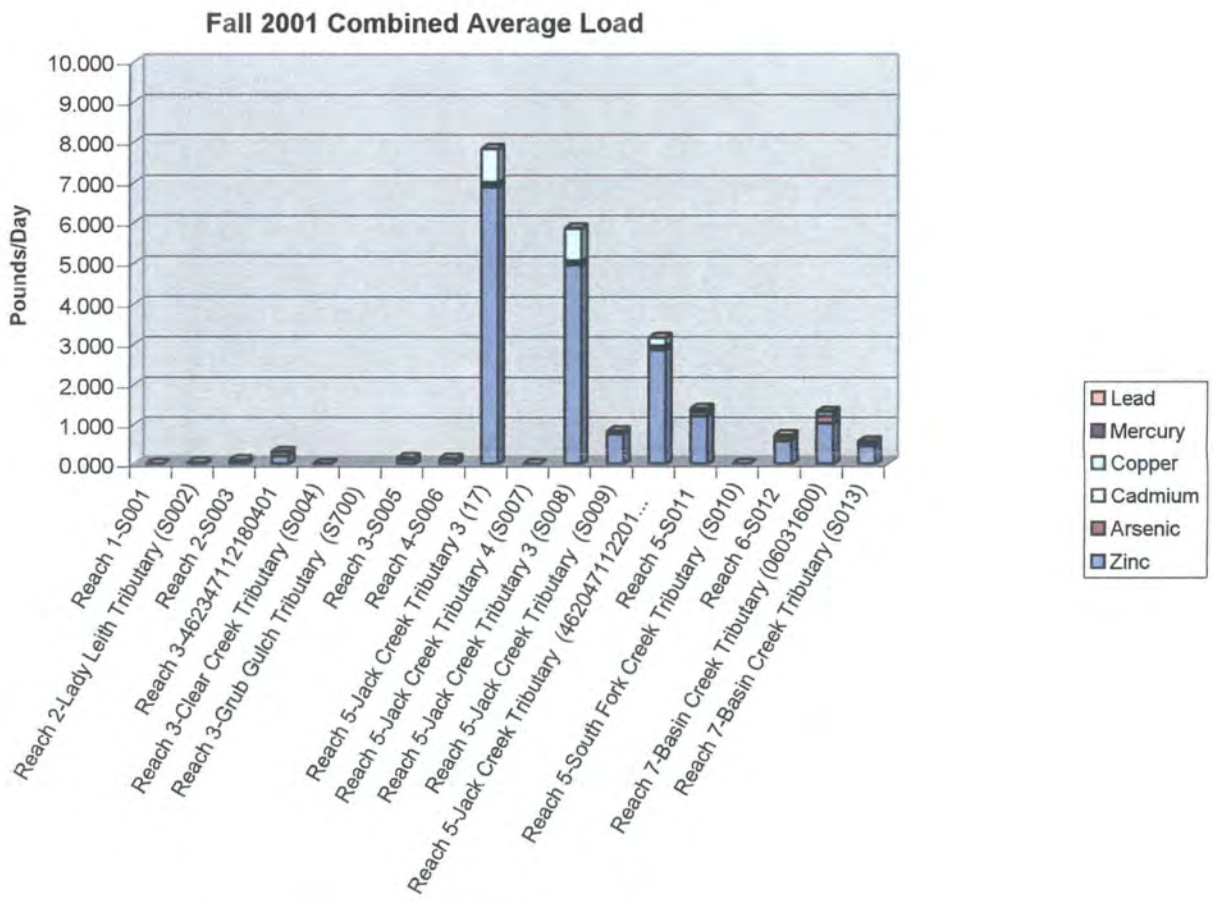


Figure 6.7-4 Spring/Summer and Fall 2001 Combined Total COCs Load in the Cataract Creek, Basin Watershed OU2





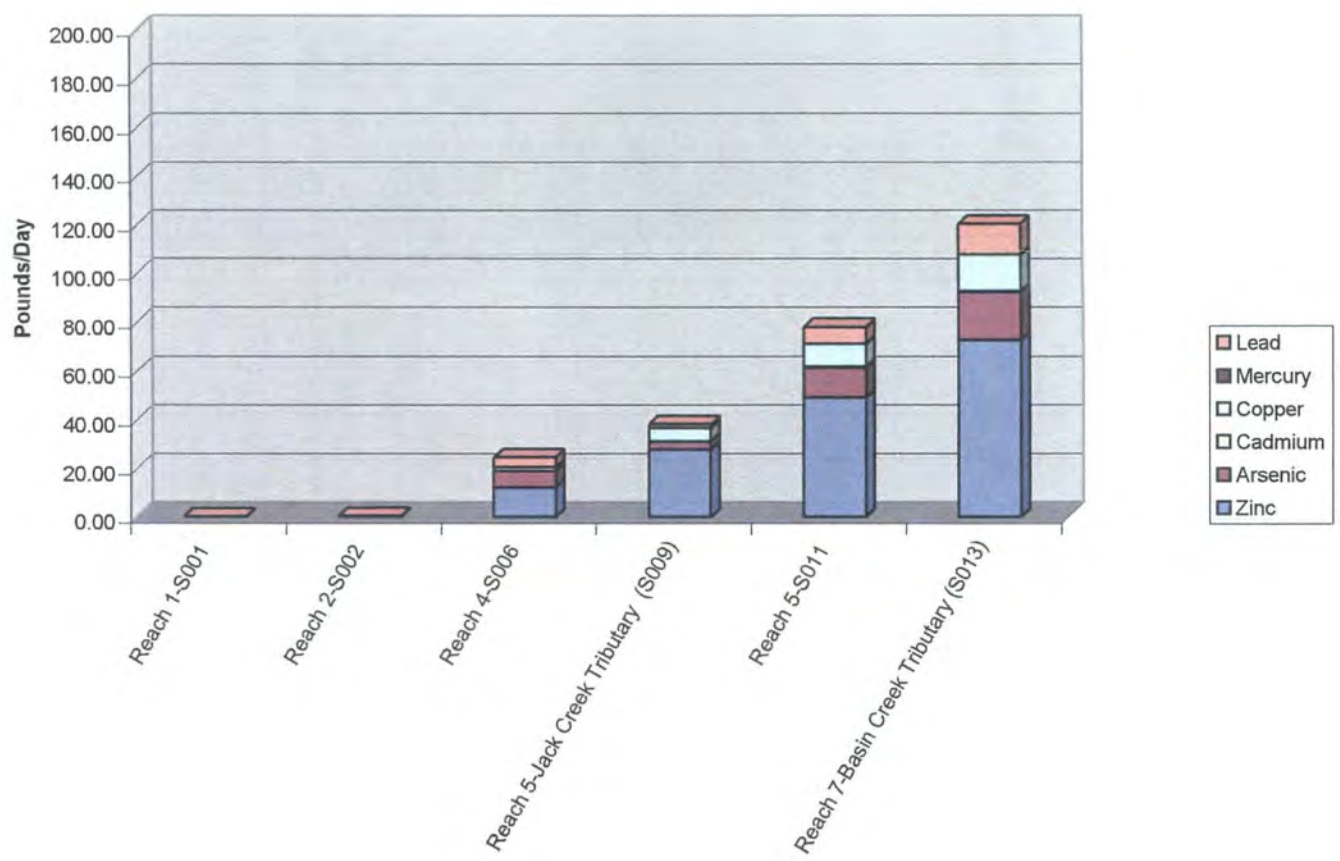
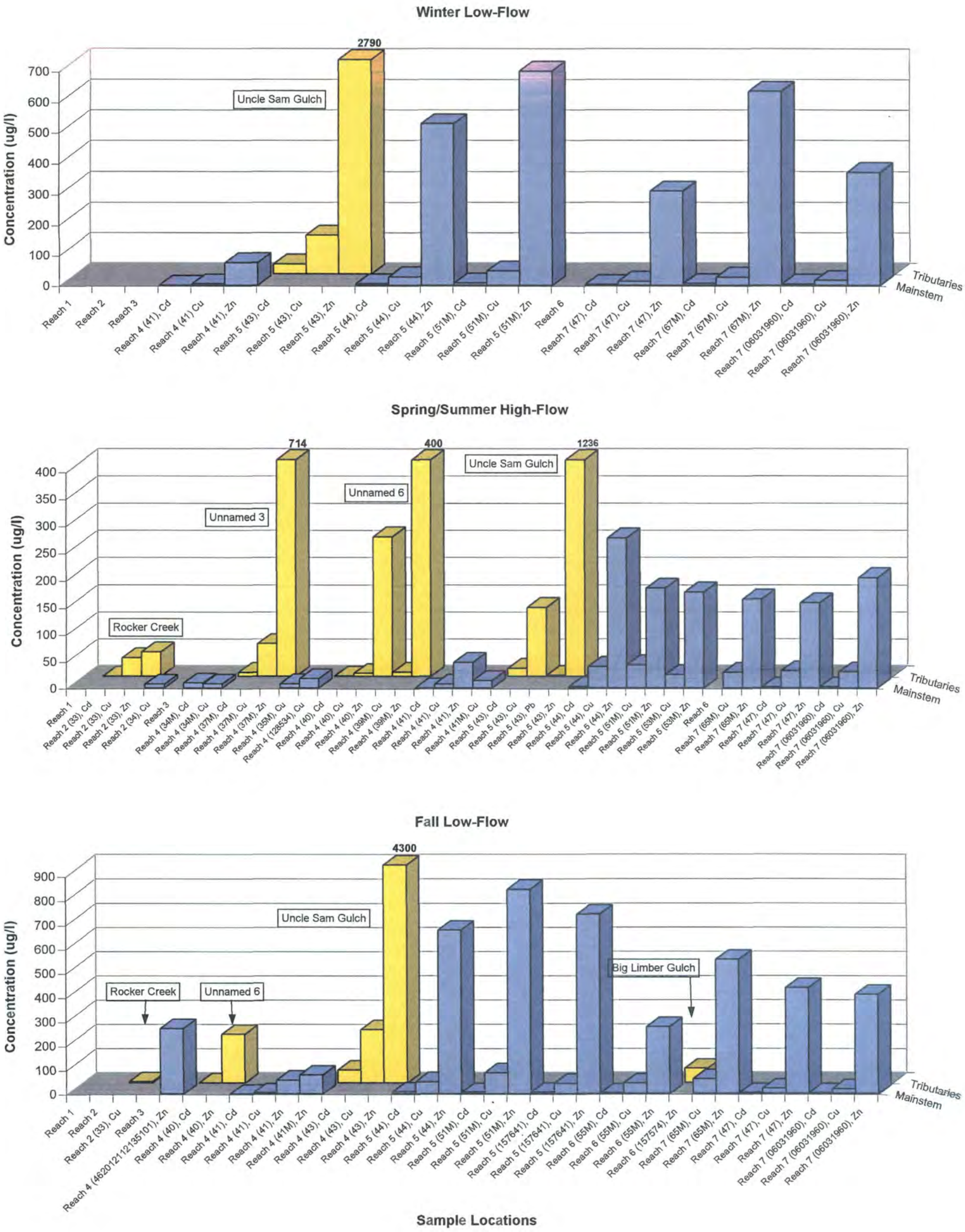
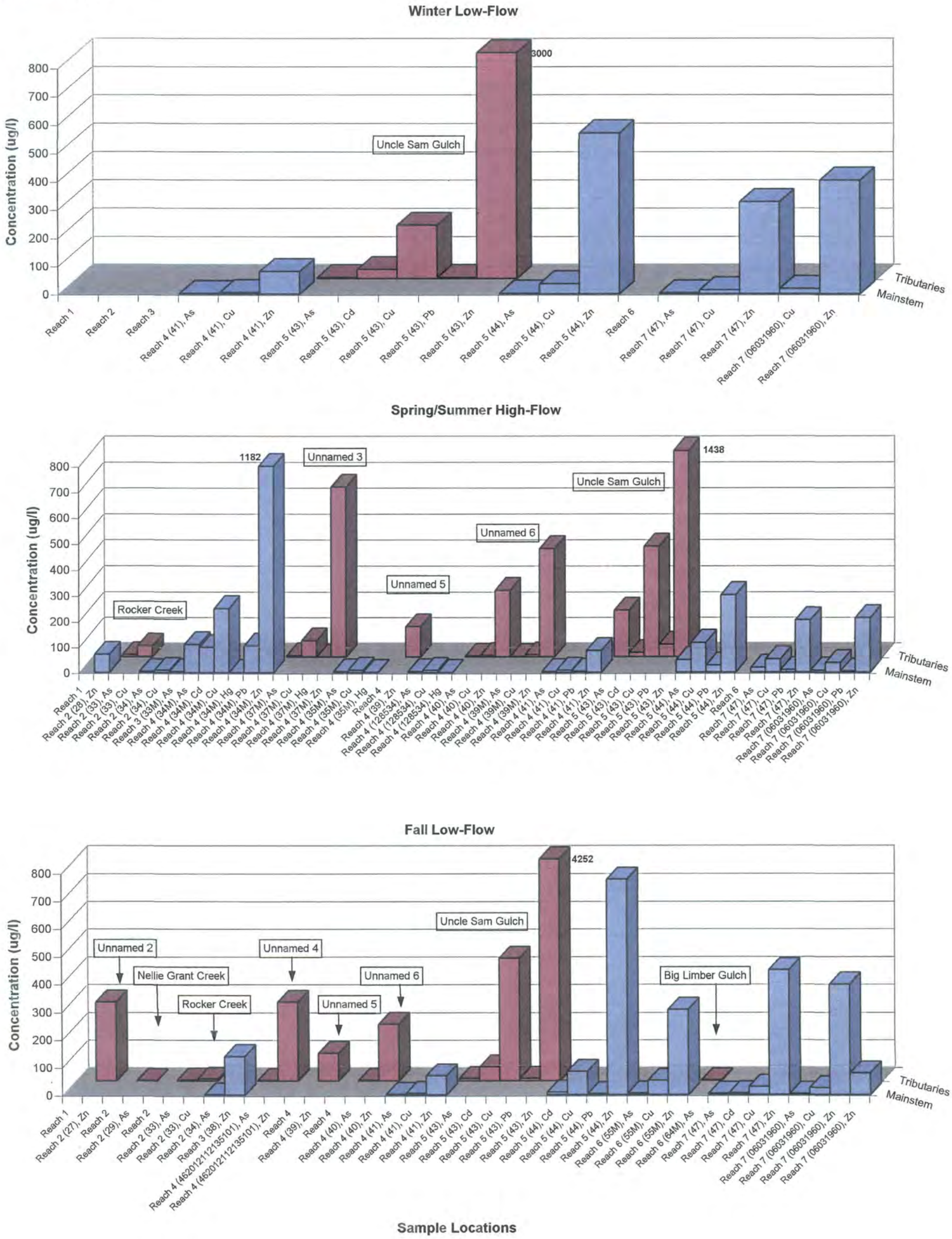


Figure 7.3-1 Historical Locations Along Cataract Creek Where COCs Exceeded Ecological Benchmarks, Basin Watershed OU2



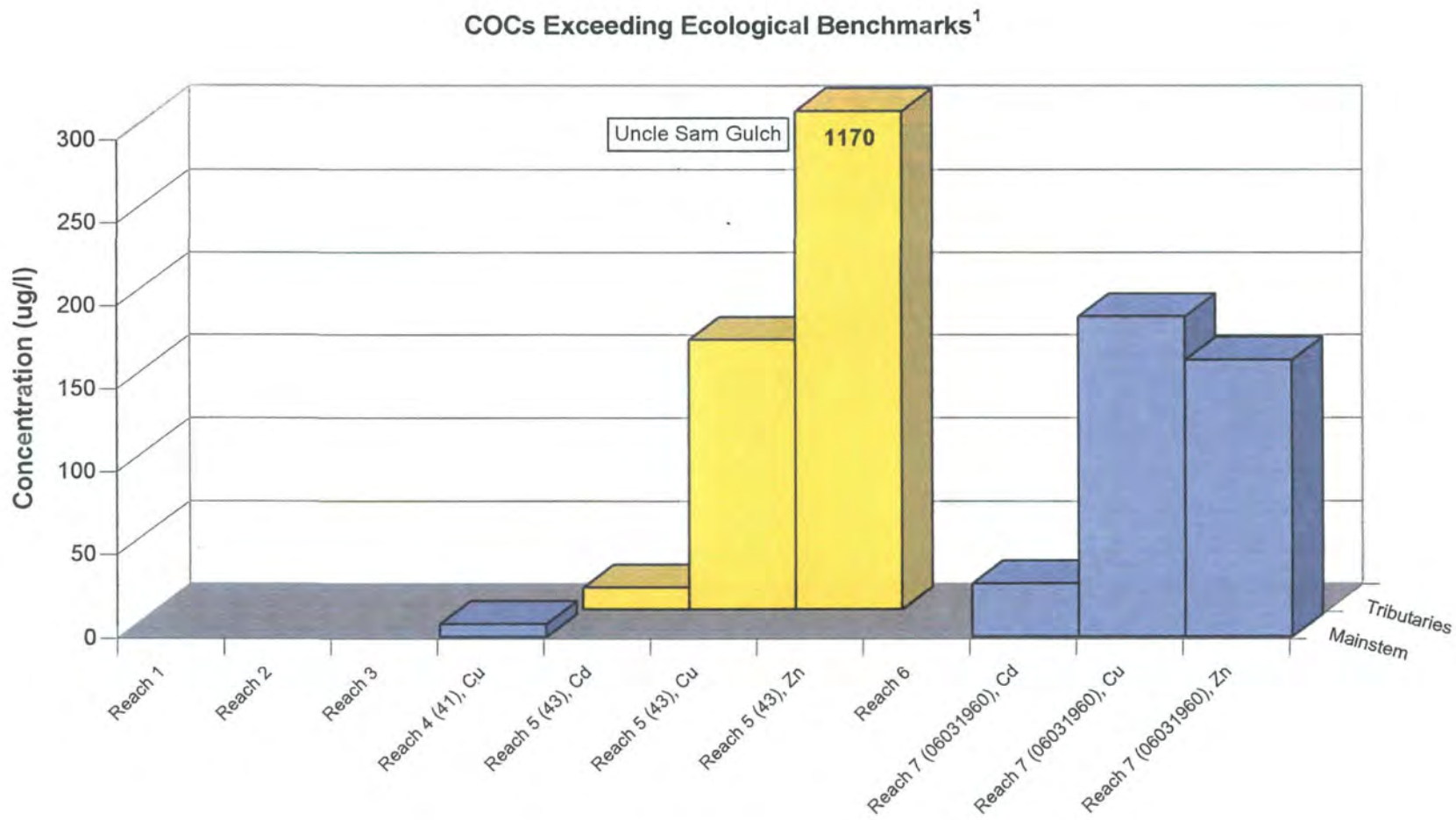
Notes:
Concentration values are mean detected concentrations exceeding benchmarks.
Concentration values greater than upper scale limits are presented on graph.
Y-axis scale varies between figures.
Sample locations appear in brackets.

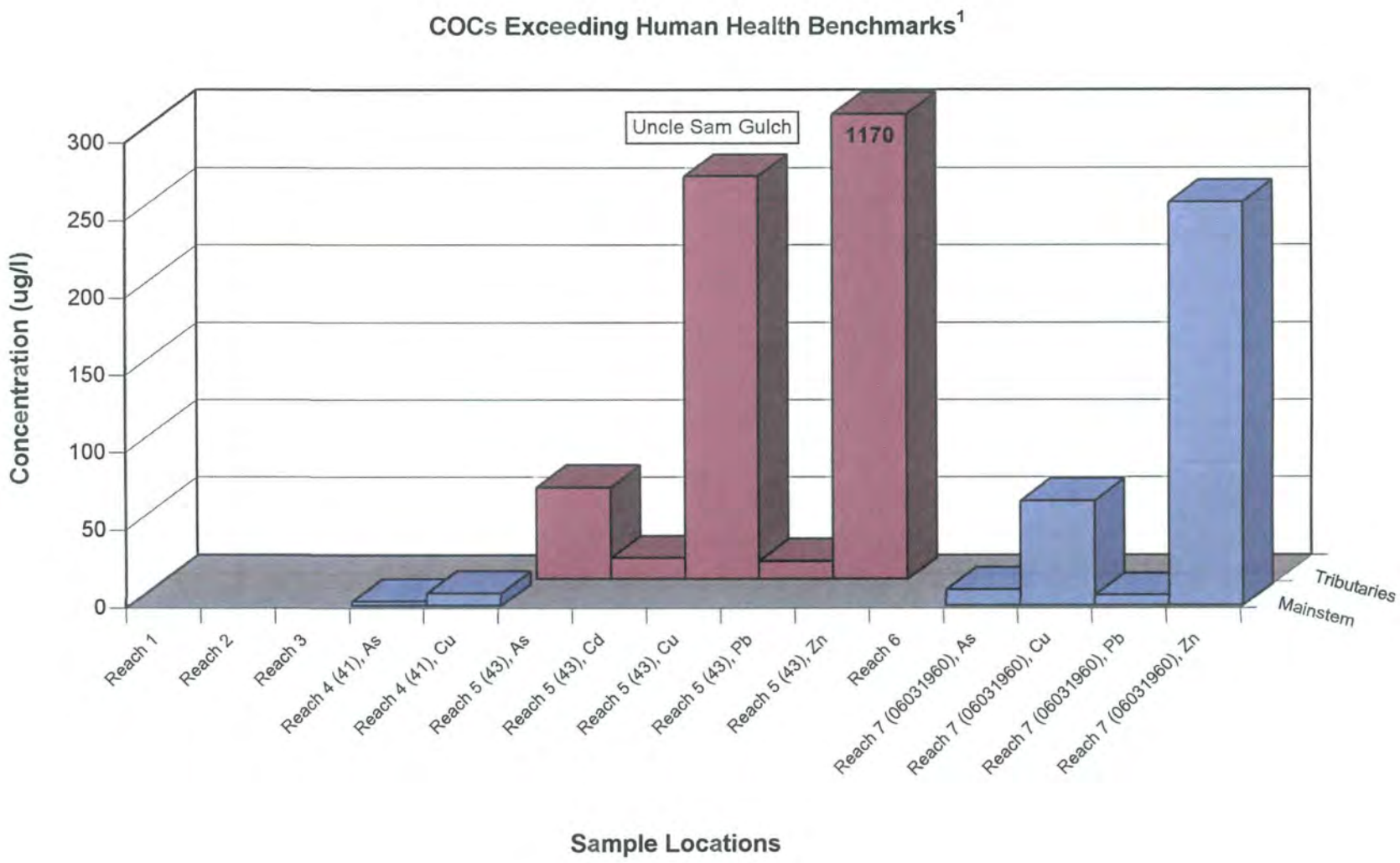
Figure 7.3-2 Historical Locations Along Cataract Creek Where COPCs Exceeded Human Health Benchmarks, Basin Watershed OU2



Notes:
Concentration values are mean detected concentrations exceeding benchmarks.
Concentration values greater than upper scale limits are presented on graph.
Sample locations appear in brackets.

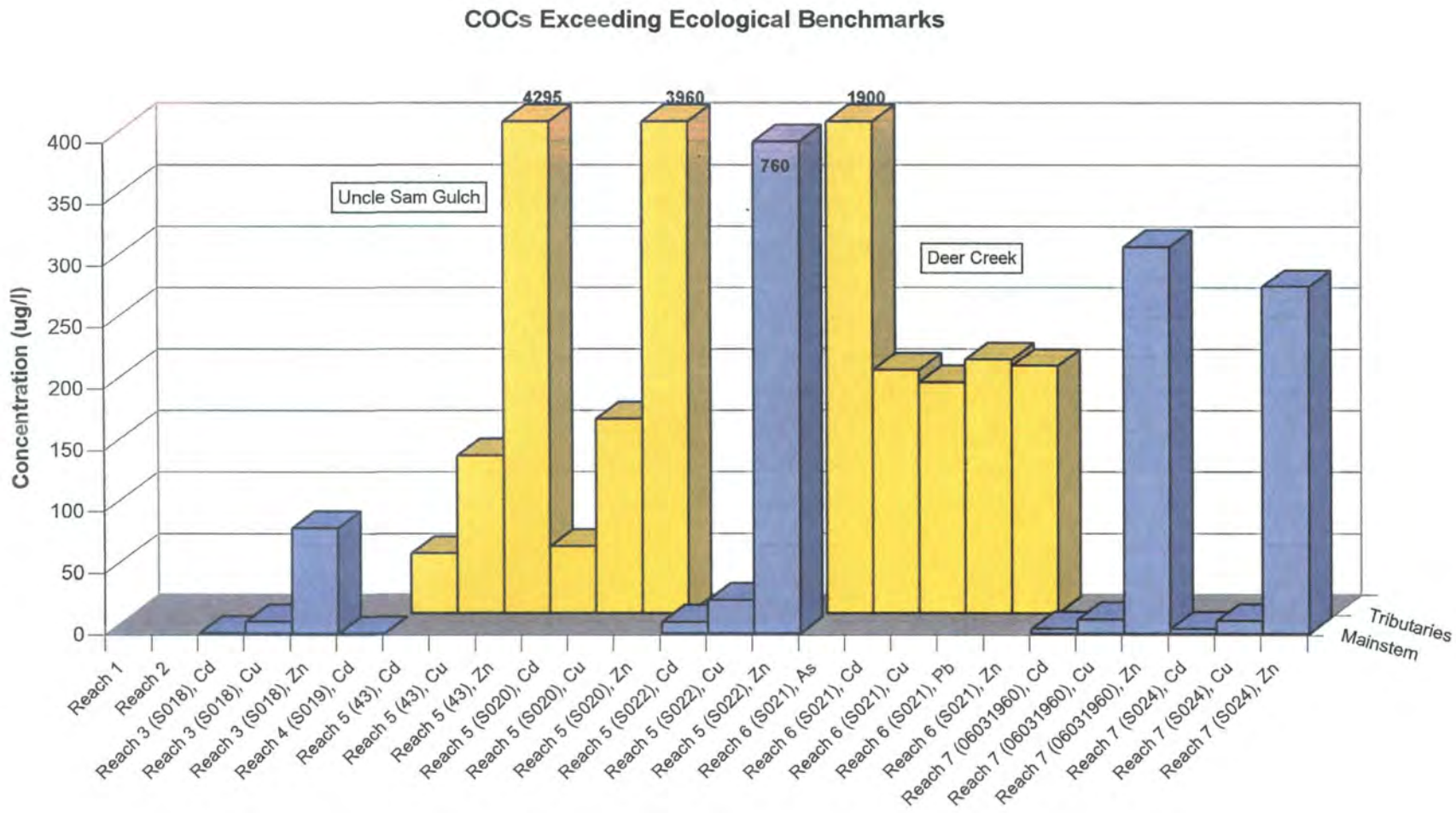
Figure 7.3-3 Locations Along Cataract Creek Where COCs Exceeded Ecological and Human Health Benchmarks Based on 2001 Spring/Summer High-Flow[1], Basin Watershed OU2

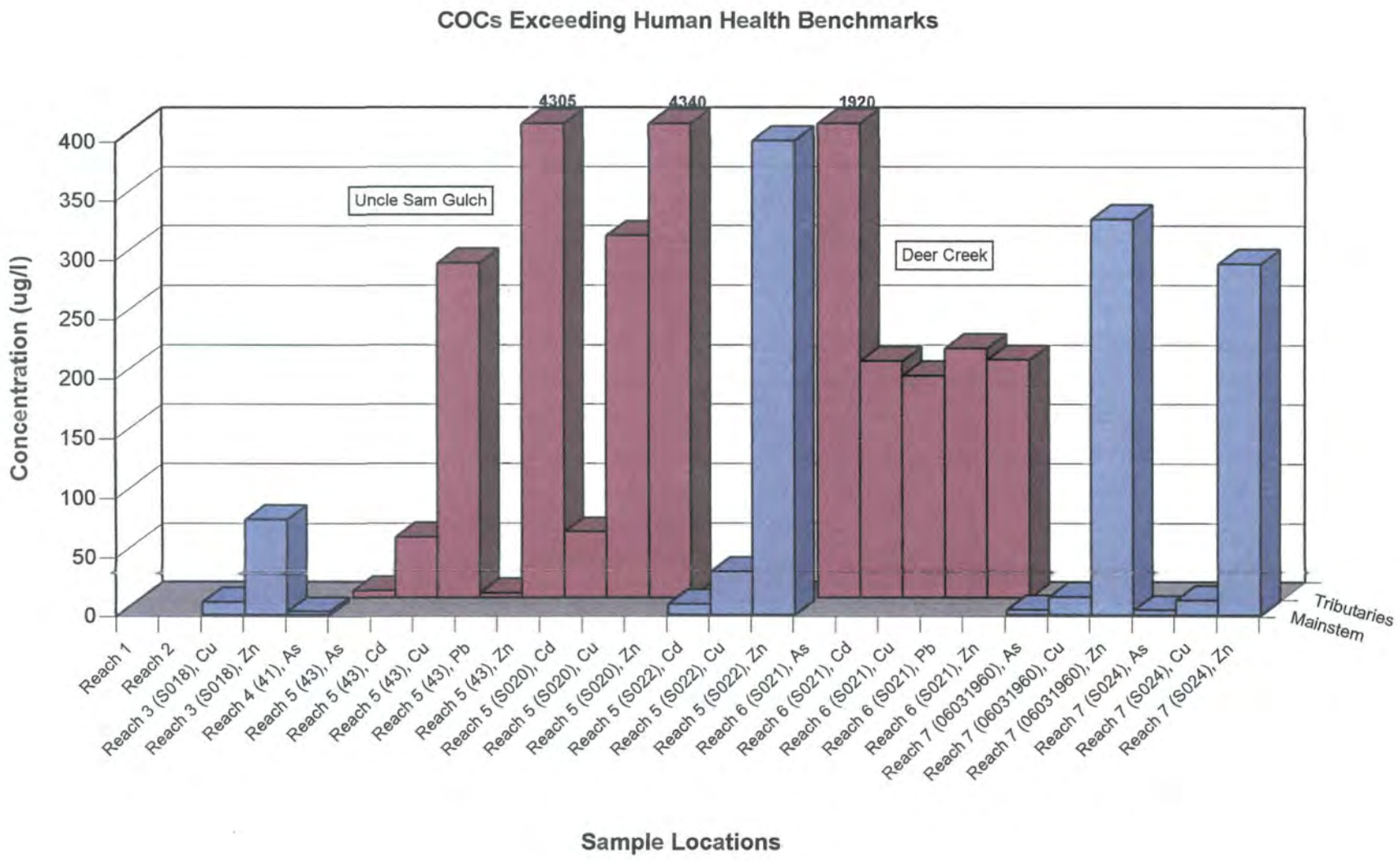




Notes:
1 - USGS provisional COCs results from measurements taken in April and May 2001.
Concentration values are mean detected concentrations exceeding benchmarks.
Concentration values greater than upper scale limit are presented on graph.
Sample locations appear in brackets.

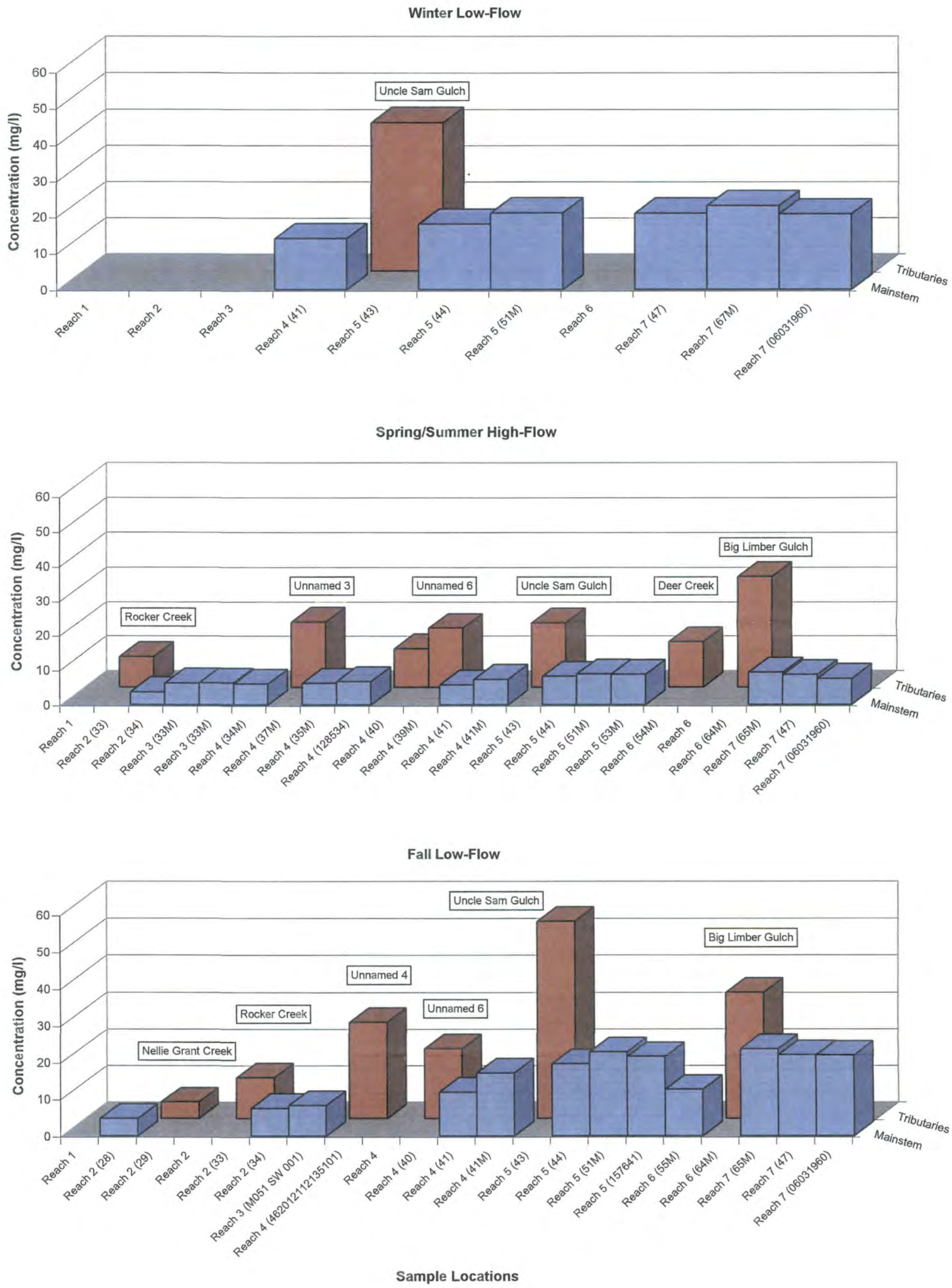
Figure 7.3-4 Locations Along Cataract Creek Where COCs Exceeded Ecological and Human Health Benchmarks Based on 2001 Fall Low-Flow, Basin Watershed OU2





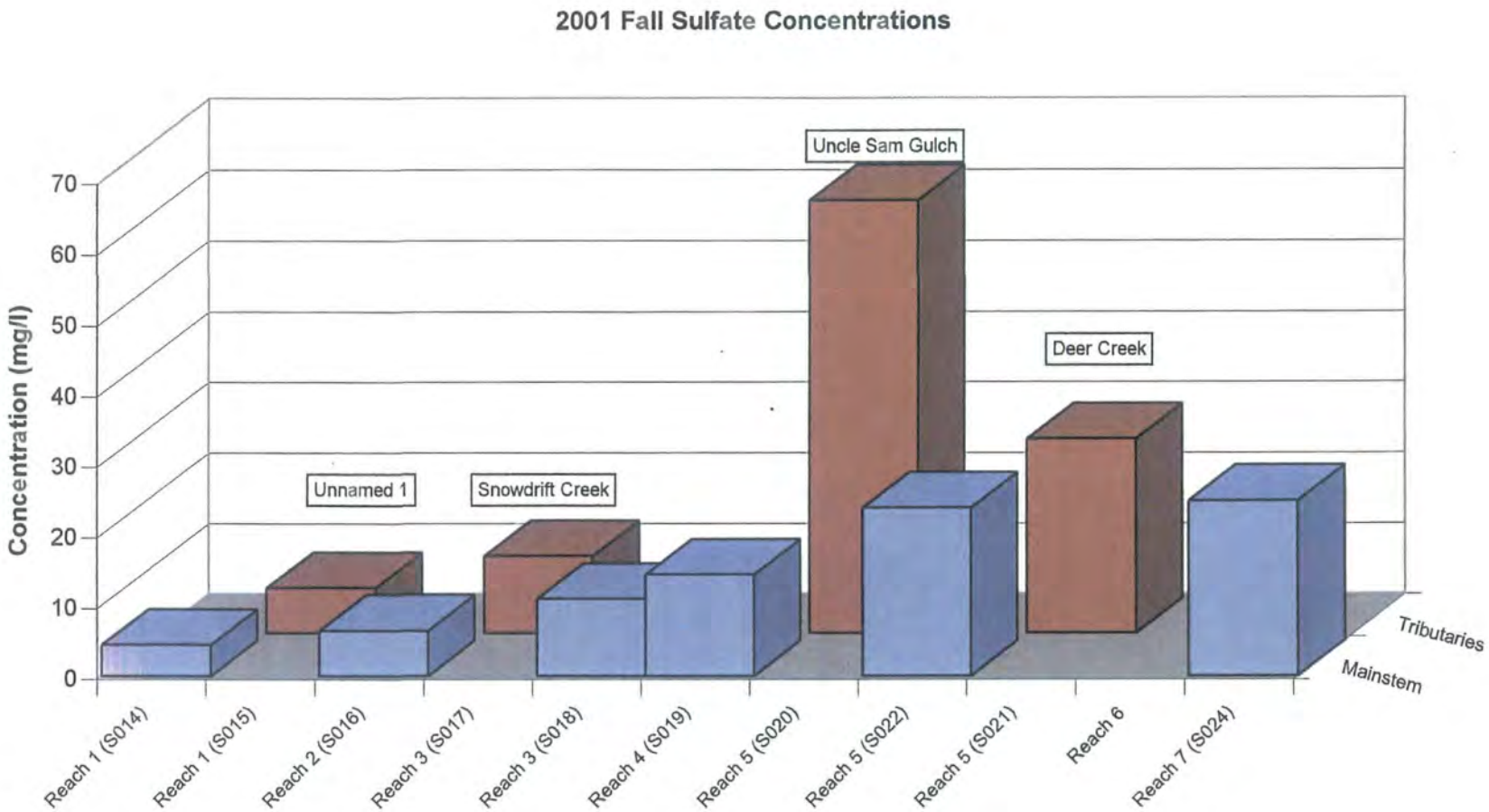
Notes:
Concentration values are mean detected concentrations exceeding benchmarks.
Concentration values greater than upper scale limit are presented on graph.
Sample locations appear in brackets.

Figure 7.3-5 Historical Sulfate Concentrations Along Cataract Creek, Basin Watershed OU2



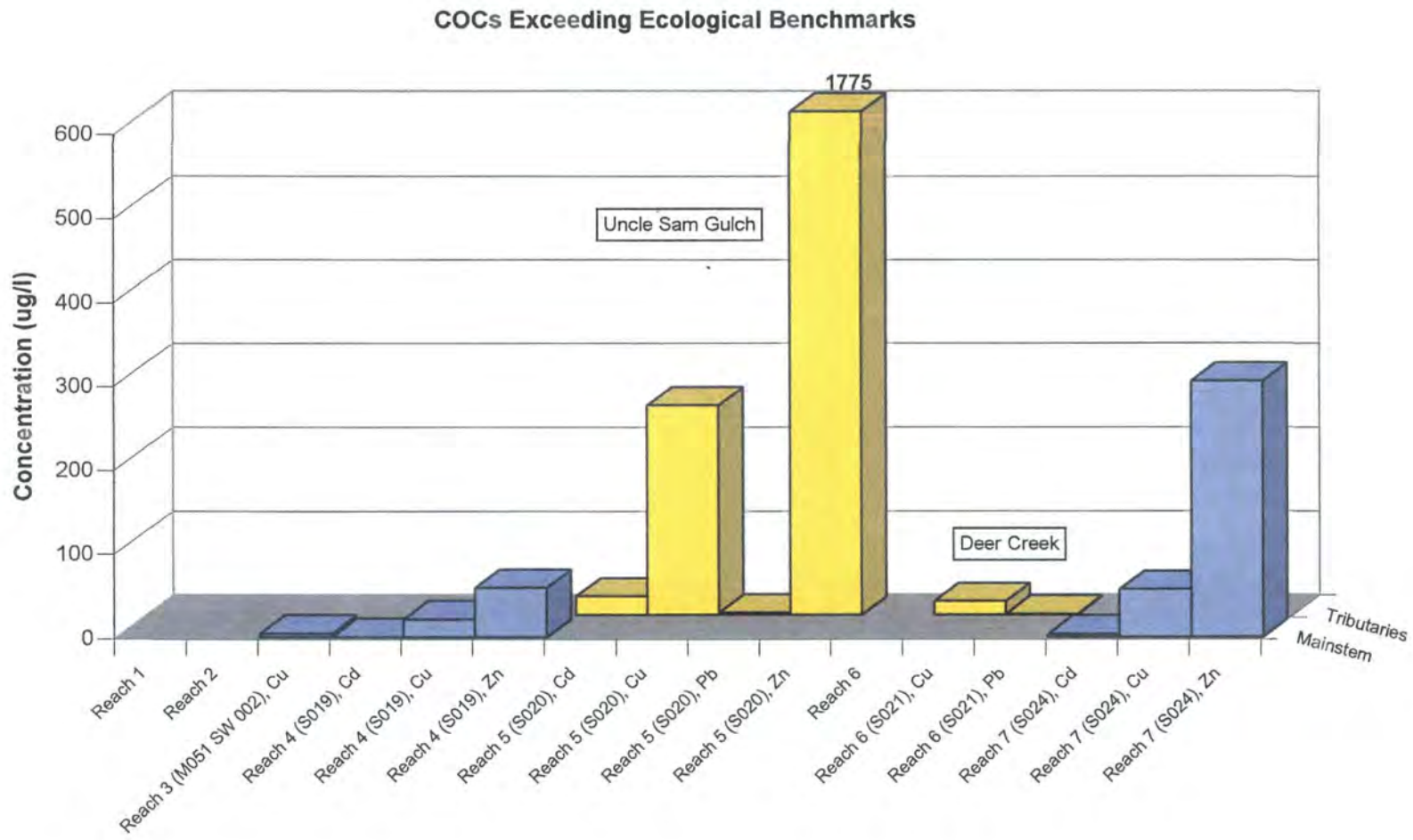
Notes:
Concentration values are mean detected concentrations.
Sample locations appear in brackets.

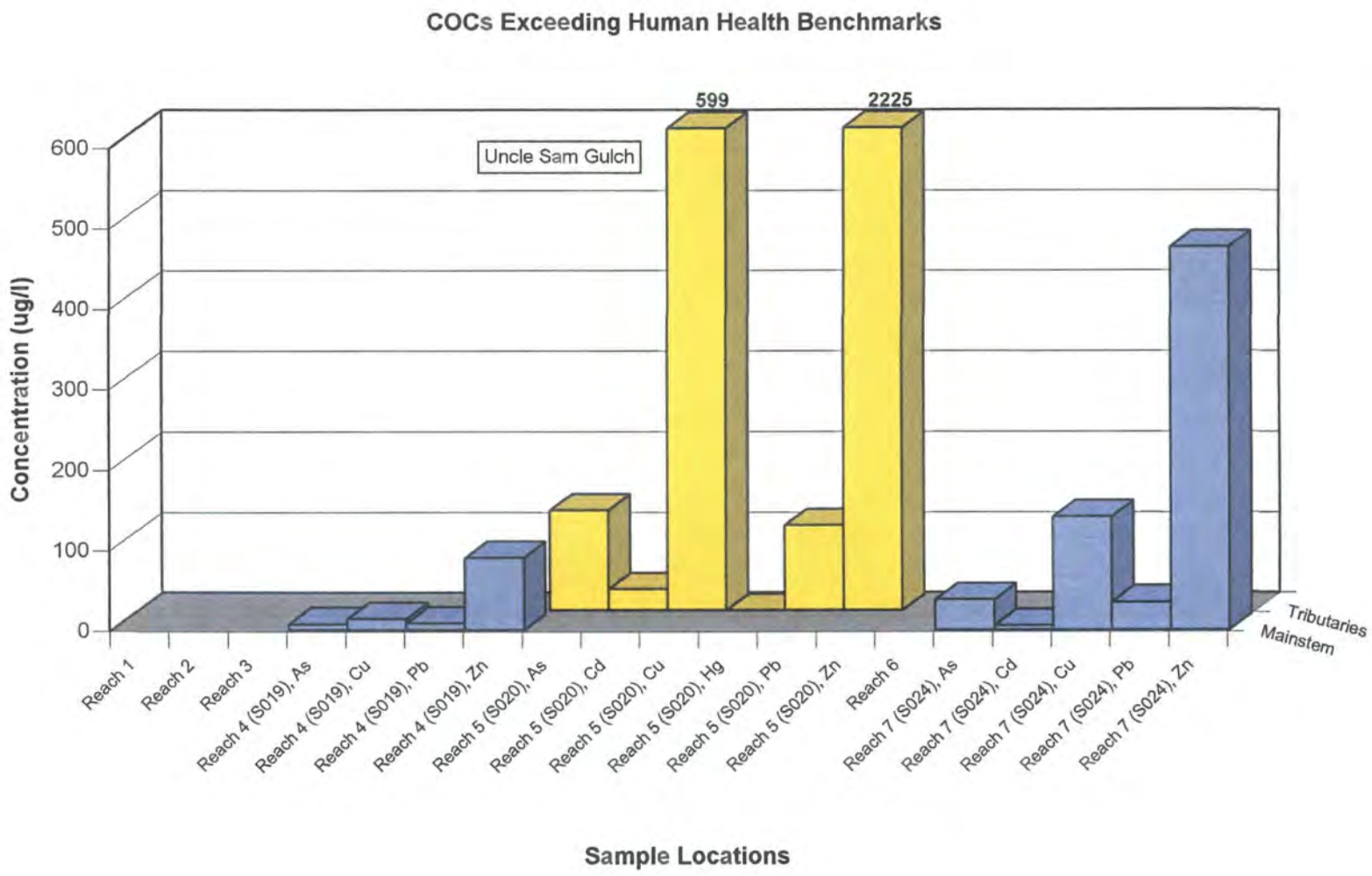
Figure 7.3-6 2001 Sulfate Concentrations Along Cataract Creek, Basin Watershed OU2



Notes:
Concentration values are mean detected concentrations.
Y-axis scale varies between figures.
Sample locations appear in brackets.

Figure 7.3-7 Locations Along Cataract Creek Where COPCs Exceeded Ecological and Human Health Benchmarks During Fall Storm High-Flow, Basin Watershed OU2





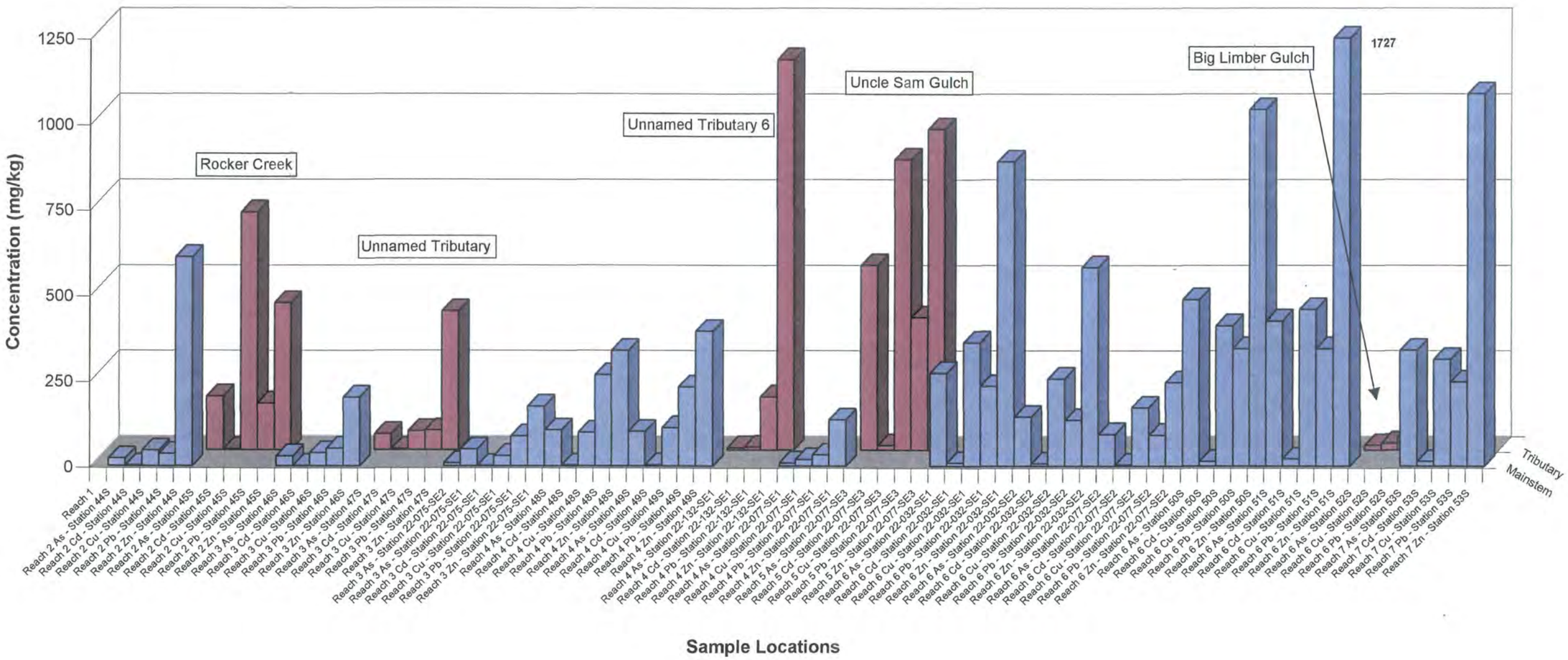
Sample Locations

Notes:
Concentration values are mean detected concentrations exceeding benchmarks.
Concentration values greater than upper scale limit are presented on graph.
Sample locations appear in brackets.

Figure 7.3-8 2001 Fall Storm High-Flow Sulfate Concentrations Along Cataract Creek, Basin Watershed OU2

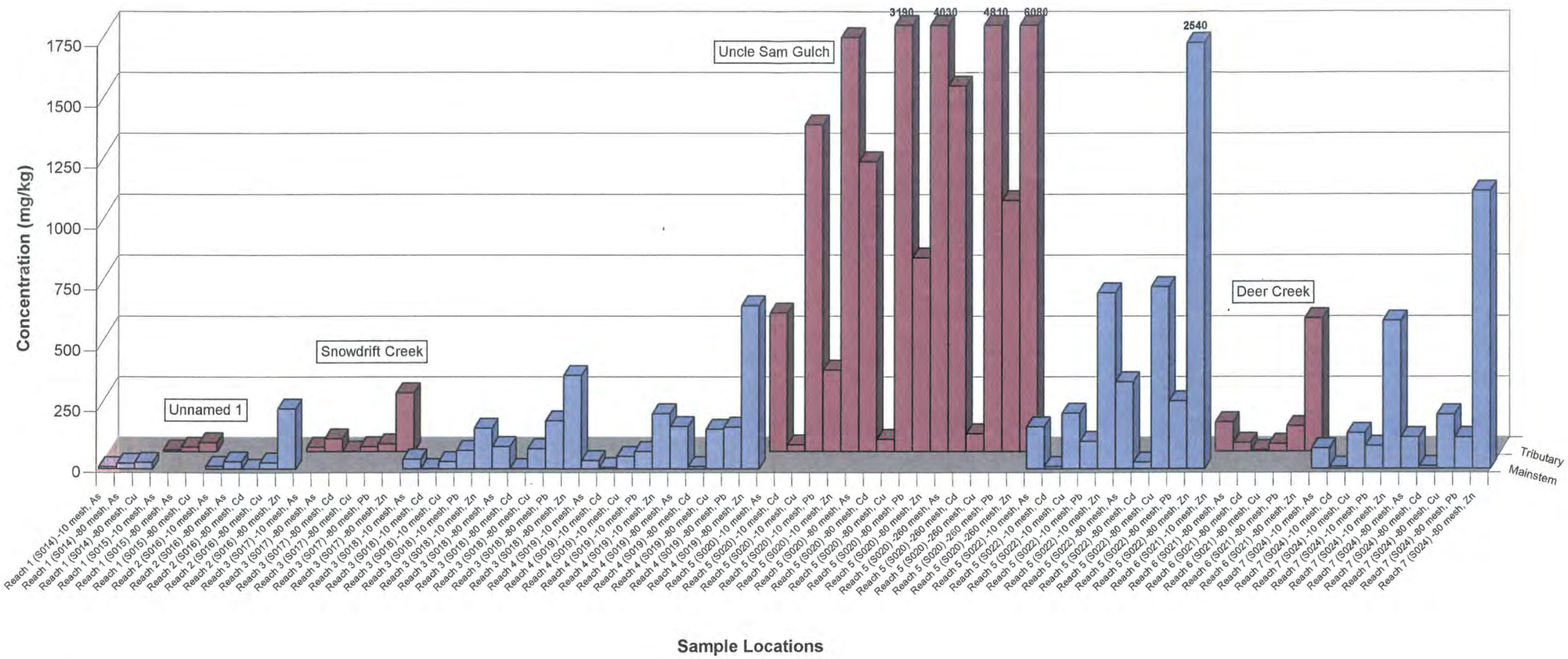
Notes:
Concentration values are mean detected concentrations.
Sample locations appear in brackets.

Figure 7.4-1 Historical Locations Along Cataract Creek Where COCS Exceeded Ecological Benchmarks in Sediment, Basin Watershed OU2



Notes:
Concentration values are mean detected concentrations exceeding benchmarks.
Concentration values greater than upper scale limit are presented on graph.
Sample locations appear in brackets.

Figure 7.4-2 Fall 2001 Locations Along Cataract Creek Where COPCs in Sediment Exceeded Human Health Basin Watershed OU2



Notes:
Concentration values are mean detected concentrations exceeding benchmarks.
Concentration values greater than upper scale limit are presented on graph.
Sample locations appear in brackets.

Figure 7.7-1 Historical Combined Dissolved COCs Load in the Cataract Creek, Basin Watershed OU2

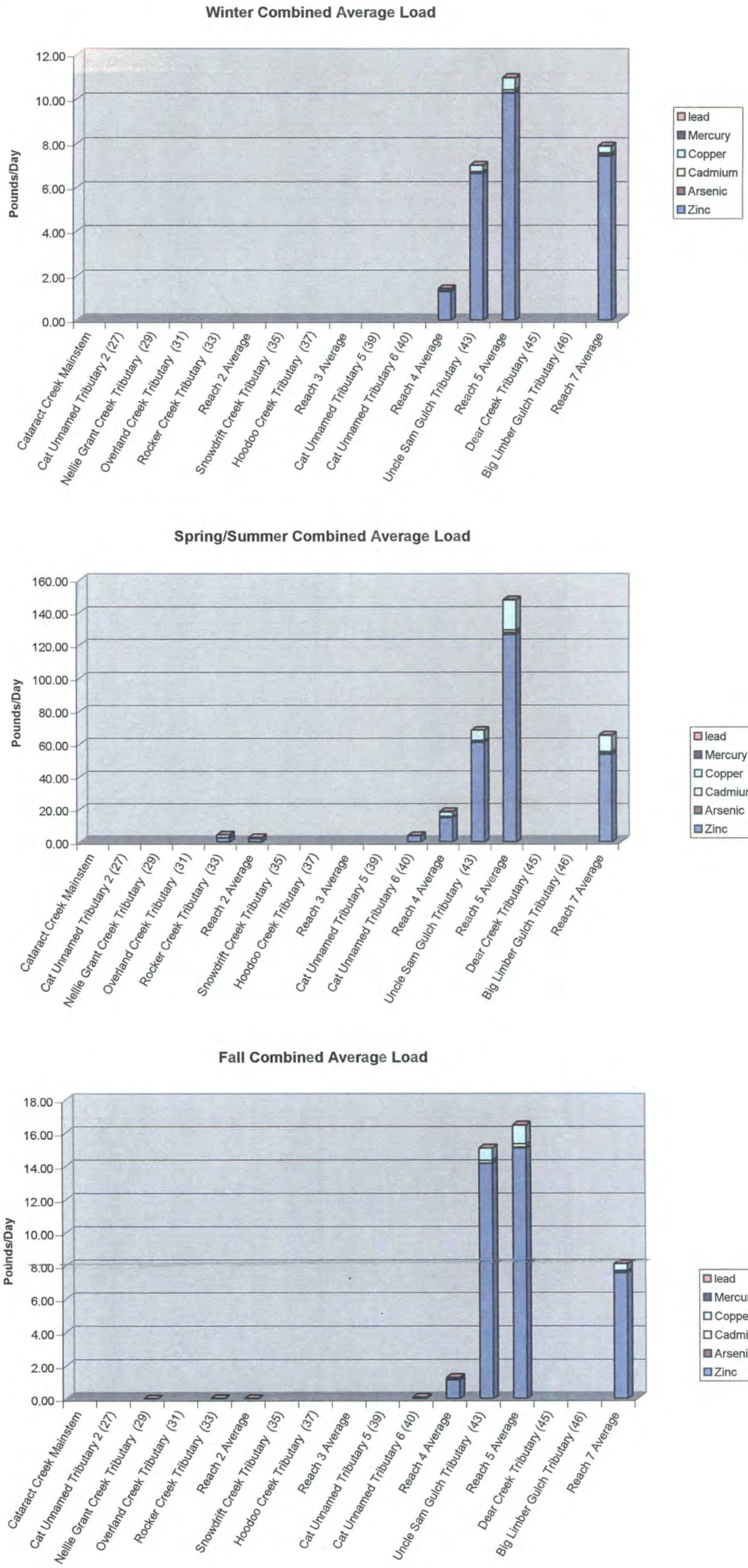
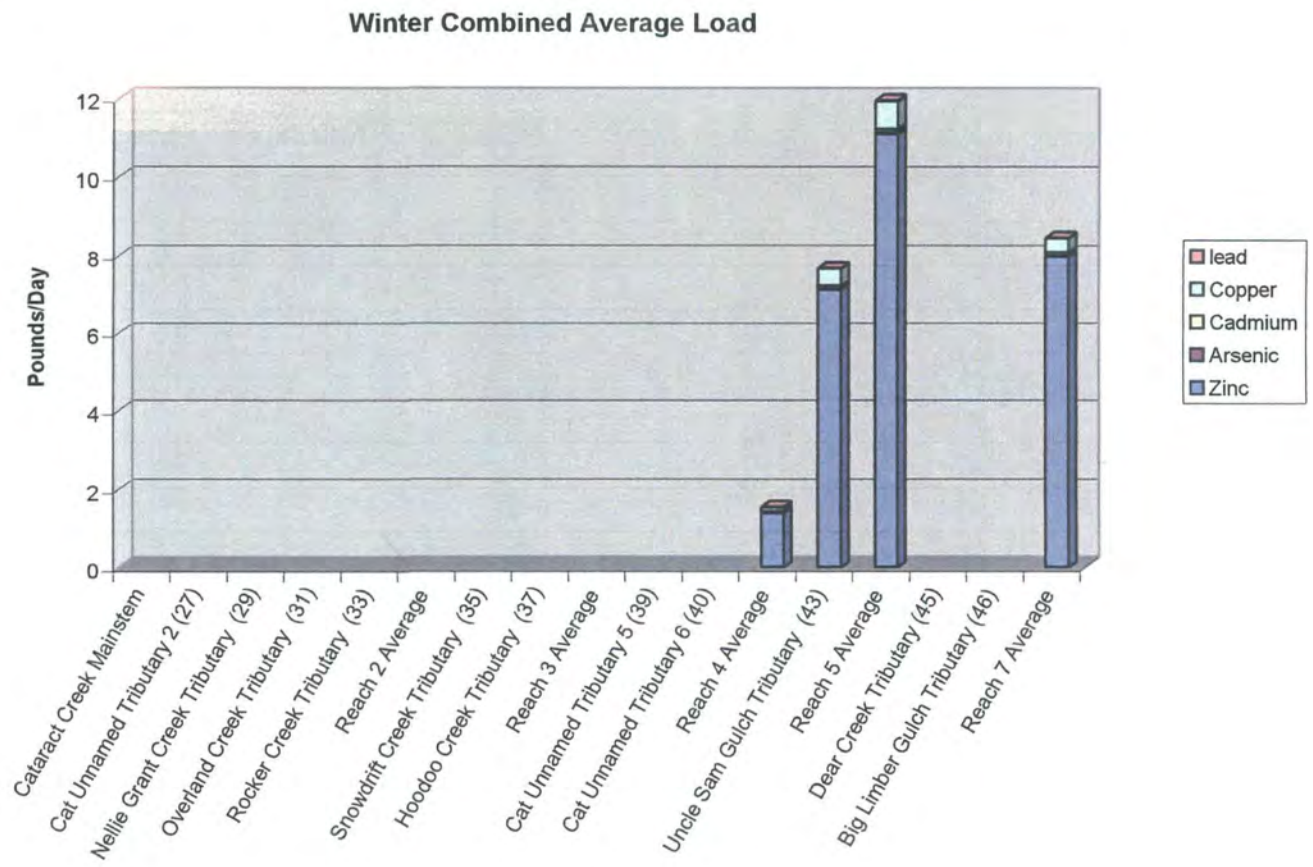
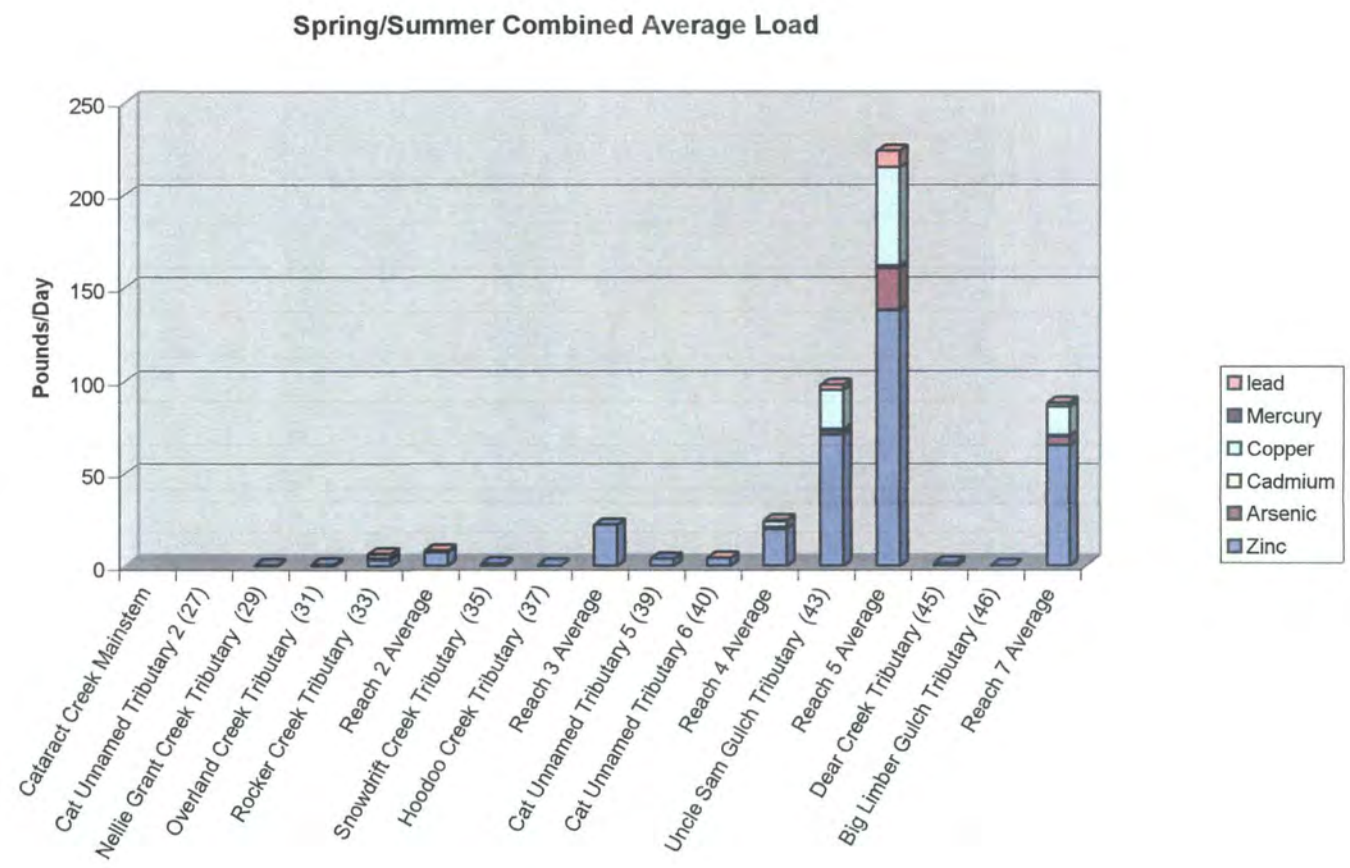


Figure 7.7-2 Historical Combined Total COCs Load in the Cataract Creek, Basin Watershed OU2





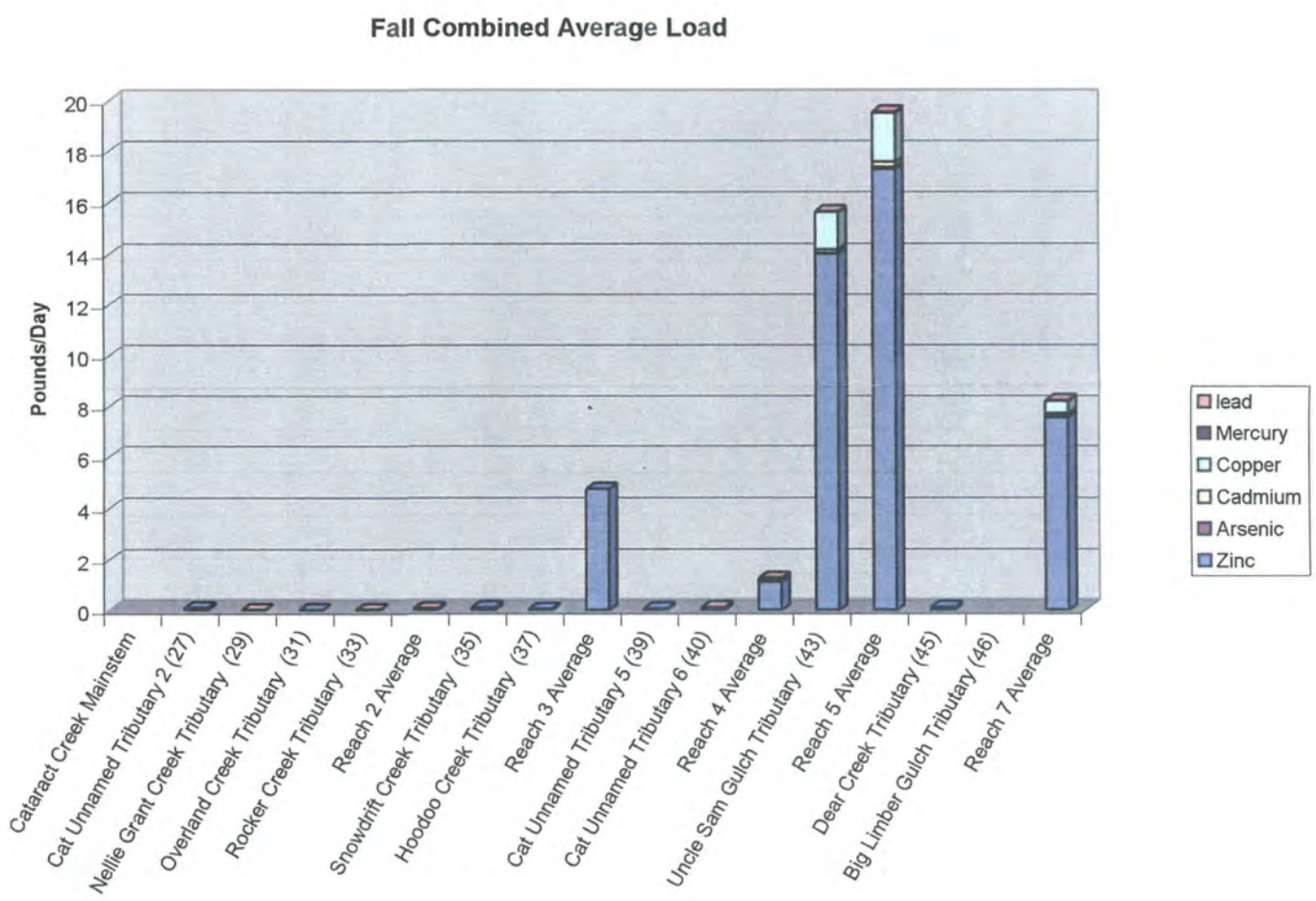
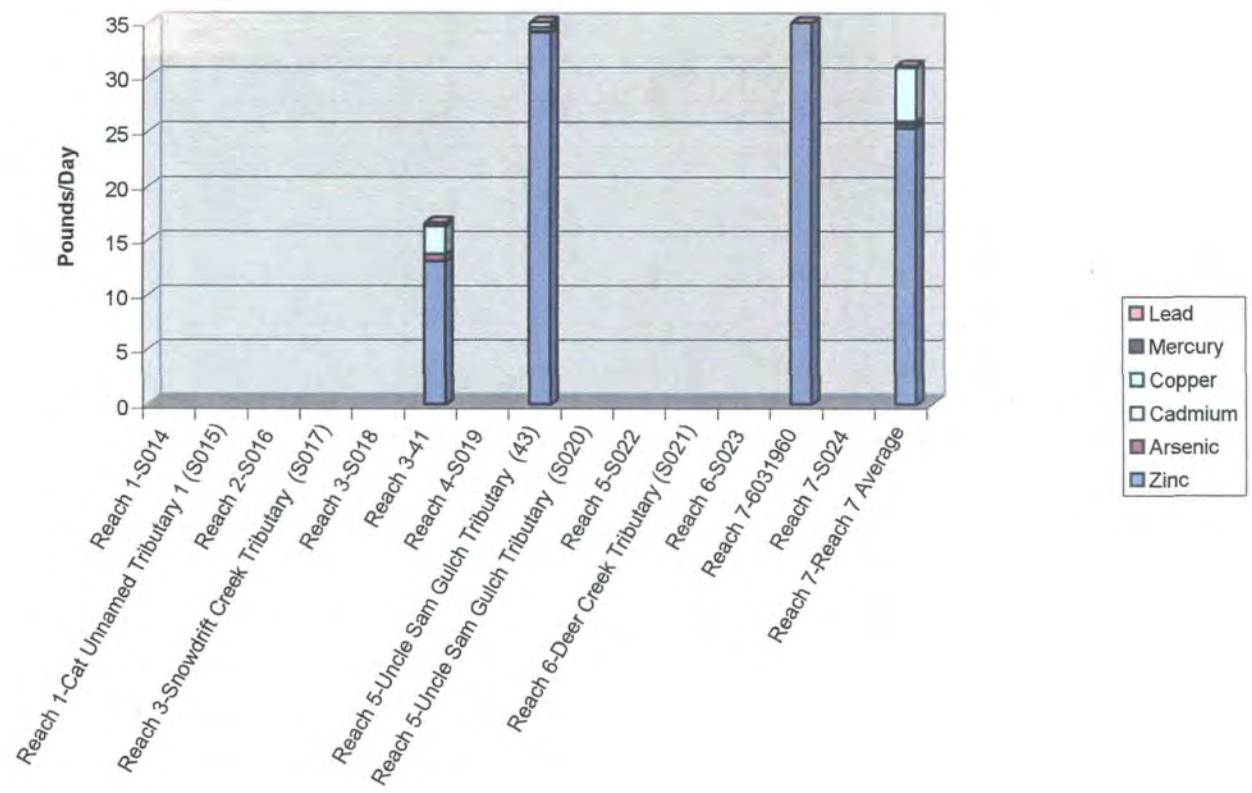
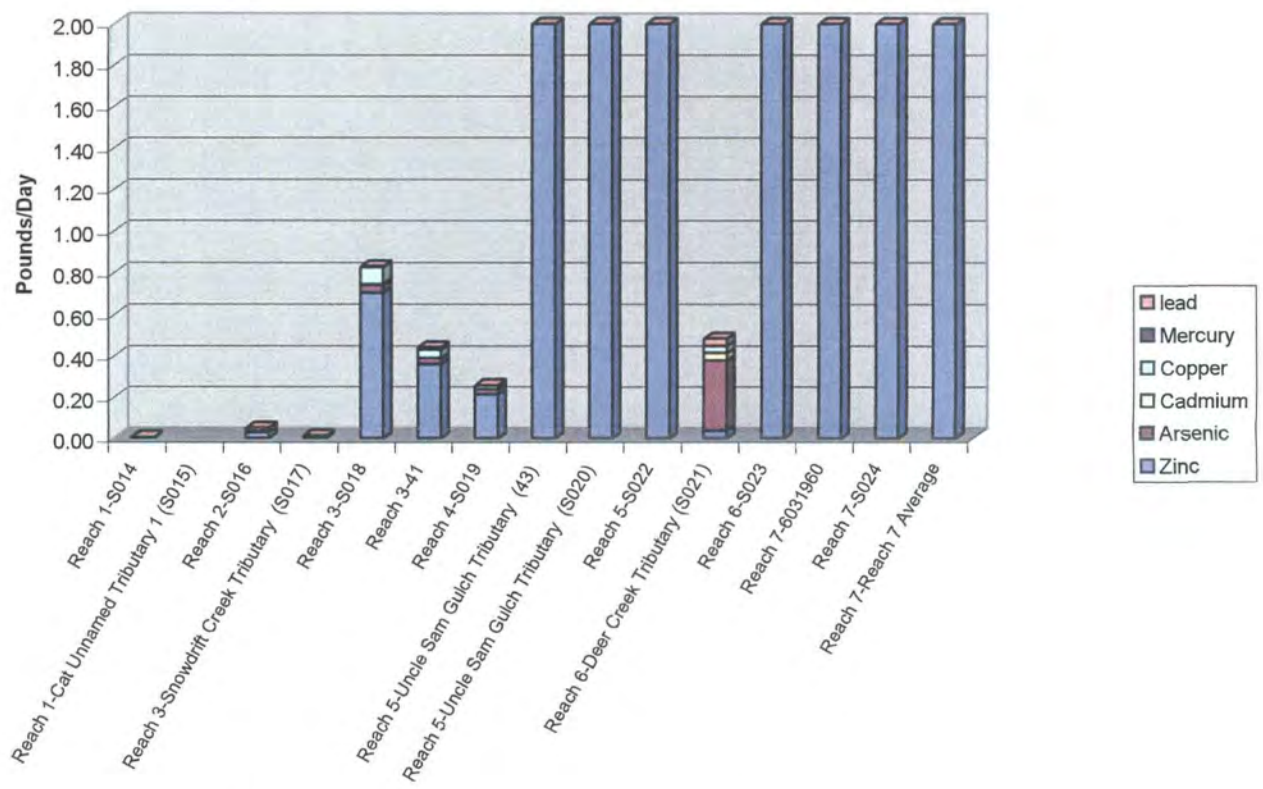


Figure 7.7-3 Spring/Summer and Fall 2001 Combined Dissolved COCs Load in the Cataract Creek, Basin Watershed OU2

Spring/Summer 2001 Combined Average Load



Fall 2001 Combined Average Load



Fall Storm 2001 Combined Average Load

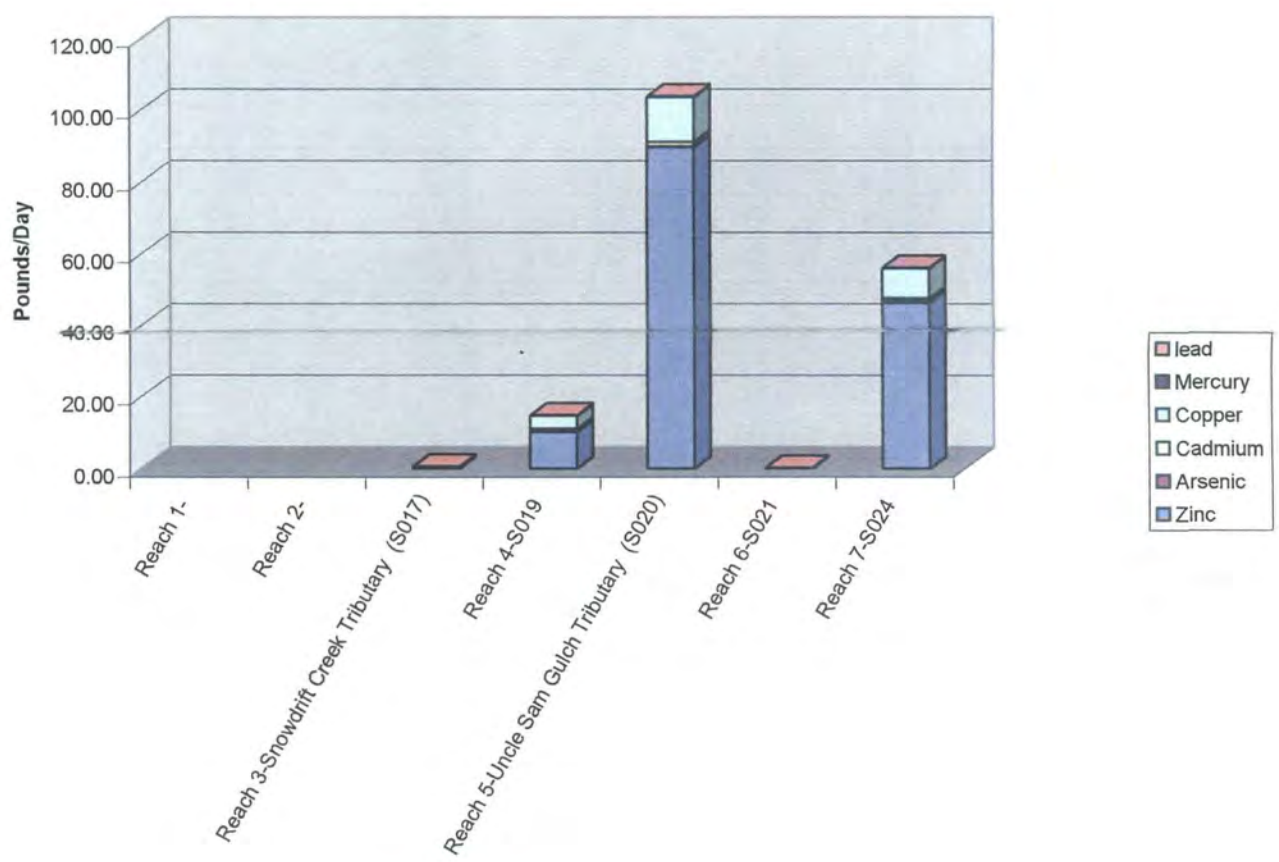
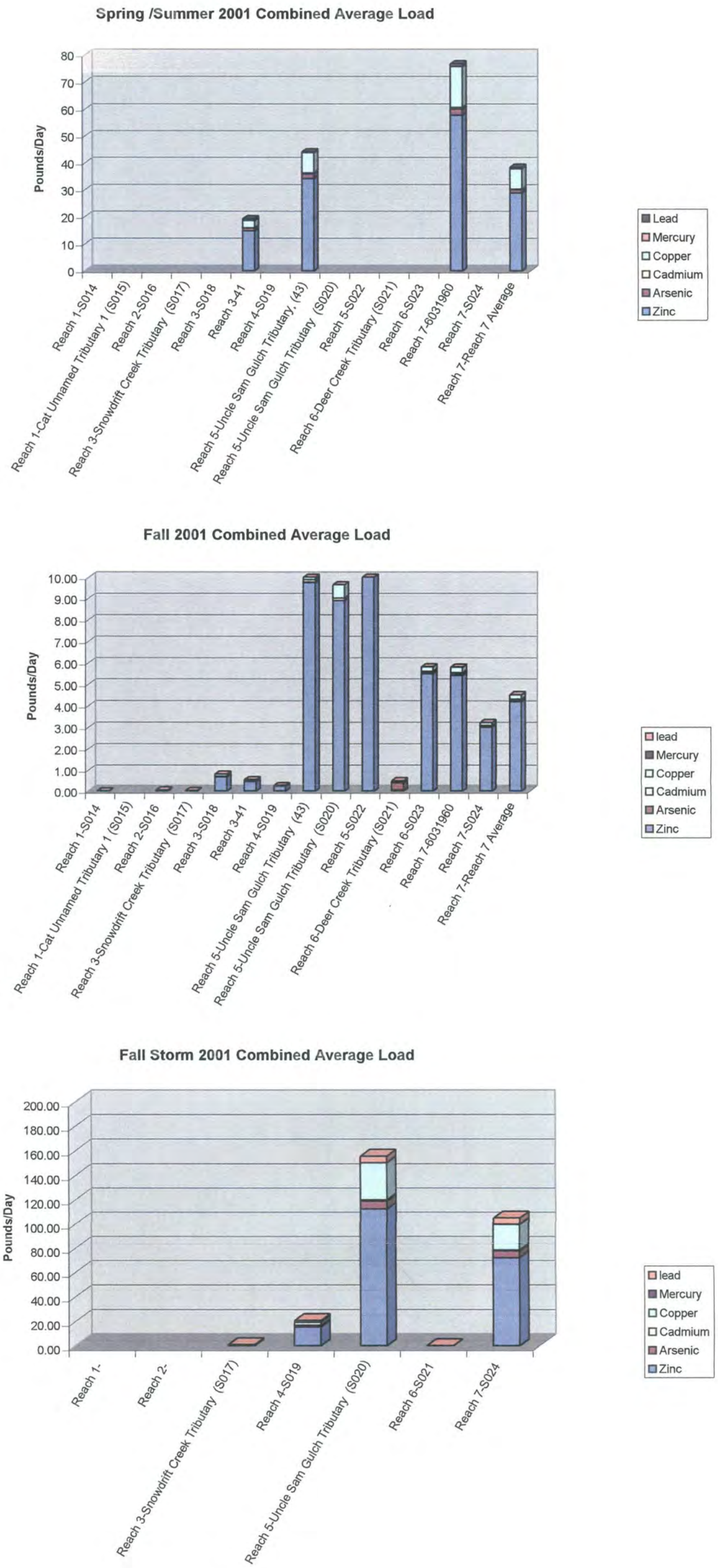


Figure 7.7-4 Spring/Summer and Fall 2001 Combined Total COCs Load in the Cataract Creek, Basin Watershed OU2



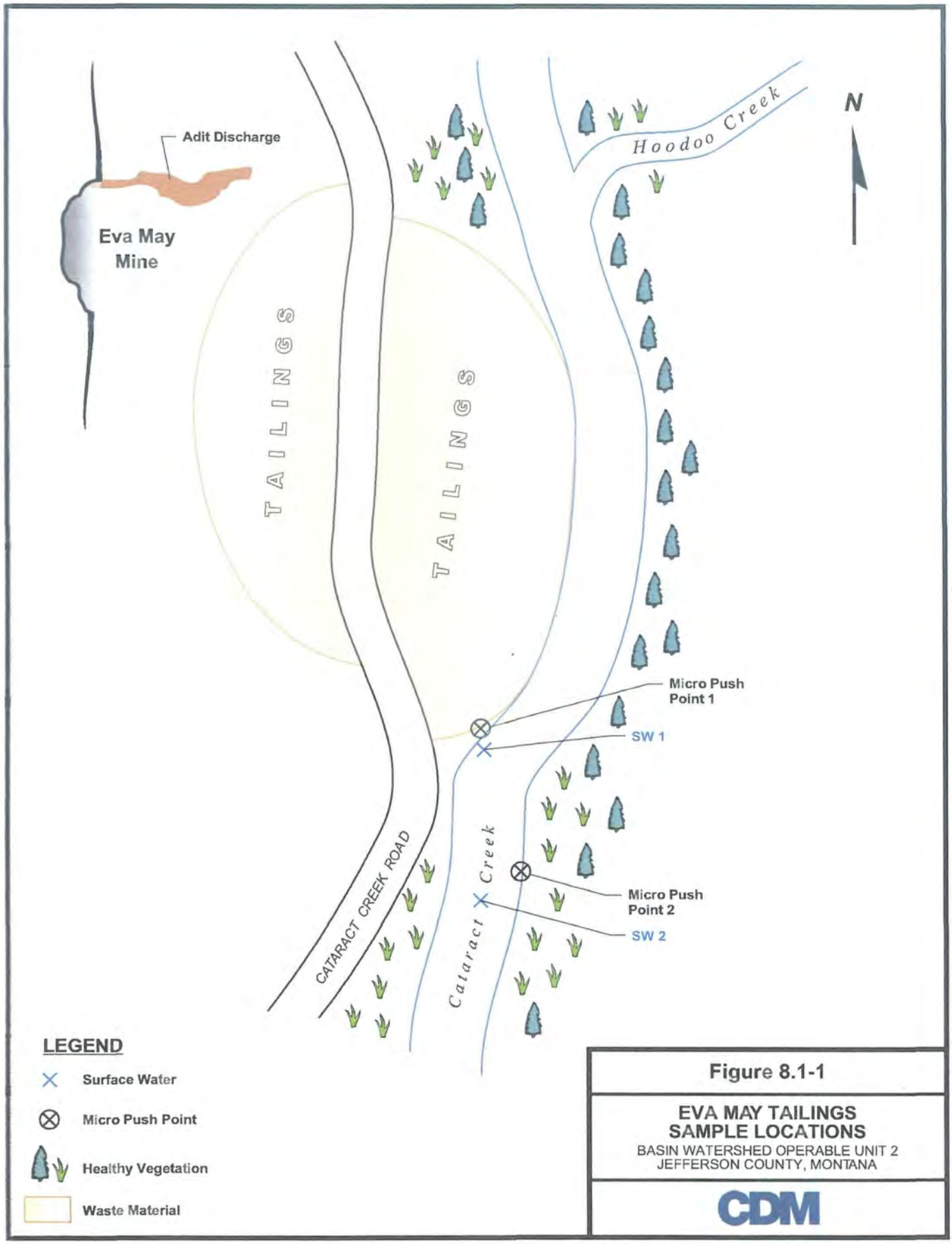


Figure 8.1-1

EVA MAY TAILINGS SAMPLE LOCATIONS

BASIN WATERSHED OPERABLE UNIT 2
JEFFERSON COUNTY, MONTANA

CDM

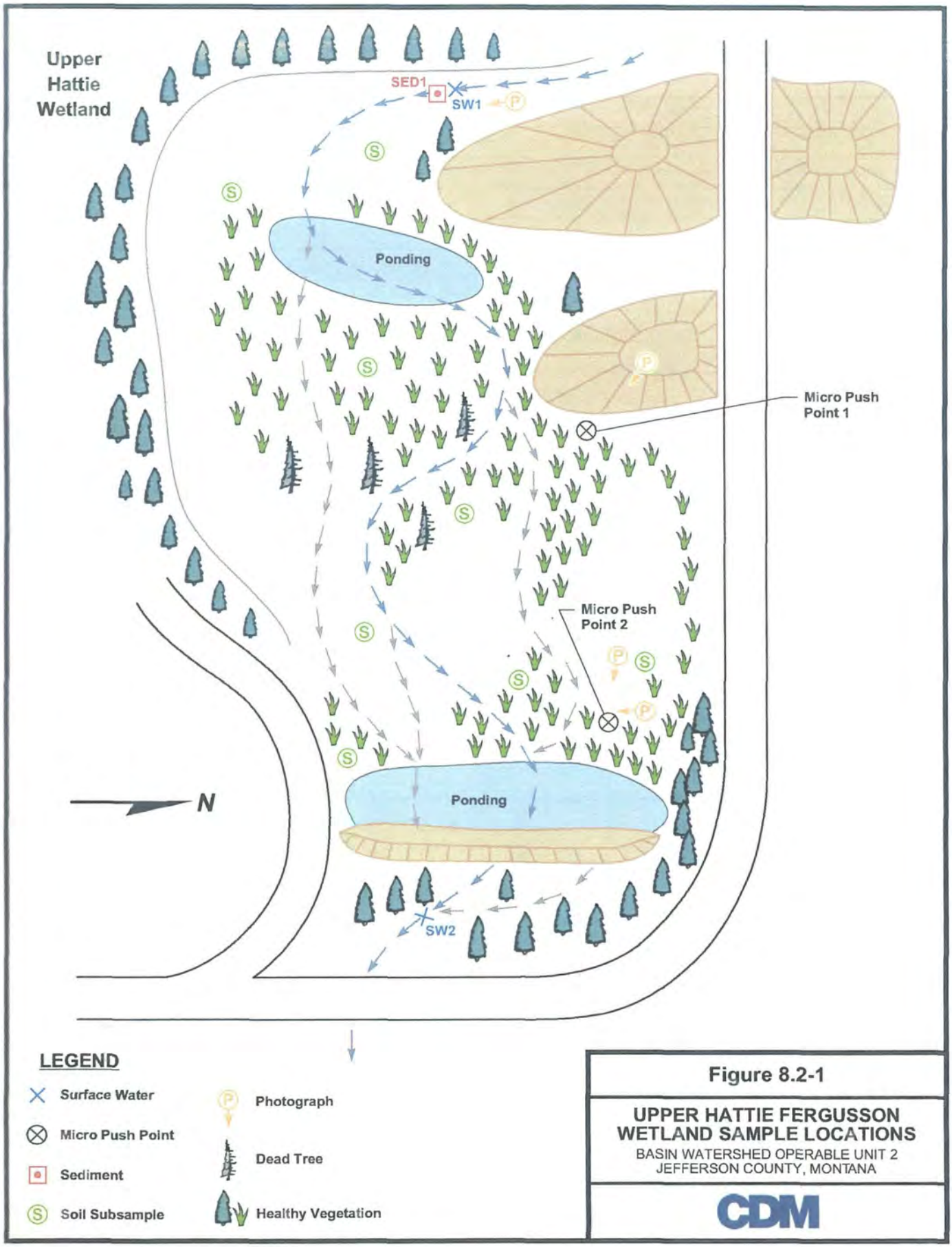


Figure 8.2-1

UPPER HATTIE FERGUSSON WETLAND SAMPLE LOCATIONS

BASIN WATERSHED OPERABLE UNIT 2
JEFFERSON COUNTY, MONTANA

CDM

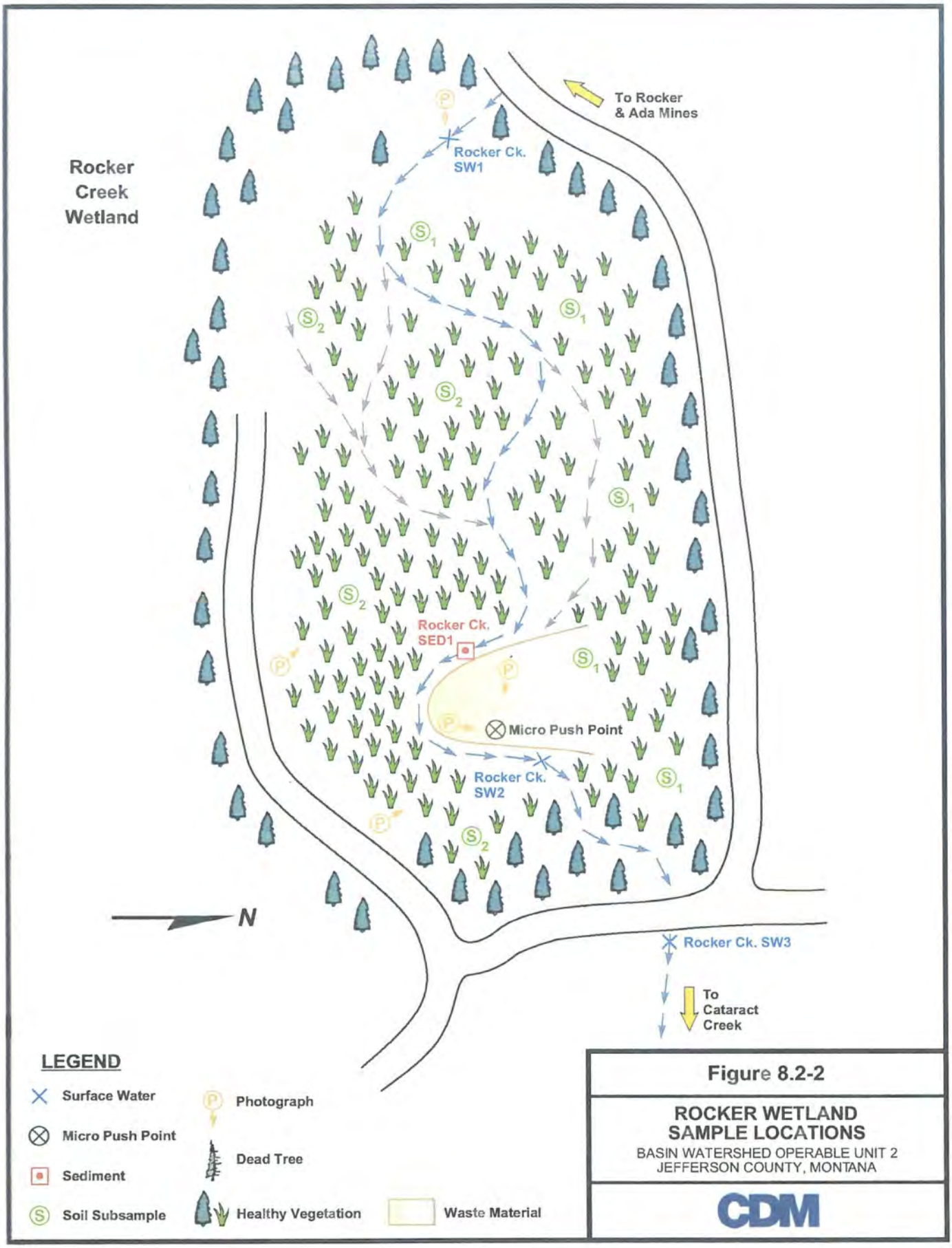


Figure 8.2-2

ROCKER WETLAND SAMPLE LOCATIONS

BASIN WATERSHED OPERABLE UNIT 2
JEFFERSON COUNTY, MONTANA

CDM

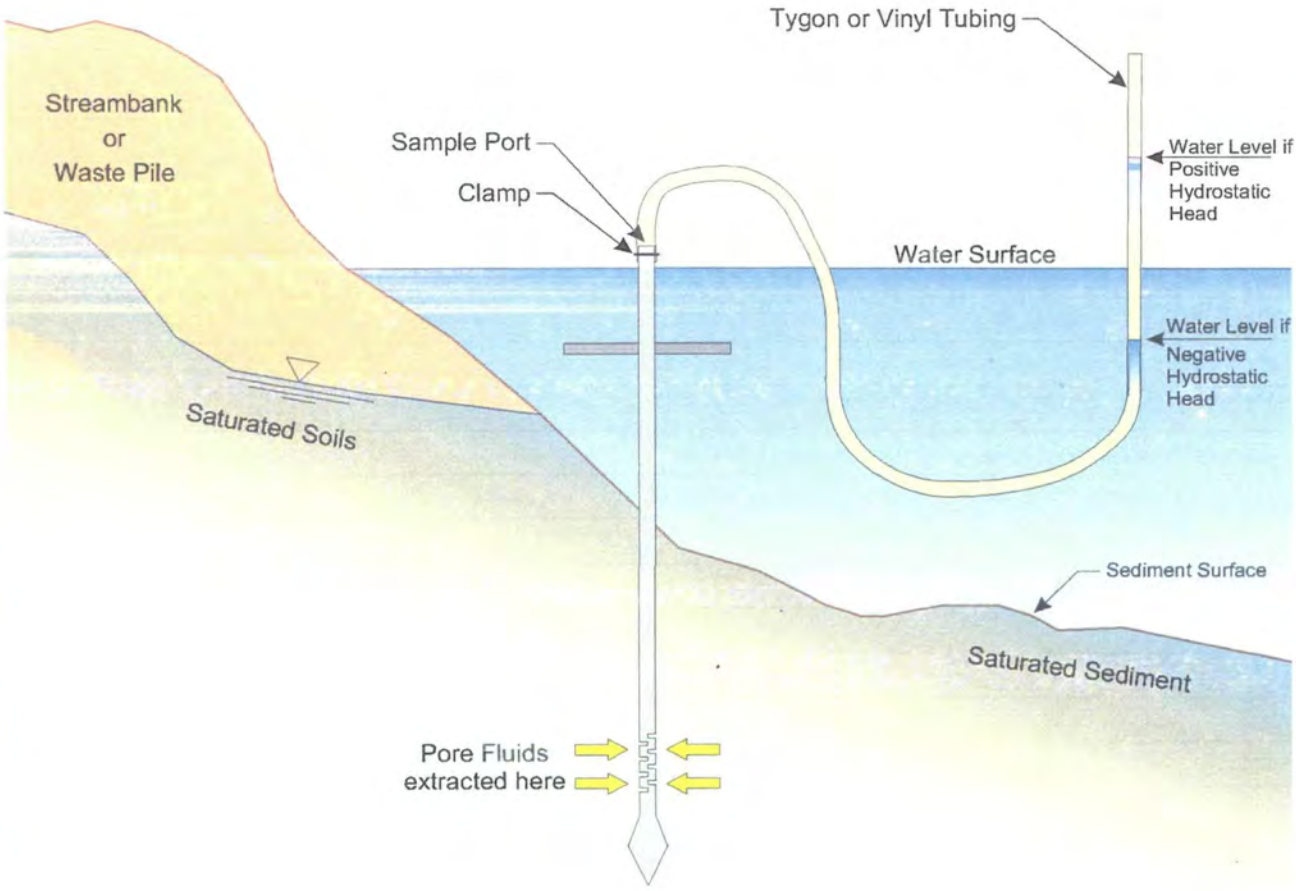


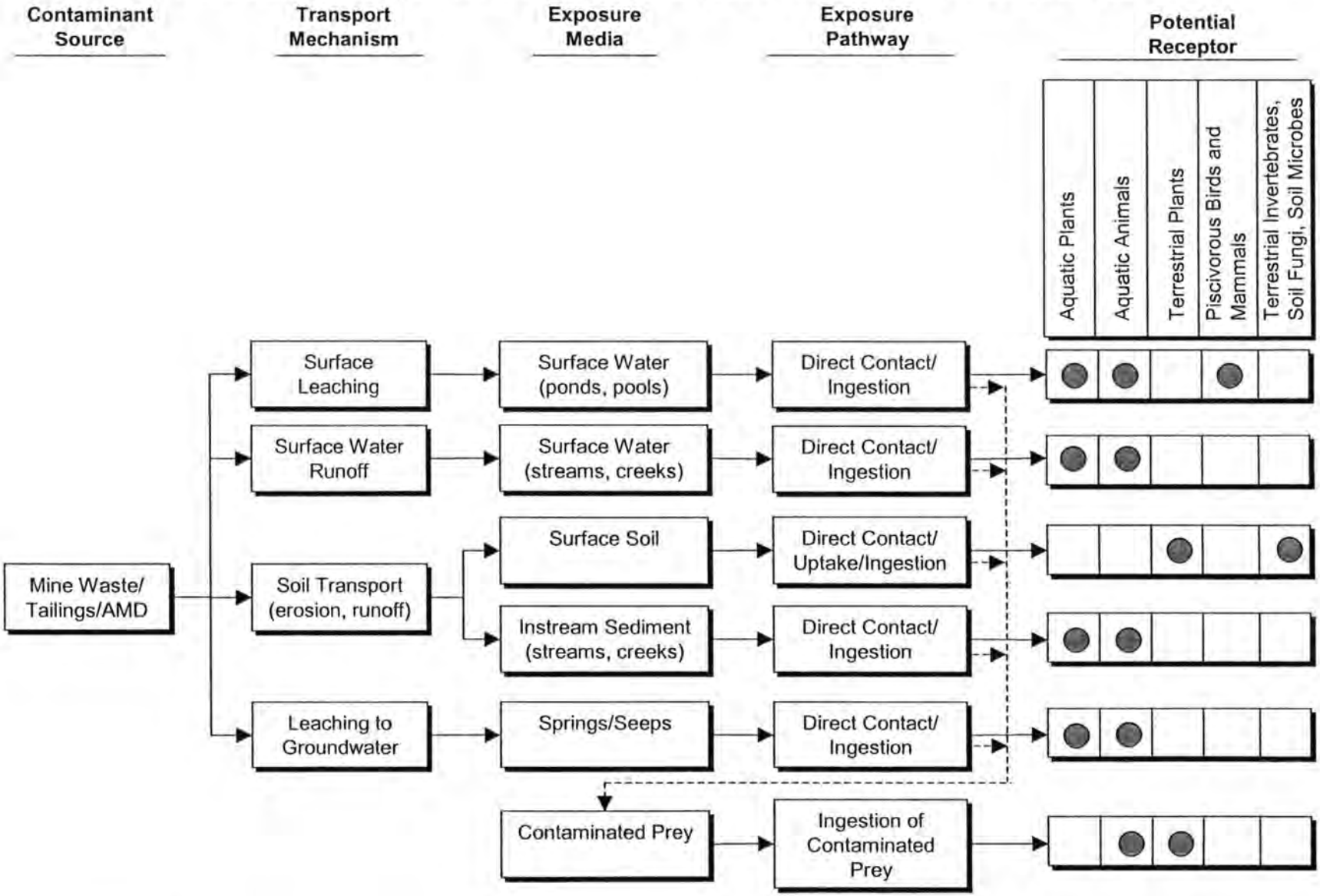
Figure 8.3-1

SCHEMATIC OF MICROPUSH POINT FUNCTION

BASIN WATERSHED OPERABLE UNIT 2
JEFFERSON COUNTY, MONTANA

CDM

Figure 10.1-1 Site Conceptual Exposure Model with Major Exposure Pathways, Basin Watershed OU2



CDM

- Incomplete Exposure Pathway

- Complete Exposure Pathway

Figure 10.1-1

This page intentionally left blank.

Tables

Table 2.1-1 Summary of Data Quality Objectives for Consideration of Historical and Recent Data, Basin Watershed OU2

Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7
Statement of the Problem	Decisions to be Made	Inputs to the Decision	Boundaries of the Study Area	Decision Rules	Acceptable Limits on Decision Errors	Optimize the Study Design
Uncontrolled releases of low pH water and inorganic constituents (or constituents of potential concern [COPCs]), primarily metals / metalliods, from abandoned or inactive mining operations (i.e., former mines and processing facilities) have and continue to contribute metals / metalliods loading and pH upsets to bedload sediment, surface water, groundwater, and terrestrial soil.	Are the contributions of inorganic constituents and low pH water detrimental to human health or the environment?	1a. Historical sample data (i.e., sediment, soil, surface water, and groundwater) that meet the following criteria: ■ Exist within the Site boundaries or adjacent "reference or background" areas ■ Are "usable" from a QA/QC standpoint ■ Were collected after 1990 **1b. Recent sample data from the Fall 2001 field sampling program.** 2. Human health and ecological-based screening levels including the following: Primary: ■ State of Montana - Circular WQB-7 standards - for SW and GW ■ Federal MCL and AWQC standards - for SW and GW ■ Industry-accepted criteria - Conservatively-Based Sediment Quality Guidelines - for SED ■ Regional or industry-accepted risk based standards - for soil Secondary: ■ Regional or industry-accepted values including Clark Fork River ERA, **and** Upper Tenmile Creek ERA for SW, GW, SED, and soil 3. Data users and decision-makers include: ■ EPA Region VIII ■ CDM ■ MDEQ ■ Secondary Stakeholders, including USGS, USFS, BLM, and BOR	1. Horizontal Extents: The Site includes Basin Creek watershed, Cataract Creek watershed, and an 8-mile segment of the Boulder River (5 miles upstream of the High Ore Creek/Boulder River confluence and 3 miles south of this confluence). Refer to Figure 2.1-1 or Plate 1-1. The following media include all horizontal extents that exist within the Site. Surface water media includes all creeks, ponded springs, seeps, and wetlands. They are defined in extent by the limits of the current waterline and/or the width of a channel. Sediment media includes all bedload, active floodplain, and tailings material within a channel feature and is submerged or regularly submerged by surface water (moist to saturated). Soil media includes solid material including soil, waste rock, overbank deposits, and tailings material that is not covered by surface water. Groundwater media includes all water media below the ground surface. 2. Vertical Extents: Existing data from all depths will be considered. These depths include ground surface to groundwater depths (typical maximum soil depths 15 feet, SED depths 5 feet, GW depths 100 feet). 3. Temporal: Existing data collected after 1990 will be considered in the evaluation, but they may include impact from 1860s activities through the present.	1. Do any data at the sampled locations exceed media-specific risk-based benchmark values and/or toxicity reference values (TRVs)? If yes, possible actions include: ■ No further action ■ Additional assessment ■ Remedial action If not, possible actions include: ■ No further action ■ Additional assessment 2. Are there media at locations where decision rule no. 1 cannot be answered (i.e., data gaps)? If yes, possible actions include: ■ No further action ■ Additional assessment ■ Remedial action If not, possible actions include: ■ No further action ■ Additional assessment ■ Remedial action	1. For the purposes of the RI, individual data points will be compared to standards for determination of exceedences. There will a tolerable limit for the measured concentration of ±20 percent. There will be no "gray zone" surrounding the screening level values. 2. The point of compliance is subjective. Decision rules will be applied to specific data points to determine location-specific risks; however, data will also be evaluated collectively, on a "watershed-basis". Conclusions and recommendations (based on the decision rule response) may be refined based on secondary considerations, such as physical setting, natural buffering, etc.	1. No site characterization work is currently planned. However, the historical data has been evaluated under the preceding six steps of EPA's DQO process. The basis of evaluation has been established and all future studies will implement this approach and the framework of the DQOs developed thus far. **2. The Fall 2001 field program was streamlined and optimized to minimize sample collection costs and target data gap resolution for those identified in the historical data set. No additional site characterization is planned.**

Notes:

AWQC - Aquatic Water Quality Standards
GW - Groundwater
SW - Surface Water
SED - Sediment
BLM - Bureau of Land Management
DQO - Data Quality Objective
BOR - Bureau of Reclamation
EPA - US Environmental Protection Agency
ERA - Ecological Risk Assessment
COPC - Chemical of Potential Concern
MDEQ - Montana Department of Environmental Quality
QA/QC - Quality Assurance/Quality Control
RI - Remedial Investigation
MCL - Maximum Contaminant Levels
USGS - US Geological Survey
USFS - US Forest Service

Bold-face - denotes modifications of the DQOs to evaluate the Fall 2001 (recent) data.

Table 2.1-2 Summary of Data Quality Objectives for Fall 2001 Field Sampling Program, Basin Watershed OU2

Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7
Statement of the Problem	Decisions to be Made	Inputs to the Decision	Boundaries of the Study Area	Decision Rules	Acceptable Limits on Decision Errors	Optimize the Study Design
Analytical data from historical investigations are not sufficient to adequately delineate the nature and extent of mining-related contamination in soil, surface water, and sediment within the Basin Watershed OU2. Therefore, additional soil/waste material, sediment, and surface water sampling is required to minimize identified data gaps.	The investigation purpose is to minimize data gaps necessary to complete the RI. Specifically, the study question that needs to be answered is "Are the data the right type, quantity, and quality to determine what remedial actions should be taken within the watershed?" The following alternative actions have been identified: ■ For waste material: no action, further investigation, stabilization in place, or removal ■ For sediment: no action, further investigation, or removal ■ For surface water/adit/seep drainage: no action, further investigation, passive treatment, or active treatment The planning team include: ■ EPA Region VIII (decision maker) ■ CDM ■ Other Stakeholders including USBR, USFS, USGS, MDFWP, MDEQ	Based on the investigation question, the following information is required: ■ The concentration and distribution of constituents in the soil/waste material, sediment, and surface water, as defined in the historical data ■ The concentration and distribution of selected inorganic constituents in the soil/waste material, sediment, and surface water ■ The distance of each mine waste material to a perennial stream ■ Condition of prior reclamation if it has occurred ■ The distance to the nearest residence ■ The distance to the nearest recreational cabin ■ If the site is accessible (distance to the nearest road) ■ The size of the waste piles ■ If there is any evidence of erosion, leaching, or off-site migration of waste material ■ The potential for a landslide or catastrophic release	The investigation will be performed within the horizontal boundaries presented in Figure 2.1-1. The vertical boundaries range from: (1) the top of any waste pile sampled to approximately 18 inches below the surface of any waste pile sampled, or (2) approximately six inches below the surface of any stream bed samples. Sample locations correspond to those areas identified by the EPA and CDM where analytical data from previous investigations are not sufficient to adequately delineate the nature and extent of contamination, or where sampling is necessary to confirm constituent concentrations. The temporal boundaries include the time of initial mining to the time of sampling because any activity prior to sampling may have affected the sampling media.	The sampling phase decision process consists of the following steps: 1. Assess whether the data are usable based on the data validation and evaluation processes. If yes, continue; if no, it may be necessary to devise a second sampling phase to collect usable data. 2. Assess whether the data are sufficiently complete to minimize data gaps in the RI analysis. This assessment includes the following results: a. If the data gathered during this investigation fill in the data gaps necessary to complete the RI, then further investigation is not necessary to support remedial alternative decisions, as stated in step 2. b. If the data gathered during this investigation do not fill in the data gaps necessary to complete the RI, then further investigation may be necessary. Or, it may be determined that further investigation will not be conducted. If further investigation is not conducted then alternative actions as stated in step 2 will be determined.	Professional judgement will be used to determine if the data gathered during this investigation are sufficient to complete the RI. Because there are no values that the data will be compared to, no tolerable limits on decision errors can be set. For the same reason, no "gray region" has been identified.	This step identifies a resource-effective data collection design for generating data that are expected to satisfy the DQOs. The data collection design (sampling program) are described in detail in the Field Sampling Plan (Sections 3 and 4 of the August 2001 SAP (CDM 2001b).

Notes:

DQO - Data Quality Objective
EPA - US Environmental Protection Agency
MDEQ - Montana Department of Environmental Quality
MDFWP - Montana Department of Fish Wildlife and Parks
USGS - US Geological Survey
USBR - US Bureau of Reclamation
USFS - US Forest Service
CDM - CDM Federal Programs Corporation

Table 2.2-1 Summary of Historical Data Sources, Basin Watershed OU2

Data Type	Data Source and Description
Multi-media physicochemical data	USGS Open File Reports (OFR) USGS database USFS technical reports MBMG technical reports MBMG AML database MDEQ technical reports MDEQ GWIC database Montana AMRB technical reports
Geology	USGS geologic and mineral deposit maps for Basin and Jefferson City quadrangles
Climatological data	WRCC website SNOTEL database
Topography	USGS files USGS 7.5-minute quadrangle maps
Photographs	MDEQ files USGS AML website Site visits
Aerial Photographs	USGS files
Surface water flow data	USGS OFRs USGS database

Note: Bibliography details for these data sources are presented in Section 12 - References.

AML - abandoned mine lands
AMRB - Abandoned Mines and Reclamation Bureau
GWIC - Groundwater Information Center
MBMG - Montana Bureau of Mines and Geology
MDEQ - Montana Department of Environmental Quality
SNOTEL - snowpack telemetry system
USFS - US Forest Service
USGS - US Geological Survey
WRCC - Western Region Climate Center

Table 2.2-2 Mine Sites in Basin Watershed OU2 Investigated by the State of Montana

Mines Inventoried	Montana PA Number	Mines Inventoried	Montana PA Number
Basin Millsite	22-036	Jack Creek Tailings	22-296
Boulder Chief Mine	22-132	Josephine Mine	22-031
Buckeye Mine	22-072	Lady Leith Mine	22-316
Bullion Mine	22-008	Mantle East Mine	22-032
Bullion Smelter	22-505	Marguerite Mine	22-301
Crescent / Alsace Mines	22-106	Morning Glory Mine	22-077
Crystal Mine	22-073	Old Basin Millsite	22-500
Doris Mine	22-293	Perry's Park Mine	22-039
Enterprise Mine	22-074	Rocker / Ada Mines	22-170
Eva May Mine	22-075		

Source: AMRB / Pioneer 1993, 1994, 1996.

OU2 - Operable Unit 2
PA - Preliminary Assessment
AMRB - Abandoned Mine and Reclamation Bureau

Table 2.2-3 Mine Sites That Impact Lands Administered by USFS, Basin Watershed OU2

Basin Creek Watershed Mine Sites		Cataract Creek Watershed Mine Sites	
Inventoried and Designated Non-Priority Sites		**Inventoried and Designated Non-Priority Sites**	
Adelaide Mine	Josephine Mine	Apollo Mine	Manhattan Mine
Aurora Mine	Keller's Hematite Mine	BaKaMa Mine	Mantle Mine
Boulder Mine	Lula Bell Mine	Billie T Mine	Mary Anne Mine
Columbus Mine	Marguerite Mine	Custer Mine	Mike #14 Mine
Doris Mine	Morning Star Mine	Elmer Mine	Minneapolis Mine
Dumortierite Prospect	N462471 Mine	Eva May Mine and Mill	Peirmont #1 Mine
Golden Glow Mine	Pearl Mine	First Shot / Last Shot Mine	Quartz Creek Mine
Highland Mine	Solar Mine	Great Shield Mine	Saint Lawrence Mine
Jack Creek Ridge MIne	Unnamed Fire Clay Mine	Hidden Treasure Mine	Saturday Night MIne
Jessie Mine	Venus Mine	Ida May Mine	Seattle Mine
Joe Bower's Mine		John T. Mine	South Mantle Mine
		Jumbo Mine	Sparkling Water Mine
		Klondyke Mine	Sylvan Mine
		Lizzie Osborne Mine	Unnamed #3 Mine
		Louise Mine	
Inventoried and Designated Priority Sites		**Inventoried and Designated Priority Sites**	
Basin Belle Mine		Ada Mine	Morning Glory Tailings
Buckeye-Enterprise Mine and Tailings		Black Bear Mine	Morning Marie Mine
Bullion Mine and Smelter		Blue Diamond-Occidental Mines	Mountain Chief Mine
Daily West Mine		Boulder Chief Mine	Overland Creek Mine
Double Shaft Mine		Cataract Mine	Phantom Mine
Hawkeye Mine		Cataract Tailings	Rocker Mine
Hector Mine		Cracker Mine	Rocker Extension Mine
Lady Leith Mine		Cresent Mine	Sirius Mine
Lower Hector Mine		Crystal Mine	Uncle Sam Mine
Morning Mine		Eldorado & Plateau Mine	Unnamed #1 Mine
North Ada - Peirmont Mine		Gray Lead Mine	Unnamed #2 Mine
Vindicator Mine		Hattie Ferguson Mine	Unnamed #4 Mine
Winter's Camp Mine		Ida M. Mine	Vera and Marie Mine
		Morning Glory Mine	

Notes: USFS - US Forest Service

Table 2.2-4 Mine Sites That Impact Lands Administered by BLM, Basin Watershed OU2

Cataract Creek Watershed Mines	Boulder River Watershed Mines
Inventoried and Designated Non-Priority Sites	**Inventoried and Designated Non-Priority Sites**
Hiawatha Mine	Obelisk Mine
Minneapolis Mine and Placer	
Mount Thompson Mine	
North Waldy Mine	
Redwing Mine	
Virginia Mine	
Waldy Mine	
Inventoried and Designated Priority Site	**Inventoried and Designated Priority Site**
Mantle Mine	

Notes:

BLM - Bureau of Land Management

Table 2.3-1 Historical Mine Site Inventory, Previous Work, and Prioritization, Basin Watershed OU2

Mine Name	Subarea	(3) Easting	(3) Northing	No. of Areas Mined at Site	(1) Historical Scores	(2) Priority	Historical Work	Historical Reference
24JF0131	MIDDLE CATARACT CREEK	5135035.129	406204.6319	1	-	Low	-	-
24JF0132	MIDDLE CATARACT CREEK	5137308.433	408077.8856	1	-	Low	-	-
24JF0134	MIDDLE CATARACT CREEK	5136927.432	408706.5369	1	-	Low	-	-
24JF0141	MIDDLE CATARACT CREEK	5136806.782	408020.7355	1	-	Low	-	-
24JF0142	MIDDLE CATARACT CREEK	5135116.808	408129.8117	1	-	Low	-	-
24JF0177	LOWER BOULDER RIVER	5122599.816	409520.441	1	-	Low	-	-
24JF0178	LOWER BOULDER RIVER	5123433.655	408592.2367	1	-	Low	-	-
24JF0179	LOWER BOULDER RIVER	5123681.306	407855.6352	1	-	Low	-	-
24JF0183	UPPER BOULDER RIVER	5124206.735	405901.484	1	-	Low	-	-
24JF0185	UPPER BOULDER RIVER	5124602.058	406166.5318	1	-	Low	-	-
24JF0188	UPPER BOULDER RIVER	5124875.108	403575.7266	1	-	Low	-	-
24JF0240	LOWER CATARACT CREEK	5126468.368	404090.4189	1	-	Low	-	-
24JF0241	LOWER CATARACT CREEK	5126526.112	404185.3278	1	-	Low	-	-
24JF0247	MIDDLE CATARACT CREEK	5135206.579	406407.8323	1	-	Low	-	-
24JF0249	UPPER CATARACT CREEK	5137702.134	404940.9793	1	-	Low	-	-
24JF0250	UPPER CATARACT CREEK	5139442.038	406217.3319	1	-	Low	-	-
24JF0444	MIDDLE CATARACT CREEK	5134603.328	402820.0751	1	-	Low	-	-
24JF0489	UNCLE SAM GULCH	5130520.27	403188.3758	1	-	Low	-	-
24JF0490	UNCLE SAM GULCH	5130552.02	403588.4266	1	-	Low	-	-
24JF0515	UPPER BOULDER RIVER	5123554.306	406801.5331	1	-	Low	-	-
24JF0516	UPPER BOULDER RIVER	5124381.407	406075.119	1	-	Low	-	-
24JF0517	UPPER BOULDER RIVER	5123363.805	406337.9821	1	-	Low	-	-
24JF0520	LOWER BASIN CREEK	5127224.709	400856.395	1	-	Low	-	-
24JF0524	LOWER BASIN CREEK	5126612.328	401736.606	1	-	Low	-	-
24JF0525	LOWER BASIN CREEK	5127173.813	401092.8716	1	-	Low	-	-
24JF0676	MIDDLE CATARACT CREEK	5129821.768	404833.0291	1	-	Low	-	-
24JF0683	MIDDLE CATARACT CREEK	5130012.269	405175.9298	1	-	Low	-	-
24JF0696	MIDDLE CATARACT CREEK	5129986.869	405309.2801	1	-	Low	-	-
24JF0833	MIDDLE CATARACT CREEK	5132711.024	405722.0309	1	-	Low	-	-
24JF0890	LOWER BASIN CREEK	5128793.066	401435.7723	1	-	Low	-	-
ADA	MIDDLE CATARACT CREEK	5135081.462	403688.166	1	3.79	High	Y	MBMG (May 1995)
ADELAIDE	LOWER BASIN CREEK	5126586.427	401808.013	1	-	Low	Y	MBMG OFR 321
ADIT, MINE, WASTE ROCK DUMP	UPPER BASIN CREEK	5141004.387	399772.145	1	-	Low	Y	RTI Database
ALMA NO. 2	UPPER BASIN CREEK	5140969	400259.313	1	-	Low	-	-
ALPINE	MIDDLE CATARACT CREEK	5134658.126	402578.289	1	-	Low	N	AML Database 2000
ALSACE	UPPER CATARACT CREEK	5141525.832	404593.3	1	4.82	High	Y	AML Database 2000
AMERICAN EAGLE	UPPER CATARACT CREEK	5141174.297	403250.9376	1	-	Low	Y	RTI Database
APOLLO	MIDDLE CATARACT CREEK	5133874.11	406105.828	1	-	Low	Y	MBMG (May 1995)
ATLANTIC	LOWER CATARACT CREEK	5126883.746	405761.3765	1	-	Low	-	-
ATTWATER MILL	UPPER BOULDER RIVER	5124635.87	403289	1	-	-	-	-
BAKAMA	MIDDLE CATARACT CREEK	5136207.761	409062.727	2	-	Low	Y	MBMG (May 1995)
BASIN BELLE	LOWER BASIN CREEK	5126689	401313.313	1	-	Medium	Y	MBMG OFR 321
BASIN CREEK MINE	UPPER BASIN CREEK	5141709	400361.094	2	-	Medium	N	MBMG OFR 321

Table 2.3-1 Historical Mine Site Inventory, Previous Work, and Prioritization, Basin Watershed OU2

Mine Name	Subarea	(3) Easting	(3) Northing	No. of Areas Mined at Site	(1) Historical Scores	(2) Priority	Historical Work	Historical Reference
BASIN CREEK PLACER	LOWER BASIN CREEK	5127671.863	400375.072	1	-	Low	Y	MBMG Database
BASIN CREEK PLACER 1	MIDDLE BASIN CREEK	5129921.802	398535.9673	1	-	Low	Y	RTI Database
BASIN CREEK PLACER 2	MIDDLE BASIN CREEK	5131327.772	397792.7441	1	-	Low	Y	RTI Database
BASIN CREEK PLACER 3	MIDDLE BASIN CREEK	5132369.232	397432.9673	1	-	Low	Y	RTI Database
BASIN GOLD & SILVER	UNCLE SAM GULCH	5131765	402422.688	1	-	Low	Y	MBMG Database
BASIN HISTORIC DISTRICT	LOWER BASIN CREEK	5124913.208	402604.1746	1	-	Low	-	-
BASIN JIBE	UPPER BOULDER RIVER	5124987	401631	1	-	Low	-	-
BASIN MILLSITE	UPPER BOULDER RIVER	5124938	403288.625	1	3.98	High	Y	RTI Database
BASIN QUARTZ MASS	LOWER CATARACT CREEK	5125097	404392.406	1	-	Low	Y	MBMG Database
BASIN STREET TAILINGS	UPPER BOULDER RIVER	5124961.29	402416.86	1	-	-	-	-
BAZZER CLAIM	MIDDLE CATARACT CREEK	5134569.078	404986.687	1	-	Low	Y	MBMG Database
BEE CLAIM	MIDDLE CATARACT CREEK	5136755.982	407525.4345	1	-	Low	Y	RTI Database
BIG CHIEF	UPPER BASIN CREEK	5141288	400991.188	1	-	Low	-	-
BIG LUMBER GULCH	LOWER CATARACT CREEK	5126632	404950.813	1	-	Low	Y	MBMG Database
BIG MEDICINE	LOWER CATARACT CREEK	5126598.213	404442.236	1	-	Low	Y	RTI Database
BILLIE T.	MIDDLE CATARACT CREEK	5134360	408321.5	1	-	Low	Y	MBMG Database
BING HAMPTON	MIDDLE CATARACT CREEK	5134790.989	402892.98	1	-	Low	Y	AML Database 2000
BLACK BEAR	MIDDLE CATARACT CREEK	5133187.275	404255.178	2	-	Medium	Y	MBMG (May 1995)
BLUE DIAMOND / OCCIDENTAL	MIDDLE CATARACT CREEK	5134345.061	408995.819	1	-	Medium	Y	MBMG (May 1995)
BLUEBIRD	MIDDLE CATARACT CREEK	5134432	410001.5	2	-	Low	Y	RTI Database
BOSTON	LOWER CATARACT CREEK	5127856.295	404956.06	1	-	Low	Y	AML Database 2000
BOULDER CHIEF	MIDDLE CATARACT CREEK	5131430.147	406926.225	2	5.93	High	Y	MBMG (May 1995)
BOULDER VESTAL	LOWER CATARACT CREEK	5127190.648	404500.878	1	-	Low	Y	AML Database 2000
BUCKEYE MINE	UPPER BASIN CREEK	5138991.25	400588.7878	3	55.45	High	Y	MBMG OFR 321
BUCKEYE MINE (CATARACT)	LOWER CATARACT CREEK	5127861	405224.875	1	-	Low	-	-
BULLION MINE	JACK CREEK	5134423	400348.594	1	99.48	High	Y	MBMG OFR 321
BULLION SMELTER	JACK CREEK	5134576.779	398955.851	1	0.11	High	Y	MBMG OFR 321
BUSTER	LOWER BASIN CREEK	5125807	402369.813	1	-	Low	-	-
CALIFORNIA	LOWER CATARACT CREEK	5127768.72	405490.528	1	-	Low	Y	AML Database 2000
CAPTAIN COOK	MIDDLE CATARACT CREEK	5129916	405188.031	1	-	Low	Y	RTI Database
CARTWRIGHT CABINS	LOWER CATARACT CREEK	5128730.723	403073.077	1	-	Low	Y	RTI Database
CARTWRIGHT CABINS 2	LOWER CATARACT CREEK	5128774.016	403080.4256	1	-	Low	Y	RTI Database
CATARACT	MIDDLE CATARACT CREEK	5132491	405287	1	-	Medium	Y	MBMG (May 1995)
CATARACT CITY	UPPER BOULDER RIVER	5125164.466	403752.5128	1	-	Low	Y	RTI Database
CATARACT CREEK PLACER	MIDDLE CATARACT CREEK	5135650.572	406012.221	1	-	Low	Y	MBMG Database
CATARACT MEADOWS CORRAL	UPPER CATARACT CREEK	5138826.086	405487.0804	1	-	Low	Y	RTI Database
CATARACT PLACER	LOWER CATARACT CREEK	5124965.775	404136.46	1	-	Low	Y	RTI Database
CATERACT FLATS PLACER	LOWER CATARACT CREEK	5125537	403842.5	1	-	Low	Y	MBMG Database
CLEVELAND/DELBERT CLAIMS	UPPER BASIN CREEK	5135447.879	395930.3112	1	-	Low	-	-
CLIPPER	MIDDLE CATARACT CREEK	5132726	405185.5	1	-	Low	Y	RTI Database
CLIPPER / EDNA	MIDDLE CATARACT CREEK	5132508.408	405242.768	1	-	Low	Y	AML Database 2000
COLUMBUS	LOWER BASIN CREEK	5126809.231	401184.787	1	-	Low	Y	MBMG OFR 321
CONFIDENCE	UPPER BOULDER RIVER	5124723.14	403752.5128	1	-	Low	-	-

Table 2.3-1 Historical Mine Site Inventory, Previous Work, and Prioritization, Basin Watershed OU2

Mine Name	Subarea	(3) Easting	(3) Northing	No. of Areas Mined at Site	(1) Historical Scores	(2) Priority	Historical Work	Historical Reference
CORBITT	UPPER CATARACT CREEK	5141373.988	405658.571	1	-	Low	Y	AML Database 2000
CRACKER	MIDDLE CATARACT CREEK	5130727.3	404757.095	1	-	Medium	Y	MBMG (May 1995)
CREDEN MINES	LOWER BASIN CREEK	5125086.231	402816.811	1	-	Low	Y	MBMG Database
CRESCENT	UPPER CATARACT CREEK	5141595.142	404305.482	2	4.82	High	Y	MBMG (May 1995)
CRYSTAL	UNCLE SAM GULCH	5133703	402762	2	238.88	High	Y	MBMG (May 1995)
CRYSTAL GROUP	UPPER BASIN CREEK	5134297	396733.094	1	-	Low	Y	MBMG Database
CULLEN CLAIM	UPPER BASIN CREEK	5139835.738	402026.3235	1	-	Low	-	-
CUSTER	LOWER CATARACT CREEK	5128719	405711.406	2	-	Low	Y	AML Database 2000
DAILY WEST	LOWER BASIN CREEK	5127725	400196.188	2	-	Medium	Y	MBMG OFR 321
DEER LODGE	LOWER CATARACT CREEK	5127788.5	405152.219	2	-	Low	Y	AML Database 2000
DELGATE	JACK CREEK	5135046.245	398761.4821	1	-	Low	Y	RTI Database
DEW DROP	JACK CREEK	5135409.471	402847.243	1	-	Low	Y	RTI Database
DIMON	LOWER BASIN CREEK	5126206.356	402772.9232	1	-	Low	Y	RTI Database
DORIS	LOWER BASIN CREEK	5126250	401713.094	2	0.79	High	Y	MBMG OFR 321
DOROTHY SNOW	UPPER BASIN CREEK	5140177.399	401037.487	1	-	Low	Y	AML Database 2000
DOUBLE SHAFT	UPPER BASIN CREEK	5139198.649	401878.616	1	-	Medium	Y	MBMG OFR 321
DUMORTIERITE PROSPECT	JACK CREEK	5135464	399018.906	1	-	Low	Y	MBMG OFR 321
EDNA	MIDDLE CATARACT CREEK	5132447.353	405199.646	1	-	Low	Y	RTI Database
ELDORADO AND PLATEAU	UPPER CATARACT CREEK	5140612.78	406002.067	2	-	Medium	Y	MBMG (May 1995)
ELEPHANT	MIDDLE CATARACT CREEK	5132793.506	404677.8365	1	-	Low	Y	RTI Database
ELMER	LOWER CATARACT CREEK	5129575.5	403546.406	1	-	Low	Y	MBMG (May 1995)
ENTERPRISE MINE	UPPER BASIN CREEK	5138988	400594	1	245.76	High	Y	MBMG OFR 321
EVA MAY	MIDDLE CATARACT CREEK	5133515.482	405991.421	2	10.15	High	Y	MBMG (May 1995)
EVENING STAR	UNCLE SAM GULCH	5131575.917	403259.677	1	-	Low	Y	MBMG Database
FATHER MURPHY	LOWER CATARACT CREEK	5128347.5	405775.094	1	-	Low	Y	RTI Database
FINN'S CABIN AND SAUNA	LOWER BOULDER RIVER	5123263	409606.313	1	-	Low	Y	RTI Database
FIRST SHOT / LAST SHOT	JACK CREEK	5134601.353	402274.838	2	-	Low	Y	AML Database 2000
FOURTH OF JULY	MIDDLE CATARACT CREEK	5133794.968	405041.707	1	-	Low	Y	RTI Database
FREE SILVER	MIDDLE CATARACT CREEK	5135883.545	404249.4678	1	-	Low	Y	RTI Database
GARFIELD	UNCLE SAM GULCH	5130918.01	403622.695	2	-	Low	Y	AML Database 2000
GOLD FLAKE	LOWER CATARACT CREEK	5127251.964	405665.132	1	-	Low	Y	RTI Database
GOLD HILL	LOWER CATARACT CREEK	5127598.837	406605.1845	1	-	Low	-	-
GOLDEN ASSETS MINE	UNCLE SAM GULCH	5131535	403294.906	1	-	Low	Y	MBMG Database
GOLDEN GLOW	UPPER BASIN CREEK	5140833	401794.313	1	-	Low	Y	MBMG OFR 321
GRAY LEAD	MIDDLE CATARACT CREEK	5134527.128	404642.5287	1	-	Medium	Y	MBMG (May 1995)
GREAT SHIELD	MIDDLE CATARACT CREEK	5134824	404524	1	-	Low	N	MBMG (May 1995)
GRUB CREEK STATION	UPPER BASIN CREEK	5140501.907	400252.311	1	-	Low	Y	RTI Database
HANNA	MIDDLE CATARACT CREEK	5133022	404922.906	1	-	Low	Y	MBMG Database
HANSON	UPPER CATARACT CREEK	5137587.834	405855.3812	1	-	Low	-	-
HATTIE FERGUSON	MIDDLE CATARACT CREEK	5131599.927	404697.151	3	-	Medium	Y	MBMG (May 1995)
HAWKEYE MINE	JACK CREEK	5136752	401412	1	-	Medium	Y	MBMG OFR 321
HECTOR	LOWER BASIN CREEK	5127500	401345.906	2	-	Medium	Y	MBMG OFR 321
HECTOR - LOWER	LOWER BASIN CREEK	5127307.163	401181.7718	1	-	Medium	Y	MBMG OFR 321

Table 2.3-1 Historical Mine Site Inventory, Previous Work, and Prioritization, Basin Watershed OU2

Mine Name	Subarea	(3) Easting	(3) Northing	No. of Areas Mined at Site	(1) Historical Scores	(2) Priority	Historical Work	Historical Reference
HIAWATHA	LOWER CATARACT CREEK	5128633.5	405867.594	1	-	Low	Y	AML Database 2000
HIDDEN TREASURE	LOWER BASIN CREEK	5126715	401613.5	1	-	Low	N	MBMG (May 1995)
HIGHLAND	LOWER BASIN CREEK	5125864.7	401323.594	1	-	Low	Y	MBMG OFR 321
HOGBACK	LOWER CATARACT CREEK	5126303.33	404714.4249	1	-	Low	Y	RTI Database
HOLLAND	MIDDLE CATARACT CREEK	5134658.126	402578.289	1	-	Low	N	AML Database 2000
HOPE	LOWER BASIN CREEK	5129096.103	401681.1455	1	-	Low	-	-
HOPE/KATIE	UPPER BASIN CREEK	5124757.98	402068.49	1	-	-	-	-
HUOT	LOWER CATARACT CREEK	5129084	401840.406	1	-	Low	Y	RTI Database
IDA M.	MIDDLE CATARACT CREEK	5131699	406612.688	2	-	Medium	Y	MBMG (May 1995)
IDA MAY	UPPER CATARACT CREEK	5141378.483	405434.707	2	-	Low	Y	MBMG (May 1995)
INDEPENDENCE MINE	LOWER CATARACT CREEK	5127315	404168.938	1	-	Low	Y	MBMG Database
JACK CREEK RIDGE	JACK CREEK	5135624	398657.594	2	-	Low	Y	MBMG OFR 321
JACK CREEK TAILINGS	JACK CREEK	5135064	398926.594	1	1.22	High	Y	AML Database 2000
JACK MTN. IRON	JACK CREEK	5133282	400223.094	1	-	Low	Y	MBMG Database
JAMES	MIDDLE CATARACT CREEK	5134436	402666	1	-	Low	N	AML Database 2000
JESSIE	LOWER BASIN CREEK	5125777.092	400728.602	1	-	Low	Y	MBMG OFR 321
JIB SHAFT	UPPER BOULDER RIVER	5124755	401561.5	3	-	Low	Y	RTI Database
JOE BOWER'S MINE	UPPER BASIN CREEK	5136227.787	396040.3173	1	-	Low	Y	MBMG OFR 321
JOE METESH LESSEE	LOWER BASIN CREEK	5125405	402448.594	1	-	Low	Y	MBMG Database
JOHN T.	MIDDLE CATARACT CREEK	5134532	404207.156	1	-	Low	Y	MBMG (May 1995)
JOSEPHINE	UPPER BASIN CREEK	5141055.152	399248.494	2	26.80	High	Y	MBMG OFR 321
JUMBO	MIDDLE CATARACT CREEK	5132628.275	406636.791	1	-	Low	Y	MBMG (May 1995)
KATIE & KATIE EXTENSION	UPPER BOULDER RIVER	5125007.5	402441.063	1	-	Low	-	-
KELLER'S HEMATITE	JACK CREEK	5134784	399049.906	1	-	Low	Y	MBMG OFR 321
KLONDYKE	MIDDLE CATARACT CREEK	5132453	403822.813	1	-	Low	Y	MBMG (May 1995)
LADY HENNESSEY	UPPER BASIN CREEK	5141365.121	401374.899	2	-	Low	Y	RTI Database
LADY LANE	UPPER BASIN CREEK	5140833	401794.313	1	-	Low	Y	RTI Database
LADY LEITH	UPPER BASIN CREEK	5138357.44	401733.84	2	2.13	High	Y	MBMG OFR 321
LADY NELL	UPPER CATARACT CREEK	5136999	403317.594	1	2.13	High	Y	AML Database 2000
LADY RICKER	UPPER CATARACT CREEK	5140631.258	403372.062	1	-	-	-	-
LAPLATE	LOWER CATARACT CREEK	5129713.5	403901.188	1	-	Low	Y	RTI Database
LAST CHANCE	UPPER BOULDER RIVER	5124380.239	402592.048	1	-	Low	-	-
LAST SHOT	JACK CREEK	5135219.009	402717.2098	1	-	Low	Y	RTI Database
LINCOLN	UNCLE SAM GULCH	5134183.354	402379.026	1	-	Low	Y	RTI Database
LIZZIE	LOWER CATARACT CREEK	5127130.5	406050.031	1	-	Low	Y	RTI Database
LIZZIE OSBORNE	MIDDLE CATARACT CREEK	5133413.154	407403.725	2	-	Low	-	-
LOG CABIN AND STONE FIREPLACE	LOWER CATARACT CREEK	5128336	404905	1	-	Low	N	RTI Database
LONE STAR	LOWER BASIN CREEK	5125840.944	402678.5108	1	-	Low	N	RTI Database
LOTTA	UPPER BOULDER RIVER	5124754	401380.813	1	-	Low	-	-
LOUISE	LOWER CATARACT CREEK	5129449	402470.906	1	-	Low	Y	MBMG (May 1995)
LOWER DITCH	UPPER BASIN CREEK	5140706.469	400724.6011	1	-	Low	Y	RTI Database
LULA	LOWER BASIN CREEK	5125401.64	402248.3932	1	-	Low	Y	RTI Database
LULA BELL	UPPER BASIN CREEK	5140820	401841	1	-	Low	Y	MBMG OFR 321

Table 2.3-1 Historical Mine Site Inventory, Previous Work, and Prioritization, Basin Watershed OU2

Mine Name	Subarea	(3) Easting	(3) Northing	No. of Areas Mined at Site	(1) Historical Scores	(2) Priority	Historical Work	Historical Reference
LYONS PROSPECT	UPPER BASIN CREEK	5137362	396229.906	1	-	Low	Y	MBMG Database
MAGDELENA GROUP	UPPER BASIN CREEK	5138996.82	401608.095	1	-	Low	Y	MBMG Database
MAMMOTH	UNCLE SAM GULCH	5133531	402828	1	-	Low	N	AML Database 2000
MANHATTAN	LOWER CATARACT CREEK	5127944.317	405001.394	1	-	Low	Y	MBMG (May 1995)
MANTLE	LOWER CATARACT CREEK	5127105	404226.625	1	0.29	High	Y	MBMG Database
MANTLE SOUTH	LOWER CATARACT CREEK	5126475	404071.5	1	-	Low	Y	MBMG (May 1995)
MARGUERITE	LOWER CATARACT CREEK	5129089	401802.188	2	0.01	High	Y	MBMG OFR 321
MARSHALL-CHANGES MINES	MIDDLE CATARACT CREEK	5131476	405090.813	1	-	Low	Y	MBMG Database
MARY ANNE	MIDDLE CATARACT CREEK	5134346.713	402539.633	2	-	Low	Y	AML Database 2000
MAYFLOWER	LOWER BASIN CREEK	5125640	401594.688	1	-	Low	Y	RTI Database
MERRY WIDOW	UPPER BOULDER RIVER	5124584.69	403916.81	1	-	-	-	-
MEYERS GULCH	LOWER BASIN CREEK	5126373	401779.094	1	-	Low	Y	AML Database 2000
MIDDLE SNOWDRIFT CREEK	MIDDLE CATARACT CREEK	5135799.303	407382.36	1	-	Low	Y	AML Database 2000
MIDNIGHT	JACK CREEK	5135649.704	402284.7658	1	-	Low	Y	RTI Database
MIKE #14	MIDDLE CATARACT CREEK	5132538.061	404143.478	1	-	Low	Y	MBMG (May 1995)
MINNEAPOLIS	LOWER CATARACT CREEK	5127677.5	405072.281	2	-	Low	Y	MBMG (May 1995)
MINNEAPOLIS PLACER & PROSPECT	LOWER CATARACT CREEK	5126933	405044.844	1	-	Low	-	-
MOCCASON	JACK CREEK	5133973	401431.094	1	-	Low	Y	AML Database 2000
MOLLY SNOW	UPPER BASIN CREEK	5140174.587	400543.23	1	-	Low	Y	AML Database 2000
MONTANA	LOWER CATARACT CREEK	5126469.845	403792.7762	1	-	Low	Y	RTI Database
MONTANA CENTRAL RR ORE BINS	UPPER BOULDER RIVER	5123423	406370.813	1	-	Low	Y	RTI Database
MORNING	JACK CREEK	5135425.748	402161.118	2	-	Medium	Y	MBMG OFR 321
MORNING GLORY	LOWER CATARACT CREEK	5129948.768	403982.1274	1	-	Low	-	-
MORNING GLORY	MIDDLE CATARACT CREEK	5130094.819	404147.2277	2	2.13	High	Y	MBMG (May 1995)
MORNING MARIE	MIDDLE CATARACT CREEK	5130377.169	404364.63	1	-	Medium	Y	MBMG (May 1995)
MORNING STAR	UPPER BASIN CREEK	5136135.65	395913.858	1	-	Low	Y	MBMG OFR 321
MOUNTAIN CHIEF	MIDDLE CATARACT CREEK	5129905.063	405293.416	2	-	Medium	Y	MBMG (May 1995)
MT. THOMPSON	LOWER CATARACT CREEK	5129695	406089.438	1	-	Low	Y	MBMG Database
NE BASIN	LOWER CATARACT CREEK	5126022.5	403559.094	1	-	Low	-	-
NE NE SECTION 13	JACK CREEK	5135678	401010.188	1	-	Low	Y	AML Database 2000
NE NE SECTION 28	UPPER CATARACT CREEK	5141554	404204.5	1	-	Low	Y	AML Database 2000
NE NW SECTION 16 (51)	MIDDLE CATARACT CREEK	5135429	404960.406	1	-	Low	Y	AML Database 2000
NE NW SECTION 17	MIDDLE CATARACT CREEK	5135126.826	403280.15	1	-	-	-	-
NE NW SECTION 3	LOWER CATARACT CREEK	5128859	406569.188	1	-	Low	Y	AML Database 2000
NE SE SECTION 14	MIDDLE CATARACT CREEK	5133744.05	408462.1	1	-	-	-	-
NE SE SECTION 28	UPPER CATARACT CREEK	5140732.099	405464.239	1	-	-	-	-
NE THREE BROTHERS	UPPER CATARACT CREEK	5138995	404011.688	1	-	Low	Y	AML Database 2000
NEAR BOULDER VESTAL	LOWER CATARACT CREEK	5126981.242	404798.515	1	-	-	-	-
NEAR QUARTZ CREEK	UPPER CATARACT CREEK	5140933.833	402979.671	1	-	-	-	-
NEPTUNE	UPPER BASIN CREEK	5140365.811	400888.686	1	-	Low	Y	RTI Database
NEPTUNE CABINS	UPPER BASIN CREEK	5140464.39	400769.021	1	-	Low	Y	RTI Database
NEW COTTAGE	LOWER CATARACT CREEK	5127669.448	405055.951	1	-	Low	Y	AML Database 2000
NORTH ADA - PIERMONT	UPPER CATARACT CREEK	5135865.342	403247.731	1	-	Medium	Y	MBMG OFR 321

Table 2.3-1 Historical Mine Site Inventory, Previous Work, and Prioritization, Basin Watershed OU2

Mine Name	Subarea	(3) Easting	(3) Northing	No. of Areas Mined at Site	(1) Historical Scores	(2) Priority	Historical Work	Historical Reference
NW NE SECTION 32	UNCLE SAM GULCH	5130633.139	403466.38	1	-	Low	Y	RTI Database
NW SE SECTION 14	MIDDLE CATARACT CREEK	5133806.317	407978.576	1	-	-	-	-
NW SW SECTION 27	UPPER CATARACT CREEK	5140508	406000.406	1	-	Low	Y	AML Database 2000
NW SW SECTION 29	UNCLE SAM GULCH	5131081	402753.688	1	-	Low	Y	AML Database 2000
OBELISK	UPPER BOULDER RIVER	5124919.558	405087.0296	1	-	Low	Y	RTI Database
OLD BALDY GROUP	UPPER BASIN CREEK	5141666	401107.5	1	-	Low	Y	MBMG Database
OLD BASIN MILLSITE	UPPER BOULDER RIVER	5124774	401347.094	2	9.59	High	Y	AMRB 1994 Project Report
OUSLEY	UPPER CATARACT CREEK	5140305	405143.313	1	-	Low	Y	AML Database 2000
OVERLAND CREEK	UPPER CATARACT CREEK	5136830.258	404869.329	1	-	Medium	Y	MBMG (May 1995)
PEARL	UPPER BASIN CREEK	5139470	398487.875	1	-	Low	Y	MBMG OFR 321
PEN YAN	MIDDLE CATARACT CREEK	5134465	409517.813	1	-	Low	Y	AML Database 2000
PENN PLACER	MIDDLE BASIN CREEK	5131883.171	397522.5912	1	-	Low	Y	RTI Database
PERRY PARKS	UPPER BASIN CREEK	5139399	399959.5	2	0.005	High	Y	MBMG OFR 321
PHANTOM	LOWER CATARACT CREEK	5129593.679	403872.871	1	-	Medium	Y	MBMG (May 1995)
PIRATE	LOWER CATARACT CREEK	5127169.21	403779.9803	1	-	Low	Y	RTI Database
PLACER	UPPER BASIN CREEK	5139210.16	401935.054	1	-	Low	Y	AML Database 2000
PLACER 2313	LOWER CATARACT CREEK	5125971	403742.313	1	-	Low	Y	AML Database 2000
PLACER 2623	LOWER CATARACT CREEK	5128138.691	404990.8489	1	-	Low	Y	RTI Database
PLACER DITCH	UPPER BASIN CREEK	5139156.545	400491.531	1	-	Low	Y	RTI Database
PROTECTION	LOWER CATARACT CREEK	5128124	405557.594	1	-	Low	Y	RTI Database
QUARTZ CREEK	UPPER CATARACT CREEK	5140953	403188.594	1	-	Low	-	-
RED BIRD	MIDDLE CATARACT CREEK	5133411.112	404955.9654	1	-	Low	Y	RTI Database
REDEMPTION	LOWER CATARACT CREEK	5127621	402912.5	1	-	Low	Y	MBMG Database
REDEMPTION	LOWER CATARACT CREEK	5129620.5	406592.969	1	-	Low	Y	RTI Database
REDWING	LOWER CATARACT CREEK	5128830.398	406298.252	1	-	Medium	-	-
ROBIE BURNS	MIDDLE CATARACT CREEK	5132945.991	405307.8602	1	-	Low	Y	RTI Database
ROCKER	MIDDLE CATARACT CREEK	5135279.47	404112.224	1	3.79	High	Y	MBMG (May 1995)
ROCKER EXTENSION	MIDDLE CATARACT CREEK	5135044.142	403945.138	1	-	Medium	Y	MBMG (May 1995)
ROCKER WETLAND	MIDDLE CATARACT CREEK	5135463.97	405531.1	1	-	-	-	-
ROCKY POINT	MIDDLE CATARACT CREEK	5134654	403788.656	1	-	Low	Y	RTI Database
ROSE MINE	LOWER CATARACT CREEK	5126522	403968.469	2	-	Low	Y	MBMG Database
RTI RECON: A	LOWER BASIN CREEK	5126109.703	401934.816	1	-	Low	-	-
RTI RECON: E	JACK CREEK	5133424.389	396811.1638	1	-	Low	-	-
RTI RECON: O	JACK CREEK	5134065.74	397839.8658	1	-	Low	-	-
RTI RECON: P	JACK CREEK	5134606.862	400126.539	1	-	Low	-	-
RTI RECON: R	LOWER BASIN CREEK	5128375.836	399560.084	1	-	Low	-	-
RUBY DIGGINGS	UPPER BASIN CREEK	5141321.641	401473.8724	1	-	Low	-	-
RUTH	LOWER CATARACT CREEK	5126435.537	404158.306	2	-	Low	Y	MBMG Database
SAGINAW	LOWER CATARACT CREEK	5129504	404385.281	1	-	Low	-	-
SAINT LAWRENCE	UNCLE SAM GULCH	5133775.002	402258.308	1	-	Low	Y	MBMG (May 1995)
SAINT NICK	MIDDLE CATARACT CREEK	5132579	403632.688	1	-	Low	Y	MBMG (May 1995)
SATURDAY NIGHT	LOWER CATARACT CREEK	5128317.748	403440.8	1	-	Low	Y	MBMG (May 1995)
SE NE SECTION 28	UPPER CATARACT CREEK	5140782	405022.313	1	-	Low	-	-

Table 2.3-1 Historical Mine Site Inventory, Previous Work, and Prioritization, Basin Watershed OU2

Mine Name	Subarea	(3) Easting	(3) Northing	No. of Areas Mined at Site	(1) Historical Scores	(2) Priority	Historical Work	Historical Reference
SE NW SECTION 30	UPPER BASIN CREEK	5140921.553	402025.703	1	-	Low	Y	AML Database 2000
SE SE SECTION 21	UPPER CATARACT CREEK	5142449	405048.313	1	-	Low	-	-
SE SE SECTION 25	UPPER BASIN CREEK	5140408.139	400741.914	1	-	Low	-	-
SE SE SECTION 35	UPPER BASIN CREEK	5138939.036	399211.024	1	-	Low	Y	AML Database 2000
SE SW SECTION 2	MIDDLE CATARACT CREEK	5136867	407867.406	1	-	Low	Y	AML Database 2000
SE SW SECTION 28	MIDDLE CATARACT CREEK	5130738	404843.813	1	-	Low	Y	AML Database 2000
SE SW SECTION 32	LOWER BASIN CREEK	5124812	402867.813	1	-	Low	Y	AML Database 2000
SEATTLE	LOWER CATARACT CREEK	5127669.448	405055.951	1	-	Low	Y	MBMG (May 1995)
SELF - RISER	LOWER CATARACT CREEK	5128414	405492.813	1	-	Low	Y	AML Database 2000
SILICA QUARTZ MINE	UPPER BOULDER RIVER	5140916.799	401845.59	1	-	Low	Y	RTI Database
SILVER REEF	LOWER CATARACT CREEK	5126127.073	404311.3816	1	-	Low	-	-
SIRIUS	MIDDLE CATARACT CREEK	5132278.023	404181.096	1	-	Medium	Y	MBMG (May 1995)
SMELTER CREEK ADIT	Jack Creek	5134529	399214.813	1	-	Low	-	-
SNOWBIRD	UNCLE SAM GULCH	5134299.07	402853.479	1	-	Low	-	-
SOLAR	UPPER BASIN CREEK	5139514.5	398680	2	-	Low	Y	MBMG OFR 321
SPARKING WATER	UNCLE SAM GULCH	5133701	402966.313	2	-	Low	Y	MBMG (May 1995)
SW NW SECTION 28	MIDDLE CATARACT CREEK	5131667	404687.313	1	-	Low	Y	AML Database 2000
SW NW SECTION 29	UNCLE SAM GULCH	5131878.209	402754.375	1	-	Low	Y	AML Database 2000
SW NW SECTION 7	JACK CREEK	5136752	401412	1	-	Low	Y	AML Database 2000
SW SE SECTION 1	LOWER BASIN CREEK	5127753	400388.906	1	-	Low	Y	AML Database 2000
SW SE SECTION 29	UNCLE SAM GULCH	5131534	403401.813	1	-	Low	Y	AML Database 2000
SW SE SECTION 4	UPPER CATARACT CREEK	5137181.093	405188.804	1	-	-	-	-
T&B	UPPER BASIN CREEK	5141296.241	401188.1218	1	-	Low	-	-
TIMBERLINE	MIDDLE CATARACT CREEK	5133962.284	408792.565	1	-	-	-	-
TOTTEN MINE	MIDDLE CATARACT CREEK	5132785	408276	1	-	Low	Y	MBMG Database
UNCLE SAM	UNCLE SAM GULCH	5130937.037	403525.684	1	-	Medium	Y	MBMG (May 1995)
UNNAMED 001	MIDDLE CATARACT CREEK	5134206.432	406083.568	1	-	Medium	Y	MBMG (May 1995)
UNNAMED 002	MIDDLE CATARACT CREEK	5134868.048	405297.653	1	-	Medium	Y	MBMG (May 1995)
UNNAMED 003	MIDDLE CATARACT CREEK	5133588	404534.813	1	-	Low	Y	MBMG (May 1995)
UNNAMED 004	MIDDLE CATARACT CREEK	5134705.867	405194.15	1	-	Medium	Y	MBMG (May 1995)
UNNAMED FIRE CLAY	JACK CREEK	5134849	398795	1	-	Low	N	MBMG OFR 321
UNNAMED LEAD & SILVER	LOWER CATARACT CREEK	5126770	405981.094	1	-	Low	Y	MBMG Database
UNNAMED PLACER	UPPER BASIN CREEK	5136594	396046	1	-	Low	Y	MBMG Database
UNNAMED QUARRY	UPPER BASIN CREEK	5135733	395838.688	1	-	Low	Y	MBMG Database
UNNAMED SILVER; LEAD; & ZINC	LOWER BASIN CREEK	5128437	400100.906	1	-	Low	Y	MBMG Database
UPPER DITCH	UPPER BASIN CREEK	5141028.783	401080.8643	1	-	Low	-	-
VANDALIA	MIDDLE CATARACT CREEK	5137470	408794.906	1	-	Low	-	-
VENUS	UPPER BASIN CREEK	5140997.791	400902.3712	1	-	Low	Y	MBMG OFR 321
VERA AND MARIE	MIDDLE CATARACT CREEK	5130516.869	404440.081	2	-	Medium	Y	MBMG (May 1995)
VICTORY	LOWER CATARACT CREEK	5126951.104	405112.716	1	-	Low	-	-
VINDICATOR	JACK CREEK	5136077.289	401259.787	2	-	Medium	Y	MBMG OFR 321
VIOLA	LOWER CATARACT CREEK	5128761.298	403874.6641	1	-	Low	-	-
VIRGINIA	LOWER CATARACT CREEK	5127788.5	405152.219	1	-	Low	Y	AML Database 2000

Table 2.3-1 Historical Mine Site Inventory, Previous Work, and Prioritization, Basin Watershed OU2

Mine Name	Subarea	(3) Easting	(3) Northing	No. of Areas Mined at Site	(1) Historical Scores	(2) Priority	Historical Work	Historical Reference
VOGEL	LOWER CATARACT CREEK	5127791.336	405490.56	1	-	-	-	-
WALDY	LOWER CATARACT CREEK	5128949.311	406306.109	1	-	Medium	-	-
WALDY NORTH	LOWER CATARACT CREEK	5129692	406328.125	1	-	Low	-	-
WEST MOUNT THOMPSON	MIDDLE CATARACT CREEK	5130606	406006.125	1	-	Low	Y	AML Database 2000
WHITE PINE	LOWER CATARACT CREEK	5128654	404924.281	2	-	Low	Y	AML Database 2000
WINTER'S CAMP	UPPER BASIN CREEK	5135918.091	395911.8435	2	-	Medium	Y	MBMG OFR 321

(1) - Historical scoring presents results of Abandoned and Inactive Mines Scoring System (AIMSS) by Montana Department of Environmental Quality. The lower the score, the less potential for detrimental environmental impacts.

(2) - Mine sites are selected as high priority when they were scored by AIMSS, selected as medium if they were labeled as potential sources by Montana Bureau of Mines and Geology

(3) - Coordinates are reported in Universal Transverse Mercator (UTM), Zone 12, North American Datum (NAD) 1983. Coordinates for main area of mine are reported when there is more than 1 area at the site

† - Coordinates based on section centerpoint

* - Selected by MBMG as mines that may pose environmental problems to USFS administered land

** - Selected by MBMG as mines that may pose environmental problems to BLM land

_ - No historical data available

Y - Yes

N - No

AML - Abandoned Mine Lands

BLM - Bureau of Land Management

OFR - Open File Report

RTI - Renewable Technologies, Incorporated

USFS - United States Forest Service

Table 2.4-1 Abandoned Mine Sites Categorized by Vein Groups, Basin Watershed OU2

Mine Name	Vein Grouping
Basin Creek AOC Vein Grouping	
Solar	Vein Group 1
Pearl	
Morning Star	Vein Group 2
Winter's Camp	
Joe Bower's	
Morning	Vein Group 3
Dew Drop	
First Shot Last Shot	
Bullion Mine	Vein Group 4
Mocassin	
Cataract Creek AOC Vein Grouping	
Redwing	Vein Group 5
Waldy	
Boston	Vein Group 6
California	
Deer Lodge	
Manhattan	
Minneapolis	
New Cottage	
Virginia	
Independence Mine	Vein Group 7
Boulder Vestal	
24JF0240	Vein Group 8
24JF0241	
Ruth	
North Ada - Piermont	Vein Group 9
Free Silver	
Crystal	Vein Group 10
Mammoth	
Sparking Water	
Black Bear	Vein Group 11
Eva May	
Red Bird	
Unnamed 003	
Blue Diamond/Occidental	Vein Group 12
Billie T	
Pen Yan	
Cataract	Vein Group 13
Cataract Tails	
Clipper	
Clipper / Edna	
Edna	
Klondyke	
Mike #14	
Saint Nick	
Sirius	
Boulder Chief	Vein Group 14
Ida M.	
24JF0683	Vein Group 15
Mountain Chief	
Waldy North	
Laplate	Vein Group 16
Phantom	
Regalia	
Saginaw	

Table 2.4-2 Abandoned Mine Sites Selected for Priority Characterization vs Actual Mine Sites Investigated

Watershed	Mine Name	Mine Site Identification Number	Mine Subarea	Samples Planned for Collection Fall 2001	Actual Samples Collected Fall 2001	Comments
Basin Creek	24JF0520	613	Main	W	None	No longer there
Basin Creek	24JF0524	616	Main	W	W	
Basin Creek	24JF0525	614	Main	W	None	No longer there
Basin Creek	ADELAIDE	1	Main	W	W	
Basin Creek	ADIT, MINE, WASTE ROCK DUMP	2	Main	None	W	Added to evaluation during RI
Basin Creek	AURORA	5	Area 2	W	W	
Basin Creek	BASIN CREEK PLACER	9	Main	W	W	
Basin Creek	BUCKEYE MINE [1][A]	247	Main	A, R	None	Remediated
Basin Creek	BULLION MINE [1][A]	251	Main	A, R	A	
Basin Creek	BULLION SMELTER [3][A]	252	Main	A, R	A, W	Sampled by USFS
Basin Creek	BUSTER	253	Main	W	None	No access granted
Basin Creek	CLEVELAND/DELBERT CLAIMS	588	Main	W	None	No access granted
Basin Creek	COLUMBUS	254	Main	W	W	
Basin Creek	CREDEN MINES	314	Main	W	None	Identified as low impact and not sampled
Basin Creek	CULLEN CLAIM	595	Main	W	None	Identified as low impact and not sampled
Basin Creek	DAILY WEST	256	Main	None		Sampled by USFS
Basin Creek	DELGATE	258	Main	W	None	No access granted
Basin Creek	DEW DROP	338	Main	W	W	
Basin Creek	DOROTHY SNOW	262	Main	W	W, GW	
Basin Creek	DOUBLE SHAFT	263	Main	A, W	W	
Basin Creek	ENTERPRISE MINE [A]	266	Main	A, R	None	Remediated
Basin Creek	FIRST SHOT LAST SHOT	94	Main	W	A, W	
Basin Creek	GOLDEN GLOW	267	Main	W	None	No access granted
Basin Creek	GRUB CREEK STATION	268	Main	W	W	
Basin Creek	HAWKEYE MINE [4]	269	Main	A, W	None	No access granted
Basin Creek	HECTOR	270	Main	None		Sampled by USFS
Basin Creek	HECTOR - LOWER	296	Main	None		Sampled by USFS
Basin Creek	HIDDEN TREASURE	100	Main	W	None	No longer there
Basin Creek	JACK CREEK TAILINGS	276	Main	W	None	No access granted
Basin Creek	JACK MTN. IRON	317	Main	W	None	Not located
Basin Creek	JESSIE	277	Main	W	W	
Basin Creek	JOE BOWER'S MINE	281	Main	A, W	None	No access granted
Basin Creek	JOE METESH LESSEE	282	Main	W	None	No access granted
Basin Creek	JOSEPHINE [A]	283	Main	A, R	A, W, GW	
Basin Creek	LADY HENESSEY	287	Main	None	W	Added to evaluation during RI
Basin Creek	LADY LANE	353	Main	W	None	No access granted
Basin Creek	LADY LEITH [2][A]	289	Main	A, R	A, W	Sampled by USFS
Basin Creek	LAST SHOT	355	Main	W	None	No access granted
Basin Creek	LOWER DITCH	295	Main	W	None	Removed by Basin Creek Mine
Basin Creek	LULA	359	Main	W	None	No access granted
Basin Creek	LULA BELL	297	Main	W	None	No longer there
Basin Creek	MAGDELENA GROUP	299	Main	W	W	
Basin Creek	MEYERS GULCH	302	Main	W	W	
Basin Creek	MOLLY SNOW	304	Main	W	W	
Basin Creek	MORNING [3]	305	Main	A, W	None	Sampled by USFS
Basin Creek	MORNING STAR	307	Main	None	A, W	Added to evaluation during RI
Basin Creek	NEPTUNE	18	Main	W	W	
Basin Creek	PENN PLACER	370	Main	W	None	No access granted
Basin Creek	PERRY PARKS [A]	26	Main	W, R	None	No access granted
Basin Creek	PLACER	28	Main	W	W	
Basin Creek	PLACER DITCH	29	Main	W	None	No access granted
Basin Creek	RTI RECON: A	619	Main	W	None	No access granted
Basin Creek	RTI RECON: E	602	Main	W	None	No access granted
Basin Creek	RTI RECON: O	594	Main	W	None	No access granted
Basin Creek	RTI RECON: P	592	Main	W	A, W	
Basin Creek	RTI RECON: R	611	Main	W	W	
Basin Creek	SE NW SECTION 30	321	Main	W	A, W	
Basin Creek	SE SE SECTION 25	32	Main	W	None	Not located
Basin Creek	SE SE SECTION 35	322	Main	W	W	
Basin Creek	SE SW SECTION 32	325	Main	W	None	Not located
Basin Creek	SMELTER CREEK ADIT	509	Main	W	A	Waste remediated
Basin Creek	SOLAR	33	Main	W	None	No access granted
Basin Creek	SW NW SECTION 7	35	Main	W	None	No access granted
Basin Creek	SW SE SECTION 1	326	Main	W	None	Not located
Basin Creek	UNNAMED FIRE CLAY	36	Main	W	None	No access granted
Basin Creek	UNNAMED PLACER	37	Main	W	None	No access granted
Basin Creek	UNNAMED QUARRY	38	Main	W	None	No access granted

[A] Designates historical radioactive material screening measurements above 0.03 millirems/hour.

[1], [2], [3] Mines proposed for remediation by the US Forest Service during 2001, 2002, 2003 respectively.

[4] Mines proposed for remediation by the US Forest Service during a future cleanup.

A - Adit sample

S - Seep sample

W - Waste rock sample

R - Radiation sample

GW - Groundwater sample

Table 2.4-2 Abandoned Mine Sites Selected for Priority Characterization vs Actual Mine Sites Investigated

Watershed	Mine Name	Mine Site Identification Number	Mine Subarea	Samples Planned for Collection Fall 2001	Actual Samples Collected Fall 2001	Comments
Basin Creek	UNNAMED URANIUM	40	Main	W	None	In Tenmile Creek watershed
Basin Creek	UPPER DITCH	41	Main	W	None	Removed by Basin Creek mine
Basin Creek	VENUS	42	Main	W	None	Removed by Basin Creek mine
Basin Creek	VINDICATOR [3]	43	Main	A	A	
Basin Creek	WASTE ROCK DUMP	45	Main	W	None	In Tenmile Creek watershed
Basin Creek	WINTER'S CAMP [4]	46	Main	A, W	None	No access granted
Boulder River	24JF0185	623	Main	W	None	No longer there
Boulder River	24JF0188	621	Main	W	None	No longer there
Boulder River	24JF0515	628	Main	W	None	No longer there
Boulder River	24JF0516	625	Main	W	None	No longer there
Boulder River	24JF0517	630	Main	W	None	No longer there
Boulder River	BASIN MILL SITE [A]	13	Main	R	None	Sampled during Basin OU1 program
Boulder River	CATARACT CITY	335	Main	W	None	Identified as low impact and not sampled
Boulder River	CONFIDENCE	622	Main	W	None	No access granted
Boulder River	JIB SHAFT	278	Main	W	None	No access granted
Boulder River	LAST CHANCE	624	Main	W	None	No access granted
Boulder River	LOTTA	294	Main	W	None	No access granted
Boulder River	MERRY WIDOW	704	Main	None	A	Added to evaluation during RI
Boulder River	MONTANA CENTRAL RR ORE BINS	363	Main	W	None	Identified as low impact and not Sampled
Boulder River	OBELISK	366	Main	W	None	No access granted
Boulder River	SILICA QUARTZ MINE	391	Main	W	None	Identified as low impact and not sampled
Cataract Creek	24JF0131	591	Main	W	None	No access granted
Cataract Creek	24JF0249	597	Main	W	None	No longer there
Cataract Creek	24JF0444	593	Main	W	None	No access granted
Cataract Creek	24JF0490	604	Main	W	None	Identified as low impact and not sampled
Cataract Creek	ADA	48	Main	A	A	
Cataract Creek	ALPINE	394	Main	W	A, W	
Cataract Creek	ALSACE	49	Main	W	W, GW	
Cataract Creek	AMERICAN EAGLE	50	Main	W	None	No longer there
Cataract Creek	APOLLO	51	Main	W	A, W, GW	
Cataract Creek	BAKAMA	52	Main	W	W	
Cataract Creek	BASIN QUARTZ MASS	54	Main	W	None	No access granted
Cataract Creek	BAZZER CLAIM	55	Main	W	None	No access granted
Cataract Creek	BEE CLAIM	56	Main	W	None	No access granted
Cataract Creek	BIG MEDICINE	332	Main	W	W	
Cataract Creek	BING HAMPTON	59	Main	W	A, W	
Cataract Creek	BLACK BEAR	60	Main	A, W	None	Sampled Area 2
Cataract Creek	BLACK BEAR	61	Area 2	A, W	A, W	Sampled by USFS
Cataract Creek	BLUE DIAMOND/OCCIDENTAL	62	Main	A, W	A, W	
Cataract Creek	BOSTON	63	Main	None	W	Added to evaluation during RI
Cataract Creek	BOULDER CHIEF [A]	64	Main	R	R	
Cataract Creek	BOULDER VESTAL	66	Main	None	W	Added to evaluation during RI
Cataract Creek	CALIFORNIA	67	Main	None	GW	Added to evaluation during RI
Cataract Creek	CARTWRIGHT CABINS	68	Main	W	None	
Cataract Creek	CARTWRIGHT CABINS 2	69	Main	W	A, W, GW	
Cataract Creek	CATARACT	70	Main	None	A	Added to evaluation during RI
Cataract Creek	CATARACT CREEK PLACER	313	Main	W	None	Identified as low impact and not sampled
Cataract Creek	CATARACT PLACER	73	Main	W	W	
Cataract Creek	CATARACT TAILS	74	Main	W	W, GW	
Cataract Creek	CATERACT FLATS PLACER	71	Main	W	None	Identified as low impact and not sampled
Cataract Creek	CLIPPER / EDNA (COPPER KING)	76	Main	None	W	Added to evaluation during RI
Cataract Creek	CORBITT	77	Main	W	A, W, GW	
Cataract Creek	CRACKER	78	Main	A	A, W	Also sampled by USFS
Cataract Creek	CRESCENT [A]	79	Main	A, W, R	A	Also sampled by USFS
Cataract Creek	CRYSTAL	82	Main	None	A	
Cataract Creek	CRYSTAL [A]	83	Area 2	A, R	A	Added to evaluation during RI
Cataract Creek	EDNA	339	Main	None	W	Added to evaluation during RI
Cataract Creek	ELDORADO AND PLATEAU	88	Main	S, W	A, W, GW	
Cataract Creek	EVA MAY [A]	91	Main	A, R	A, W, GW	
Cataract Creek	EVENING STAR	93	Main	W	W	
Cataract Creek	FATHER MURPHY	343	Main	W	None	No access granted
Cataract Creek	FOURTH OF JULY	345	Main	W	W	
Cataract Creek	FREE SILVER	346	Main	W	None	Identified as low impact and not sampled
Cataract Creek	GARFIELD	347	Main	W	A, W	
Cataract Creek	GOLD FLAKE	349	Main	W	W	
Cataract Creek	GOLDEN ASSETS MINE	316	Main	W	None	No access granted
Cataract Creek	GRAY LEAD	96	Main	A, W	None	Sampled by USFS

[A] Designates historical radioactive material screening measurements above 0.03 millirems/hour.

[1], [2], [3] Mines proposed for remediation by the US Forest Service during 2001, 2002, 2003 respectively.

[4] Mines proposed for remediation by the US Forest Service during a future cleanup.

A - Adit sample

S - Seep sample

W - Waste rock sample

R - Radiation sample

GW - Groundwater sample

Table 2.4-2 Abandoned Mine Sites Selected for Priority Characterization vs Actual Mine Sites Investigated

Watershed	Mine Name	Mine Site Identification Number	Mine Subarea	Samples Planned for Collection Fall 2001	Actual Samples Collected Fall 2001	Comments
Cataract Creek	GREAT SHIELD	97	Main	W	None	No access granted
Cataract Creek	HANNA	98	Main	W	None	No access granted
Cataract Creek	HATTIE FERGUSON	101	Main	A, W	A	
Cataract Creek	HOLLAND	393	Main	W	W	
Cataract Creek	IDA M.	106	Main	A, W	None	No access granted
Cataract Creek	IDA MAY	108	Main	None	W	Added to evaluation during RI
Cataract Creek	INDEPENDENCE MINE	110	Main	W	None	No access granted
Cataract Creek	JAMES	111	Main	W	A	
Cataract Creek	JOHN T.	112	Main	W	None	No access granted
Cataract Creek	JUMBO	113	Main	None	W	Added to evaluation during RI
Cataract Creek	KLONDYKE	114	Main	W	W, GW	
Cataract Creek	LADY RICKER	705	Main	None	A, W	Added to evaluation during RI
Cataract Creek	LINCOLN	356	Main	W	None	Same vein as Marry Anne
Cataract Creek	LIZZIE OSBORNE	116	Main	W	W	
Cataract Creek	LOG CABIN AND STONE FIREPLACE	292	Main	W	None	No access granted
Cataract Creek	LOWER HATTIE FERGUSON	102	Main	None	W, GW	Added to evaluation during RI
Cataract Creek	MANHATTAN	121	Main	A, W	W	
Cataract Creek	MARY ANNE	125	Main	W	W	
Cataract Creek	MIDDLE SNOWDRIFT CREEK	127	Main	W	W	
Cataract Creek	MIKE #14	128	Main	A, W	W	
Cataract Creek	MINNEAPOLIS	129	Main	A, W	A, W	
Cataract Creek	MORNING GLORY [A]	132	Tailings	None	None	Sampled by USFS
Cataract Creek	MORNING GLORY [A]	131	Main	W, R	R	Sampled by USFS
Cataract Creek	MORNING MARIE	133	Main	A, W	A, W	
Cataract Creek	MOUNTAIN CHIEF	134	Main	A, W	None	Identified as low impact and not sampled
Cataract Creek	MT. THOMPSON	136	Main	W	None	Identified as low impact and not sampled
Cataract Creek	NE BASIN	510	Main	W	None	No access granted
Cataract Creek	NE NE SECTION 28	137	Main	W	None	Identified as low impact and not sampled
Cataract Creek	NE NW SECTION 17	706	Main	None	W, GW	Added to evaluation during RI
Cataract Creek	NE SE SECTION 14	703	Main	None	A, W	Added to evaluation during RI
Cataract Creek	NEAR BOULDER VESTAL	707	Main	None	GW	Added to evaluation during RI
Cataract Creek	NEW COTTAGE	140	Main	None	A, W	Initially identified as Minneapolis mine
Cataract Creek	NORTH ADA - PIERMONT [3]	20	Main	S	W	No flow available for sampling
Cataract Creek	NW SW SECTION 27	319	Main	W	None	Not located
Cataract Creek	OUSLEY	141	Main	W	None	Not located
Cataract Creek	OVERLAND CREEK	142	Main	W	A, W, GW	
Cataract Creek	PHANTOM	144	Main	A, W	A	Sampled by USFS
Cataract Creek	PLACER 2313	30	Main	W	None	No access granted
Cataract Creek	PROTECTION	146	Main	W	None	No access granted
Cataract Creek	QUARTZ CREEK	147	Main	W	A, W	
Cataract Creek	REDEMPTION	149	Main	W	None	No access granted
Cataract Creek	REDWING	150	Main	A	A	
Cataract Creek	ROCKER [A]	152	Main	A, R	A	
Cataract Creek	ROCKER EXTENSION	153	Main	A	A	
Cataract Creek	ROCKER WETLAND	708	Main	None	W	Added to evaluation during RI
Cataract Creek	ROCKY POINT	375	Main	W	None	No access granted
Cataract Creek	RUTH	156	Main	W	W	
Cataract Creek	SAINT LAWRENCE	158	Main	W	GW	
Cataract Creek	SATURDAY NIGHT	160	Main	W	W	
Cataract Creek	SE NE SECTION 28	163	Main	W	None	Identified as low impact and not sampled
Cataract Creek	SEATTLE	161	Main	W	A, W	
Cataract Creek	SIRIUS	164	Main	A, W	A, W	Also sampled by USFS
Cataract Creek	SNOWBIRD	381	Main	W	A, W	
Cataract Creek	SW NW SECTION 29	105	Main	W	W	
Cataract Creek	SW SE SECTION 29	327	Main	W	None	Not located
Cataract Creek	SW SE SECTION 4	701	Main	None	A, W	Added to evaluation during RI
Cataract Creek	SYLVAN	167	Main	W	A, W	
Cataract Creek	TIMBERLINE	702	Main	None	A, W	Added to evaluation during RI
Cataract Creek	TOTTEN MINE	168	Main	W	None	Identified as low impact and not Sampled
Cataract Creek	UNCLE SAM	169	Main	S, W	W	
Cataract Creek	UNNAMED 001	171	Main	S, W	A, W	
Cataract Creek	UNNAMED 002	172	Main	A, W	A, W	
Cataract Creek	UNNAMED 004	174	Main	A, W	A, W	
Cataract Creek	VERA AND MARIE	175	Main	S, W	W	
Cataract Creek	VOGEL	241	Main	None	A, W	Added to evaluation during RI
Cataract Creek	WALDY	177	Main	A	A	
Cataract Creek	WALDY NORTH	178	Main	A	None	No access granted

[A] Designates historical radioactive material screening measurements above 0.03 millirems/hour.

[1], [2], [3] Mines proposed for remediation by the US Forest Service during 2001, 2002, 2003 respectively.

[4] Mines proposed for remediation by the US Forest Service during a future cleanup.

A - Adit sample

S - Seep sample

W - Waste rock sample

R - Radiation sample

GW - Groundwater sample

Table 2.4-3 Fall 2001 Sampling Program Summary, Basin Watershed OU2

Media	Analysis						
	Dissolved TAL Metals	Total TAL Metals	Nutrients	Common Anions	General Water Quality Parameters	ABA	Radiological
Groundwater, Micropush Point	7	7	0	6	6	NA	NA
Groundwater, Pond	2	2	0	2	2	NA	NA
Groundwater, Shaft/Well	11	11	0	11	11	NA	NA
Sediment, 10 mesh	NA	36	NA	NA	NA	7	NA
Sediment, 80 mesh	NA	27	NA	NA	NA	NA	NA
Sediment, 260 mesh	NA	4	NA	NA	NA	NA	NA
Subsurface Wasterock/Tailings	NA	80	NA	NA	NA	78	5
Surface Wasterock/Tailings	NA	83	NA	NA	NA	NA	6
Surface Water, Adit/Seep	51	51	1	51	51	NA	NA
Surface Water, Storm	19	19	3	19	19	NA	NA
Surface Water, Stream	39	39	6	39	39	NA	NA
Wetland Groundwater	3	3	NA	3	3	NA	NA
Wetland Surface Soil	4	4	NA	NA	NA	NA	NA
Wetland Surface Water	5	5	NA	5	5	NA	NA

TAL - Target Analyte List

ABA - Acid Base Acounting

Common Anions- Sulfate, Chloride, Fluoride

NA - Not Analyzed

Water Quality Parameters - Acidity, Hardness, Total Suspended Solids and Total Dissolved Solids

Nutrients - Ammonia, Nitrate/Nitrite, Orthophosphate

Radiological - Gross Alpha, Gross Beta, Gross Gamma, Uranium, and Thorium

This page intentionally left blank.

Table 2.4-4 Proposed vs Actual Surface Water and Sediment Sample Analysis

	Proposed Surface Water and Sediment Sample Station Locations	Actual Surface Water and Sediment Sample Station Locations			
Stations	**Rational for Proposed Stations**	**Rational for Actual Stations**	**Easting**	**Northing**	**Storm Sampling**
CDM Station 001	To assess water and sediment quality in Basin Creek upgradient of the Enterprise / Buckeye mine.	Same as proposed location.	401608.095	5138996.86	Yes
CDM Station 002	To assess water and sediment quality in Lady Leith tributary.	Same as proposed location.	401528.58	5138893.61	Yes
CDM Station 003	To assess water and sediment quality in Basin Creek downgradient of the Enterprise / Buckeye mine (Historic USGS Station 8).	Same as proposed location.	400016.9	5138716.73	No
CDM Station 004	For use as potential baseline/reference water and sediment quality on Basin Creek (Historic USGS Station 10) – assumes that existing mines are small and of little impact, reflecting the natural mineralized/pre-mining conditions to some degree.	Same as proposed location.	398629.25	5138740.499	No
CDM Station 005	To validate water quality improvement on Basin Creek (Historic USGS Station 12).	Same as proposed location.	396401.54	5136171.85	No
CDM Station 006	To assess water and sediment quality in Basin Creek prior to inputs from Jack Creek and South Fork Basin Creek.	Relocated - approximately 8000 feet upgradient (on Basin Creek) of the confluence Basin Creek and Jack Creek. Access to private property was denied by the landowner at proposed location.	396044.014	5135255.788	Yes
CDM Station 007	For use as potential baseline/reference water and sediment quality for Jack Creek – assumes that existing mines are small and of little impact, reflecting the natural mineralized/pre-mining conditions to some degree (Historic USGS Station 18).	Same as proposed location.	399398.203	5135569.6	No
CDM Station 008	To assess water and sediment quality in the Bullion Mine Tributary (Historic USGS Station 17).	Same as proposed location.	399538.431	5135415.538	No
CDM Station 009	To assess water and sediment quality in Jack Creek (USGS Station 4662047112201901).	Same as proposed location.	397001.194	5133401.179	Yes
CDM Station 010	For use as potential baseline/reference water and sediment quality for the assumed unimpacted South Fork Basin Creek - assumes that existing mines are small and of little impact, reflecting the natural mineralized/pre-mining conditions to some degree.	Relocated - approximately 8000 feet upgradient (on South Fork) of the confluence of Basin Creek and South Fork Creek. Access to private property was denied by the landowner at proposed location.	394861.99	5134098.42	No [1]
CDM Station 011	To assess the impact of Jack Creek on Basin Creek water and sediment quality, and represent the water quality data upgradient of the confluence with South Fork Basin Creek	Same as proposed location.	397845.888	5131185.545	Yes
CDM Station 012	To assess water and sediment quality in Basin Creek in the Lower Basin Creek subbasin.	Same as proposed location.	400534.27	5127516.44	No
CDM Station 013	To assess water and sediment quality in Basin Creek prior to discharging into the Boulder River (Historic USGS Station 24).	Same as proposed location.	402714.921	5124921.041	Yes
CDM Station 014	To assess the impact of the Crescent and Eldorado and Plateau mines on Cataract Creek.	Relocated - approximately 6000 feet northwest of proposed location to characterize the northwest portion of the Cataract Creek headwaters. Difficult access at original location	403499.739	5140337.947	No [1]
CDM Station 015	For use as potential baseline/reference water and sediment quality in Cataract Creek (Historic USGS Station 26) – assumes that existing mines are small and of little impact, reflecting the natural mineralized/pre-mining conditions to some degree.	Relocated - approximately 6000 feet northwest of proposed location to characterize the northwest portion of the Cataract Creek headwaters. Difficult access at original location	403334.224	5140292.349	No
CDM Station 016	To assess the impact of Rocker Creek on Cataract Creek (Historic USGS Station 34).	Relocated - 1500 feet south of proposed location. New location is better suited for flow measurements.	405979.564	5134931.646	No
CDM Station 017	For use as potential baseline/reference water and sediment quality for the assumed unimpacted tributary of Cataract Creek - assumes that existing mines are small and of little impact, reflecting the natural mineralized/pre-mining conditions to some degree (Historic USGS Station 35).	Same as proposed location.	406458.017	5134831.666	Yes
CDM Station 018	To assess the water and sediment quality in Cataract Creek	Same as proposed location.	405540.224	5132833.909	No

NOTES:

Surface water samples analyzed for Total and Dissolved TAL Metals, Water quality, TDS, TSS, Nutrients and Acidity

Storm water samples not analyzed for nutrients

TAL - Target Analyte List

USGS - U.S. Geological Survey

No [1] - Difficult and lengthy headwater access. Therefore, used storm water sample proposed for this station to evaluate upstream and downstream storm conditions at the Apollo Mine.

Nutrients - Ammonia, Phosphate, Nitrate/Nitrite

Water quality - Sulfate, Chloride, Fluoride, Alkalinity

Table 2.4-4 Proposed vs Actual Surface Water and Sediment Sample Analysis

	Proposed Surface Water and Sediment Sample Station Locations	Actual Surface Water and Sediment Sample Station Locations			
Stations	Rational for Proposed Stations	Rational for Actual Stations	Easting	Northing	Storm Sampling
CDM Station 020	To assess water and sediment quality in Uncle Sam Gulch (Historic USGS Station 43).	Same as proposed location.	404100.483	5130157.991	Yes
CDM Station 021	For use as potential baseline/reference water and sediment quality in Cataract Creek (Historic USGS Station 45)– assumes that existing mines are small and of little impact, reflecting the natural mineralized/pre-mining conditions to some degree.	Same as proposed location.	403344.41	5128342.29	Yes
CDM Station 022	To assess impact below Uncle Sam Gulch on Cataract Creek.	Relocated - 2000 feet north of proposed location. New location better suited for flow measurements.	403402.252	5128773.425	No
CDM Station 023	To assess water and sediment quality in Cataract Creek in the Lower Cataract Creek subbasin.	Same as proposed location.	404144.419	5126400.068	No
CDM Station 024	To assess water and sediment quality in Cataract Creek prior to discharging into the Boulder River (Historic USGS Station 47).	Same as proposed location.	404350.55	5124880.66	Yes
CDM Station 025	To assess water and sediment quality in Boulder River at entry into Basin Watershed OU2 study area.	Same as proposed location.	401490.5	5124808.811	Yes
CDM Station 026	To assess water and sediment quality in Boulder River upstream of Basin Creek.	Same as proposed location.	402755.171	5124445.054	Yes
CDM Station 027	To assess water and sediment quality in Boulder River upstream of Cataract Creek, and to assess water and sediment quality in Boulder River downstream of Basin Creek and evaluate the impact from Basin Creek.	Same as proposed location.	404263.915	5124840.244	Yes
CDM Station 028	To assess water and sediment quality in Boulder River upstream of High Ore Creek, and to assess water and sediment quality in Boulder River downstream of Cataract and evaluate the impact from Cataract Creek.	Same as proposed location.	407248.097	5124019.252	Yes
CDM Station 029	To assess water and sediment quality in High Ore Creek prior to discharging into the Boulder River (Historic USGS Station 56).	Same as proposed location.	407263.042	5124096.559	Yes
CDM Station 030	To assess water and sediment quality in Boulder River exiting the Site (Historic USGS Station 58).	Same as proposed location.	409426.01	5122472.94	Yes
Cataract Upstream of Apollo	Not Proposed	To assess impact of Apollo Mine Waste on Cataract Creek	406149.353	5133878.957	Yes
Cataract Downstream of Apollo	Not Proposed	To assess impact of Apollo Mine Waste on Cataract Creek	406187.603	5133747.202	Yes
Cataract at Eva May	Not Proposed	To assess impact of Eva May Mine Waste on Cataract Creek, and to compare results with groundwater discharging into the Creek	405991.421	5133515.482	No
Rocker Creek Headwater	Not Proposed	To assess water quality in Rocker Creek headwater at Bing Hampton Mine	402892.98	5134790.989	No
Jack Creek Headwater	Not Proposed	To assess water quality in Jack Creek headwater at First Shot/Last Shot Mine	402274.838	5134601.353	No
Grub Creek	Not Proposed	To assess water quality in Grub Creek near it's headwaters	400416.878	5140687.399	No
Clear Creek	Not Proposed	To assess water quality in Clear Creek near it's headwaters	399248.494	5141055.152	No

NOTES:

Surface water samples analyzed for Total and Dissolved TAL Metals, Water quality, TDS, TSS, Nutrients and Acidity

Storm water samples not analyzed for nutrients

TAL - Target Analyte List

USGS - U.S. Geological Survey

No [1] - Difficult and lengthy headwater access. Therefore, used storm water sample proposed for this station to evaluate upstream and downstream storm conditions at the Apollo Mine.

Nutrients - Ammonia, Phosphate, Nitrate/Nitrite

Water quality - Sulfate, Chloride, Fluoride, Alkalinity

Table 2.4-5 Fall 2001 Sampling Program Quality Control Summary, Basin Watershed OU2

	Analysis																				
Media	**Dissolved TAL Metals**			**Total TAL Metals**			**Nutrients**			**Common Anions**			**General Water Quality Parameters**			**ABA**			**Radiological**		
	Normal Samples	Duplicate Samples	Rinsate Samples	Normal Samples	Duplicate Samples	Rinsate Samples[5]	Normal Samples	Duplicate Samples	Rinsate Samples[5]	Normal Samples	Duplicate Samples	Rinsate Samples[5]	Normal Samples	Duplicate Samples	Rinsate Samples[5]	Normal Samples	Duplicate Samples	Rinsate Samples[5]	Normal Samples	Duplicate Samples	Rinsate Samples[5]
Adit/Seep	51	3	NA	51	3	3	1	1	NA	51	4	NA	51	4	NA	NA	NA	NA	NA	NA	NA
Groundwater [1]	21	1	NA	21	1	2	0	0	NA	21	1	NA	20	1	NA	NA	NA	NA	NA	NA	NA
Surface Water [2]	63	3	NA	63	3	3	9	1	NA	63	3	NA	61	3	NA	NA	NA	NA	NA	NA	NA
Sediment [3]	NA	NA	NA	67	4	3	NA	NA	NA	NA	NA	NA	NA	NA	NA	7	0	NA	NA	NA	NA
Waste Rock/Tailings [4]	NA	NA	NA	167	9	9	NA	NA	NA	NA	NA	NA	NA	NA	NA	79	5	NA	12	0	NA
Container Blanks	NA	NA	NA	2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Low pH Filter Blank	2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Normal pH Filter Blank	2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Groundwater [1]- MicroPush Point, Pond, Shaft and Wetland Groundwater Combined
Surface Water [2] - Baseflow, Stormflow, and Wetland Surface Water Combined
Sediment [3] - 10, 80, 260 Mesh Sediment Combined
Waste Rock/Tailings [4] - Surface and Subsurface Wasterock/Tailings, and Wetland Soil Combined
Rinsate Samples[5] - No Rinsate Samples collected because secondary non-enforceable analysis and cost-saving measure

Water Quality Parameters - Acidity, Hardness, Total Suspended Solids, and Total Dissolved Solids
ABA - Acid Base Acounting
Radiological - Gross Alpha, Gross Beta, Gross Gamma, Uranium, and Thorium,
Common Anions - Sulfate, Chloride, Fluoride

TAL - Target Analyte List
Nutrients - Ammonia, Nitrate/Nitrite, orthophosphate

Table 3.1-1 Climate Summary from SNOTEL Monitoring Stations, Basin Watershed OU2

	Monthly Averages*											
Station	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Basin Creek												
Minimum Temperature	28.7	18.6	12.5	13.1	14.9	18.1	23.7	31.6	37.2	43.6	44.4	37.4
Average Temperature	36.1	25.6	19.7	20.7	23	26.6	32.2	40.6	47.5	55.6	56.1	47.4
Maximum Temperature	45.4	32.5	26.6	27.7	31.5	36.5	42.4	52	59.7	69.8	70.8	59.7
Average Precipitation	0.9	2.53	1.52	0.94	1.04	1.66	2.72	3.29	3.69	2.05	1.72	1.68
Frohner Meadow												
Minimum Temperature	28.5	18.7	12.1	12.4	12.2	16.7	23.6	31	38	43.1	42.5	35.9
Average Temperature	37	26.5	20.6	20.6	21.5	26.3	32.9	41.2	48.3	56.1	56.4	47.2
Maximum Temperature	47.5	34.2	28.3	28.3	30.8	37	44	53.2	60.8	70.8	71.3	60.7
Average Precipitation	0.9	1.75	1.74	1.61	1.38	1.45	2.13	2.71	3.46	2.48	1.51	1.93
Rocker Peak												
Minimum Temperature	25.4	15.5	10.1	12.1	12.3	14.5	19.7	27.6	34.1	39.9	40.8	33
Average Temperature	33	21.3	15.7	17.4	18.5	22.3	28	35.8	43.8	50.7	51.4	41.8
Maximum Temperature	41.7	27.7	22	23.3	26.1	30.6	37.7	45.9	54.4	62.6	63.7	52.8
Average Precipitation	0.96	2.09	2.33	0.89	3.34	2.35	3.19	3.38	3.92	2.93	1.75	2.11

Note: Temperature - degrees Fahrenheit
Precipitation - inches
* Number of years used to calculate the monthly averages vary (refer to Section 3.1)

This page intentionally left blank.

Table 4.1-1 Summary of Chemicals of Concern, Basin Watershed OU2

Analytes		Surface Water	Sediment	Soil
Aluminum	Al	X	X	X
Antimony	Sb	X	X	X
Arsenic	As	X	X	X
Barium	Ba	X	X	X
Beryllium	Be	X	X	X
Cadmium	Cd	X	X	X
Chromium	Cr	X	X	X
Cobalt	Co	X	X	X
Copper	Cu	X	X	X
Iron	Fe	X	X	X
Lead	Pb	X	X	X
Manganese	Mn	X	X	X
Mercury	Hg	X	X	X
Nickel	Ni	X	X	X
Selenium	Se		X	X
Silver	Ag	X	X	X
Thallium	Tl	X		X
Vanadium	V	X	X	X
Zinc	Zn	X	X	X
Total		**18**	**18**	**19**

COC - chemical of concern

Table 4.1-2 Ecological Benchmarks Levels for Inorganic Constituents, Basin Watershed OU2

	ECOLOGICAL BENCHMARKS		
Analyte	Surface Water Benchmarks (ug/L)	Sediment Benchmarks (mg/kg)	Soil Benchmarks (mg/kg)
Aluminum	87	nd	50
Antimony	30	2	3.5
Arsenic	150	5.9	10
Barium	nd	200	165
Beryllium	5.3	nd	1.1
Cadmium	0.78	0.59	1.6
Chromium	11	37.3	0.4
Cobalt	23	20	20
Copper	4.1	18.7	40
Cyanide	5.2	nd	nd
Iron	1000	20000	50
Lead	1.16	53	50
Manganese	120	460	100
Mercury	0.65	0.13	0.1
Molybdenum	nd	10	2
Nickel	24	15.9	30
Selenium	5	nd	0.81
Silver	0.12	0.5	2
Strontium	nd	nd	nd
Thallium	40	nd	1
Tin	nd	nd	50
Vanadium	nd	nd	2
Zinc	42.1	110	50
pH	nd	nd	<5

Notes:

ND- No Data

Table 4.1-3 Human Health Benchmarks Levels for Inorganic Constituents, Basin Watershed OU2

	HUMAN HEALTH BENCHMARKS					
Analyte	Surface Water (ug/L)	Sediment (mg/kg)	Residential Soil (mg/kg)	Industrial Soil (mg/kg)	Recreational Soil (mg/kg)	Groundwater (ug/L)
Aluminum	nd	nd	50 [e]	78000	2000000	nd
Antimony	6	nd	20 [3][a]	31	820	6
Arsenic	18	3740	60 [3][b]	60	290 [3]	5 [g]
Barium	2000	nd	3000 [3][c]	5500	140000	2000
Beryllium	4	nd	1.1 [f]	160	4100	4
Cadmium	5	nd	5.1 [3][d]	562	nd	5
Cadmium - food	nd	nd	nd	78	2000	nd
Cadmium - water	nd	nd	nd	39	1000	nd
Chromium	100	nd	0.4 [b]	nd	nd	100
Chromium (III)	nd	nd	nd	120000	3100000	nd
Chromium (VI)	nd	nd	nd	230	6100	nd
Cobalt	nd	nd	1000 [3][c]	4700	120000	nd
Copper	5.2	nd	50 [3][b]	3100	82000	1300
Cyanide	200	nd	nd	nd	nd	200
Iron	300	nd	50 [c]	23000	610000	300
Lead	3.2	1000	94 [3][d]	1000	nd	15
Magnesium	nd	nd	nd	26954	nd	nd
Manganese	50	nd	100 [c]	nd	nd	50
Mercury	0.05	865993677	0.1 [b]	99	377 [3]	0.05
Molybdenum	nd	nd	200 [3][c]	390	10000	nd
Nickel	100	nd	30 [e]	1600	41000	100
Selenium	50	nd	0.81 [f]	390	10000	50
Silver	4.1	nd	50 [3][c]	390	10000	35
Strontium	4200	nd	nd	47000	1200000	4200
Thallium	1.7	nd	1 [e]	5.5	140	2
Tin	nd	nd	50	47000	1200000	nd
Vanadium	nd	nd	2 [e]	550	14000	nd
Zinc	67	nd	196 [3][d]	23000	610000	2100
pH	nd	nd	<5 [illegible]	nd	nd	nd

Notes:

1 - Table 3-3. Ecotoxicity of Surface Soil COCs. Draft Human Health Risk Assessment (Section 1-3), Upper Tenmile Creek Mining Area Superfund Site, Lewis and Clark County, Montana. (CDM) October 2000.

(a) Interim Remediation Criteria (agricultural use)

(b) Earthworm TRV

(c) Microorganism TRV

(d) Phytotoxicity TRV

2 - Westinghouse Savannah River Site (SRS), Ecological Screening Values for Surface Water, Sediment, and Soil, (G.P. Friday), November 1998. Table 3 value presented is the lower of three categories of standards: Oak Ridge National Labs (ORNL), Canadian Council of Ministers of the Environment (CCME), and Dutch Ministry Standards.

(e) ORNL - Lowest value between standards for earthworms, micro-organisms, and soils phytotoxicity. Most listed values are soil phytotoxicity, except Cr and As (earthworms).

(f) Dutch Ministry Standard - Maximum Permissible Concentration (MPC)

3 - Lowest screening level not selected. Local (Upper Tenmile Creek ERA) screening level selected.

4 - Table ES-3. Preliminary Remediation Goals - Surface Water, Final Remedial Investigation Report for Basin Mining Area Superfund Site Town of Basin Operable Unit 1 (OU1) Jefferson County, Montana, (CDM Federal), October 2000. Values are Central Tendency Exposures (CTE).

(g) - Proposed MCL, May 2000.

nd- No Data

Table 4.2-1 Summary of COC Nondetects that Exceeded Ecological and Human Health Benchmarks

	Nondetects Exceeding Ecological Benchmarks											
	Arsenic		Cadmium		Copper		Lead		Mercury		Zinc	
	Number of Nondetects Exceeding	Total Number of Results	Number of Nondetects Exceeding	Total Number of Results	Number of Nondetects Exceeding	Total Number of Results	Number of Nondetects Exceeding	Total Number of Results	Number of Nondetects Exceeding	Total Number of Results	Number of Nondetects Exceeding	Total Number of Results
Aqueous[1]	0	1095	262	1131	16	1135	144	1066	4	559	2	1198
Sediment	5	518	174	474	0	516	0	522	4	113	0	523
Soil	0	1129	188	980	0	1117	0	1174	3	268	0	1182
Groundwater	na	62	na	62	na	62	na	62	na	60	na	62

	Nondetects Exceeding Human Health Benchmarks											
	Arsenic		Cadmium		Copper		Lead		Mercury		Zinc	
	Number of Nondetects Exceeding	Total Number of Results	Number of Nondetects Exceeding	Total Number of Results	Number of Nondetects Exceeding	Total Number of Results	Number of Nondetects Exceeding	Total Number of Results	Number of Nondetects Exceeding	Total Number of Results	Number of Nondetects Exceeding	Total Number of Results
Aqueous[1]	55	1095	0	1131	3	1135	3	1066	111	559	0	1198
Sediment	2	518	0	474	0	516	0	522	0	113	0	523
Soil	2	1129	0	980	0	1117	0	1174	0	268	0	1182
Groundwater	10	62	8	62	0	62	0	62	0	60	0	62

Notes:

1- Aqueous results include results for non-storm and storm stream surface water, adits, seep, and springs

na Not Applicable

Table 4.3-1 Summary of Selected Baseline Stations, Basin Watershed OU2

		Other Parameters (mg/l)			Arsenic		Cadmium		Copper		Mercury		Lead		Zinc	
Media	Station/Mine	pH	SO4	TDS	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot
Basin Creek AOC																
Aqeuous	S001	6.81	5.1	63	10 U	10 U	1 U	0.041	2 U	2.7	0.043	0.2 U	1 U	0.33	10 U	10 U
Aqeuous	South Fork Creek Tributary (S010)	7.91	3.4	49	10 U	10 U	1 U	1 U	2 U	0.64	0.2 U	0.2 U	1 U	1 U	10 U	10 U
Sediment	Clear Creek Tributary (S004)	ND	ND	NA	ND	20.6	NA	0.26	NA	5.4	NA	0.07	NA	43.5	NA	31.8
Sediment	S010	ND	ND	NA	ND	7.2	NA	0.59	NA	3.7	NA	0.06	NA	9.6	NA	32.5
Waste Material	Hawkeye Mine	4	0.02 *	NA	NA	5.4	NA	ND	NA	9.3	NA	0.59	NA	21.3	NA	29.2
Waste Material	Jessie	4.1	0.01 *	NA	NA	16.6	NA	0.13	NA	22.2	NA	0.09	NA	33.3	NA	55.6
Cataract Creek AOC																
Aqeuous	S014	ND	ND	ND	4	4	0.02	0.02	0.76	0.51	0.2 U	0.2 U	0.2	0.2	2	2
Aqeuous	Cat Unnamed Tributary 1 (S015)	ND	ND	ND	4	4	0.02	0.02	0.77	0.95	0.2 U	0.2 U	0.2	0.61	3	1
Sediment	S015	ND	ND	NA	ND	6.8	NA	0.59	NA	18	NA	0.06	NA	7.3	NA	32.4
Sediment	S014	ND	ND	NA	ND	8.9	NA	0.58	NA	14.8	NA	0.06	NA	7.8	NA	34
Waste Material	Vogel	2.5	NA	NA	NA	431	NA	0	NA	9.3	NA	0.36	NA	38.9	NA	16.5
Waste Material	Big Medicine	2.5	NA	NA	NA	96.9	NA	0	NA	6.2	NA	0.62	NA	107	NA	21.5
Boulder River AOC																
Aqeuous	S025	8.7	12	26	4	4	0.03	0.02	2	2	0.03	0.03	0.2	0.2	3	3
Aqeuous	S027	9.0	15	113	7	4	0.1	0.2	13	15	0.03	0.03	0.2	0.2	30	39
Sediment	S025	ND	ND	NA	ND	4	NA	ND	NA	6	NA	0.07	NA	3.9	NA	30.2
Sediment	S027	ND	ND	NA	ND	9.8	NA	0.73	NA	17.5	NA	0.06	NA	10.7	NA	167

Notes:

ND- No Data

NA- Not Appilcable

* As Percent Sulfate

This page intentionally left blank.

Table 5.2-1 Summary of Surface Water Flows in the Boulder River, Basin Watershed OU2

		Historical Flow Results (1996-2000)				2001 RI Flow Results				
Stream Reaches	Stream Location	Station	Mean Winter Low-Flow (cfs)	Mean Spring/Summer High-Flow (cfs)	Mean Fall Low-Flow (cfs)	Station	Spring/Summer High-Flow (cfs)[1]	Fall Low-Flow (cfs)	Fall Low-Flow (cfs)[1]	Fall Storm High-Flow (cfs)
Reach 1	Boulder River Mainstem above Kleinsmith Gulch	3	17	361	18	S025	407	8	9	32
Reach 2	Tributary (Kleinsmith Gulch)	4	NM	0.4	0.3	NA	NM	NM	NM	NM
	Boulder River above Basin Creek, near Basin	NA	NM	NM	NM	S026	NM	9	NM	29
Reach 3	Tributary (Basin Creek at Basin)	24	4	120	5	S013	75	2	4	49
	Boulder River Mainstem below Basin Creek	25	25	265	28	NA	NM	NM	NM	NM
	Boulder River above Cataract Creek	NA	NM	NM	NM	S027	NM	11	NM	58
Reach 4	Tributary (Cataract Creek)	47	4	86	4	S024	41	2	3	28
	Boulder River Mainstem below Cataract Creek	48	26	310	33	NA	NM	NM	NM	NM
	Boulder River above High Ore Creek	NA	NM	NM	NM	S028	NM	13	NM	NM
Reach 5	Tributary (High Ore Creek)	56	2	4	1	S029	2	0.1	0.4	2
	Tributary (Galena Gulch)	57	NM	5	0.4	NA	NM	NM	NM	NM
	Boulder River Mainstem below Little Galena Gulch	58	29	569	28	S030	694	13	21	54

Notes:

1 - USGS provisional flow results from measurements taken in April, May, August, and September 2001

NM - Not Measured

NA - Not Applicable

- Shading indicates tributary inflow to mainstem

This page intentionally left blank.

Table 5.3-1 Surface Water COC Concentrations in Boulder River, Basin Watershed OU2

		Winter (Dec, Jan, Feb, Mar) Total and Dissolved COC Concentrations (ug/l)														Spring/Summer (Apr, May, Jun, Jul) Total and Dissolved COC Concentrations (ug/l)														Fall (Aug, Sep, Oct, Nov) Total and Dissolved COC Concentrations (ug/l)													
		Other Parameters (mg/l)			Arsenic		Cadmium		Copper		Mercury	Lead		Zinc		Other Parameters (mg/l)			Arsenic		Cadmium		Copper		Mercury		Lead		Zinc		Other Parameters (mg/l)			Arsenic		Cadmium		Copper		Mercury		Lead		Zinc	
Reach	StationGroup	pH	SO4	TDS	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Diss	Tot	Diss	Tot	pH	SO4	TDS	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	pH	SO4	TDS	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot
Historical																																													
Reach 1	3	7.7	15	102	2	**3**	0.1	1	1	1	0.1	1	1	3	10	7.9	7.7	67	4	**5**	0.1	1	4	**7**	nd	nd	1	1.4	3.9	13	8	13.4	104	3	**4**	0	1	2	2	0.1	nd	1	1	2	14
	1M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	15	105	3	**3**	nd	2	2	2	0.12	nd	nd	2	6	8
	06031450	7.7	nd	82	2	nd	nd	0.1	2	1	nd	1	1	14	31	8.1	nd	62	3	**3**	nd	0.1	2	2	nd	nd	1	1	2.5	31	8	nd	83	3	**4**	nd	0.11	1	2	nd	nd	1	1	3	31
Reach 2	Kleinsmith Gulch Trib (4)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	20
	144335	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	17.5	106	3	**3**	nd	2	**5**	**6**	0.12	**0.1**	nd	2	12	18
Reach 3	Basin Creek Trib (24)	nd	nd	nd	4	**5**	**0.4**	1	3	3	0.1	1	1	**83**	**87**	nd	nd	nd	6	**16**	**0.5**	1	**10**	**16**	nd	nd	1	**7**	**70**	**96**	nd	nd	nd	6	**8**	**0.35**	1	4	5	0.1	nd	1	1	**51**	57
	Basin Creek Trib (06031600)	7.6	nd	57	4	nd	nd	0.4	2	3	nd	1	1	**75**	**76**	7.5	nd	39	6	**13**	nd	0.6	**9**	**11**	nd	nd	1	**5**	**64**	**74**	7.5	nd	57	5	**7**	nd	0.36	3	5	nd	nd	1	1	**63**	**72**
	25	7.9	16	100	3	nd	nd	1	**6**	**8**	nd	1	1	**44**	40	7.9	8.4	68	5	nd	0.1	1	**8**	**10**	nd	nd	1	2	29	40	8.2	14	102	5	nd	**0.2**	1	**10**	**11**	nd	nd	1	1	39	40
	121570	nd	14	95.1	5	nd	nd	nd	**9**	nd	nd	nd	nd	**53**	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	890812	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	8.3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	26M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	25	nd	nd	nd	nd	4.9	nd	nd	nd	**17**	nd	nd	nd	nd	nd	**70**	nd
Reach 4	Cataract Creek Trib (06031960)	7.6	nd	79	3	nd	**4**	4.3	**16.1**	**19**	nd	1	1	**370**	**404**	7.5	nd	38	3	**8**	**2**	2	**30**	**37**	nd	nd	1	3	**204**	**214**	7.7	nd	80	3.3	**4**	**5**	5	**21**	**25**	nd	nd	1	1	**412**	**399**
	Cataract Creek Trib (47)	nd	nd	nd	3	**4**	**3**	3	**13**	**14**	0.1	1	1	**309**	**327**	nd	nd	nd	3	**18**	**2**	2	**32**	**52**	nd	nd	1	**9**	**158**	**205**	nd	nd	nd	3.5	**5**	**5**	**6**	**24**	**29**	0.1	nd	1	1	**440**	**450**
	Cataract Creek Trib (67M)	nd	nd	nd	4	nd	**6**	nd	**27**	nd	nd	nd	nd	**634**	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	26M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	8.6	62	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	25	nd	nd	18.4	98.5	4.9	nd	nd	nd	**17**	nd	nd	nd	nd	nd	**70**	nd
	890815	nd	nd	nd	7	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	68M	nd	16	94.9	4	nd	nd	nd	**13**	nd	nd	nd	nd	**159**	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	69M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	87	60	nd	nd	nd	nd	**17**	nd	nd	nd	nd	nd	**51**	nd	nd	18.7	100	4.7	nd	nd	nd	**27**	nd	nd	nd	nd	nd	**134**	nd
	48	7.7	17	100	3	nd	**0.6**	1	**7**	**9**	nd	1	1	**80**	**80**	7.9	8.5	67	4	nd	**0.4**	1	**12**	**16**	nd	nd	1	3	**48**	65	8	15	101	5	nd	**0.7**	1	**12**	**14**	nd	nd	1	1	**80**	**90**
	70M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	9.0	60	nd	nd	nd	nd	**8**	nd	nd	nd	nd	nd	**49**	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	71M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	8.9	60	nd	nd	nd	nd	**17**	nd	nd	nd	nd	nd	**48**	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	890816	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	6.4	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	179234	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	**11**	nd	2	nd	**16**	nd	nd	nd	**7**	nd	**131**	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	179232	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	11	68	4	**9**	nd	2	**12**	**16**	nd	nd	nd	**6**	**71**	**81**	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Reach 5	High Ore Creek Trib (179235)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	53	164	22	**48**	**3**	4	3	**11**	nd	nd	nd	**44**	**792**	**1010**	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	High Ore Creek Trib (06032300)	7.9	nd	180	22	nd	**2.97**	3.3	2.3	**6**	nd	1	**12**	**1120**	**1130**	8.6	nd	210	32	**49**	**2**	3	3	**6**	nd	nd	1	**18**	**431**	**512**	7.9	nd	nd	26	**36**	**1.98**	2	3	5	nd	nd	1	**10**	**575**	**620**
	High Ore Creek Trib (56)	8	75	196	15	**109**	**5**	**9**	**4**	**26**	0.1	1	**109**	**1972**	**2960**	8.2	46	147	13	**69**	**3**	4	**6**	**17**	nd	nd	1	**60**	**829**	**1136**	8.3	73.2	227	23	**37.8**	**3.04**	4	3	**6**	0.1	nd	1	**11**	**1097**	**1304**
	179233	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	13	64	5	nd	nd	nd	**11**	nd	nd	nd	nd	nd	**106**	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Galena Gulch Trib (57)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.8	nd	75	1	nd	0.1	1	2	**7**	nd	nd	1	**4**	1	20	8.3	nd	180	1	nd	0.1	1	1	1	0.1	nd	1	1	1	10
	58	7.9	20	107	4	**5**	**0.77**	1	**7**	**10**	0.1	1	1	**171**	**190**	7.9	8.4	61	4	**12**	**0.3**	1	**11**	**19**	nd	nd	1	**6**	**49**	**84**	nd	nd	nd	5.4	**7**	**1**	1	**9**	**11**	0.1	nd	1	1	**146**	**164**
	06032400	7.7	nd	87	4	nd	nd	0.86	**6**	**7.8**	nd	1	1	**132**	**148**	7.7	nd	51	5	nd	nd	0.6	**10.75**	**14.2**	nd	nd	1	3	**61**	**76**	7.8	nd	84	4.7	**7**	nd	1	**7**	**10**	nd	nd	1	2	**98**	**114**
2001																																													
Reach 1	S025	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	8.7	12	26	4	**4**	0.03	0.02	2	2	0.03	0.03	0.2	0.2	3	3
	06031450	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.7	nd	52	3	**9**	nd	0.2	**4**	**12**	0.23	nd	1	**4**	5	37	8.5	nd	nd	3	**4**	nd	0.11	1	3	nd	nd	1	1	1	31
Reach 2	S026	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	13	122	6	**4**	0.1	0.2	**15**	**18**	0.03	0.03	0.2	0.3	42	52
Reach 3	Basin Creek Trib (06031600)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.3	nd	62	4	**10**	nd	0.6	**9**	**12**	0.23	nd	1	3	**73**	**85**	nd	nd	nd	6	**8**	nd	0.3	4	4	nd	nd	1	1	38	44
	Basin Creek Trib (S013)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	17	90	7	**6**	**0.3**	0.3	4	3	0.03	0.03	0.2	0.3	35	35
	S027	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	9.0	15	113	7	**4**	0.1	0.2	**13**	**15**	0.03	0.03	0.2	0.2	30	39
Reach 4	Cataract Creek Trib (S024)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	5	**4**	**4**	4	**11**	**13**	0.03	0.03	0.2	0.2	**282**	**296**
	Cataract Creek Trib (06031960)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.5	nd	67	3	**11**	**2**	3	**44**	**68**	0.23	nd	1	**5**	**230**	**261**	8.1	nd	nd	3	**5**	**4**	4	**12**	**15**	nd	nd	1	1	**315**	**334**
	S028	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	8.3	19	114	7	**7**	**0.5**	0.5	**10**	**13**	0.03	0.03	0.2	0.2	**48**	55
Reach 5	High Ore Creek Trib (S29)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	36	**36**	**3**	3	3	4	0.03	0.03	0.2	3	**343**	**386**
	High Ore Creek Trib (06032300)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	8.1	nd	216	18	**88**	**3**	**6**	3	**19**	0.23	nd	1	**65**	**1340**	**1800**	8.3	nd	nd	27	**33**	**3**	4	3	5	nd	nd	1	3	**559**	**607**
	S030	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	22	121	10	**8**	**0.5**	0.5	**9**	**11**	0.03	0.03	0.2	0.3	**48**	59
	06032400	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.2	nd	55	4	**12**	nd	0.7	**10**	**24**	0.23	nd	1	**7**	35	**87**	nd	nd	nd	6	**8**	nd	0.8	**9**	**10**	nd	nd	1	1	**88**	**96**
September 6, 2001 Storm Event																																													
Reach 1	S025	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	13	109	4	**4**	0.02	0.06	2	3	0.03	0.03	0.2	1	2	13
Reach 2	S026	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	12	118	4	**4**	0.05	0.22	**6**	**17**	0.03	0.03	0.2	**4**	11	46
Reach 3	Basin Creek Trib (S013)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	16	92	4	**74**	**0.55**	2.4	**12**	**57**	0.03	**0.1**	0.5	**49**	**73**	**275**
	S027	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	8	15	113	6	**42**	**0.28**	1.4	**11**	**41**	0.03	0.03	0.4	**21**	40	**183**
Reach 4	Cataract Creek Trib (S024)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	8	16	98	4	**37**	**4**	**5.8**	**57**	**141**	0.03	0.04	0.8	**34**	**305**	**476**
	S028	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	17	105	7	**47**	**1**	3.2	**24**	**81**	0.03	0.03	0.6	**29**	**108**	**313**
Reach 5	High Ore Creek Trib (S29)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	247	466	20	**116**	**6**	**10**	**8**	**28**	0.03	**0**	1.0	**136**	**1500**	**2160**
	S030	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	23	105	6	**48**	**1**	4	**26**	**97**	0.03	0.03	0.9	**38**	**130**	**424**

Notes:
nd - No Data for that sample
ug/L - micrograms per liter
Tot - Total Comcentrations
Dis - Dissolved Concentrations
SO4 - Sulfate
TDS - Total Dissolved Solids
mg/L - micrograms per liter
Values in **bold underline** exceed benchmarks

Table 5.4-1 Boulder River Sediment Mean COC Results, Basin Watershed OU2

		Total Concentrations in (mg/kg)					
Reach	Station	Arsenic	Cadmium	Copper	Mercury	Lead	Zinc
			Historical				
Reach 1	1B	***229***	***2***	***450***	nd	***184***	***310***
	4S	***14***	nd	***25***	nd	20	***120***
Reach 2	5S	***89***	***4***	***305***	nd	***72***	***820***
Reach 3	1T	***457.69***	nd	***423.85***	nd	***237.46***	***226.19***
	2B	***39.2***	***3***	***254.4***	nd	49.4	***281***
	6S	***60***	***3***	***205***	nd	***57***	***530***
	7S	***30***	nd	***51***	nd	46	***330***
	8S	***58.5***	nd	***150***	nd	***92***	***635***
	9S	***135***	***7***	***285***	nd	***140***	***1015***
Reach 4	3B	***217***	***4***	***495***	nd	***248.33***	***470***
	4B	***39.75***	***6***	***75***	nd	***84***	***115.75***
	10S	***68.5***	nd	***103.5***	nd	***80***	***445***
	11S	***81***	***9***	***195***	nd	***96.5***	***890***
Reach 5	High Ore Tributary (19B)	***1292***	***18.31***	***408.31***	nd	***2874.62***	***2903.85***
	5B	***155.33***	***4.5***	***157.67***	nd	***188***	***390***
	12S	***210***	***11.5***	***350***	nd	***285***	***1650***
	13S	***1665***	***18.5***	***455***	nd	***460***	***2600***
	14S	***676.67***	***5***	***256.67***	nd	***296.67***	***1446.67***
	High Ore Tributary (63S)	***4233.33***	***27***	***540***	nd	***1400***	***6133.33***
			2001 Minus 10-Mesh				
Reach 1	S025	4	nd	6	0.07	3.9	30.2
Reach 2	S026	***6.4***	nd	***33.3***	0.07	5.8	***227***
Reach 3	Basin Creek Tributary (S013)	***41.2***	***2.2***	***27.3***	0.07	33.4	***239***
	S027	***9.8***	***0.73***	17.5	0.06	10.7	***167***
Reach 4	Cataract Creek Tributary (S024)	***84.8***	***8.1***	***147***	0.07	***94***	***609***
	S028	***22.05***	***1.7***	***40***	0.07	25.15	***240.5***
Reach 5	High Ore Tributary (S29)	***397***	***9.5***	***70***	0.06	***281***	***2230***
	S030	***28***	***2.9***	***41.8***	0.07	41.4	***629***
			2001 Minus 80-Mesh				
Reach 1	S025	***7.2***	0.06	14.9	0.05	10	79
Reach 2	S026	***7.8***	0.37	***29.4***	0.05	9.9	***150***
Reach 3	S027	***24.3***	***3***	***66.9***	0.05	32.2	***453***
Reach 4	Cataract Creek Tributary (S024)	***130***	***10.9***	***222***	0.05	***129***	***1140***
	S028	***41.5***	***14***	***159***	0.06	***53.35***	***1155***
Reach 5	High Ore Tributary (S29)	***3150***	***28.3***	***316***	***0.3***	***1090***	***5700***
	S030	***267***	***3.9***	***102***	0.06	***85.1***	***765***
			2001 Minus 260-Mesh				
Reach 3	S027	***55.2***	***10***	***206.5***	0.08	***77.8***	***887***
Reach 4	S028	***65***	***28.3***	***340***	0.12	***90.5***	***1610***

Notes: nd- No data Values in **bold underline** exceed benchmarks

Table 5.5-1 Summary of COC Concentrations Acid Base Accounting Parameters in Mine Waste in Boulder River AOC, Basin Watershed OU2

	Concentration of COCs (mg/kg)											
Station	Arsenic		Cadmium		Copper		Mercury		Lead		Zinc	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
00BOU1-08-N-SS	***65.7***	***66***	***2***	***2***	***146***	***146***	***0.2***	***0.2***	***78***	***78***	***753***	***753***
00BOU1-09-N-SS	***201***	***201***	***3***	***3***	***270***	***270***	***0.5***	***0.5***	***161***	***161***	***915***	***915***
00BOU1-20-N-SS	***558***	***615***	***10***	***11***	***391***	***413***	***1.4***	***1.6***	***1220***	***1220***	***3100***	***3710***
00BOU1-22-N-SS	***416***	***416***	***9***	***9***	***493***	***493***	***1.3***	***1.3***	***414***	***414***	***2730***	***2730***
00BOU1-31-N-SS	***406***	***406***	***2***	***2***	***416***	***416***	***0.7***	***0.7***	***283***	***283***	***465***	***465***
Basin Mill Site	***39***	***5128***	0.5 U	***214***	25.5	***963***	0.01	***0.6***	26	***11900***	***73***	***12500***

	Field Parameter		Acid Base Accounting Parameters (MT CaCO3/1000 MT)						Total Sulfur Makeup					
Station	pH (Paste)		Neutralization		Acid Potential (AP)		Net Neutralization		% Sulfide		% Sulfate		NP/AP	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
00BOU1-08-N-SS	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
00BOU1-09-N-SS	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
00BOU1-20-N-SS	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
00BOU1-22-N-SS	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
00BOU1-31-N-SS	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
Basin Mill Site	3.5	6.2	3.63	94.4	0	90.9	-87	94.4	0.01	2.16	0.01	0.85	na	0.04

Milligrams per Kilogram
Calcium Carbonate

MT - Metric Tonne
% - Percent

U - Undetect
R - Rejected

nd - No data
na - Not Applicable

Values in **bold underline** exceed benchmarks

CDM

Table 5.5-2 Summary of COC Concentrations in Adits and Seep Discharges at Mine Sites in Boulder River AOC, Basin Watershed OU2

	COC Concentrations (ug/L)												
	Arsenic		Cadmium		Copper		Mercury		Lead		Zinc		Sulfate (mg/l)
Station	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	
Merry Widow Adit	10 U	10 U	1 U	1 U	2	2	0.2 U	0.2 U	1 U	1 U	32	29	45

U- Nondetect ug/L - Micrograms per liter mg/L - Milligrams per liter

Table 5.5-3 Boulder River Watershed Mine Sites with Radioactivity in Waste Material, Basin Watershed OU2

Mine	Location/Description	Radioactivity Range (mR/HR)
Basin Millsite	Waste rock pile 1	0.05
	Waste rock pile 2	0.08
	Waste rock pile 3	0.06
	Waste rock pile 4	0.04
	Waste rock pile 5	0.08
	Waste rock pile 6	0.05
	Waste rock pile 7	0.05
	Tailings pile 1	0.03 - 0.08

mR/HR - millirems/hour

Table 5.6-1 Summary of COC Concentrations in Groundwater in the Boulder River AOC, Basin Watershed OU2

		Arsenic (ug/L)		Cadmium (ug/L)		Copper (ug/L)		Lead (ug/L)		Mercury (ug/L)		Zinc (ug/L)	
Station	Sample Type	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
00BOU1-01-N-GW	Groundwater Well	10 U	nd	5 U	nd	10 U	nd	3 U	nd	0.2 U	nd	6	nd
00BOU1-03-N-GW	Groundwater Well	10 U	nd	5 U	nd	6	nd	3	nd	0.2 U	nd	25	nd
00BOU1-05-N-GW	Groundwater Well	nd	10 U	nd	5 U	nd	10 U	nd	4.8	nd	0.2 U	nd	451
00BOU1-06-N-GW	Groundwater Well	10 U	nd	5 U	nd	76	nd	3 U	nd	0.2 U	nd	23	nd
00BOU1-07-N-GW	Groundwater Well	10 U	nd	5 U	nd	10 U	nd	3 U	nd	0.2 U	nd	103	nd
00BOU1-08-N-GW	Groundwater Well	nd	10 U	nd	5 U	nd	10 U	nd	16	nd	0.2 U	nd	17
00BOU1-09-N-GW	Groundwater Well	10 U	nd	5 U	nd	10 U	nd	3 U	nd	0.2 U	nd	36	nd
00BOU1-10-N-GW	Groundwater Well	10 U	nd	5 U	nd	10 U	nd	3 U	nd	0.2 U	nd	55.2	nd
BM-GW-2	Groundwater Well	10 U	nd	5 U	nd	10 U	nd	3 U	nd	0.2 U	nd	32	nd
BM-GW-5	Groundwater Well	10 U	nd	5 U	nd	10 U	nd	3 U	nd	0.2 U	nd	299	nd

U- Nondetect S.U. - Standard Units nd - No Data ug/L - Micrograms per liter

This page intentionally left blank.

Table 5.7-1 COC Loads in the Boulder River, Basin Watershed OU2

		Winter (Dec, Jan, Feb, Mar) Total and Dissolved Loads in pounds per day (lbs/day)													Spring/Summer (Apr, May, Jun, Jul) Total and Dissolved Loads in pounds per day (lbs/day)													Fall (Aug, Sep, Oct, Nov) Total and Dissolved Loads in pounds per day (lbs/day)													
		Arsenic		Cadmium		Copper		Mercury	lead		Zinc		Combined		Arsenic		Cadmium		Copper		Mercury	lead		Zinc		Combined		Arsenic		Cadmium		Copper		Mercury	lead		Zinc		Combined	
Reaches	Stations	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot
																					Historical																				
Reach 1	3	0.2	0.2	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.3	0.9	0.7	1.4	6.8	10.1	0.2	1.9	7.8	12.9	nc	1.9	2.7	7.6	25.3	24.3	53.0	0.3	0.3	0.0	0.1	0.2	0.2	0.0	nc	0.1	0.1	0.2	1.4	0.8	2.1
	1M	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
	06031450	0.1	nc	nc	0.0	0.2	0.1	nc	0.1	0.1	1.1	2.3	1.4	2.5	1.4	1.5	nc	0.1	1.0	1.2	nc	0.5	0.5	1.2	15.4	4.1	18.6	0.2	0.2	nc	0.0	0.1	0.1	nc	nc	0.1	0.1	0.2	2.2	0.5	2.6
	Reach 1 Average	0.2	0.2	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.7	1.7	1.1	2.1	3.8	5.0	0.1	0.7	3.7	5.5	0.0	1.2	1.5	3.9	26.9	12.8	39.6	0.2	0.3	0.0	0.1	0.1	0.2	0.0	0.0	0.1	0.1	0.3	1.5	0.8	2.1
Reach 2	Kleinsmith Gulch Trib (4)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.0	nc	0.0	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.0	nc	0.0
Reach 3	Basin Creek Trib (24)	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	1.8	1.9	2.0	2.1	3.6	10.0	0.3	0.6	6.5	10.0	nc	0.7	4.7	45.2	62.2	56.3	87.6	0.1	0.2	0.0	0.0	0.1	0.1	0.0	nc	0.0	0.0	1.2	1.3	1.5	1.7
	Basin Creek Trib (06031600)	0.1	nc	nc	0.0	0.1	0.1	nc	0.0	0.0	1.9	1.9	2.1	2.0	1.6	3.4	nc	0.1	2.4	3.0	nc	0.3	1.3	16.8	19.4	21.0	27.4	0.1	0.2	nc	0.0	0.1	0.1	nc	nc	0.0	0.0	1.5	1.7	1.7	2.0
	Basin Creek Trib Average	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	1.9	1.9	2.0	2.1	2.6	6.5	0.2	0.4	4.3	6.1	0.0	0.5	2.8	30.4	38.6	38.0	54.4	0.1	0.2	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	1.3	1.5	1.6	1.8
	25	0.4	nc	nc	0.1	0.8	1.1	nc	0.1	0.1	5.9	5.4	7.3	6.7	6.4	nc	0.1	1.4	10.7	13.6	nc	1.4	2.9	40.8	57.2	59.5	75.1	0.8	nc	0.0	0.2	1.5	1.7	nc	nc	0.2	0.2	5.9	6.0	8.3	8.0
	Reach 3 Average	0.5	0.0	0.0	0.1	1.0	1.1	0.0	0.1	0.1	6.5	5.4	8.2	6.8	6.4	0.1	0.1	1.4	10.7	13.6	0.2	1.4	2.9	38.2	57.2	57.2	75.2	0.9	0.0	0.0	0.2	2.0	1.7	0.0	0.0	0.2	0.2	8.2	6.0	11.4	8.0
Reach 4	Cataract Creek Trib (06031960	0.1	nc	0.1	0.1	0.3	0.4	nc	0.0	0.0	7.6	8.3	8.1	8.8	0.5	1.2	0.4	0.4	5.0	6.1	nc	0.2	0.4	33.6	35.1	39.5	43.3	0.1	0.1	0.1	0.1	0.3	0.4	nc	nc	0.0	0.0	6.5	6.4	7.0	6.9
	Cataract Creek Trib (47)	0.1	0.1	0.1	0.1	0.3	0.3	0.0	0.0	0.0	7.2	7.6	7.7	8.1	1.6	8.6	0.7	0.9	14.8	24.2	nc	0.5	4.3	73.7	95.1	91.3	133.1	0.1	0.1	0.1	0.1	0.5	0.6	0.0	nc	0.0	0.0	8.5	8.7	9.2	9.5
	Cataract Creek Trib (67M)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
	Cataract Creek Trib Average	0.1	0.1	0.1	0.1	0.4	0.4	0.0	0.0	0.0	9.6	8.0	10.2	8.6	1.0	4.1	0.6	0.7	9.8	14.0	0.0	0.3	1.8	57.0	65.8	68.7	86.4	0.1	0.1	0.1	0.1	0.4	0.5	0.0	0.0	0.0	0.0	7.5	7.5	8.1	8.2
	26M	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
	890815	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
	68M	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
	69M	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
	48	0.4	nc	0.1	0.1	1.0	1.3	nc	0.1	0.1	11.2	11.2	12.9	12.8	6.7	nc	0.7	1.7	19.2	25.9	nc	1.7	5.0	79.5	108.7	107.7	141.3	0.9	nc	0.1	0.2	2.1	2.5	nc	nc	0.2	0.2	14.2	16.0	17.6	18.9
	Reach 4 Average	0.7	0.0	0.1	0.1	1.4	1.3	0.0	0.1	0.1	16.8	11.2	19.1	12.8	6.5	16.7	0.7	2.8	22.0	26.6	0.5	1.7	8.4	81.1	154.4	112.4	209.0	0.9	0.0	0.1	0.2	3.3	2.5	0.0	0.0	0.2	0.2	16.9	16.0	21.5	18.9
Reach 5	High Ore Creek Trib (179235)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
	High Ore Creek Trib (06032300	0.1	nc	0.0	0.0	0.0	0.0	nc	0.0	0.0	3.6	3.7	3.7	3.7	0.1	0.1	0.0	0.0	0.0	0.0	nc	0.0	0.0	1.0	1.2	1.1	1.4	0.1	0.1	0.0	0.0	0.0	0.0	nc	nc	0.0	0.0	1.1	1.2	1.2	1.3
	High Ore Creek Trib (56)	0.2	1.2	0.1	0.1	0.0	0.3	0.0	0.0	1.2	21.1	31.6	21.3	34.3	0.3	1.7	0.1	0.1	0.1	0.4	nc	0.0	1.5	20.0	27.5	20.6	31.1	0.1	0.2	0.0	0.0	0.0	0.0	0.0	nc	0.0	0.1	5.7	6.8	5.9	7.1
	High Ore Creek Trib Average	0.1	0.8	0.0	0.0	0.0	0.1	0.0	0.0	0.4	10.8	14.2	10.9	15.6	0.3	0.7	0.0	0.0	0.1	0.1	0.0	0.0	0.5	9.1	11.7	9.5	13.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	3.5	3.1	3.7
	Galena Gulch Trib (57)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.0	nc	0.0	0.0	0.1	0.2	nc	0.0	0.1	0.0	0.6	0.1	0.9	0.0	nc	0.0	0.0	0.0	0.0	0.0	nc	0.0	0.0	0.0	0.0	0.0	0.0
	Galena Gulch Trib Average	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.0	nc	0.0	0.0	0.1	0.2	nc	0.0	0.1	0.0	0.6	0.1	0.9	0.0	nc	0.0	0.0	0.0	0.0	0.0	nc	0.0	0.0	0.0	0.0	0.0	0.0
	58	0.6	0.8	0.1	0.2	1.2	1.6	0.0	0.2	0.2	27.1	30.1	29.1	32.8	12.9	38.1	1.0	3.1	34.5	60.0	nc	3.1	18.5	150.1	259.8	201.6	379.6	0.8	1.0	0.1	0.2	1.4	1.7	0.0	nc	0.2	0.2	22.2	25.0	24.7	27.9
	06032400	0.6	nc	nc	0.1	0.9	1.2	nc	0.2	0.2	20.7	23.2	22.3	24.7	3.4	nc	nc	0.5	8.1	10.6	nc	0.7	2.2	45.4	56.6	57.6	70.0	0.6	0.8	nc	0.1	0.9	1.2	nc	nc	0.1	0.2	12.1	14.1	13.7	16.5
	Reach 5 Average	0.6	0.8	0.1	0.1	1.0	1.4	0.0	0.2	0.2	23.8	26.6	25.8	29.1	8.6	23.7	0.6	1.6	21.3	32.3	0.8	1.9	8.6	137.6	153.1	170.8	219.3	0.7	0.9	0.1	0.1	1.1	1.5	0.0	0.0	0.1	0.2	16.8	19.2	18.9	21.9

Notes:

Diss-Dissolved NC- Not calculated Stations with no concentration or flow data are excluded

Tot-Total COC - Contaminant of Concern

Table 5.7-1 COC Loads in the Boulder River, Basin Watershed OU2

		Winter (Dec, Jan, Feb, Mar) Total and Dissolved Loads in pounds per day (lbs/day)													Spring/Summer (Apr, May, Jun, Jul) Total and Dissolved Loads in pounds per day (lbs/day)													Fall (Aug, Sep, Oct, Nov) Total and Dissolved Loads in pounds per day (lbs/day)													
		Arsenic		Cadmium		Copper		Mercury	lead		Zinc		Combined		Arsenic		Cadmium		Copper		Mercury	lead		Zinc		Combined		Arsenic		Cadmium		Copper		Mercury		lead		Zinc		Combined	
Reaches	Stations	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot
2001																																									
Reach 1	S025	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.2	0.2	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.4
	06031450	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	6.4	18.7	nc	0.4	9.7	25.8	0.5	2.2	7.7	9.9	80.2	28.6	132.7	0.2	0.2	nc	0.0	0.1	0.1	nc	nc	0.1	0.1	0.1	1.6	0.3	1.9
	Average Reach 1	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	6.4	18.7	nc	0.4	9.7	25.8	0.5	2.2	7.7	9.9	80.2	28.6	132.7	0.2	0.2	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.8	0.3	1.1
Reach 2	S026	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.3	0.2	0.0	0.0	0.7	0.9	0.0	0.0	0.0	0.0	2.0	2.6	3.1	3.7
Reach 3	Basin Creek Trib (06031600)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	1.2	2.6	nc	0.2	2.3	3.2	0.1	0.3	0.8	19.3	22.5	23.1	29.2	0.1	0.2	nc	0.0	0.1	0.1	nc	nc	0.0	0.0	0.9	1.0	1.1	1.3
	Basin Creek Trib (S013)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.6	0.6
	Basin Creek Trib Average	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	1.2	2.6	nc	0.2	2.3	3.2	0.1	0.3	0.8	19.3	22.5	23.1	29.2	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.7	0.7	0.9	0.9
	S027	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.4	0.3	0.0	0.0	0.8	0.9	0.0	0.0	0.0	0.0	1.7	2.3	2.9	3.4
Reach 4	Cataract Creek Trib (S024)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	2.9	3.0	3.1	3.2
	Cataract Creek Trib (06031960	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.5	1.7	0.4	0.5	7.3	11.2	0.0	0.2	0.8	37.8	42.9	46.1	57.0	0.1	0.1	0.1	0.1	0.2	0.2	nc	nc	0.0	0.0	5.1	5.4	5.4	5.8
	Cataract Creek Trib Average	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.5	1.7	0.4	0.5	7.3	11.2	0.0	0.2	0.8	37.8	42.9	46.1	57.0	0.1	0.1	0.1	0.1	0.1	0.2	0.0	0.0	0.0	0.0	3.9	4.2	4.2	4.5
	S028	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.5	0.5	0.0	0.0	0.7	0.9	0.0	0.0	0.0	0.0	3.4	3.9	4.6	5.3
Reach 5	High Ore Creek Trib (S29)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3
	High Ore Creek Trib (06032300	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.1	0.7	0.0	0.1	0.0	0.2	0.0	0.0	0.5	10.8	14.6	11.1	16.0	0.1	0.1	0.0	0.0	0.0	0.0	nc	nc	0.0	0.0	1.2	1.3	1.3	1.4
	High Ore Creek Trib Average	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.1	0.7	0.0	0.1	0.0	0.2	0.0	0.0	0.5	10.8	14.6	11.1	16.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.8	0.7	0.8
	S030	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.7	0.6	0.0	0.0	0.6	0.8	0.0	0.0	0.0	0.0	3.3	4.0	4.6	5.4
	06032400	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	13.3	44.9	nc	2.7	37.6	88.4	0.9	3.7	26.2	131.1	325.8	186.6	488.0	0.7	0.8	nc	0.1	1.0	1.1	nc	nc	0.1	0.1	9.9	10.8	11.7	13.0
	Reach 5 Average	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	13.3	44.9	nc	2.7	37.6	88.4	0.9	3.7	26.2	131.1	325.8	186.6	488.0	0.7	0.7	0.0	0.1	0.8	1.0	0.0	0.0	0.1	0.1	6.2	7.0	7.8	8.8
September 6, 2001 Storm Event																																									
Reach 1	S025	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.7	0.7	0.0	0.0	0.3	0.5	0.0	0.0	0.0	0.2	0.3	2.3	1.5	3.8
Reach 2	S026	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.8	0.8	0.0	0.0	1.0	3.0	0.0	0.0	0.0	0.7	1.9	8.1	3.7	12.5
Reach 3	Basin Creek Trib (S013)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	1.1	19.5	0.1	0.6	3.2	15.0	0.0	0.0	0.1	12.8	19.3	72.5	23.9	120.4
	S027	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	2.0	13.2	0.1	0.4	3.4	12.9	0.0	0.0	0.1	6.6	12.5	57.6	18.2	90.7
Reach 4	Cataract Creek Trib (S024)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.6	5.6	0.6	0.9	8.6	21.3	0.0	0.0	0.1	5.2	46.1	71.9	56.0	104.9
Reach 5	High Ore Creek Trib (S29)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.2	1.0	0.1	0.1	0.1	0.2	0.0	0.0	0.0	1.2	12.7	18.3	13.0	20.7
	S030	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	1.7	13.9	0.3	1.1	7.5	28.2	0.0	0.0	0.3	11.2	37.9	123.5	47.7	177.9

Notes:

Diss-Dissolved
Tot-Total

nc- Not calculated
COC - Contaminant of Concern

Stations with no concentration or flow data are excluded from table

Table 6.2-1 Summary of Surface Water Flows in the Basin Creek, Basin Watershed OU2

		Historical Flow Results (1996-2000)				2001 RI Flow Results				
Stream Reaches	Stream Location	Station	Mean Winter Low-Flow (cfs)	Mean Spring/Summer High-Flow (cfs)	Mean Fall Low-Flow (cfs)	Station	Spring/Summer 2001 High-Flow (cfs)[1]	Fall 2001 Low-Flow (cfs)	Fall 2001 Low-Flow (cfs)[1]	Fall 2001 Storm High-Flow (cfs)
Reach 1	Basin Creek Mainstem above Lady Leith Tributary	NA	NM	NM	NM	S001	NM	0.1	NM	1
Reach 2	Tributary (Lady Leith)	NA	NM	NM	NM	S002	NM	0.2	NM	1
	Basin Creek Mainstem above Buckeye Mine	5	NM	8	0.4	NA	NM	NM	NM	NM
	Tributary (Buckeye Mine Tributary)	6	NM	2	0.03	NA	NM	NM	NM	NM
	Basin Creek Mainstem below Buckeye Mine tributary	7	NM	9	0.4	NA	NM	NM	NM	NM
	Basin Creek Mainstem below Buckeye Mine	8	NM	13	0.5	NA	NM	NM	NM	NM
	Basin Creek Mainstem below Buckeye Mine	NA	NM	NM	NM	S003	NM	0.3	NM	NM
Reach 3	Basin Creek Mainstem below Buckeye Mine	462347112180401	0.2	4	1	462347112180401	NM	NM	0.7	NM
	Tributary (Grub Gulch)	9	NM	13	NM	NA	NM	NM	NM	NM
	Tributary (Clear Creek mouth)	10	NM	11	0.1	S004	NM	0.1	NM	NM
	Tributary (Jimmys Creek)	11	NM	6	0.02	NA	NM	NM	NM	NM
	Basin Creek Mainstem above Joe Bowers Creek	12	NM	75	NM	S005	NM	0.9	NM	NM
Reach 4	Tributary (Joe Bowers Creek)	13	NM	10	0.3	NA	NM	NM	NM	NM
	Basin Creek Mainstem below Joe Bowers Creek Tributary	14	NM	85	NM	NA	NM	NM	NM	NM
	Tributary (Weasel Gulch)	15	NM	6	0.1	NA	NM	NM	NM	NM
	Basin Creek Mainstem below Weasel Gulch Tributary	NA	NM	NM	NM	S006	NM	1	NM	23
Reach 5	Jack Creek Tributary above Bullion Mine Tributary	16	NM	8	0.5	NA	NM	NM	NM	NM
	Bullion Mine Tributary at Jack Creek	17	0.2	2	0.3	S008	NM	0.1	NM	NM
	Tributary (to Jack Creek)	18	NM	16	1	S007	NM	0.1	NM	NM
	Jack Creek Tributary below Bullion Mine Tributary	19	NM	15	1	NA	NM	NM	NM	NM
	Bullion Smelter Tributary	20	NM	5	0.4	NA	NM	NM	NM	NM
	Tributary (Jack Creek mouth)	NA	NM	NM	NM	S009	NM	0.3	NM	11
	Tributary (Jack Creek mouth)	462047112201901	0.8	6	2	462047112201901	12.35	NM	1.3	NM
	South Fork Creek Tributary	NA	NM	NM	NM	S010	NM	0.4	NM	NM
	Tributary (Unnamed 1)	21	NM	2	0.1	NA	NM	NM	NM	NM
	Basin Creek Mainstem below Unnamed Tributary 1	NA	NM	NM	NM	S011	NM	2	NM	44
Reach 6	Basin Creek Mainstem below Unnamed Tributary 1	22	NM	233	3	NA	NM	NM	NM	NM
	Tributary (Saul Haggerty Gulch)	23	NM	9	0.2	NA	NM	NM	NM	NM
	Basin Creek Mainstem below Saul Haggerty Gulch	NA	NM	NM	NM	S012	NM	3	NM	NM
Reach 7	Basin Creek Mainstem above Boulder River	06031600	5	49	4	06031600	75	NM	4	NM
	Basin Creek Mainstem above Boulder River	24	4	120	4	S013	NM	2	NM	49

Notes:

1 - USGS provisional flow results from measurements taken in April, May, August, and September 2001
NM - Not Measured
NA - Not Applicable
RI - Remedial Investigation
cfs - cubic feet per second
- Shading indicates tributary flow data

This page intentionally left blank.

Table 6.3-1 Surface Water COC Concentrations in Basin Creek, Basin Watershed OU2

Historical

Winter (Dec, Jan, Feb, Mar) Total and Dissolved COC Concentrations (ug/l)

Reach	StationGroup	Other Parameters (mg/l) pH	SO4	TDS	Arsenic Diss	Arsenic Tot	Cadmium Diss	Cadmium Tot	Copper Diss	Copper Tot	Mercury Diss	Lead Diss	Lead Tot	Zinc Diss	Zinc Tot
Reach 1		nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Reach 2	128486	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	22-072-SW3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	22-074-SW1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	22-074-SW2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Lady Leith Tributary (22-316-SW1)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Lady Leith Tributary (22-316-SW2)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Basin Unnamed Tributary 2 (2M)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	3M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	5	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Basin Unnamed Tributary 1 (6)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	7	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	8	7	nd	nd	14.4	nd	nd	0.31	2.7	5	nd	***2.14***	***81***	40	43
Reach 3	Clear Creek Tributary (10)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Jimmys Creek Tributary (11)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	12	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Clear Creek Tributary (22 031-SW1)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Clear Creek Tributary (22 031-SW2)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	462347112180401	7	nd	nd	24.4	nd	nd	0.28	2.2	1.3	nd	***1.3***	***6***	38	38
	Grub Gulch Tributary (9)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Basin Creek Tributary (06031600)	7.6	nd	57	3.5	nd	nd	0.35	2.2	2.5	nd	1	1	***75***	***76***
Reach 4	Joe Bowers Creek Tributary (13)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	14	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Weasel Gulch Tributary (15)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Reach 5	6M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	7M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	8M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	9M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	10M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	11M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	123695	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	123697	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	123704	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	123705	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	123708	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	128483	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	128484	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	128493	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	13M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	14M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	15M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	16	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

Spring/Summer (Apr, May, Jun, Jul) Total and Dissolved COC Concentrations (ug/l)

Reach	StationGroup	Other Parameters (mg/l) pH	SO4	TDS	Arsenic Diss	Arsenic Tot	Cadmium Diss	Cadmium Tot	Copper Diss	Copper Tot	Mercury Diss	Mercury Tot	Lead Diss	Lead Tot	Zinc Diss	Zinc Tot
Reach 1		nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Reach 2	128486	nd	645	946.37	***441***	nd	***144.4***	nd	***2900***	nd	0.18	nd	***122***	nd	***25000***	nd
	22-072-SW3	nd	nd	89	nd	***18.1***	nd	2.57	nd	***15.9***	nd	0.04	nd	***14.5***	nd	***165***
	22-074-SW1	nd	nd	43	nd	***3.71***	nd	2.57	nd	2.43	nd	***0.13***	nd	***5.42***	nd	12.9
	22-074-SW2	nd	nd	80	nd	***10.1***	nd	2.57	nd	***6.23***	nd	0.04	nd	***9.67***	nd	***129***
	Lady Leith Tributary (22-316-SW1)	nd	nd	10	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Lady Leith Tributary (22-316-SW2)	nd	nd	9	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Basin Unnamed Tributary 2 (2M)	nd	1.5	33.33	2.4	nd	nd	nd	3.7	nd	0.18	nd	nd	nd	10.7	nd
	3M	nd	8.05	48.39	20.2	nd	nd	nd	***12.9***	nd	0.11	nd	***11.2***	nd	***152.5***	nd
	5	8.1	2.7	nd	2	***4***	nd	1	2	2	nd	nd	1	1	6	40
	Basin Unnamed Tributary 1 (6)	7.1	6.6	nd	3	***8***	***1.9***	2	***11***	***14***	nd	nd	1	1	***234***	***250***
	7	7.3	5.27	34.5	4	***6***	***0.45***	1	***6***	***6.33***	nd	nd	1	3	***95.67***	***106***
	8	7.02	7.02	35	22.5	***153***	***1***	1.25	***14***	***20.25***	nd	nd	***11.5***	***102***	***155.3***	***174***
Reach 3	Clear Creek Tributary (10)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	30
	Jimmys Creek Tributary (11)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10
	12	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	50
	Clear Creek Tributary (22 031-SW1)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Clear Creek Tributary (22 031-SW2)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	462347112180401	8	nd	nd	11.2	***36.5***	***1.11***	0.9	***12.8***	***13.55***	nd	nd	***5.44***	***29***	***115.5***	***116***
	Grub Gulch Tributary (9)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	40
	Basin Creek Tributary (06031600)	7.45	nd	39	5.9	***13***	nd	0.56	***8.9***	***11.45***	nd	nd	1	***5***	***63.5***	***73.5***
Reach 4	Joe Bowers Creek Tributary (13)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10
	14	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	40
	Weasel Gulch Tributary (15)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10
Reach 5	6M	nd	6.98	46.76	2.7	nd	nd	nd	***5.5***	nd	0.14	nd	nd	nd	31.1	nd
	7M	nd	9.1	51.66	3.6	nd	nd	nd	***4.1***	nd	0.1	nd	nd	nd	11.6	nd
	8M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	9M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	10M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	11M	nd	8.4	58.75	4.8	nd	nd	nd	3.6	nd	0.1	nd	nd	nd	12.3	nd
	123695	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	123697	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	123704	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	123705	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	123708	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	128483	nd	14.4	92.88	2.3	nd	nd	nd	2	nd	0.12	nd	nd	nd	13	nd
	128484	nd	7.8	52.12	1	nd	nd	nd	2	nd	0.15	nd	nd	nd	6.7	nd
	128493	nd	17.1	60.94	3.1	nd	***4.6***	nd	***27.4***	nd	0.1	nd	nd	nd	***442.7***	nd
	13M	nd	49	92.1	1	nd	***21.8***	nd	***80.2***	nd	0.12	nd	nd	nd	***2750***	nd
	14M	nd	45.8	92.21	1	nd	***18.9***	nd	***38.2***	nd	0.1	nd	nd	nd	***2230***	nd
	15M	nd	16.9	60.64	2.6	nd	***4***	nd	***21.7***	nd	0.1	nd	nd	nd	***373.2***	nd
	16	7.85	6.05	42	4	***9.5***	nd	1	***5.5***	***8.5***	nd	nd	1	***4.5***	15.5	30

Fall (Aug, Sep, Oct, Nov) Total and Dissolved COC Concentrations (ug/l)

Reach	StationGroup	Other Parameters (mg/l) pH	SO4	TDS	Arsenic Diss	Arsenic Tot	Cadmium Diss	Cadmium Tot	Copper Diss	Copper Tot	Mercury Diss	Mercury Tot	Lead Diss	Lead Tot	Zinc Diss	Zinc Tot
Reach 1		nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Reach 2	128486	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	22-072-SW3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	22-074-SW1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	22-074-SW2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Lady Leith Tributary (22-316-SW1)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Lady Leith Tributary (22-316-SW2)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Basin Unnamed Tributary 2 (2M)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	3M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	5	7.73	6.73	54	2.33	***2.67***	nd	1	1	1.67	nd	nd	1	3	5.67	17.8
	Basin Unnamed Tributary 1 (6)	8.1	6.05	55	1.5	***3***	nd	1	1	1	nd	nd	1	1	21.5	30.5
	7	7.75	6.75	53	2.5	***2.5***	nd	1	1	1	nd	nd	1	1	9.5	23
	8	7.65	8	54.7	20.75	***27.3***	***0.2***	1	2	3.25	0.1	nd	***1.25***	***4.75***	31	37.3
Reach 3	Clear Creek Tributary (10)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	30
	Jimmys Creek Tributary (11)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10
	12	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10
	Clear Creek Tributary (22 031-SW1)	nd	nd	40	nd	***7.8***	nd	4	nd	***13.7***	nd	***0.13***	nd	***39.8***	nd	***84.1***
	Clear Creek Tributary (22 031-SW2)	nd	nd	4	nd	***3.5***	nd	4	nd	nd	nd	***0.11***	nd	2	nd	15.6
	462347112180401	7.3	nd	nd	19.4	***31***	nd	0.5	3.7	4.5	nd	nd	***3.57***	***8***	***93***	***85***
	Grub Gulch Tributary (9)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	20
	Basin Creek Tributary (06031600)	7.45	nd	57	5	***7***	nd	0.36	3.2	4.65	nd	nd	1	1	***63***	***72***
Reach 4	Joe Bowers Creek Tributary (13)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10
	14	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Weasel Gulch Tributary (15)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10
Reach 5	6M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	7M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	8M	nd	18.3	75.5	4.5	nd	***5***	nd	nd	nd	nd	nd	nd	nd	11	nd
	9M	nd	8.1	58.5	9.9	nd	nd	nd	nd	nd	nd	nd	nd	nd	26	nd
	10M	nd	5.4	57.7	0.6	nd	***5***	nd	nd	nd	nd	nd	nd	nd	5	nd
	11M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	123695	nd	5.4	44.4	0.8	nd	***5***	nd	***10***	nd	nd	nd	nd	nd	5	nd
	123697	nd	21.3	70.5	0.1	nd	***8***	nd	nd	nd	nd	nd	nd	nd	5	nd
	123704	nd	17.1	98.9	0.5	nd	nd	nd	***15***	nd	nd	nd	nd	nd	9	nd
	123705	nd	125	197	0.6	nd	***68***	nd	***1230***	nd	nd	nd	nd	nd	***7310***	nd
	123708	nd	7.1	40.8	1	nd	***7***	nd	nd	nd	nd	nd	nd	nd	8	nd
	128483	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	128484	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	128493	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	13M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	14M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	15M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	16	7.8	9.63	69	6.33	***6.67***	0.1	1	3	2.67	nd	nd	1	1	26.3	30

Table 6.3-1 Surface Water COC Concentrations in Basin Creek, Basin Watershed OU2

		Winter (Dec, Jan, Feb, Mar) Total and Dissolved COC Concentrations (ug/l)															Spring/Summer (Apr, May, Jun, Jul) Total and Dissolved COC Concentrations (ug/l)															Fall (Aug, Sep, Oct, Nov) Total and Dissolved COC Concentrations (ug/l)														
		Other Parameters (mg/l)			Arsenic		Cadmium		Copper		Mercury	Lead		Zinc		Other Parameters (mg/l)			Arsenic		Cadmium		Copper		Mercury		Lead		Zinc		Other Parameters (mg/l)			Arsenic		Cadmium		Copper		Mercury		Lead		Zinc	
Reach	StationGroup	pH	SO4	TDS	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Diss	Tot	Diss	Tot	pH	SO4	TDS	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	pH	SO4	TDS	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot
Reach 5 (cont)	16M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	35.9	82.7	4.3	nd	10	nd	27	nd	nd	nd	105	nd	765	nd
	17	6.8	84	146	1	5	39	38	270	360	nd	1	5	4490	###	7.05	35	71.2	4.83	31.5	15.85	13.9	97.52	247.3	nd	nd	1.27	87.9	1780	2057	5.93	100	163	0.92	10	42.7	34.6	450	580	0.1	nd	3.74	18	4659	5096
	17M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.7	46.6	4.5	nd	nd	nd	nd	nd	nd	nd	nd	7	nd
	18	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.93	nd	nd	nd	nd	0.1	nd	1.67	nd	nd	nd	nd	nd	20	10	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10
	18M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.8	54.37	1.2	nd	nd	nd	2.5	nd	0.19	nd	nd	nd	17	nd	nd	10.4	59.6	6.3	nd	nd	nd	nd	nd	nd	nd	nd	14	nd
	19	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.51	12.8	51.4	3.17	32.5	3.46	3.83	32.57	61.67	nd	nd	1	14.7	391.7	442	7.7	34	91.3	1.75	16.3	10.9	11.5	62.6	145	0.1	nd	1	4.25	1060	1190
	19M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.5	52.37	1.3	nd	nd	nd	2	nd	0.15	nd	nd	nd	5.5	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	20	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10
	22-008-SW1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	72	nd	2.02	nd	2.57	nd	12.2	nd	0.04	nd	4.96	nd	45.2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	22-008-SW2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	114	nd	208	nd	26.4	nd	631	nd	0.04	nd	15.4	nd	2960	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	22-008-SW3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	137	nd	92.5	nd	22.9	nd	424	nd	0.04	nd	15.2	nd	2570	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	22-296-SW1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	58	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	22-296-SW2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	54	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Jack Creek Tributary near mouth (20M)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	25.9	71.8	7.8	nd	nd	nd	11	nd	nd	nd	nd	nd	324	nd
	Jack Creek Tributary near mouth (21M)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	17	62.38	5	nd	3.7	nd	16.4	nd	0.1	nd	nd	nd	206	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Jack Creek Tributary near mouth (462047112201901)	7.2	nd	58	3.1	nd	3.23	3.28	11.2	16	nd	1	1	392	442	7.43	nd	48.1	5.7	11.3	2.27	2.61	29.35	30.77	0.23	nd	1	2.5	239.3	258	6.7	nd	nd	3.7	7	3.28	3.25	17.2	22.5	nd	nd	1	1	405	385
	Unnamed Tributary 3 (21)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10
	22M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	15.3	58.8	5.7	nd	18	nd	17	nd	nd	nd	nd	nd	178	nd
	4M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	5	47.1	8.1	nd	19	nd	5	nd	nd	nd	nd	nd	24	nd
	5M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	6.16	45.69	8.4	10.6	nd	2	2.9	2.5	0.1	nd	nd	2	17.1	21.4	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Reach 6	128198	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	1	nd	2	nd	2	nd	nd	nd	2	nd	4	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	22	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.2	5.4	32	4	12	0.5	1	10	14	nd	nd	1	6	65	80	6.6	16	69	7	9	0.6	1	4	5	0.1	nd	1	1	92	90
	Saul Haggerty Gulch Tributary (23)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10
	23M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10.2	52.55	6.6	11.9	nd	2	2	13.5	0.12	nd	nd	2	98.4	121	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Reach 7	22-293-SW1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	53	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	22-293-SW2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	64	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	25M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	8.89	54.53	14.5	nd	nd	nd	7.8	nd	0.1	nd	nd	nd	54.7	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	24	7.67	19	74.5	4	4.67	0.4	1	3	3	0.1	1	1	83.3	87	7.57	7.16	43.89	5.5	15.5	0.51	1	10.1	15.5	nd	nd	1.04	7.3	69.8	96	7.85	18	75	6.25	7.5	0.35	1	4	4.75	0.1	nd	1	1	51.3	57
																				2001																									
Reach 1	S001	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	6.81	5.1	63	nd	nd	nd	0.04	nd	2.7	0.04	nd	nd	0.33	nd	nd
Reach 2	Lady Leith Tributary (S002)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.14	8.2	64	nd	7.6	0.09	0.07	nd	2.9	0.03	nd	nd	0.34	17.5	20.1
	S003	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	8.11	9	67	nd	nd	nd	0.23	3.5	nd	nd	nd	nd	nd	24.7	28.9
	462347112180401	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.65	nd	nd	20.1	31.5	nd	0.34	2	3.9	nd	nd	1.11	3.5	49.5	54
Reach 3	Grub Gulch Tributary (S700)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	22.6	78	nd	nd	0.05	0.07	0.75	0.86	nd	nd	0.66	0.77	22.9	24.2
	Clear Creek Tributary (M283)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	5.4	9	27	5.8	nd	0.68	0.72	17.9	17.6	0.20	0.20	59.2	69.2	95.2	91.1
	Clear Creek Tributary (S004)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	5.7	8.3	49	nd	nd	nd	0.13	nd	nd	nd	nd	nd	nd	66.2	21.9
	S005	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.1	12.6	61	nd	9.5	nd	0.08	nd	nd	nd	nd	nd	0.62	16.9	19.9
Reach 4	S006	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.48	11.5	57	7.4	nd	0.3	0.08	5.2	1.7	nd	nd	0.86	nd	nd	16.5
Reach 5	Jack Creek Tributary (17)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	6	nd	nd	9	61	11.5	12.3	110	164	nd	nd	1.27	19	1340	1350	5.65	nd	nd	0.55	45	46.1	48.4	516	632	nd	nd	1.86	13	5450	5320
	Jack Creek Tributary (S007)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	60	26.3	81	nd	nd	0.02	0.02	0.57	1.9	nd	nd	0.24	0.49	3.9	6.6
	Jack Creek Tributary (S008)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	4.6	125	234	nd	nd	64.6	nd	925	1060	nd	nd	9.4	nd	6480	6570

Table 6.3-1 Surface Water COC Concentrations in Basin Creek, Basin Watershed OU2

		Winter (Dec, Jan, Feb, Mar) Total and Dissolved COC Concentrations (ug/l)														Spring/Summer (Apr, May, Jun, Jul) Total and Dissolved COC Concentrations (ug/l)														Fall (Aug, Sep, Oct, Nov) Total and Dissolved COC Concentrations (ug/l)													
		Other Parameters (mg/l)			Arsenic		Cadmium		Copper		Mercury	Lead		Zinc		Other Parameters (mg/l)			Arsenic		Cadmium		Copper		Mercury		Lead		Zinc		Other Parameters (mg/l)			Arsenic		Cadmium		Copper		Mercury		Lead		Zinc	
Reach	StationGroup	pH	SO4	TDS	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Diss	Tot	Diss	Tot	pH	SO4	TDS	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	pH	SO4	TDS	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot
Reach 5 (cont)	Jack Creek Tributary at the mouth (462047112201901)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.25	nd	61	3.85	**22.5**	**2.28**	3.2	**35.65**	**101.2**	0.23	nd	1	**8**	**279.5**	**365**	7.6	nd	nd	4.45	nd	**3.15**	3.48	**12.5**	**28.2**	nd	nd	1	1	**346**	**397**
	Jack Creek Tributary at the mouth (S009)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	6.4	27.4	85	5.5	nd	**3.3**	nd	**14.7**	**31.5**	nd	nd	0.69	nd	**387**	**430**
	South Fork Creek Tributary (S010)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.91	3.4	49	nd	nd	nd	nd	nd	0.64	nd	nd	nd	nd	nd	nd
	S011	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.2	15	70	7.4	**9**	**0.66**	0.66	**5**	**37.9**	nd	nd	0.21	0.36	**90.1**	**89.3**
Reach 6	S012	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.58	15.8	87	8.2	**5.9**	**0.32**	0.33	3.5	nd	nd	nd	0.28	0.44	**42.4**	40.2
Reach 7	6031600	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.3	nd	61.8	4.35	**10**	nd	0.58	**8.75**	**12**	0.23	nd	1	3	**73**	**85**	7.75	nd	nd	5.9	nd	nd	0.3	3.5	4.3	nd	nd	1	1	38	44
	S013	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	17.4	90	6.6	**6.1**	**0.25**	0.25	4	**56.9**	nd	nd	nd	0.32	34.8	34.8
September 6, 2001 Storm Event																																													
Reach 1	S001	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	5.6	66	nd	**4.3**	0.02	0.04	2.2	2.7	nd	nd	0.23	0.86	4.3	6.4
Reach 2	S002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	6.1	69	nd	**9**	0.09	0.24	2	2.9	nd	nd	0.28	**6.4**	23.7	40.6
Reach 4	S006	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	19.9	112	7.4	**52.9**	**0.3**	0.66	**5.2**	**12**	nd	nd	0.86	**33**	**43.3**	**95.9**
Reach 5	Jack Creek Tributary (S009)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	18.4	95	nd	**54.4**	**3.1**	4.4	**39.4**	**93.5**	nd	nd	0.69	**25.4**	**338**	**480**
	S011	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	13.5	98	nd	**51.9**	**0.98**	1.8	**15.5**	**37.9**	nd	nd	0.57	**28.7**	**113**	**205**
Reach 7	S013	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	15.7	92	nd	**74**	**0.55**	2.4	**12.2**	**56.9**	nd	nd	0.49	**48.6**	**73.2**	**275**

Notes:
nd - No Data for that sample
ug/L - micrograms per liter
Tot - Total Comcentrations
Dis - Dissolved Concentrations
SO4 - Sulfate
TDS - Total Dissolved Solids
mg/L - micrograms per liter
Values in **bold underline** exceed benchmarks

Table 6.4-1 Basin Creek Sediment Mean COC Results, Basin Watershed OU2

		Total Concentrations in (mg/kg)					
Reach	Station	Arsenic	Cadmium	Copper	Mercury	Lead	Zinc
		Historical					
Reach 2	20S	45	nd	27	nd	91	270
	21aS	380	nd	100	nd	210	670
	21bS	880	nd	76	nd	460	510
	21cS	4000	nd	130	nd	1500	660
	21dS	4200	nd	190	nd	2200	860
	21eS	4500	5	130	nd	1600	820
Reach 3	Grub Gulch (22-039-SE1)	20.44	0.5	6.8	13.94	8	69.9
	Clear Creek Tributary (22S)	35	nd	13	nd	61	210
	Clear Creek Tributary (22-031-SE1)	82.2	nd	41.9	0.17	465	45.9
	Clear Creek Tributary (22-031-SE2)	32.2	nd	11.4	0.09	72.4	53.5
	Clear Creek Tributary (22-031-SE500)	102	nd	nd	nd	341	161
	22-072-SE1000	464.64	nd	nd	nd	203.9	204.72
	22-072-SE3	997	0.9	44.3	0.06	589	253
	22-072-SE500	1043.39	138	62.08	nd	414.69	295.86
	22-074-SE1	15	nd	12.9	0.03	34	95
	22-074-SE1000	464.64	nd	nd	nd	203.9	204.72
	22-074-SE2	2360	1.2	60.6	0.08	415	208
	22-074-SE500	1043.39	138	62.08	nd	414.69	295.86
	22-316-SE1	41.4	1.4	15.3	0.04	77.1	65.7
	22-316-SE1000	183	nd	nd	nd	139	522
	22-316-SE2	211	4.5	31.7	0.07	203	357
	22-316-SE500	157	nd	nd	nd	161	443
	23S	500	4	49	nd	340	690
Reach 5	South Fork Tributary (25S)	44	nd	13	nd	87	150
	9B	279.31	3.4	135.46	nd	359.15	300.77
	8B	25.5	2	21.6	nd	66.3	113.4
	12B	63.83	3	93.83	nd	38	336.67
	13B	83.78	7.78	317.78	nd	89.11	1061.11
	14B	690	6.75	363.86	nd	521.86	555
	15B	675	8.62	356.5	nd	332.5	875
	22-008-SE500	1235.23	nd	227.47	nd	278.92	289.38
	22-008-SE1000	2913.69	nd	418.29	nd	626.64	602.68
	22-008-SED1	9	0.5	6.6	0.04	8	34
	22-008-SED2	2180	nd	192	0.06	179	313
	22-008-SED3	1230	0.9	146	0.07	393	275
	22-296-SE1	573	4.2	127	0.01	158	284
	22-296-SE2	263	1.7	83.1	0.02	79	201
	Bullion Mine Tributary (32S)	45	nd	47	nd	59	240
	Bullion Mine Tributary (33S)	2300	nd	320	nd	870	690
	Bullion Mine Tributary (34S)	4600	4	360	nd	1400	630
	Bullion Mine Tributary (35S)	3800	5	300	nd	12000	740
	Bullion Mine Tributary (36S)	2880	2.5	93.5	nd	3010	770
	Bullion Mine Tributary (37S)	2900	nd	54	nd	2600	110
	38S	205	nd	114	nd	175	385
	39S	845	3	350	nd	495	475
	40S	572.5	6.75	268	nd	486	764
	41S	690	12	380	nd	260	1400

Table 6.4-1 Basin Creek Sediment Mean COC Results, Basin Watershed OU2

		Total Concentrations in (mg/kg)					
Reach	**Station**	**Arsenic**	**Cadmium**	**Copper**	**Mercury**	**Lead**	**Zinc**
Reach 5 (cont)	43aS	***84***	nd	***58***	nd	***70***	***180***
	Jack Creek Tributary (42S)	***690***	***19***	***470***	nd	***270***	***2400***
	Jack Creek Tributary (24S)	***140***	nd	***29***	nd	***200***	***380***
	26S	***330***	***2***	***130***	nd	***210***	***580***
	10B	***31.1***	***3***	***18.8***	nd	***57***	***153***
	27S	***340***	***8***	***180***	nd	***190***	***1100***
Reach 6	11B	***165***	nd	***120***	nd	***92.5***	***245***
	28S	***210***	***7***	***110***	nd	nd	nd
	22-293-SE1	***45.9***	***2.5***	***161***	0.07	***89.3***	***284***
	22-293-SE100	nd	nd	nd	nd	***117***	***275***
	22-293-SE2	***74.5***	***3.3***	***27.3***	0.06	***67.1***	***292***
Reach 7	29S	***210***	***7***	***120***	nd	***160***	***950***
	30S	***160***	***4***	***92***	nd	***165***	***560***
	31S	***110***	***4***	***93***	nd	***160***	nd
2001 Minus 10-Mesh							
Reach 1	S001	***6.85***	0.06	13	0.07	24.65	52
	Lady Leith Tributary (S002)	***137.5***	***3.4***	***23.95***	0.07	***155***	***454.5***
Reach 2	S003	***504***	***1.6***	***27.6***	0.06	***271***	***217***
	Clear Creek Tributary (S004)	***20.6***	0.26	5.4	0.07	43.5	31.8
Reach 3	S005	91.7	1.5	11	0.06	66.6	164
Reach 4	S006	***76.7***	***1.8***	13.2	0.07	***99.3***	***187***
Reach 5	Jack Creek Tributary (S007)	***12.3***	0.07	14.5	0.08	10.6	71.3
	Jack Creek Tributary (S008)	***1050***	***12.1***	***509***	0.07	***280***	***863***
	Jack Creek Tributary at mouth (S009)	***367***	***11.3***	***231***	0.06	***151***	***1100***
	S010	***7.2***	***0.59***	3.7	0.06	9.6	32.5
	S011	***196***	***2.8***	***61.8***	0.06	***111***	***294***
Reach 6	S012	***31.3***	***2.6***	***24.7***	0.06	47	***264***
Reach 7	S013	***41.2***	***2.2***	***27.3***	0.07	33.4	***239***
2001 Minus 80-Mesh							
Reach 1	S001	***21.2***	0.21	***33.9***	0.05	***55.1***	***141***
	Lady Leith Tributary (S002)	***365***	***7***	***46.6***	0.05	***362***	***960***
Reach 2	S003	***3220***	***5.9***	***121***	0.05	***1430***	***916***
Reach 3	S005	***343***	***4.5***	***42.2***	0.08	***220***	***603***
Reach 4	S006	173	2.7	24.8	0.05	383	374
Reach 5	Jack Creek Tributary (S007)	***17.2***	0.08	***29.8***	0.05	20.15	***130***
	Jack Creek Tributary (S008)	***1360***	***15.2***	***1280***	0.05	***577***	***1250***
	Jack Creek Tributary at mouth (S009)	***684***	***21***	***476***	0.12	***341***	***2230***
	S010	***9.4***	0.05	7.5	0.05	15.6	39.4
	S011	***222***	***6.5***	***112***	0.05	***150***	***497***
Reach 6	S012	***103***	***4.9***	***66.9***	0.05	***124***	***627***
2001 Minus 260-Mesh							
Reach 5	S009	***1095***	***38.4***	***876.5***	***0.27***	***522***	***3620***

Notes: nd- No data Values in **bold underline** exceed benchmarks

Table 6.5-1 Summary of COC Concentrations Acid Base Accounting Parameters in Mine Waste in BAsin Creek AOC, Basin Watershed OU2

	Concentration of COCs (mg/kg)												Field Parameters		Acid Base Accounting (MT CaCO3/1000 MT)								Total Sulfur (mg/kg) Makeup							
Mine Sites	Arsenic		Cadmium		Copper		Mercury		Lead		Zinc		pH (Paste)		Neutralization Potential (NP)		Acid Potential (AP)		Net Neutralization Potential (NNP)		Net Acid Potential (NAP)		Total Sulfur		% Sulfide		% Sulfate		NP/AP (Ratio)	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
High Probability of Generating Acid (% Sulfide >= 0.3 and NP/AP <1)																														
BULLION MINE	105	190	36.9	45.9	839	1060	0.22	0.72	24200	25400	8180	9530	2	3	-1.2	-1.2	91	91	-92	-92	nd	nd	29100	29100	2.25	2.25	0.66	0.66	-0.0132	-0.013
BM-SO-004	3	18100	0.04	6	10 U	3500	0.06 U	0.575	5.7	11300	20	9100	2.4	7.2	-0.6	10	23	23	-33	10	nd	nd	500	7800	0.44	0.9*	0.29	0.29	-0.03	-0.03
NORTH ADA [1]	840	5380	2	10	70	180	nd	nd	1140	6250	60	1830	2.4	5.7	1	2	0	21	-21	2	nd	nd	nd	nd	0.09*	0.76*	nd	nd	na	0.05
AURORA	43.2	222	0.04	0.77	54.5	549	0.17	0.25	9240	20000	64.3	90.3	2.2	2.2	-2.4	-2.4	27	27	-29	-29	nd	nd	8500	8500	0.52	0.52	0.33	0.33	-0.09	-0.09
BASIN BELLE	2660	5310	0.04	nd	9.1	15	0.23	0.27	545	694	110	192	2.5	4	-1	-1	20	20	-21	-21	nd	nd	6500	6500	0.46	0.46	0.19	0.19	-0.05	-0.05
ADELAIDE	20400	79500	0.05 U	0.39	34.4	75.5	0.06 U	0.06	603	2360	71.6	160	2	3	-3.2	-3.2	19	19	-22	-22	nd	nd	6200	6200	0.45	0.45	0.17	0.17	-0.17	-0.17
DORIS	21.6	49.1	3.8	5.2	151	159	0.64	1.9	172	486	706	852	2.7	5	8.2	11	18	21	-13	-7	nd	nd	5700	6800	0.27	0.39	0.29	0.3	0.46	0.39
BASIN CREEK PLACER	52.2	73.9	0.05 U	0.36	51.3	73.8	0.15	0.75	3900	4780	492	769	2.4	3.5	-1.3	-1.3	38	38	-39	-39	nd	nd	12100	12100	0.38	0.38	0.83	0.83	-0.03	-0.03
Medium Probability of Generating Acid (% Sulfide < 0.3 and NP/AP <1)																														
24JF0524	889	1740	0.05 U	1.7	26.8	28.7	0.26	0.28	1340	1650	502	762	2.3	4	-3	-3	13	13	-16	-16	nd	nd	4300	4300	0.23	0.23	0.2	0.2	-0.23	-0.23
BUCKEYE MINE	43.5	50.9	1.4	6.4	58.6	151	0.45	0.56	2710	14800	303	1480	2.5	4.5	-0.2	-0.2	15	15	-15	-15	nd	nd	4700	4700	0.22	0.22	0.25	0.25	-0.01	-0.01
ENTERPRISE MINE	58.8	63.7	2.5	3	94.6	101	0.09	0.24	1590	2110	837	953	2.8	4	14	14	26	26	-12	-12	nd	nd	8200	8200	0.18	0.18	0.65	0.65	0.54	0.54
FIRST SHOT / LAST SHOT	504	623	3.1	6.9	73.4	88.9	0.06 U	0.11	2160	4930	966	1600	4.7	5	12	12	19	19	-7.2	-7.2	nd	nd	6200	6200	0.17	0.17	0.45	0.45	0.63	0.63
BULLION SMELTER [1]	52	5246	0.08	0.4	37.1	177	0.08	0.704	53.3	10600	46.4	371	2	5	0.2	0.2	11	11	-11	-11	nd	nd	3400	3400	0.15	0.15	0.19	0.19	0.02	0.02
ADIT, MINE, WASTE ROCK DUMP	1330	1840	0.04	nd	19.6	30.4	0.12	0.2	4090	4900	53.6	68.4	2.2	3	-1.1	-1.1	7.7	7.7	-8.8	-8.8	nd	nd	2400	2400	0.13	0.13	0.11	0.11	-0.14	-0.14
DOUBLE SHAFT	155	185	1	1.7	280	311	0.89	2.2	3180	3720	331	434	3.2	5	4.4	4.4	8.2	8.2	-3.8	-3.8	nd	nd	2600	2600	0.09	0.09	0.17	0.17	0.54	0.54
COLUMBUS	120	122	0.24	2.4	23.2	57.8	0.14	0.16	807	832	183	473	3	3	1.5	1.5	6.5	6.5	-5	-5	nd	nd	2100	2100	0.08	0.08	0.13	0.13	0.23	0.23
DAILY WEST [1]	21.4	21.7	2.1	7.5	74.9	96.7	0.06 U	nd	286	354	292	1150	3	6	1.3	1.3	5.2	5.2	-3.9	-3.9	nd	nd	1700	1700	0.03	0.03	0.13	0.13	0.25	0.25
DEW DROP	289	473	0.13	0.46	29.2	32.5	0.06 U	0.19	570	589	169	192	2.9	5	1.4	1.4	4.1	4.1	-2.7	-2.7	nd	nd	1300	1300	0.03	0.03	0.1	0.1	0.34	0.34
DOROTHY SNOW	11.6	14.9	2 U	4.2	91.6	123	0.1	0.18	858	947	271	369	3.8	4.5	1.7	1.7	3.6	3.6	-2	-2	nd	nd	1200	1200	0.03	0.03	0.09	0.09	0.47	0.47
Low Probability of Generating Acid (% Sulfide < 0.3 and NP/AP >1)																														
GRUB CREEK STATION	29.6	53.5	0.08	0.22	3.6	9.6	0.05 U	0.14	31.2	58.4	68.2	89.9	4	5	1.7	1.7	1.4	1.4	0.3	0.3	nd	nd	500	500	0.03	0.03	0.02	0.02	1.21	1.21
HAWKEYE MINE	4	5.4	0.04	nd	8.3	9.3	0.34	0.59	18.6	21.3	23	29.2	3.9	5.5	2.6	2.6	1	1	1.6	1.6	nd	nd	300	300	0.02	0.02	0.01	0.01	2.60	2.60
HECTOR [1]	11.3	16.1	1.2	2.3	27.4	29.6	0.05 U	nd	119	167	255	321	5	5	6.2	6.2	1.9	1.9	4.2	4.2	nd	nd	600	600	0.05	0.05	0.02	0.02	3.26	3.26
HECTOR - LOWER [1]	4.9	17.7	6.9	9.9	218	299	1.2	1.4	1060	1240	814	853	7	7.5	50	50	14	14	36	36	nd	nd	4600	4600	0.16	0.16	0.3	0.3	3.57	3.57
JACK CREEK TAILINGS	46.1	47.9	0.5 U	0.66	27.8	28.4	0.05 U	nd	32.5	44.2	117	143	4.9	7	7.3	7.3	1.9	1.9	5.4	5.4	nd	nd	600	600	0.05	0.05	0.01	0.01	3.84	3.84
JESSIE	7.6	16.6	0.04	0.13	15.8	22.2	0.06 U	0.09	18.9	33.3	32.6	55.6	4.1	6.5	5.4	5.4	0.9	0.9	4.5	4.5	nd	nd	300	300	0.03	0.03	0.01	0.01	6.00	6.00
Unknown Probability, Lack of ABA Data																														
JOSEPHINE	33.31	33.31	6.43	6.43	1429.3	1429.3	0.96	0.96	1825	1825	1312.8	1312.8	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
LADY HENNESSEY	51.9	51.9	1.4	1.4	30.3	30.3	0.05 U	nd	123	123	185	185	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
LADY LEITH [1]	9.8	9.8	1.5	nd	36.7	36.7	0.24	nd	50.1	50.1	198	198	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
MAGDELENA GROUP	5	63000	0.4 U	370	17.9	4800	0.03	1.1	30	93000	45	28000	nd	nd	nd	nd	nd	nd	nd	nd	4.59	20.9	nd	nd	nd	nd	nd	nd	na	na
MEYERS GULCH	0	13000	0.51	1300	0 U	9000	0.21	2.37	0 U	16000	0 U	18000	nd	nd	nd	nd	nd	nd	nd	nd	2.45	18.1	nd	nd	nd	nd	nd	nd	na	na
MOLLY SNOW	10	140	0.45	50	30	1540	0.55	1.21	210	39900	140	6910	2.2	6.9	1	5	nd	nd	-120	-1	33.7	33.7	1300	32400	0.1*	3.1*	nd	nd	na	na
MORNING [1]	5.68 U	44.4	2.4	11.9	82.2	717	0.066	3.33	39	3493	494	5654	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
MORNING STAR	88	96729	0.7	270.2	49.7	235.43	0.068	0.209	99.84	3520	78	338.57	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
NEPTUNE	36.21	97.62	1.4	3.21	29.57	61.84	0.26	0.5	42.08	123.22	134.53	309.57	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
PERRY PARKS	0 U	160	0	71	0 U	730	0.4	1.59	0 U	4050	1.59 U	11600	2.8	7.2	1	4	nd	nd	-32	-26	nd	nd	10800	18600	0.2*	0.8*	nd	nd	na	na
PLACER	11	190	2 U	6.39	40	580	1.49	1.49	90	1910	510	1374.2	2.7	6.4	1	nd	nd	nd	-29	-29	nd	nd	14300	14300	0.7*	0.7*	nd	nd	na	na
RTI RECON: P	60.21	3562.1	2.2	4	38.69	918.64	0.044	0.096	26.28	1126.5	156.06	561.74	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
RTI RECON: R	34	10000	1.49	100	20.78	1020	0.054	218	30	20600	190.09	5020	2.2	7.6	1	36	nd	nd	-45	-2	nd	nd	2200	26700	0.1*	1.1*	nd	nd	na	na
SE NW SECTION 30	130	11600	2 U	17	30	490	nd	nd	120	14000	70	550	1.9	6.4	1	5	nd	nd	-12	5	nd	nd	500	4200	0.1*	0.3*	nd	nd	na	na
SE SE SECTION 35	73.87	73.87	nd	nd	nd	nd	48.06	48.06	24.16	24.16	109.34	112.64	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
VINDICATOR [1]	25.87	3960	1.41	64	26.71	1020	0.45	0.45	40	3870	94.28	6130	3	7.8	1	16	nd	nd	-28	8	nd	nd	500	14400	0.1*	0.8*	nd	nd	na	na
SMELTER CREEK ADIT	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	4	5	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na

Notes:

mg/kg - Milligrams MT - Metric Tonne U - Undetect nd - No data % Total Sulfur Values NA - Not Applicable Max - Maximum

CaCO3 - Calcium (% - Percent R - Rejected na - Not Applicable No data Min - Minimum Values in **bold underline** exceed benchmarks

Table 6.5-2 Summary of COC Concentrations in Adits and Seep Discharges at Mine Sites in Basin Creek AOC, Basin Watershed OU2

	Discharge (gpm)		Arsenic				Cadmium				Copper				Lead				Mercury				Zinc				pH		Sulfate	
			Total (ug/L)		Dissolved (ug/L)		Total (ug/L)		Dissolved (ug/L)		Total (ug/L)		Dissolved (ug/L)		Total (ug/L)		Dissolved (ug/L)		Total (ug/L)		Dissolved (ug/L)		Total (ug/L)		Dissolved (ug/L)					
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
VINDICATOR	0.2	7	10 U	**5.3**	10 U	10 U	0.083	**10.2**	0.08	**10.1**	1.7	**39.3**	1.8	**44.5**	1.2	**31.7**	1 U	**5.6**	0.20 U	0.20 U	0.20 U	0.20 U	12.4	**638**	**293**	**643**	**7.14**	**7.85**	**9.4**	**46**
LADY LEITH	1	6	**40.0**	**68.1**	**10.8**	**25.8**	**1.9**	**10.6**	**2. U**	**12.8**	**4.6 U**	**16.4**	**2. U**	**48**	0.75	**84.3**	2 U	**236.1**	0.20 U	0.20 U	0.20 U	0.20 U	**695**	**1180**	**312.6**	**1660**	**3.67**	**7.54**	**41.5**	**104**
BULLION MINE	3	3	**2380**	**12700**	**316**	**1510**	**523**	**736**	**448**	**452.6**	**12300**	**19400**	**7770**	**11600**	**444**	**743**	**166.1**	**392**	0.20 U	**0.04 U**	**0.14 U**	0.20 U	**49800**	**80600**	**48000**	**48900**	**3.01**	**3.01**	**696**	**934**
JOSEPHINE	0.4	1	**5.5**	**15.3**	**8.5**	**15.3**	**5.4**	**11.3**	**5.2**	**11.2**	**114**	**295**	**114**	**191**	**428**	**554**	**412**	**448**	0.20 U	0.20 U	0.20 U	0.20 U	**550**	**1430**	**586**	**1070**	**3.2**	**5.2**	**45.8**	**74.9**
MORNING STAR	0.07	0.07	10 U	10 U	10 U	10 U	1 U	1 U	1 U	1 U	2.5	2.5	1.7	1.7	1 U	1 U	1	1	0.20 U	0.20 U	0.20 U	0.20 U	32.8	32.8	32.1	32.1	**6.25**	**6.25**	**4.2**	**5.2**
RTI RECON: P	0.003	0.003	**71.5**	**71.5**	**18.3**	**18.3**	**0.48**	**0.48**	**0.28**	**0.28**	**11.0**	**11.0**	**1.9**	**1.9**	**38.9**	**38.9**	1 U	1 U	0.20 U	0.20 U	0.20 U	0.20 U	**80.4**	**80.4**	**48.4**	**48.4**	**6.6**	**6.6**	**17.6**	**17.6**
AURORA	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	ND	ND	ND	ND
BUCKEYE MINE	nd	nd	nd	nd	nd	nd	nd	nd	**98.9**	**98.9**	nd	nd	**819**	**819**	nd	nd	**20000**	**2000**	nd	nd	**0.1 U**	**0.1 U**	nd	nd	**20000**	**20000**	**3.24**	**3.24**	**678**	**678**
BULLION SMELTER	nd	nd	**10.0 U**	nd	**4.7**	nd	**1.0 U**	nd	**1.0 U**	nd	**0.29**	nd	**0.21**	nd	0.31	0.31	1 U	1 U	0.20 U	nd	0.20 U	nd	**9.5**	nd	**1.6**	nd	**15**	**15**	ND	ND
COLUMBUS	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	ND	ND	ND	ND
ENTERPRISE MINE	nd	nd	**15500**	**15500**	nd	nd	**146**	**146**	nd	nd	**1340**	**1340**	nd	nd	**1340**	**1340**	nd	nd	**0.08**	**0.08**	nd	nd	**23400**	**23400**	nd	nd	ND	ND	ND	ND
HAWKEYE MINE	nd	nd	nd	nd	**2.8**	**11.1**	nd	nd	**2. U**	**2.U**	nd	nd	**2.U**	**2.U**	nd	nd	2 U	2 U	nd	nd	**0.1**	**0.12**	nd	nd	**58.2**	**152**	**6.87**	**6.99**	**17**	**141**
JESSIE	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	ND	ND	ND	ND
MEYERS GULCH	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	ND	ND	ND	ND
MORNING	nd	nd	nd	nd	**4.4**	**45**	nd	nd	**4.2**	**10**	nd	nd	**7**	**207.8**	nd	nd	2 U	**100**	nd	nd	nd	nd	nd	nd	**81**	**1395**	**6.26**	**5.99**	**5.4**	**34.2**
SE NW SECTION 30	nd	nd	**104**	**104**	10 U	10 U	**1.1**	**1.1**	**0.21**	**0.21**	**7.4**	**7.4**	**0.79**	**0.79**	**47.3**	**47.3**	1 U	1 U	0.20 U	0.20 U	0.20 U	0.20 U	**146**	**146**	**79.2**	**79.2**	**6.43**	**6.9**	**20.7**	**20.7**
SE SE SECTION 35	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	ND	ND	ND	ND
SMELTER CREEK ADIT	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	ND	ND	ND	ND

gpm - Gallons per minute U - Nondetect nd - No Data ug/L - micrograms per liter Values in **bold underline** exceed benchmarks

Table 6.6-1 Summary of COC Concentrations in Groundwater in the Basin Creek AOC, Basin Watershed OU2

		Arsenic (ug/L)		Cadmium (ug/L)		Copper (ug/L)		Lead (ug/L)		Mercury (ug/L)		Zinc (ug/L)		pH	Sulfate
Mine/Subarea	**Sample Type**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**(S.U.)**	**(mg/l)**
Upper Basin Creek Subarea	Spring	2.2	1.6	2U	2 U	2 U	2 U	2 U	2 U	0.11	nd	2.1	2.3	7.81	6.7
Josephine	Shaft	8.6	22.4	0.15	0.11	29.8	7.8	1030	308	0.061	0.2 U	13	10.5	nd	2.3
Josephine	Shaft	8.4	10	nd	0.034	9.4	1.5	147	11.7	0.2 U	0.2 U	9.1	13.4	nd	0.78
Dorothy	Shaft	10 U	10 U	0.27	0.052	1.8	0.57	8.7	0.44	0.2 U	0.2 U	30	17.9	nd	1.9
Jack Creek Subarea	Spring	nd	26.7	nd	2 U	nd	2.1	nd	2 U	nd	0.1 U	nd	22.2	7.4	21.1
Jack Creek Subarea	Spring	nd	29.3	nd	2 U	nd	2 U	nd	2 U	nd	0.1 U	nd	23.8	7.68	20.9
Lower Basin Creek Subarea	Residential Groundwater Well	nd	2.4	nd	3.3 U	nd	7.6	nd	0.9 U	nd	0.2 U	nd	29.5	nd	nd
Lower Basin Creek Subarea	Residential Groundwater Well	nd	1.96	nd	0.31 U	nd	1.4	nd	1.7 U	nd	0.073 U	nd	77.7	nd	nd
Jack Creek Subarea	Spring	nd	5	nd	2 U	nd	2.5	nd	2 U	nd	0.1 U	nd	162	7.08	30.7
Josephine	Shaft	nd	7	nd	4 U	nd	5.9 U	nd	22.8	nd	0.075 U	nd	15.6 U	nd	nd

Notes: U- Nondetect; nd - No Data; S.U. - Standard Units; ug/L - micrograms per liter; mg/L - milligrams per liter

This page intentionally left blank.

Table 6.7-1 COC Loads in the Basin Creek, Basin Watershed OU2

		Winter (Dec, Jan, Feb, Mar) Total and Dissolved Loads in pounds per day (lbs/day)													Spring/Summer (Apr, May, Jun, Jul) Total and Dissolved Loads in pounds per day (lbs/day)														Fall (Aug, Sep, Oct, Nov) Total and Dissolved Loads in pounds per day (lbs/day)													
		Arsenic		Cadmium		Copper		Mercury		lead		Zinc		Combined	Arsenic		Cadmium		Copper		Mercury		lead		Zinc		Combined		Arsenic		Cadmium		Copper		Mercury		lead		Zinc		Combined	
Reaches	Stations	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot
Historical																																										
Reach 2	5	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.09	0.17	nc	0.04	0.09	0.09	nc	nc	0.04	0.04	0.26	1.71	0.47	2.05	0.01	0.01	nc	0.00	0.00	0.00	nc	nc	0.00	0.01	0.01	0.04	0.02	0.06
	Buckeye Mine Tributary	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.03	0.07	0.02	0.02	0.10	0.13	nc	nc	0.01	0.01	2.15	2.29	2.30	2.52	0.00	0.00	nc	0.00	0.00	0.00	nc	nc	0.00	0.00	0.00	0.00	0.00	0.01
	7	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.20	0.29	0.02	0.05	0.29	0.31	nc	nc	0.05	0.15	4.67	5.15	5.23	5.95	0.01	0.01	nc	0.00	0.00	0.00	nc	nc	0.00	0.00	0.02	0.05	0.03	0.06
	8	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	1.56	10.60	0.07	0.09	0.97	1.40	nc	nc	0.80	7.07	10.74	12.02	14.13	31.18	0.06	0.07	0.00	0.00	0.01	0.01	0.00	nc	0.00	0.01	0.08	0.10	0.15	0.20
Reach 3	462347112180401	0.03	nc	nc	0.00	0.00	0.00	nc	0.00	0.01	0.05	0.05	0.09	0.06	0.26	0.86	0.03	0.02	0.30	0.32	nc	nc	0.13	0.68	2.71	2.71	3.43	4.59	0.12	0.18	nc	0.00	0.02	0.03	nc	nc	0.02	0.05	0.55	0.50	0.71	0.77
	Grub Gulch Tributary (9)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	2.81	nc	2.81	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
	Clear Creek Tributary (10)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	1.78	nc	1.78	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.01	nc	0.01
	Jimmys Creek Tributary (11)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.30	nc	0.30	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.00	nc	0.00
	12	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	20.23	nc	20.23	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
Reach 4	Joe Bowers Creek Tributary (13)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.54	nc	0.54	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.02	nc	0.02
	14	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	18.35	nc	18.35	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
	Weasel Gulch Tributary (15)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.32	nc	0.32	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.01	nc	0.01
Reach 5	16	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.16	0.39	nc	0.04	0.23	0.35	nc	nc	0.04	0.19	0.64	1.24	1.07	2.20	0.02	0.02	0.00	0.00	0.01	0.01	nc	nc	0.00	0.00	0.07	0.08	0.10	0.12
	Jack Creek Tributary 3 (17)	0.00	0.01	0.04	0.04	0.28	0.37	nc	0.00	0.01	4.60	4.72	4.92	5.13	0.06	0.41	0.21	0.18	1.28	3.24	nc	nc	0.02	1.15	23.34	26.97	24.90	31.96	0.00	0.02	0.08	0.06	0.82	1.06	0.00	nc	0.01	0.03	8.55	9.35	9.46	10.53
	Jack Creek Tributary 4 (18)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.01	nc	0.14	nc	nc	nc	nc	nc	1.73	0.86	1.88	0.86	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.06	nc	0.06
	19	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.26	2.64	0.28	0.31	2.65	5.01	nc	nc	0.08	1.19	31.85	35.91	35.12	45.07	0.01	0.08	0.06	0.06	0.32	0.75	0.00	nc	0.01	0.02	5.49	6.16	5.89	7.08
	Jack Creek Tributary 6 (20)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.25	nc	0.25	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.02	nc	0.02
	Jack Creek Tributary (462047112201901)	0.01	nc	0.01	0.01	0.05	0.07	nc	0.00	0.00	1.67	1.88	1.75	1.97	0.18	0.35	0.07	0.08	0.90	0.95	0.01	nc	0.03	0.08	7.36	7.94	8.55	9.40	0.04	0.07	0.03	0.03	0.17	0.22	nc	nc	0.01	0.01	3.93	3.74	4.18	4.07
	Basin Unnamed Tributary 3 (21)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.13	nc	0.13	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.01	nc	0.01
Reach 6	22	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	5.03	15.09	0.63	1.26	12.57	17.60	nc	nc	1.26	7.54	81.72	100.57	101.20	142.06	0.11	0.15	0.01	0.02	0.06	0.08	0.00	nc	0.02	0.02	1.49	1.46	1.69	1.72
	Saul Haggerty Gulch Tributary (23)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.47	nc	0.47	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.01	nc	0.01
Reach 7	Basin Creek Tributary (06031600)	0.09	nc	nc	0.01	0.06	0.06	nc	0.03	0.03	1.90	1.93	2.07	2.02	1.56	3.44	nc	0.15	2.35	3.03	nc	nc	0.26	1.32	16.79	19.43	20.97	27.37	0.12	0.17	nc	0.01	0.08	0.11	nc	nc	0.02	0.02	1.50	1.71	1.71	2.02
	24	0.09	0.10	0.01	0.02	0.07	0.07	0.00	0.02	0.02	1.81	1.88	2.00	2.09	3.56	10.03	0.33	0.65	6.53	10.03	nc	nc	0.67	4.72	45.16	62.11	56.25	87.53	0.15	0.17	0.01	0.02	0.09	0.11	0.00	nc	0.02	0.02	1.19	1.32	1.46	1.65

Notes:

Diss-Dissolved

Tot-Total

NC- Not calculated

COC - Contaminant of Concern

Stations with no concentration or flow data are excluded from table

Table 6.7-1 COC Loads in the Basin Creek, Basin Watershed OU2

		Winter (Dec, Jan, Feb, Mar) Total and Dissolved Loads in pounds per day (lbs/day)													Spring/Summer (Apr, May, Jun, Jul) Total and Dissolved Loads in pounds per day (lbs/day)														Fall (Aug, Sep, Oct, Nov) Total and Dissolved Loads in pounds per day (lbs/day)													
		Arsenic		Cadmium		Copper		Mercury		lead		Zinc		Combined	Arsenic		Cadmium		Copper		Mercury		lead		Zinc		Combined		Arsenic		Cadmium		Copper		Mercury		lead		Zinc		Combined	
Reaches	Stations	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot
2001																																										
Reach 1	S001	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Reach 2	Lady Leith Tributary (S002)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.03	0.04
	S003	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.05	0.05	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.04	0.04	0.09	0.10
Reach 3	462347112180401	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.07	0.11	nc	0.00	0.01	0.01	nc	nc	0.00	0.01	0.18	0.19	0.26	0.33
	Clear Creek Tributary (S004)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.04	0.02
	Grub Gulch Tributary (S700)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
	S005	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.06	0.05	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.08	0.10	0.16	0.16
Reach 4	S006	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.07	0.03	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.11	0.11	0.19	0.16
Reach 5	Jack Creek Tributary 3 (17)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.13	0.86	0.16	0.17	1.54	2.30	nc	nc	0.02	0.27	18.80	18.94	20.65	22.53	0.00	0.06	0.06	0.06	0.67	0.82	nc	nc	0.00	0.02	7.06	6.89	7.79	7.85
	Jack Creek Tributary 4 (S007)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	Jack Creek Tributary 3 (S008)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.00	0.05	0.05	0.05	0.70	0.80	0.00	0.00	0.01	0.02	4.89	4.96	5.65	5.88
	Jack Creek Tributary (S009)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.01	0.02	0.01	0.01	0.03	0.06	0.00	0.00	0.00	0.00	0.69	0.77	0.73	0.85
	Jack Creek Tributary (462047112201901)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.26	1.50	0.15	0.21	2.38	6.74	0.02	nc	0.07	0.53	18.62	24.29	21.49	33.27	0.03	0.07	0.02	0.03	0.09	0.20	nc	nc	0.01	0.01	2.50	2.87	2.65	3.17
	S011	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.10	0.12	0.01	0.01	0.07	0.08	0.00	0.00	0.00	0.00	1.21	1.20	1.39	1.42
	South Fork Creek Tributary (S010)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.01
Reach 6	S012	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.12	0.09	0.00	0.00	0.05	0.05	0.00	0.00	0.00	0.01	0.63	0.59	0.81	0.75
Reach 7	Basin Creek Tributary (06031600)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	1.76	4.05	nc	0.23	3.54	4.86	0.09	nc	0.40	1.21	29.54	34.40	35.34	44.75	0.14	0.18	nc	0.01	0.08	0.10	nc	nc	0.02	0.02	0.89	1.03	1.14	1.34
	Basin Creek Tributary (S013)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.09	0.08	0.00	0.00	0.05	0.04	0.00	0.00	0.00	0.00	0.47	0.47	0.62	0.60
September 6, 2001 Storm Event																																										
Reach 1	S001	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.03	0.03	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.01	0.03	0.05	0.08	0.10
Reach 2	S002	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.03	0.05	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.04	0.14	0.24	0.18	0.34
Reach 4	S006	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.94	6.68	0.04	0.08	0.66	1.52	0.00	0.00	0.11	4.17	5.47	12.12	7.21	24.58
Reach 5	Jack Creek Tributary (S009)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.25	3.15	0.18	0.25	2.28	5.41	0.00	0.00	0.04	1.47	19.55	27.76	22.30	38.04
	S011	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	1.03	12.41	0.23	0.43	3.71	9.07	0.01	0.01	0.14	6.86	27.03	49.03	32.14	77.82
Reach 7	Basin Creek Tributary (S013)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	1.13	19.50	0.14	0.63	3.22	15.00	0.01	0.01	0.13	12.81	19.29	72.48	23.92	120.44

Notes:

Diss-Dissolved
Tot-Total

nc- Not Calculated
COC - Contaminant of Concern

Stations with no concentration or flow data are excluded from table

Table 6.7-2 Summary of COC Loads from Adits and Seep Discharges at Mine Sites in Basin Creek AOC, Basin Watershed OU2

	COC Loads (lbs/day)											
	Arsenic		Cadmium		Copper		Lead		Mercury		Zinc	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
BULLION MINE	0.403	0.048	0.023	0.014	0.616	0.368	0.024	0.012	nc	nc	2.558	1.552
LADY LEITH	0.005	0.002	0.001	0.001	0.001	0.003	0.006	0.017	nc	nc	0.085	0.120
VINDICATOR	0.00045	nc	0.001	0.001	0.003	0.004	0.003	0.000	nc	nc	0.054	0.054
JOSEPHINE	0.00018	0.00018	0.00014	0.00013	0.004	0.002	0.007	0.005	nc	nc	0.017	0.013
MORNING STAR	nc	nc	nc	nc	0	0	nc	0	nc	nc	0.00003	0.00003

Notes: nc- Not Calculated lbs/day - pounds per day

Table 6.8-1 Basin Creek AOC Mine Sites Radioactivity Levels, Basin Watershed OU2

	Field Measurement		Laboratory Measurements (Picocuries/gram)												
Mine	Background Radiation near Mine	Radiation at Mine	Alpha	Beta	Cesium-137	Potasium-40	Radium-226	Thorium-228	Thorium 230	Thorium-232	Thorium-232	Uranium-234	Uranium-235	Uranium-238	Uranium-238DHP
Josephine Mine	0.2	0.04 - 0.52	125.00	129.00	0.59	30.60	12.70	0.69	6.45	0.71	0.82	0.52	0.02 U	0.42	1.70 U
Rti Recon: P	0.31	0.19	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Bullion Smelter	nm	0.06-0.13	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Smelter Creek Adit	0.18	0.12	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Rti Recon: R	0.09	0.1	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Crystal Mine	nm	0.05 - 0.10	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Bullion Mine	nm	0.03 - 0.08	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Buckeye Mine	nm	0.04 - 0.08	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Lady Leith Mine	nm	0.045-0.07	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Doris Mine	nm	0.05 - 0.07	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Enterprise Mine	nm	0.05 - 0.06	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Adelaide	0.11	0.09	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Dew Drop	0.04	0.07	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
24Jf0524	0.06	0.05	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Perry Park Mine	nm	0.05	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Aurora	0.03	0.03	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Grub Creek Station	0.03	0.03	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Magdelena Group	0.02	0.03	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Neptune	0.03	0.03	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Adit, Mine; Waste Rock Dump	0.03	0.02	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Jessie	0.02	0.02	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Morning Star	0.03	0.02	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Columbus	0.01	0.01	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Meyers Gulch	0.01	0.01	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Molly Snow	0.01	0.01	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Placer	0.02	0.01	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Se Nw Section 30	0.01	0.01	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Se Se Section 35	0.01	0.01	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Notes: nm- Not measured ns- Not sampled U- Non detect

Table 7.2-1 Summary of Historical Flows in Cataract Creek, Basin Watershed OU2

		Historical Flow Results				2001 RI Flow Results				
Stream Reaches	Stream Location	Station	Mean Winter Low-Flow (cfs)	Mean Spring/Summer High-Flow (cfs)	Mean Fall Low-Flow (cfs)	Station	Spring/Summer 2001 High-Flow (cfs)[1]	Fall 2001 Low-Flow (cfs)	Fall 2001 Low-Flow (cfs)[1]	Fall 2001 Storm High-Flow (cfs)
Reach 1	Cataract Creek Mainstem	na	nm	nm	nm	S014	nm	0.1	nm	nm
	Tributary (Unnamed 1)?	na	nm	nm	nm	S015	nm	0.002	nm	nm
Reach 2	Cataract Creek Mainstem	26	nm	nm	0.3	na	nm	nm	nm	nm
	Tributary (Unnamed 2)	27	nm	nm	0.1	na	nm	nm	nm	nm
	Cataract Creek Mainstem	28	nm	20	0.3	na	nm	nm	nm	nm
	Tributary (Nellie Grant Creek)	29	nm	7	0.1	na	nm	nm	nm	nm
	Cataract Creek Mainstem	30	nm	28	1	na	nm	nm	nm	nm
	Tributary (Overland Creek)	31	nm	7	0.1	na	nm	nm	nm	nm
	Cataract Creek Mainstem	32	nm	57	0.7	na	nm	nm	nm	nm
	Tributary (Rocker Creek)	33	nm	10	0.2	na	nm	nm	nm	nm
	Cataract Creek Mainstem	34	nm	67	1	na	nm	nm	nm	nm
	Cataract Creek Mainstem	na	nm	nm	nm	S016	nm	0.6	nm	nm
Reach 3	Tributary (Snowdrift Creek)	na	nm	nm	nm	S017	nm	0.3	nm	5
	Tributary (Snowdrift Creek)	35	nm	10	2	na	nm	nm	nm	nm
	Cataract Creek Mainstem	36	nm	100	8	na	nm	nm	nm	nm
	Tributary (Hoodoo Creek)	37	nm	4	1	na	nm	nm	nm	nm
	Cataract Creek Mainstem	38	nm	103	12	na	nm	nm	nm	nm
	Cataract Creek Mainstem	na	nm	nm	nm	S018	nm	2	nm	nm
Reach 4	Tributary (Unnamed 3)	37M	nm	nm	nm	na	nm	nm	nm	nm
	Tributary (Unnamed 4)	22-132-SW1	nm	nm	nm	na	nm	nm	nm	nm
	Tributary (Unnamed 5)	39	nm	6	0.1	na	nm	nm	nm	nm
	Tributary (Unnamed 6)	40	nm	3	0.1	na	nm	nm	nm	nm
	Cataract Creek Mainstem	41	3	64	4	41	62	nm	2	nm
	Cataract Creek Mainstem	na	nm	nm	nm	S019	nm	1	nm	32
Reach 5	Tributary (Uncle Sam Gulch)	43	0.4	9	1	43	5	nm	0.4	nm
	Tributary (Uncle Sam Gulch)	na	nm	nm	nm	S020	nm	0.4	nm	9
	Cataract Creek Mainstem	44	4	84	4	na	nm	nm	nm	nm
	Cataract Creek Mainstem	na	nm	nm	nm	S022	nm	2	nm	nm
Reach 6	Tributary (Deer Creek)	45	nm	8.5	1	na	nm	nm	nm	nm
	Tributary (Deer Creek)	na	nm	nm	nm	S021	nm	0.05	nm	0.43
	Cataract Creek Mainstem	na	nm	nm	nm	S023	nm	2	nm	nm
Reach 7	Tributary (Big Limber Gulch)	46	nm	0.7	nm	na	nm	nm	nm	nm
	Cataract Creek Mainstem	47	4	86	4	na	nm	nm	nm	nm
	Cataract Creek Mainstem	060313960	4	31	3	060313960	41	nm	3	nm
	Cataract Creek Mainstem	na	nm	nm	nm	S024	nm	2	nm	28

Notes:

1 - USGS provisional flow results from measurements taken in April, May, August, and September 2001

nm - Not Measured

na - Not Applicable

- Shading indicates tributary inflow to mainstem

This page intentionally left blank.

Table 7.3-1 Surface Water COC Concentrations in Cataract Creek, Basin Watershed OU2

		Winter (Dec, Jan, Feb, Mar) Total and Dissolved COC Concentrations (ug/l)														Spring/Summer (Apr, May, Jun, Jul) Total and Dissolved COC Concentrations (ug/l)														Fall (Aug, Sep, Oct, Nov) Total and Dissolved COC Concentrations (ug/l)													
		Other Parameters (mg/l)			Arsenic		Cadmium		Copper		Mercury	Lead		Zinc		Other Parameters (mg/l)			Arsenic		Cadmium		Copper		Mercury		Lead		Zinc		Other Parameters (mg/l)			Arsenic		Cadmium		Copper		Mercury		Lead		Zinc	
Reach	StationGroup	pH	SO4	TDS	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Diss	Tot	Diss	Tot	pH	SO4	TDS	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	pH	SO4	TDS	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot
Historical																																													
Reach 1	Cataract Creek Mainstem	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Reach 2	26	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10
	Cat Unnamed Tributary 2 (27)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	285
	28	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	70	nd	nd	nd	1	1	nd	1	1	1	nd	nd	1	1	17	25
	Nellie Grant Creek Tributary (29)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10	nd	nd	nd	1	1	nd	1	1	1	nd	nd	1	1	1	20
	30	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	50	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	30
	Overland Creek Tributary (31)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	20	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	20
	32	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	30	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10
	Rocker Creek Tributary (33)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	2	9	0.3	1	35	44	nd	nd	1	2	46	60	nd	nd	nd	2	3	0.1	1	5	7	0.1	nd	1	1	19	20
	34	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	1	3	0.1	1	7	8	nd	nd	1	1	29	30	nd	nd	nd	1	1	0.1	1	2	2	0.1	nd	1	1	10	10
Reach 3	Snowdrift Creek Tributary (35)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	20	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10
	36	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	30	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10
	Hoodoo Creek Tributary (37)	7	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10
	38	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	50	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	140
Reach 4	Cat Unnamed Tributary 5 (39)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	120	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	100
	Cat Unnamed Tributary 6 (40)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	2	4	0.7	1	6	7	nd	nd	1	1	258	260	nd	nd	nd	2	2	0.6	1	1	1	nd	nd	1	1	202	205
	41	nd	nd	nd	2	2	0.3	1	5	6	nd	1	1	75	80	nd	nd	nd	2.7	3	0.3	0.2	7	9	nd	nd	1	2.5	42	56.6	nd	nd	nd	2	2	0.3	0.26	4.65	4.6	nd	nd	1	1	58	57.6
Reach 5	Uncle Sam Gulch Tributary (43)	nd	nd	nd	2	4	32	32	127	190	nd	1	4	2790	3000	nd	nd	nd	3.9	42	15	22	129	429	nd	nd	1	50	1236	1438	nd	nd	nd	1	6	53.8	42.4	221	442	0.1	nd	1	9	4300	4252
	44	nd	nd	nd	2	3	6	5	28	36	nd	1	1	528	570	nd	nd	nd	3	49	3	3	40	117	nd	nd	1	19.7	276.9	303	nd	nd	nd	2	4	9	9.25	50.9	85.5	0.1	nd	1	2.25	678	778
Reach 6	Deer Creek (45)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	30	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	20
Reach 7	Big Limber Gulch Tributary (46)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	20	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10
	47	nd	nd	nd	3	4	3	3	13	14	0.1	1	1	309	327	nd	nd	nd	3.5	18	2	2	32	52	nd	nd	1	9	158.4	205	nd	nd	nd	4	5	5	6	24	29	0.1	nd	1	1	440	450
	6031960	nd	nd	nd	3	nd	4	4	16.1	19	nd	1	1	370	404	nd	nd	nd	3	8	2	2	30	37	nd	nd	1	3	204	214	nd	nd	nd	3	4	5	5	21	25	nd	nd	1	1	412	399
2001																																													
Reach 1	S014	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	4	4	0.02	0.02	0.76	0.51	0.03	0.03	0.2	0.2	2	2
	Cat Unnamed Tributary 1 (S015)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	4	4	0.02	0.02	0.77	0.95	0.03	0.03	0.2	0.61	3	1
Reach 2	S016	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	4	4	0.02	0.03	2	1.9	0.03	0.03	0.2	0.44	8	5
Reach 3	Snowdrift Creek Tributary (S017)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	4	4	0.02	0.02	2	0.92	0.03	0.03	0.2	0.2	3	4
	S018	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	4	4	0.49	0.58	10	11.2	0.03	0.03	0.23	0.93	86	81
	41	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	2.1	3	nd	0.2	7.7	8.1	nd	nd	1	2	39	44	nd	nd	nd	3	3	nd	0.18	3	3.95	nd	nd	1	1	30.5	38
Reach 4	S019	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	4	4	0.2	0.2	3.4	3.9	0.03	0.03	0.2	0.2	40.6	42.6
Reach 5	Uncle Sam Gulch Tributary (43)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	3.3	59	13	14	162	260	nd	nd	1	12	1170	1170	nd	nd	nd	1	6	49	52	128	282	nd	nd	1	4	4295	4305
	Uncle Sam Gulch Tributary (S020)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	4	4	54	56	158	305	0.03	0.03	0.54	3.1	3960	4340
	S022	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	5	4	9	9	27	37	0.03	0.03	0.55	0.87	760	777
Reach 6	Deer Creek Tributary (S021)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	1268	1281	132	133	125	125	0.03	0.03	137	140	136	137
	S023	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	4	4	6	6	14	16	0.03	0.03	0.31	0.29	447	444
Reach 7	6031960	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	2.9	11	2.4	2.7	44.4	67.8	0.23	nd	1	5	229.5	261	nd	nd	nd	3	5	4	4	12	15	nd	nd	1	1	315	334
	S024	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	5	4	4	4	11	13	0.03	0.03	0.2	0.2	282	296
September 6, 2001 Storm Event																																													
Reach 1	ND	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Reach 2	ND	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Reach 3	Snowdrift Creek Tributary (S017)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	4	4	0.04	0.12	2.5	4	0.04	0.04	0.21	2	10.4	20.8
Reach 4	S019	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	4	7	0.31	0.61	21.4	13.9	0.03	0.03	1	8	58.9	89.8
Reach 5	Uncle Sam Gulch Tributary (S020)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	4	125	22.5	26.5	250	599	0.04	0.1	3	106	1775	2225
Reach 6	S021	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	4	4	0.06	0.12	16.5	3.8	0.03	0.03	1	1.8	17.8	17.8
Reach 7	S024	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	4	37	4	6	56.7	141	0.03	0.04	0.78	34.4	305	476

Table 7.4-1 Cataract Creek Sediment Mean COC Results, Basin Watershed OU2

		Total Concentrations in (mg/kg)					
Reach	**Station**	**Arsenic**	**Cadmium**	**Copper**	**Mercury**	**Lead**	**Zinc**
			Historical				
Reach 2	44S	***35***	nd	***51***	nd	36	***600***
	45S	***240***	nd	***1100***	nd	***210***	***490***
Reach 3	46S	***44***	nd	***32***	nd	***60***	***230***
	47S	***65***	***3***	***61***	nd	***61***	***420***
	22-075-SE1	***49***	***0.8***	***30.2***	0.04	***87***	***174***
	22-075-SE2	***8***	nd	9.4	0.02	14	75
Reach 4	48S	***150***	***3***	***140***	nd	***250***	***450***
	49S	***150***	***4***	***190***	nd	***240***	***610***
	22-132-SE1	***6.95***	***9.1***	17.6	0.03	***156***	***1140***
	22-132-SE1000	nd	nd	***85***	nd	***1196***	***1937***
	22-077-SE1	***9***	nd	***19.3***	0.01	33	***135***
Reach 5	16B	***3942.86***	***27.14***	***3971.43***	nd	***1025.71***	***1291.43***
	17B	***825***	***29.75***	***1252.67***	nd	***377.5***	***1811.67***
	22-073-SE1	***434***	***8.1***	***27.4***	0.05	***513***	***1110***
	22-073-SE2	***1900***	***1***	***203***	0.06	***999***	***487***
	54S	***39***	nd	***36***	nd	34	***160***
	55S	***3600***	***7***	***560***	nd	***1900***	***920***
	56S	***3900***	nd	***220***	nd	nd	***2700***
	57S	***1300***	***39***	***2300***	nd	***920***	***3800***
	22-077-SE3	***539***	***13.6***	***848***	0.03	***387***	***937***
Reach 6	22-032-SE1	***271***	***9.5***	***360***	0.05	***232***	***889***
	22-032-SE2	***144***	***7.4***	***254***	0.02	***134***	***580***
	22-077-SE2	***93***	***4.1***	***170***	0.01	***91***	***243***
	50S	***706.67***	***13.67***	***650***	nd	***506.67***	***1530***
	51S	***660***	***21***	***660***	nd	***500***	***2600***
	52S	***19***	nd	***21***	nd	47	***110***
Reach 7	53S	***456.67***	***12***	***420***	nd	***323.33***	***1446.67***
			2001 Minus 10-Mesh				
Reach 1	S014	***8.9***	0.58	14.8	0.06	7.8	34
	S015	***6.8***	***0.59***	18	0.06	7.3	32.4
Reach 2	S016	***11.2***	0.58	13.3	0.06	10.5	91.3
Reach 3	S017	***17.7***	nd	5.2	0.07	9.2	67
	M051	***374.9***	0.08	***19.3***	***0.16***	***471.9***	70
	M059	***14.3***	0.11	9.8	0.06	16.4	31.5
Reach 4	S018	***40.8***	***0.98***	***29.4***	0.07	***75.3***	***167***
	S019	***34.7***	***5.2***	***51***	0.06	***72***	***227***
Reach 5	S020	***568***	***26.7***	***1340***	0.07	***333***	***1700***
	S022	***173***	***9.7***	***228***	0.07	***112***	***723***
Reach 6	S021	4.8	nd	9	0.07	24.1	***119***
Rach 7	S024	***84.8***	***8.1***	***147***	0.07	***94***	***609***
			2001 Minus 80-Mesh				
Reach 1	S014	***22.5***	0.04	***27.4***	0.05	21.5	64.9
	S015	***17.7***	0.08	***36.8***	0.05	21.4	73.9
Reach 2	S016	***29.7***	***0.91***	***26.2***	0.05	27.5	***247***
Reach 3	S017	***51.7***	***1.6***	***19.6***	0.05	30.8	***240***
Reach 4	S018	***91***	***2.3***	***82.5***	0.05	***197***	***383***
	S019	***174***	***10***	***162***	0.05	***171***	***670***
Reach 5	S020	***1190***	***49.3***	***3190***	0.06	***795***	***4030***
	S022	***356***	***26.5***	***749***	0.05	***278***	***2540***
Reach 6	S021	***34.9***	***5.2***	***31.2***	0.06	***103***	***547***
Reach 7	S024	***130***	***10.9***	***222***	0.05	***129***	***1140***
			2001 Minus 260-Mesh				
Reach 5	S020	***1500***	***72.6***	***4810***	0.11	***1030***	***6080***

Notes: nd- No data Values in **bold underline** exceed benchmarks

This page intentionally left blank.

Table 7.5-1 Summary of COC Concentrations Acid Base Accounting Parameters in Mine Waste in Cataract AOC, Basin Watershed OU2

	Concentration of COCs Sulfur (mg/kg)												Field Parameter		Acid Base Accounting Parameters (MT CaCO3/1000 MT)								Total Sulfur (mg/kg) Makeup					
Mine Sites	Arsenic		Cadmium		Copper		Mercury		Lead		Zinc		pH (Paste)		Neutralization Potential (NP)		Acid Potential (AP)		Net Neutralization Potential		Net Acid Potential		Total Sulfur		% Sulfide	% Sulfate	NP/AP (Ratio)	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max			Min	Max
High Probability of Generating Acid (% Sulfide >= 0.3 and NP/AP <1)																												
Apollo	**2680**	**26200**	0.083 U	0.089	14.6	16.5	0.079	**0.24**	**375**	**732**	38.8	**65.3**	2	3	-2.4	-2.4	27	27	-30	-30	nd	nd	8700	8700	0.58	0.29	-0.09	-0.09
Cartwright Cabins 2	**410**	**438**	0.51	1.4	32	32.4	**0.18**	**0.25**	**2440**	**3670**	**223**	**334**	2	3	6.8	6.8	88.8	88.8	-81.9	-81.9	nd	nd	28400	28400	0.91	1.93	0.08	0.08
Clipper / Edna	**106**	**150**	0.04 U	0	**88.5**	**238**	**0.18**	**0.49**	**142**	**208**	**60.9**	**156**	6.8	6.8	25	25	53	53	-28	-28	nd	nd	17100	17100	0.66	1.05	0.47	0.47
Corbitt	**11.6**	**13**	**3.5**	**3.6**	25.8	37	**0.19**	**0.36**	**3150**	**6770**	**535**	**564**	2.8	6	-1.1	4.9	8.6	22	-23	-3.7	nd	nd	2700	7000	0.31	0.39	-0.13	-0.05
Eldorado And Plateau	**90.3**	**1370**	0.05 U	**8.2**	**515**	**998**	**0.41**	**0.6**	**5570**	**6260**	**456**	**1670**	3	7	13	13	28	28	-15	-15	nd	nd	8900	8900	0.38	0.51	0.46	0.46
Hattie Ferguson	**275**	**4200**	1.5	**86**	**230**	**690**	0.29 UR	**1.3**	**354**	**21100**	**590**	**6240**	4	7	-0.05	0	36.38	36.38	-36.42	-36.42	nd	nd	11600	11600	0.43	0.74	0.00	0.00
Klondyke	**2420**	**3520**	0.91	1.3	**196**	**278**	**0.58**	**0.75**	**7730**	**8780**	**441**	**511**	2.8	3.8	-1.3	-1.3	20.61	20.61	-21.93	-21.93	nd	nd	6600	6600	0.39	0.26	-0.06	-0.06
Lizzie Osborne	**367**	**826**	0.2	0.64	**40.7**	**60.8**	0.05 U	0.06	**954**	**1160**	**141**	**190**	2.4	3	0.1	0	56.19	56.19	-56.13	-56.13	nd	nd	18000	18000	1.58	0.22	0.00	0.00
Mary Anne	**2580**	**2780**	0.21	0.59	**122**	**123**	**0.17**	**0.18**	**816**	**1510**	**114**	**194**	2.5	3	-2.3	-2.3	13	13	-16	-16	nd	nd	4200	4200	0.3	0.12	-0.18	-0.18
Middle Snowdrift Creek	**477**	**681**	0.52	0.95	**51.7**	**81.8**	0.08	**0.1**	**664**	**772**	**184**	**189**	4	5.6	19	19	21	21	-2.8	-2.8	nd	nd	6800	6800	0.42	0.27	0.90	0.90
Ne Se Section 14	**156**	**261**	0.13 U	0	15	29.5	0.05 U	**0.22**	**132**	**219**	34	43.7	2.2	3	-1.7	-1.7	23	23	-24	-24	nd	nd	7300	7300	0.57	0.16	-0.07	-0.07
New Cottage	**239**	**351**	0.34	0.48	34.4	38.5	**0.11**	**0.18**	**422**	**515**	**201**	**239**	2.1	4.5	-0.7	-0.7	58.1	58.1	-58.8	-58.8	nd	nd	18600	18600	0.63	1.23	-0.01	-0.01
Sirius	**38**	**17200**	0.99	**39**	20	**340**	**0.3**	**0.78**	30	**19700**	**90**	**3920**	2.9	5.9	-4.3	4.7	18.8	34	-34	-23.05	7.95	7.95	500 U	15800	0.34	0.26	-0.23	-0.13
Sylvan	**187**	**230**	**5.4**	**14.8**	**185**	**389**	**0.23**	**UR**	**3510**	**14700**	**809**	**2020**	2	3	-3.8	-3.8	33.8	33.8	-37.5	-37.5	nd	nd	10800	10800	0.37	0.71	-0.11	-0.11
Timberline	**1380**	**2470**	0.13 U	0.78	30.6	34.1	0.06 U	0.08	**1420**	**1780**	**172**	**185**	2.3	3.5	-0.8	-0.8	166	166	-167	-167	nd	nd	53200	53200	4.54	0.78	0.00	0.00
Unnamed 001	**41.2**	**142**	1.5	**1.6**	**67.2**	**85.7**	0.07 U	**0.15**	**520**	**1640**	**183**	**364**	2.3	3.2	-4.5	-4.5	85.84	85.84	-90.37	-90.37	nd	nd	27500	27500	2.32	0.43	-0.05	-0.05
Medium Probability of Generating Acid (% Sulfide < 0.3 and NP/AP <1)																												
Alpine	**414**	**585**	0.08 U	0	**80.7**	**111**	**0.58**	**0.83**	**613**	**643**	15.5	37.8	2.6	6.5	0.9	0.9	4.8	4.8	-3.9	-3.9	nd	nd	1500	1500	0.09	0.06	0.19	0.19
Big Medicine	**70.5**	**96.9**	0.04 U	0	3	6.2	**0.47**	**0.62**	**81.1**	**107**	20.6	21.5	2.5	4	0.1	0.1	4.6	4.6	-4.5	-4.5	nd	nd	1500	1500	0.02	0.12	0.02	0.02
Black Bear	**100**	**92500**	0.48	**11**	29.94	**780**			**60**	**2970**	**70**	**1280**	2.9	6	1	0	0	159	-159	0	nd	nd	1000	41600	nd	nd	na	0.01
Blue Diamond / Occidental	**346**	**1940**	0.07	**4.5**	**157**	**198**	0.06 U	**0.18**	**665**	**3570**	**648**	**1130**	2.5	2.5	-1	-1	29	29	-29	-29	nd	nd	9200	9200	0.26	0.66	-0.03	-0.03
Boston	**265**	**438**	**5.7**	**16.3**	**300**	**515**	**0.22**	**0.44**	**4710**	**29200**	**888**	**2460**	2.4	4.5	-0.6	5.6	11.9	11.9	-12.5	-6.2	nd	nd	3800	3800	0.17	0.22	-0.05	-0.05
Cataract Tails	**151**	**200**	**2.5**	**3.2**	**790**	**868**	0.06 U	**0.1**	**675**	**689**	**498**	**502**	3.6	5	2.3	2.3	7.2	7.2	-4.9	-4.9	nd	nd	2300	2300	0.05	0.18	0.32	0.32
Cracker	**57**	**2530**	0.4	**32**	30	**390**	0.051	**0.25**	**120**	**21500**	**161**	**3120**	2.9	6.6	1	1.7	14	14	-12	-12	7.4	12.7	2100	71800	0.23	0.21	0.07	0.07
Eva May	**35.3**	**16273.1**	0.49 U	**167**	**56.5**	**4130**	0.05 U	**0.8**	22.67	**18400**	45.4	**20500**	3	6.3	-0.1	20.7	6.97	20.97	-7.05	-0.3	nd	nd	2200	6700	0.25	0.42	-0.01	0.00
Evening Star	**271**	**466**	0.69	**2.1**	31.4	**66.2**	**0.21**	**0.37**	**312**	**557**	**227**	**388**	3.3	6	12	12	13	13	-0.5	-0.5	nd	nd	4100	4100	0.16	0.25	0.92	0.92
Gold Flake	**107**	**192**	0.04 U	0.17	5.3	10.1	0.07 U	**0.14**	**88.4**	**229**	26.4	**50.4**	2.8	5	0.9	0.9	5.3	5.3	-4.4	-4.4	nd	nd	1700	1700	0.09	0.08	0.17	0.17
Gray Lead	**14**	**16900**	2 U	**120**	10	**810**			40	**23500**	**100**	**4970**	4.8	7.2	2	8	0	6	0	-6	nd	nd	500 U	1600	nd	nd	na	0.33
Manhattan	**79.5**	**377**	**1.6**	**1.7**	**42.1**	**182**	**0.12**	**0.39**	**182**	**2790**	**254**	**334**	3.3	5	-1.3	-1.3	3.8	3.8	-5.1	-5.1	nd	nd	1200	1200	0.02	0.1	-0.34	-0.34
Morning Glory	**15**	**2680**	2 U	**168.3**	20	**310**	0.01	**0.54**	30	**4470**	**100**	**4680**	6.8	7.7	1	157	0	12		148	nd	nd	500 U	3800	nd	nd	na	0.08
Ne Nw Section 17	**447**	**696**	0.13 U	0	**99**	**110**	**0.12**	**0.16**	**379**	**647**	33.2	**76.1**	2.5	4	-0.1	-0.1	4.5	4.5	-4.6	-4.6	nd	nd	1400	1400	0.02	0.13	-0.02	-0.02
North Ada - Piermont	0 U	**5380**	0.05 U	**10**	**0 U**	**180**	0.06 U	**0.45**	0 U	**6250**	14.94	**1830**	4.5	6.7	-1	2	8.3	21	-9	-9	nd	nd	900	7600	0.11	0.16	-0.12	-0.05
Phantom	**23.81**	**360**	**1.69**	**11**	28.52	**110**			**102.25**	**1410**	**100**	**1660**	7.3	7.5	14	80	9	81	-1	47	nd	nd	500 U	24300	nd	nd	1.56	0.17
Ruth	**196**	**313**	0.04 U	0	17.9	**51.6**	**2.2**	**2.6**	24.5	30.6	34.5	41.3	3.2	4	1.4	1.4	10.9	10.9	-9.5	-9.5	nd	nd	3500	3500	0.12	0.23	0.13	0.13
Saturday Night	**213**	**539**	**3.2**	**7.3**	**225**	**276**	**0.45**	**0.51**	**4310**	**5050**	**857**	**1570**	2.7	2.7	-0.2	0	12.5	12.5	-12.7	-12.7	nd	nd	4000	4000	0.11	0.29	-0.02	-0.02
Seattle	**457**	**503**	**5.8**	**6.8**	**159**	**186**	**0.23**	**0.44**	**4310**	**11600**	**1210**	**1270**	2.5	2.6	-0.1	0	3.8	3.8	-3.8	-3.8	nd	nd	1200	1200	0.04	0.08	-0.03	-0.03
Unnamed 002	**788**	**1440**	0.086	1.3	**76.6**	**83.8**	0.05 U	0.09	**405**	**559**	**220**	**276**	2.6	4	0.3	0	17	17	-17	-17	nd	nd	5500	5500	0.17	0.38	0.02	0.02
Vera And Marie	**164**	**179**	0.04 U	0	22.6	24.2	**0.17**	**0.38**	**249**	**393**	**59.3**	**84.9**	2.4	5	0.6	0.6	12.2	12.2	-11.5	-11.5	nd	nd	3900	3900	0.21	0.18	0.05	0.05
Vogel	**270**	**431**	0.04 U	0	7.8	9.3	0.06 U	**0.36**	38.6	38.9	10.3	16.5	2.5	3	1	1	3.4	3.4	-2.4	-2.4	nd	nd	1100	1100	0.06	0.05	0.29	0.29

MT - Metric Tonne
CaCO3 - Calcium Carbonate
%- Percent
mg/kg- Milligrams per Kilograms
U - Undetect
R - Rejected
*- % Total Sulfur Values
nd - No data
na - Not Applicable
Values in **bold underline** exceed benchmarks

Table 7.5-1 Summary of COC Concentrations Acid Base Accounting Parameters in Mine Waste in Cataract AOC, Basin Watershed OU2

	Concentration of COCs Sulfur (mg/kg)												Field Parameter		Acid Base Accounting Parameters (MT CaCO3/1000 MT)								Total Sulfur (mg/kg) Makeup					
Mine Sites	Arsenic		Cadmium		Copper		Mercury		Lead		Zinc		pH (Paste)		Neutralization Potential (NP)		Acid Potential (AP)		Net Neutralization Potential		Net Acid Potential		Total Sulfur		% Sulfide	% Sulfate	NP/AP (Ratio)	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max			Min	Max
Low Probability of Generating Acid (% Sulfide < 0.3 and NP/AP >1)																												
Bakama	***112***	***216***	0.04 U	1.2	***328***	***732***	***0.33***	***0.66***	***523***	***615***	***143***	***357***	6.3	6.3	64	64	59	59	4	4	nd	nd	19000	19000	0.88	1.02	1.1	1.1
Unnamed 004	***189***	***383***	***2.2***	***4.6***	21.4	34	***0.11***	***0.23***	***384***	***750***	***437***	***946***	7	7.3	89	89	28	28	61	61	nd	nd	9000	9000	0.47	0.44	3.2	3.2
Overland Creek	***150***	***369***	***1.7***	***2.3***	***89.1***	***100***	***0.1***	***0.12***	***244***	***924***	***324***	***441***	7	7.3	21	21	14	14	7	7	nd	nd	4300	4300	0.17	0.26	1.5	1.5
Garfield	***33.3***	***39.3***	1.5	***2.7***	22.9	30.2	0.07 U	***0.25***	***96.2***	***180***	***230***	***425***	6.5	7	44.5	48	7.9	9.92	34.62	40.14	nd	nd	2500	3200	0.14	0.18	5.6	4.5
Sw Se Section 4	***169***	***259***	0.04 U	0.09	***53.3***	***88.9***	0.09	***0.13***	***707***	***931***	***99.7***	***102***	3	5.5	-0.6	-0.6	nd	nd	-3	-3	nd	nd	1500	1500	0.06	0.08	na	na
Fourth Of July	***115***	***156***	0.57	0.6	27.2	27.9	0.08	***0.12***	***62.6***	***98.6***	***187***	***218***	4.7	5.5	4.6	4.6	1.8	1.8	2.8	2.8	nd	nd	600	600	0.05	0.01	2.6	2.6
Boulder Vestal	***27.1***	***34.2***	0.21	0.28	20.9	26.6	***0.25***	***0.41***	39.4	44.3	***84.1***	***88.1***	3.5	3.5	3.8	3.8	3.2	3.2	0.6	0.6	nd	nd	1000	1000	0.04	0.06	1.2	1.2
Holland	***10.7***	***30.8***	0.08 U	0.12	19.2	25.1	0.04	0	***146***	***238***	***55.4***	***61.9***	4.3	4.3	4.1	4.1	1.7	1.7	2.4	2.4	nd	nd	500 U	500	0.04	0.01	2.4	2.4
Ida May	***13.9***	***15.5***	***6.9***	***101***	***79.4***	***255***	***0.19***	***UR***	***978***	***992***	***1050***	***13500***	5	6.7	21	21	11	11	9.7	9.7	nd	nd	3600	3600	0.03	0.34	1.9	1.9
Bing Hampton	8.9	***22.1***	0.079 U	0	12.7	15.5	0.047 U	0	19.1	21.1	23.7	36.2	4.2	5	2.7	2.7	1.4	1.4	1.3	1.3	nd	nd	400	400	0.03	0.02	1.9	1.9
Snowbird	***458***	***937***	1	***1.9***	***82.9***	***98.7***	0.05 U	0.07	***240***	***368***	***196***	***314***	3.9	6	5	5	2.4	2.4	2.7	2.7	nd	nd	800	800	0.03	0.04	2.1	2.1
Jumbo	***108***	***172***	***8***	***26.5***	***48.6***	***139***	***0.11***	***0.22***	***379***	***538***	***1660***	***4050***	5.3	5.3	6.4	6.9	1.8	2.1	4.3	5.1	nd	nd	600	700	0.03	0.04	3.6	3.0
Morning Marie	***18***	***220***	2 U	***8.1***	33	***49***	***0.37***	***0.5***	***89.7***	***730***	***240***	***660***	5.3	6	11.5	11.5	1.4	1.4	10.1	10.1	3.3	3.3	400	400	0.03	0.01	8.2	8.2
Uncle Sam	***60.2***	***70.1***	0.08 U	0.21	28.8	31.7	0.05 U	0.08	21	38.9	44.3	***88.7***	7	7.2	24	24	2.4	2.4	21	21	nd	nd	800	800	0.03	0.05	10.0	10.0
Quartz Creek	***29.5***	***122***	0.04 U	0	24	***44.8***	0.08	***0.1***	8.4	12.4	36.3	***59.1***	4.9	6	1.2	1.2	1.1	1.1	0.8	0.8	nd	nd	300	300	0.02	0.01	1.1	1.1
Lady Ricker	***43.6***	***48.8***	0.04 U	0	20.7	***175***	***0.14***	***0.68***	10.8	13.4	23.2	31.9	5	6.8	20	23	2.8	3.4	17	19	nd	nd	900	1100	0.02	0.1	7.1	5.9
Alsace	2.7	4.7	0.04 U	0	14.6	20.2	0.05 U	0	12.8	14.9	39.5	43.8	4.8	6	9.2	9.2	1.4	1.4	7.8	7.8	nd	nd	400	400	0.02	0.02	6.6	6.6
Edna	***34.6***	***56.8***	1.1	***1.7***	12.1	19.4	0.05 U	0	***66.6***	***66.7***	***184***	***235***	5.8	5.8	5	5	0.8	0.8	4.2	4.2	nd	nd	300	300	0.01	0.01	6.3	6.3
Mike #14	6.8	9.4	0.69	***4***	9.1	9.3	***0.2***	***0.72***	41.3	***52.3***	***136***	***180***	5	6	6.6	6.6	0.6	0.6	6	6	nd	nd	200	200	0	0.02	11.0	11.0
Unknown Probability, Lack of ABA Data																												
Waldy	***340***	***340***	***4***	***4***	***68***	***68***			***2000***	***2000***	***900***	***900***	nd	nd	nd	nd	nd	nd	nd	nd	2.32	2.32	nd	nd	nd	nd	na	na
Sw Nw Section 29	6	6	0.04 U	0	30.6	30.6	***0.1***	***0.1***	12	12	43.7	43.7	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
Rocker Wetland	***115***	***467***	***2.7***	***4.2***	***215***	***4350***	***0.07 U***	***0.21***	***83***	***260***	***260***	***527***	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
Rocker	***691.4***	***1016.73***	0 U	0.34	***114.51***	***162.1***			***99.06***	***356.6***	***90.83***	***110.85***	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
Mantle	***20***	***141.72***	0.6 U	***131.7***	38.4	***66.6***	***0.208***	***0.254***	46.22	***413.6***	***61.85***	***434.2***	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
Crystal	***36.29***	***11100***	0.4	***161.5***	39.7	***1600***	0.031	***0.492***	19.66	***6858***	***67.65***	***8000***	nd	nd	nd	nd	nd	nd	nd	nd	0.5	4.09	nd	nd	nd	nd	na	na
Crescent	***74.7***	***273***	0.67	***154***	***101***	***1327***	***0.103***	***0.285***	***674***	***6397***	***118***	***1115***	4.5	5	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
Cataract	***1140***	***1139.76***	***6.12***	***6.12***	***668.39***	***668.4***			***3583***	***3583***	***1040.7***	***1040.7***	5	6	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
Boulder Chief	***10.9***	***186***	0.6 U	***197***	23.1	***653***	0.04	***0.83***	42.3	***24300***	30.2	***23700***	nd	nd	nd	nd	nd	nd	nd	nd	0.23	5.61	nd	nd	nd	nd	na	na
Ada	***190***	***2953.49***	0.5 U	***1.9***	***61.97***	***1030***	***0.263***	***1.25***	***67***	***5440***	42.4	***287***	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na

MT - Metric Tonne
CaCO3 - Calcium Carbonate
%- Percent
mg/kg- Milligrams per Kilograms
U - Undetect
R - Rejected
*- % Total Sulfur Values
nd - No data
na - Not Applicable
Values in **bold underline** exceed benchmarks

Table 7.5-2 Summary of COC Concentrations in Adits and Seep Discharges at Mine Sites in Cataract Creek AOC, Basin Watershed OU2

Mine Sites	Discharge (gpm)		Arsenic				Cadmium				Copper				Lead				Mercury				Zinc				pH		Sulfate	
			Total (ug/L)		Dissolved (ug/L)		Total (ug/L)		Dissolved (ug/L)		Total (ug/L)		Dissolved (ug/L)		Total (ug/L)		Dissolved (ug/L)		Total (ug/L)		Dissolved (ug/L)		Total (ug/L)		Dissolved (ug/L)					
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
CRYSTAL	60	60	461	9910	186	186	706	1010	729	729	11800	26700	11900	11900	154	425	149	149	0.2 U	0.2 U	0.2 U	0.2 U	63600	84300	64000	64000	3.4	3.4	468	468
NE SE SECTION 14	10	10	23	23	12	12	0.39	0.39	1 U	1 U	2 U	2 U	2 U	2 U	2.1	2.1	1 U	1 U	0.2 U	0.2 U	0.2 U	0.2 U	77.5	77.5	60.4	60.4	8.1	8.1	47.4	47.4
CRACKER	6	6	5.2	5.2	10 U	10 U	9.1	9.1	4.8	9.8	16.9	16.9	2 U	5.8	17.8	17.8	1 U	3.1	0.15	0.15	0.043	0.19	1750	1750	1026	2290	6.7	7.4	56	74.8
EVA MAY	0.1	4.0	10 U	65.9	10 U	32.5	0.065	11	1 U	10.4	2.1	67.2	2 U	13.7	0.68	38.5	1 U	1.2	0	0.23	0	0.2 U	15.8	1490	14.5	1230	6.5	7.55	13.4	66.3
CATARACT	3	3	10.6	10.6	10 U	10 U	1 U	1 U	1 U	1 U	1.8	1.8	1.6	1.6	1.5	1.5	1 U	1 U	0.2 U	0.2 U	0.2 U	0.2 U	12.4	12.4	11.8	11.8	6.3	6.3	21.6	21.6
CRESCENT	3	3	2.8	2.8	5.7	5.7	133	133	75.9	75.9	2820	2820	1543	1543	673	673	1227	1227	0.18	0.18	0.2 U	0.2 U	22400	22400	15097	15097	3.74	3.79	127	127
UNNAMED 001	2	2	5.1	5.1	10 U	10 U	2.5	2.5	1 U	1 U	97.7	97.7	4.2	4.2	36.5	36.5	1 U	1 U	0	0	0	0	318	318	10 U	10 U	7.4	7.4	31.4	31.4
CARTWRIGHT CABINS 2	2	2	10 U	9.8	10 U	9.3	1 U	0.079	1 U	1 U	2 U	4	0	2 U	2.3	8.7	1 U	1 U	0	0.2 U	0.2 U	0.2 U	10 U	19.7	4.8	6.1	5.7	7.73	53.2	54.3
HATTIE FERGUSON	2	3	10 U	45.9	10 U	42.4	1 U	258	1 U	264	2 U	1690	2 U	1690	0.41	742	1 U	726	0.2 U	0.2 U	0.2 U	0.2 U	13.7	40500	4.5	40400	3.67	8.5	46.2	236
WALDY	2	2	10 U	10 U	2	4.6	1 U	1 U	1 U	1 U	2 U	2 U	2 U	2 U	0.27	0.27	1 U	1 U	0.2 U	0.2 U	0.2 U	0.65	24.9	24.9	16.4	20.2	7	8.21	41.1	42.1
ROCKER EXTENSION	2	5	17	19.5	10 U	9.9	0.49	0.62	1 U	0.29	9.3	10.5	2 U	10	4.8	5.7	1 U	1 U	0.2 U	0.2 U	0.2 U	0.2 U	117	130	85.1	245	6.38	8.54	15.8	34.6
SW NW SECTION 29	2	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ADA	0.3	1.0	30.9	30.9	10 U	1839	0.16	0.16	1 U	47.8	8.8	8.8	2 U	5781	8.3	8.3	1 U	166.3	0	0	0	0.42	22	22	10.1	8860	2.71	6.7	24.5	733
GARFIELD	1	1	10 U	10 U	10 U	10 U	0.2	0.2	1 U	1 U	1.4	1.4	2 U	2 U	2.1	2.1	1 U	1 U	0.2 U	0.2 U	0.2 U	0.2 U	65.8	65.8	66.7	66.7	6	6.9	42.4	42.4
PHANTOM	1	1	10 U	10 U	10 U	10 U	0.057	0.057	1 U	1 U	0.69	0.69	2 U	2 U	1.4	1.4	1 U	1 U	0.2 U	0.2 U	0.2 U	0.11	10 U	10 U	2.7	7.4	7.47	7.49	32.4	37.4
BLUE DIAMOND / OCCIDENTAL	0.3	0.8	7.2	7.9	10 U	1.6	0.38	1.3	1 U	0.56	22.4	27.4	2 U	3.5	17.1	225	1 U	2.8	0	0.2 U	0	0.2 U	67.8	103	2.3	78.6	5.65	6.58	11	16
ELDORADO AND PLATEAU	0.1	0.8	10 U	29	10 U	6.7	0.16	107	1 U	105	1.2	826	0.67	540	0.64	959	1 U	51.3	0.2 U	0.054	0.2 U	0.17	40.5	9920	41.1	10090	5.06	7.38	12.4	239
LADY RICKER	0.7	0.7	15.7	20	9.1	9.1	1 U	1 U	1 U	1 U	2 U	2 U	0	0	1 U	0.58	0.21	0.21	0.2 U	0.2 U	0.2 U	0.2 U	4	15	1.1	1.1	ND	ND	13.8	13.8
APOLLO	0.7	0.7	6	168	8.2	16.5	0.16	2.1	1 U	0.23	1.4	22.1	2 U	0.48	0.86	171	1 U	1.8	0	0.066	0	0.2 U	40.9	227	10 U	68.3	3.95	7.48	26.4	28.2
MORNING MARIE	0.5	0.5	10 U	10 U	10 U	10 U	0.87	0.87	1 U	1 U	6	6	2 U	2 U	10.6	10.6	1 U	1 U	0.06	0.06	0.2 U	0.2 U	58.5	58.5	7.3	7.3	5.7	5.7	15.4	15.4
NE NW SECTION 17	0.5	0.5	39.9	39.9	7.6	7.6	4.5	4.5	4.5	4.5	119	119	107	107	35.7	35.7	31.5	31.5	0.2 U	0.2 U	0.2 U	0.2 U	829	829	777	777	3.4	3.4	35.8	35.8
ROCKER	0.5	0.5	10 U	3310	10 U	1.7	1 U	47.9	1.5	15.7	16.4	6170	51.3	816.7	1.6	256	1 U	10.8	0.2 U	0.13	0.2 U	0.28	138	6810	873	2842	3.39	4.97	147	154
SNOWBIRD	0.5	0.5	60.1	60.1	58.6	58.6	1.2	1.2	1.1	1.1	25.4	25.4	22.7	22.7	0.75	0.75	1 U	1 U	0	0	0	0	140	140	138	138	6.7	6.7	14.9	14.9
SW SE SECTION 4	0.5	0.5	75.4	75.4	10.4	10.4	13.6	13.6	13	13	115	115	65.5	65.5	102	102	1.1	1.1	0.2 U	0.2 U	0.2 U	0.2 U	1590	1590	1540	1540	4.9	6.1	88.4	88.4
UNNAMED 002	0.5	0.5	631	1380	10.7	486	0.39	1.6	1 U	0.29	18.2	21.1	2 U	2.9	29.1	36.3	1 U	1 U	0.2 U	0.2 U	0.2 U	0.22	101	138	43.7	108	6.81	7.03	58.8	179
VOGEL	0.5	0.5	25.4	25.4	26.8	26.8	1 U	1 U	1 U	1 U	2 U	2 U	2 U	2 U	1 U	1 U	1 U	1 U	0	0	0.2 U	0.2 U	2.8	2.8	6.2	6.2	6.62	7.15	50.8	50.8
UNNAMED 004	0.4	0.4	27.6	27.6	11.3	14.5	0.73	0.73	1 U	0.41	0.45	0.45	2 U	3.6	1.5	1.5	1 U	2.5	0.2 U	0.2 U	0.2 U	0.2 U	213	213	200	323	6.9	7.36	17.7	21.9
ALPINE	0.3	0.3	23.6	23.6	10 U	10 U	0.09	0.09	1 U	1 U	2.8	2.8	2 U	2 U	6.8	6.8	1 U	1 U	0	0	0	0	10 U	10 U	4.4	4.4	6.8	6.8	2.9	2.9
BLACK BEAR	0.3	0.3	140	160	117	118	0.53	0.65	0.44	0.47	2.8	4.5	1.8	1.9	17.2	34.6	1 U	1 U	0.2 U	0.2 U	0.2 U	0.2 U	178	186	176	183	4.98	4.98	8.6	8.6
SIRIUS	0.3	0.3	114	114	10 U	10 U	22.4	22.4	23.5	27	53.6	53.6	48.7	67.4	25	25	11	11.7	0.2 U	0.2 U	0.2 U	0.21	5850	5850	5580	5910	4.2	4.53	103	114
MIDDLE SNOWDRIFT CREEK	0.1	0.1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
QUARTZ CREEK	0.1	0.1	10 U	10 U	10 U	10 U	1 U	1 U	1 U	1 U	1.1	1.1	0.41	0.41	0.4	0.4	1 U	1 U	0.2 U	0.2 U	0.2 U	0.2 U	10 U	10 U	10 U	10 U	6.2	6.2	5.8	5.8
REDWING	0.1	0.1	10 U	10 U	10 U	2.9	1 U	1 U	1 U	1 U	2.3	2.3	2 U	4.3	10.7	10.7	1 U	1 U	0.2 U	0.2 U	0.2 U	0.2 U	13	13	3.6	11.5	6.5	8.3	48.6	81.7
SYLVAN	0.1	0.1	10 U	10 U	10 U	10 U	0.067	0.067	0.038	0.038	2 U	2 U	2 U	2 U	1.4	1.4	1 U	1 U	0	0	0.2 U	0.2 U	43.2	43.2	41.9	41.9	7.74	7.74	45.4	45.4
ALSACE	nd	nd	10 U	10 U	10 U	10 U	1 U	1 U	0.026	0.026	1.8	1.8	1.7	1.7	0.33	0.33	0.61	0.61	0.2 U	0.2 U	0.2 U	0.2 U	1.7	1.7	5.1	5.1	7.19	7.19	6	6
BOULDER CHIEF	nd	nd	nd	nd	4.3	4.3	nd	nd	1230	1230	nd	nd	12000	12000	nd	nd	30.4	30.4	nd	nd	0.22	0.22	nd	nd	48000	48000	2.81	2.81	646	646
CALIFORNIA	nd	nd	9	9	11.3	11.3	0.048	0.048	1 U	1 U	2 U	2 U	0.36	0.36	6.3	6.3	0.83	0.83	0.2 U	0.2 U	0.2 U	0.2 U	12.8	12.8	2.3	2.3	6.66	6.66	71.4	71.4
CATARACT TAILS	nd	nd	15.3	15.3	13.2	13.2	0.65	0.65	0.62	0.62	46.2	46.2	35.2	35.2	43.6	43.6	29	29	0	0	0	0	47.8	47.8	46.4	46.4	5	6.2	10.4	10.4
CORBITT	nd	nd	10 U	25.6	10 U	16.6	0.54	124	0.39	127	6.9	2720	337	2620	68.8	593	47.6	594	0.2 U	0.2 U	0.2 U	0.2 U	158	22600	365	22300	5.44	5.55	1.5	160
GOLD FLAKE	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
GRAY LEAD	nd	nd	nd	nd	14.7	18.6	nd	nd	3.6	4.8	nd	nd	2 U	2.5	nd	nd	4.6	10.9	nd	nd	0.2 U	0.1	nd	nd	353	495	7.35	7.4	5.2	6.4
IDA M.	nd	nd	20.2	20.2	10 U	10 U	97.2	97.2	83.9	83.9	203.3	203.3	188.3	188.3	1537	1537	69.7	69.7	0.2 U	0.2 U	0.2 U	0.2 U	6404	6404	6493	6493	5.55	5.55	129	129
KLONDYKE	nd	nd	163	163	10.8	10.8	2.3	2.3	2	2	28.2	28.2	11	11	612	612	240	240	0	0	0	0	292	292	276	276	5.36	5.36	7.1	7.1
LIZZIE OSBORNE	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
MARY ANNE	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	6	6	nd	nd
MOUNTAIN CHIEF	nd	nd	nd	nd	6.8	11.4	nd	nd	1 U	2.2	nd	nd	2 U	4.7	nd	nd	1 U	2.7	nd	nd	0.2 U	0.2 U	nd	nd	81	168	7.07	7.45	26.1	28.3
NEAR BOULDER VESTAL	nd	nd	5.7	5.7	10 U	10 U	0.17	0.17	1 U	1 U	5.5	5.5	1.1	1.1	3.2	3.2	1.1	1.1	0.2 U	0.2 U	0.2 U	0.2 U	30.7	30.7	4.1	4.1	nd	nd	199	199
NEW COTTAGE	nd	nd	63	63	10 U	10 U	1 U	1 U	1 U	1 U	2 U	2 U	2 U	2 U	0.25	0.25	1 U	1 U	0	0	0.2 U	0.2 U	2420	2420	1580	1580	6.7	6.7	299	299
OCCIDENTAL	nd	nd	nd	nd	10 U	10 U	nd	nd	1 U	1 U	nd	nd	2 U	2 U	nd	nd	1 U	1 U	nd	nd	0.2 U	0.2 U	nd	nd	8.6	8.6	6.69	6.69	16	16
OVERLAND CREEK	nd	nd	28.5	52.8	5.1	44.6	0.14	2.8	0.12	2.1	2 U	13.5	0.97	8.6	4.6	51	0.55	2	0.2 U	0.2 U	0.2 U	0.2 U	40.8	479	29.8	424	5.5	5.5	6.9	8.9

Table 7.5-2 Summary of COC Concentrations in Adits and Seep Discharges at Mine Sites in Cataract Creek AOC, Basin Watershed OU2

Mine Sites	Discharge (gpm)		Arsenic				Cadmium				Copper				Lead				Mercury				Zinc				pH		Sulfate	
			Total (ug/L)		Dissolved (ug/L)		Total (ug/L)		Dissolved (ug/L)		Total (ug/L)		Dissolved (ug/L)		Total (ug/L)		Dissolved (ug/L)		Total (ug/L)		Dissolved (ug/L)		Total (ug/L)		Dissolved (ug/L)					
ROCKER WETLAND	nd	nd	***386***	***386***	***382***	***382***	0.029	0.029	1 U	1 U	2.3	2.3	2 U	2 U	***10.4***	***10.4***	0.28	0.28	0.2 U	0.2 U	0.2 U	0.2 U	8	8	6.8	6.8	***6.43***	***6.43***	***0***	***0***
SAINT LAWRENCE	nd	nd	***80.1***	***80.1***	36.1	36.1	1.6	1.6	***1.3***	***1.3***	***17.4***	***17.4***	***6.2***	***6.2***	***29.5***	***29.5***	1 U	1 U	0	0	0	0	***302***	***302***	***265***	***265***	nd	nd	***44.7***	***44.7***
SEATTLE	nd	nd	10 U	10 U	10 U	10 U	0.62	0.62	***0.61***	***0.61***	2 U	2 U	2 U	2 U	1.1	1.1	1 U	1 U	0	0	0.2 U	0.2 U	***2000***	***2000***	***2190***	***2190***	***6.5***	***7.3***	***205***	***205***
TIMBERLINE	nd	nd	10 U	10 U	10 U	10 U	1 U	1 U	1 U	1 U	***10.1***	***10.1***	2 U	2 U	***3.3***	***3.3***	1 U	1 U	0.2 U	0.2 U	0.2 U	0.2 U	***69.3***	***69.3***	***55.8***	***55.8***	nd	nd	***9.9***	***9.9***
UNNAMED 003	nd	nd	nd	nd	77.6	77.6	nd	nd	1 U	1 U	nd	nd	3	3	nd	nd	1 U	1 U	nd	nd	0.1	0.1	nd	nd	***140***	***140***	***6.3***	***6.3***	***4.5***	***4.5***
VERA AND MARIE	nd	nd	nd	nd	4.5	4.5	nd	nd	1 U	1 U	nd	nd	2.9	2.9	nd	nd	1 U	1 U	nd	nd	0.14	0.14	nd	nd	***49.5***	***49.5***	***5.5***	***7.04***	***40.7***	***40.7***
WALDY NORTH	nd	nd	***2.7***	***2.7***	10 U	10 U	1 U	1 U	1 U	1 U	2 U	2 U	***7.5***	***7.5***	1 U	1 U	1 U	1 U	0.2 U	0.2 U	0.2 U	0.2 U	17.4	17.4	6.1	6.1	***7.2***	***7.2***	***7***	***7***

gpm - Gallons per minute U - Nondetect nd - No Data ug/L - micrograms per liter Values in **bold underline** exceed benchmarks

Table 7.6-1 Summary of COC Concentrations in Groundwater in the Cataract Creek AOC, Basin Watershed OU2

		Arsenic (ug/L)		Cadmium (ug/L)		Copper (ug/L)		Lead (ug/L)		Mercury (ug/L)		Zinc (ug/L)		pH	Sulfate
Mine/Subarea	Sample Type	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	S.U.	mg/l
CALIFORNIA	Shaft	9	11.3	0.048	2 U	1.5	0.36	6.3	0.83	0.2 U	0.2 U	12.8	2.3	6.66	71.4
NEAR BOULDER VES	Groundwater Well	5.7	10 U	0.17	2 U	5.5	1.1	3.2	1.1	0.2 U	0.2 U	30.7	4.1	nd	199
ALSACE	Pond	10 U	10 U	2 U	0.026	1.8	1.7	0.33	0.61	0.2 U	0.2 U	1.7	5.1	7.19	6
ELDORADO AND PLATEAU	Shaft	22.8	6.7	0.95	0.32	31	8.3	208	40.6	0.054	0.2 U	104	78.9	nd	12.4
SAINT LAWRENCE	Pond	80.1	36.1	1.6	1.3	17.4	6.2	29.5	2 U	nd	nd	302	265	nd	44.7
KLONDYKE	Shaft	163	10.8	2.3	2	28.2	11	612	240	nd	nd	292	276	5.36	7.1
CORBITT	Shaft	25.6	16.6	0.54	0.39	6.9	337	68.8	47.6	0.2 U	0.2 U	158	365	5.55	1.5
OVERLAND CREEK	Shaft	30.5	18.1	2.8	2.1	13.5	2.9	51	2	0.2 U	0.2 U	479	424	nd	8.9
NE NW SECTION 17	Groundwater Well	39.9	7.6	4.5	4.5	119	107	35.7	31.5	0.2 U	0.2 U	829	777	nd	35.8

U- Nondetect S.U. - Standard Units nd - No Data

This page intentionally left blank.

Table 7.7-1 COC Loads in the Cataract Creek, Basin Watershed OU2

		Winter (Dec, Jan, Feb, Mar) Total and Dissolved Loads in pounds per day (lbs/day)													Spring/Summer (Apr, May, Jun, Jul) Total and Dissolved Loads in pounds per day (lbs/day)														Fall (Aug, Sep, Oct, Nov) Total and Dissolved Loads in pounds per day (lbs/day)													
		Arsenic		Cadmium		Copper		Mercury		lead		Zinc		Combined	Arsenic		Cadmium		Copper		Mercury		lead		Zinc		Combined		Arsenic		Cadmium		Copper		Mercury		lead		Zinc		Combined	
Reaches	Stations	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot
																					Historical																					
Reach 1	Cataract Creek Mainstem	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
Reach 2	26	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.01	nc	0.01
	Cat Unnamed Tributary 2 (27)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.09	nc	0.1
	28	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	8	nc	8	0.00	0.00	nc	0.00	0.00	0.00	nc	nc	0.00	0.00	0.03	0.04	0.03	0.04
	Nellie Grant Creek Tributary (29)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.4	nc	0	0.00	0.00	nc	0.00	0.00	0.00	nc	nc	0.00	0.00	0.00	0.01	0.00	0.01
	30	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	8	nc	8	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.2	nc	0.2
	Overland Creek Tributary (31)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	1	nc	1	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.01	nc	0.01
	32	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	9	nc	9	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.04	nc	0.04
	Rocker Creek Tributary (33)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.11	0.48	0.02	0.05	2	2	nc	nc	0.05	0.11	2	3	4	6	0.00	0.00	0.00	0.00	0.00	0.01	0.00	nc	0.00	0.00	0.02	0.02	0.02	0.03
	34	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.36	1.08	0.04	0.36	3	3	nc	nc	0.36	0.36	10	11	14	16	0.00	0.00	0.00	0.00	0.01	0.01	0.00	nc	0.00	0.00	0.04	0.04	0.06	0.07
	Reach 2 Average	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.07	0.22	0.01	0.07	0.5	0.6	nc	nc	0.07	0.07	2	7	3	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	nc	0.00	0.00	0.01	0.06	0.02	0.07
Reach 3	Snowdrift Creek Tributary (35)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	1	nc	1	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.1	nc	0.1
	36	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	16	nc	16	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.4	nc	0.4
	Hoodoo Creek Tributary (37)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0	nc	0	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.05	nc	0.05
	38	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	28	nc	28	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	9	nc	9
	Reach 3 Average	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	22	nc	22	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	5	nc	5
Reach 4	Cat Unnamed Tributary 5 (39)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	4	nc	4	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.05	nc	0.05
	Cat Unnamed Tributary 6 (40)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.03	0.06	0.01	0.01	0.1	0.1	nc	nc	0.01	0.01	4	4	4	4	0.00	0.00	0.00	0.00	0.00	0.00	nc	nc	0.00	0.00	0.10	0.10	0.10	0.10
	41	0.03	0.03	0.01	0.02	0.1	0.1	nc	0.02	0.02	1	1	1	2	0.93	1.03	0.10	0.05	3	3	nc	nc	0.34	0.86	15	19	18	24	0.05	0.04	0.01	0.01	0.09	0.09	nc	nc	0.02	0.02	1	1	1	1
	Reach 4 Average	0.03	0.03	0.01	0.02	0.1	0.1	nc	0.02	0.02	1	1	1	2	0.93	1.03	0.10	0.05	3	3	nc	nc	0.34	0.86	15	19	18	24	0.05	0.04	0.01	0.01	0.09	0.09	nc	nc	0.02	0.02	1	1	1	1
Reach 5	Uncle Sam Gulch Tributary (43)	0.00	0.01	0.08	0.08	0.3	0.5	nc	0.00	0.01	7	7	7	8	0.19	2.07	0.76	1.07	6	21	nc	nc	0.06	2.47	61	71	68	98	0.00	0.02	0.18	0.14	0.73	1.45	0.00	nc	0.00	0.03	14	14	15	16
	44	0.04	0.06	0.11	0.10	0.5	0.7	nc	0.02	0.02	10	11	11	12	1.37	22.19	1.39	1.50	18	53	nc	nc	0.46	8.98	126	138	148	224	0.05	0.09	0.19	0.21	1.13	1.90	0.00	nc	0.02	0.05	15	17	16	20
	Reach 5 Average	0.04	0.06	0.11	0.10	0.5	0.7	nc	0.02	0.02	10	11	11	12	1.37	22.19	1.39	1.50	18	53	nc	nc	0.46	8.98	126	138	148	224	0.05	0.09	0.19	0.21	1.13	1.90	0.00	nc	0.02	0.05	15	17	16	20
Reach 6	Deer Creek (45)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	1	nc	1	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.1	nc	0.1
Reach 7	Big Limber Gulch Tributary (46)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.1	nc	0.1	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
	47	0.07	0.09	0.07	0.07	0.3	0.3	0.00	0.02	0.02	7	8	8	8	1.60	8.58	0.73	0.89	15	24	nc	nc	0.46	4.27	74	95	91	133	0.07	0.09	0.10	0.11	0.46	0.57	0.00	nc	0.02	0.02	9	9	9	10
	6031960	0.06	nc	0.09	0.09	0.3	0.4	nc	0.02	0.02	8	8	8	9	0.49	1.23	0.36	0.39	5	6	nc	nc	0.16	0.41	34	35	40	43	0.05	0.06	0.07	0.07	0.34	0.40	nc	nc	0.02	0.02	7	6	7	7
	Reach 7 Average	0.06	0.04	0.08	0.08	0.3	0.4	0.00	0.02	0.02	7	8	8	8	1.04	4.91	0.55	0.64	10	15	nc	nc	0.31	2.34	54	65	65	88	0.06	0.07	0.09	0.09	0.40	0.48	0.00	nc	0.02	0.02	8	8	8	8

Notes:

Diss-Dissolved

Tot-Total

nc- Not calculated

COC - Contaminant of Concern

Table 7.7-1 COC Loads in the Cataract Creek, Basin Watershed OU2

		Winter (Dec, Jan, Feb, Mar) Total and Dissolved Loads in pounds per day (lbs/day)													Spring/Summer (Apr, May, Jun, Jul) Total and Dissolved Loads in pounds per day (lbs/day)														Fall (Aug, Sep, Oct, Nov) Total and Dissolved Loads in pounds per day (lbs/day)													
		Arsenic		Cadmium		Copper		Mercury	lead		Zinc		Combined		Arsenic		Cadmium		Copper		Mercury		lead		Zinc		Combined		Arsenic		Cadmium		Copper		Mercury		lead		Zinc		Combined	
Reaches	Stations	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot
																					2001																					
Reach 1	S014	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Cat Unnamed Tributary 1 (S015)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
Reach 2	S016	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.01	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.03	0.02	0.05	0.04
Reach 3	Snowdrift Creek Tributary (S017)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
	S018	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.04	0.04	0.00	0.00	0.08	0.09	0.00	0.00	0.00	0.01	0.71	0.7	0.8	0.8
	41	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.70	1.00	nc	0.07	3	3	nc	nc	0.33	0.67	13	15	17	19	0.03	0.04	nc	0.00	0.04	0.05	nc	nc	0.01	0.01	0.36	0.5	0.4	0.5
Reach 4	S019	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.02	0.02	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.21	0.2	0.3	0.3
Reach 5	Uncle Sam Gulch Tributary (43)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.10	1.72	0.38	0.40	5	8	nc	nc	0.03	0.35	34	34	39	44	0.00	0.01	0.11	0.12	0.29	0.64	nc	nc	0.00	0.01	9.73	10	10	11
	Uncle Sam Gulch Tributary (S020)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.01	0.01	0.11	0.11	0.32	0.63	0.00	0.00	0.00	0.01	8.12	9	9	10
	S022	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.06	0.06	0.12	0.12	0.35	0.48	0.00	0.00	0.01	0.01	9.84	10	10	11
Reach 6	Deer Creek Tributary (S021)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.34	0.35	0.04	0.04	0.03	0.03	0.00	0.00	0.04	0.04	0.04	0.04	0.5	0.5
	S023	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.05	0.05	0.07	0.07	0.18	0.20	0.00	0.00	0.00	0.00	5.52	5	6	6
Reach 7	6031960	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.64	2.32	0.52	0.61	10	15	###	nc	0.22	1.11	51	58	62	77	0.06	0.07	0.07	0.07	0.19	0.25	nc	nc	0.02	0.02	5.09	5	5	6
	S024	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.05	0.04	0.04	0.04	0.11	0.13	0.00	0.00	0.00	0.00	2.88	3	3	3
	Reach 7 Average	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.32	1.16	0.26	0.30	5	7	###	nc	0.11	0.55	25	29	31	38	0.05	0.06	0.05	0.06	0.15	0.19	0.00	0.00	0.01	0.01	3.98	4	4	5
																					September 6, 2001 Storm Event																							
Reach 1		nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
Reach 2		nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
Reach 3	Snowdrift Creek Tributary (S017)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.11	0.11	0.00	0.00	0.06	0.10	0.00	0.00	0.01	0.05	0.26	0.5	0.4	0.8
Reach 4	S019	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.74	1.27	0.05	0.10	3.66	2.38	0.01	0.01	0.17	1	10	15	15	21
Reach 5	Uncle Sam Gulch Tributary (S020)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.22	6.29	1.14	1.34	####	####	0.00	0.00	0.14	5	90	112	104	156
Reach 6	S021	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.01	0.01	0.00	0.00	0.04	0.01	0.00	0.00	0.00	0.00	0.04	0.04	0.09	0.06
Reach 7	S024	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.65	5.63	0.57	0.88	8.56	####	0.00	0.01	0.12	5	46	72	56	105

Notes:

Diss-Dissolved

Tot-Total

nc- Not calculated

COC - Contaminant of Concern

Table 7.7-2 Summary of Point Source Loads at Mine Sites in Cataract Creek AOC, Basin Watershed OU2

	Arsenic (lbs/day)		Cadmium (lbs/day)		Copper (lbs/day)		Lead (lbs/day)		Mercury (lbs/day)		Zinc (lbs/day)		Combined COCs	
Mine Sites	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**
CRYSTAL	3208	60	327	236	8644	3852	138	48	nc	nc	27291	20719	39608	24916
HATTIE FERGUSON	0.7	0.7	4.2	4.3	27.4	27.4	12.0	11.8	nc	nc	655.6	654.0	700	698
CRESCENT	0.05	0.1	2.3	1.3	48.2	26.4	11.5	21.0	0.00	nc	383.1	258.2	445	307
CRACKER	0.2	nc	0.3	0.3	0.6	0.2	0.6	0.1	0.01	0.01	60.4	79.1	62	80
ELDORADO AND PLATEAU	0.1	0.03	0.5	0.4	3.5	2.3	4.1	0.2	0.00	0.00	42.3	43.0	50	46
ROCKER	8.9	0.00	0.1	0.04	16.6	2.2	0.7	0.03	0.00	0.00	18.4	7.7	45	10
EVA MAY	1.4	0.7	0.2	0.2	1.5	0.3	0.8	0.03	0.00	nc	32.2	26.5	36	28
SIRIUS	0.2	nc	0.03	0.04	0.1	0.1	0.03	0.02	nc	0.00	7.9	8.0	8	8
NE SE SECTION 14	1.2	0.6	0.02	nc	nc	nc	0.1	nc	nc	nc	4.2	3.3	6	4
SW SE SECTION 4	0.2	0.0	0.04	0.04	0.3	0.2	0.3	0.00	nc	nc	4.3	4.2	5	4
ROCKER EXTENSION	0.5	0.3	0.02	0.01	0.3	0.3	0.2	nc	nc	nc	3.5	6.6	4	7
UNNAMED 001	0.05	nc	0.02	nc	0.9	0.04	0.4	nc	nc	nc	3.1	nc	4	0
UNNAMED 002	3.7	1.3	0.00	0.00	0.1	0.01	0.1	nc	nc	0.00	0.4	0.3	4	2
NE NW SECTION 17	0.1	0.02	0.01	0.01	0.3	0.3	0.1	0.1	nc	nc	2.2	2.1	3	3
APOLLO	0.6	0.1	0.01	0.00	0.1	0.00	0.6	0.01	0.00	nc	0.8	0.2	2	0
BLUE DIAMOND / OCCIDENTAL	0.03	0.01	0.01	0.00	0.1	0.01	1.0	0.01	nc	nc	0.4	0.3	2	0
SNOWBIRD	0.2	0.2	0.00	0.00	0.1	0.1	0.00	nc	nc	nc	0.4	0.4	1	1
BLACK BEAR	0.2	0.2	0.00	0.00	0.01	0.00	0.05	nc	nc	nc	0.3	0.3	0.5	0
UNNAMED 004	0.1	0.03	0.00	0.00	0.00	0.01	0.00	0.01	nc	nc	0.5	0.7	0.5	1
CATARACT	0.2	nc	nc	nc	0.0	0.03	0.0	nc	nc	nc	0.2	0.2	0.4	0.2
ADA	0.2	9.9	0.00	0.3	0.05	31.2	0.04	0.9	nc	0.00	0.1	47.8	0.4	90.1
GARFIELD	nc	nc	0.00	nc	0.01	nc	0.01	nc	nc	nc	0.4	0.4	0.4	0.4
CARTWRIGHT CABINS 2	0.1	0.1	0.00	nc	0.03	nc	0.1	nc	nc	nc	0.2	0.1	0.4	0.1
WALDY	nc	0.04	nc	nc	nc	nc	0.00	nc	nc	0.01	0.2	0.2	0.2	0.2
MORNING MARIE	nc	nc	0.00	nc	0.02	nc	0.03	nc	0.00	nc	0.2	0.02	0.2	0.02
LADY RICKER	0.1	0.03	nc	nc	nc	0.00	0.00	0.00	nc	nc	0.1	0.00	0.1	0.04
VOGEL	0.1	0.1	nc	nc	nc	nc	nc	nc	nc	nc	0.01	0.02	0.1	0.1
ALPINE	0.03	nc	0.00	nc	0.00	nc	0.01	nc	nc	nc	nc	0.01	0.05	0.01
SYLVAN	nc	nc	0.00	0.00	nc	nc	0.00	nc	nc	nc	0.02	0.02	0.02	0.02
REDWING	nc	0.00	nc	nc	0.00	0.00	0.01	nc	nc	nc	0.01	0.01	0.01	0.01
PHANTOM	nc	nc	0.00	nc	0.00	nc	0.01	nc	nc	0.00	nc	0.04	0.01	0.04

Notes: nc- Not Calculated lbs/day - pounds per day

Table 7.8-1 Cataract Creek AOC Mine Sites Radioactivity Levels, Basin Watershed OU2

	Field Measurement (millirem/hour)		Laboratory Measurements (Picocuries/gram)												
Mine	Background Radiation near Mine	Radiation at Mine	Alpha	Beta	Cesium-137	Potasium-40	Radium-226	Thorium-228	Thorium-230	Thorium-232	Thorium-232	Uranium-234	Uranium-235	Uranium-238	Uranium-238DHP
Evening Star	0.07	0.07	161.00	147.00	6.95E-02 U	25.10	12.40	2.63	25.90	1.63	2.26	7.10	0.38	8.48	5.83
Unnamed 002	0.022	0.15	84.20	85.60	0.44	31.50	4.65	2.65	7.58	1.95	2.40	4.26	0.19	4.90	3.14 U
Snowbird	0.21	0.21	66.80	73.60	5.54E-02 U	32.70	3.25	3.90	6.62	3.74	2.23	5.00	0.16	5.40	3.48
Rocker Mine	0.055	0.105	58.90	97.80	9.27E-02 U	37.80	3.98	0.73	1.10	0.62	1.23	0.22	1.19E-02 U	0.30	1.79 U
Corbitt	0.07	0.07	56.40	81.30	9.56E-02 U	31.40	4.82	2.28	4.35	2.05	1.75	1.72	0.05	2.18	2.99
Bing Hampton	0.07	0.07	49.60	57.50	4.95E-02 U	33.60	1.50	3.83	2.88	3.69	2.27	3.41	0.20	4.53	2.10
Eva May	0.025	0.08	43.50	70.80	0.32	29.40	2.58	1.91	2.67	1.79	1.79	1.22	0.08	1.58	6.10 U
Boulder Chief	0.01	0.03 - 0.07	18.70	53.80	8.72E-02 U	34.00	1.31	1.15	1.05	1.48	1.08	1.30	0.07	1.58	6.13 U
Seattle	0.06	0.06	15.40	74.40	4.54E-02	23.50	1.17	0.86	0.31	0.55	0.80	0.10	1.08E-02 U	0.14	0.77 U
Morning Marie	2.9	2.9	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Mike #14	0.5	0.6	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Lizzie Osborne	0.5	0.5	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Hattie Ferguson	0.14	0.14-0.28	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Crescent	0.09	0.03-0.21	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Crystal Mine	NM	0.05 - 0.1	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Eldorado And Plateau	0.29	0.9	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Boston	0.05-0.13	0.05-0.09	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Mantel Mine	0.04	0.07	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Marguerite Mine	0.05	0.06	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Morning Glory Mine	0.04	0.06	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Manhattan	0.35	0.35	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Middle Snowdrift Creek	0.33	0.33	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Cartwright Cabins 2	0.25	0.25	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Ne Se Section 14	0.24	0.24	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Mary Anne	0.24	0.24	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Sylvan	0.2	0.23	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Ruth	0.16	0.16	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Ne Nw Section 17	0.09	0.16	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
New Cottage	0.15	0.15	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Unnamed 004	0.14	0.14	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Quartz Creek	0.11	0.12	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Cataract	0.19	0.12	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Sirius	0.11	0.11	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Cataract Tails	0.1	0.1	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Garfield	0.09	0.09	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Vera And Marie	0.07	0.07	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Apollo	0.04	0.07	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Vogel	0.06	0.06	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Table 7.8-1 Cataract Creek AOC Mine Sites Radioactivity Levels, Basin Watershed OU2

	Field Measurement (millirem/hour)		Laboratory Measurements (Picocuries/gram)												
Mine	Background Radiation near Mine	Radiation at Mine	Alpha	Beta	Cesium-137	Potasium-40	Radium-226	Thorium-228	Thorium-230	Thorium-232	Thorium-232	Uranium-234	Uranium-235	Uranium-238	Uranium-238DHP
Unnamed 001	0.06	0.06	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Timberline	0.06	0.06	ns	ns	6.15E-02 U	32.50	2.38	1.95	0.70	1.98	2.04	0.50	0.03	0.78	1.12 U
Lady Ricker	0.06	0.06	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Gold Flake	0.06	0.06	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Cataract Placer	0.03	0.05	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
North Ada - Piermont	0.04	0.04	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Sw Se Section 4	0.03	0.03	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Cracker	0.02	0.03	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Uncle Sam	0.02	0.02	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Ida May	0.02	0.02	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Alsace	0.01	0.02	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Overland Creek	0.01	0.01	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
California	NM	NM	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Notes: nm- Not measured ns- Not sampled U- Non detect

This page intentionally left blank.

Table 8.4-1 Micro Pushpoint Groundwater/Surface Water Interface and Pore Water Sampling Results, Basin Watershed OU2

		Arsenic		Cadmium		Copper		Mercury		Lead		Zinc		Field measurements					
Mine Site	Description	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss Oxygen	ORP	pH	Temp	Cond	Paste pH
Eva May	MPP001 Groundwater	10	20	10	11	14	22	nd	nd	0.3	0.7	1230	1320	nd	116	6.5	nd	0.2	nd
	Surface water near MPP001	10 U	10 U	0.9	0.9	13.9	16.6	nd	nd	1.0	1.0	133.0	140	nd	202	7	nd	0.1	nd
	Mine waste average	nd	1350	nd	31774	nd	802	nd	31746	nd	4299	nd	3585	nd	nd	nd	nd	nd	4
	MPP002 Baseline Groundwater	10 U	10 U	0.1	0.1	1.3	9.9	nd	nd	1.0	20.2	14.6	24.6	nd	117	6.7	nd	0.1	nd
	Surface water near MPP002	nd	nd	0.1	0.1	1.3	9.9	nd	nd	1.0	20.2	14.6	24.6	nd	202	7	nd	0.1	nd
Cartwright Cabins	MPP Groundwater	9.3	9.8	1 U	0.1	nd	4.0	nd	nd	1 U	8.7	4.8	19.7	nd	42	5.7	nd	0.2	nd
	Surface water	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	298	6.7	nd	0.2	nd
	Mine waste average	nd	424	nd	55556	ND	32	nd	0	nd	3055	nd	279	nd	nd	nd	nd	nd	3
Apollo	MPP Groundwater	16.5	34.3	0.2	0.5	0.5	2.5	nd	nd	1.8	2.0	52.2	74.3	nd	176	6.5	nd	0.2	nd
	Surface water	10 U	10 U	1 U	1 U	2 U	2.8	nd	nd	1 U	1 U	7.7	7.7	9.8	118	7.9	15	nd	nd
	Mine waste average	nd	14440	nd	55556	ND	16	nd	0	nd	554	nd	52	nd	nd	nd	nd	nd	3
Cataract Tails	MPP Groundwater	13.2	15.3	0.6	0.7	35.2	46.2	nd	nd	29.0	43.6	46.4	47.8	5.2	21	6	7.9	0.1	nd
	Surface water	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10.3	202	6.3	11.2	0.1	nd
	Mine waste average	nd	176	nd	3	nd	829	nd	0	nd	682	nd	500	nd	nd	nd	nd	nd	5
Upper Hattie Fergusson Wetland	MPP001 Groundwater	7	9	264	258	1690	1690	nd	nd	726	742	40400	40500	7	nd	4	17	1	nd
	Surface water near MPP001	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	8.8	362	3.7	19.2	0.4	nd
	Mine waste average	nd	2617	nd	24	nd	452	nd	3334	nd	12031	nd	2383	nd	nd	nd	nd	nd	3
	MPP002 Groundwater	42.4	45.9	1 U	0.03	0.4	2.1	nd	nd	0.3	6.8	14.0	18.3	7.0	-24	5.7	3.7	0.3	nd
Rocker Creek Wetland	MPP Groundwater	382	386.0	1 U	0.0	2 U	2.3	nd	nd	0.3	10.4	6.8	8	nd	-89	6.4	4.8	0.2	nd
	Surface water near MPP	10 U	5.8	0.2	0.2	6.3	8.5	nd	nd	1 U	0.5	41.9	41.2	5.7	-10	6.9	0.4	0.1	nd

Notes:

U - Non Detect
nd - No Data
Tot - Total Concentration
Diss - Dissolved Concentration
ORP - Oxidation/Reduction Potential
Cond - Conductivity

Table 8.5-1 Wetland Sampling Results, Basin Watershed OU2

		Arsenic		Cadmium		Copper		Mercury		Lead		Zinc		Field measurements					
Mine Site	Description	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss	Tot	Diss Oxygen	ORP	pH	Temp	Cond	Paste pH
Upper Hattie Fergusson Wetland	MPP001 Groundwater	7	9	264	258	1690	1690	nd	nd	726	742	40400	40500	7	nd	4	17	1	nd
	Surface water near MPP001	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	8.8	362	3.7	19.2	0.4	nd
	Mine waste average	nd	2617	nd	24	nd	452	nd	3334	nd	12031	nd	2383	nd	nd	nd	nd	nd	3
	MPP002 Groundwater	42.4	45.9	1 U	0.03	0.4	2.1	nd	nd	0.3	6.8	14.0	18.3	7	-24	5.7	3.7	0.3	nd
	Surface water entering wetland	10 U	10 U	1 U	0.2	0.7	2.0	nd	nd	1 U	3.1	7.1	22.6	5.6	191	5.6	0.2	0.1	nd
	Surface water exiting wetland	10 U	10 U	1.6	1.6	2.7	6.5	nd	nd	1 U	0.5	775	768	5.8	225	5.8	0.2	0.2	nd
	Sediment	na	34.4	na	4.0	na	51.2	na	0.22	na	93.0	na	443	na	na	na	na	na	na
Rocker Creek Wetland	MPP Groundwater	382.0	386	1 U	0.0	2 U	2.3	nd	nd	0.3	10.4	6.8	8.0	nd	-89	6.4	4.8	0.2	nd
	Surface water entering wetland	10 U	10 U	0.1	0.1	5.8	9.2	nd	nd	1 U	0.5	19.0	20.8	6.3	28	6.5	0.3	0.1	nd
	Surface water near MPP	10 U	5.8	0.2	0.2	6.3	8.5	nd	nd	1 U	0.5	41.9	41.2	5.7	-10	6.9	0.4	0.1	nd
	Surface water exiting wetland	10 U	10 U	0.4	0.2	11.6	6.3	nd	nd	0.5	1 U	41.5	35.8	5.7	26	6.8	0.4	0.1	nd
	Sediment	na	43.5	na	0.67	na	102	na	na	na	59.5	na	132	na	na	na	na	na	na

Notes:

U - Non Detect
nd - No Data
na - Not applicable

Tot - Total Concentration
Diss - Dissolved Concentration

ORP - Oxidation/Reduction Potential
Cond - Conductivity

Table 10.1-1 Selection Process for Chemicals of Potential Concern - Surface Water

Analyte		Number of Post-1990 Samples Collected	Number of Detects	Frequency of Detection	Maximum Detection (ug/L)	Screening Level (ug/L)	Exceeds SL and Retained COPC
Aluminum	Al	662	443	67%	41140	87	YES
Antimony	Sb	459	157	34%	202	30	YES
Arsenic	As	774	611	79%	6290	150	YES
Barium	Ba	607	599	99%	2050	No SL	YES
Berylium	Be	446	31	7%	202	5.3	YES
Boron	B	210	42	20%	430	No SL	YES
Bromine	Br	189	2	10%	100000	No SL	YES
Cadmium	Cd	816	531	65%	1230	0.15	YES
Calcium	Ca	721	721	100%	144000	No SL	YES
Chromium	Cr	618	79	13%	200	No SL	YES
Cobalt	Co	446	184	41%	316	23	YES
Copper	Cu	741	655	88%	13400	4.1	YES
Iron	Fe	662	637	96%	212000	1000	YES
Lead	Pb	683	233	34%	20000	1.16	YES
Lithium	Li	250	83	33%	107	No SL	YES
Magnesium	Mg	721	721	100%	59500	No SL	YES
Manganese	Mn	664	637	96%	38100	120	YES
Mercury	Hg	403	86	21%	0.65	0.65	YES
Molybdenum	Mo	372	33	9%	5	No SL	YES
Nickel	Ni	614	329	54%	196	24	YES
Potassium	K	670	660	98%	50900	No SL	YES
Selenium	Se	283	10	4%	8.4	4.61	YES
Silicon	Si	20	20	100%	35.6	No SL	YES
Silver	Ag	616	163	26%	200	0.12	YES
Sodium	Na	670	637	95%	53900	No SL	YES
Strontium	Sr	209	209	100%	1021	No SL	YES
Thallium	Tl	240	23	10%	1970	40	YES
Tin	Sn	1	1	100%	64	No SL	YES
Titanium	Ti	209	86	41%	73.5	No SL	YES
Uranium	U	162	59	36%	10	No SL	YES
Vanadium	V	446	96	22%	504	No SL	YES
Zinc	Zn	745	730	98%	72000	42.1	YES
Zirconium	Zr	208	17	8%	64	No SL	YES

Retained COPCs	Frequency of Detection	Maximum Detection (ug/L)	Screening Level (ug/L)	CLP Target Analyte	Essential Nutrient or Non-Toxic	CLP TAL Inorganic, Non-Nutrient, and Retained COPC
Al	67%	41140	87	Yes		YES
Sb	34%	202	30	Yes		YES
As	79%	6290	150	Yes		YES
Ba	99%	2050	No SL	Yes		YES
Be	7%	202	5.3	Yes		YES
B	20%	430	No SL			NO
Br	10%	100000	No SL			NO
Cd	65%	1230	0.15	Yes		YES
Ca	100%	144000	No SL	Yes	Yes	NO
Cr	13%	200	No SL	Yes		YES
Co	41%	316	23	Yes		YES
Cu	88%	13400	4.1	Yes		YES
Fe	96%	212000	1000	Yes		YES
Pb	34%	20000	1.16	Yes		YES
Li	33%	107	No SL			NO
Mg	100%	59500	No SL	Yes	Yes	NO
Mn	96%	38100	120	Yes		YES
Hg	21%	0.65	0.65	Yes		YES
Mo	9%	5	No SL			NO
Ni	54%	196	24	Yes		YES
K	98%	50900	No SL	Yes	Yes	NO
Se	4%	8.4	4.61	Yes		YES
Si	100%	35.6	No SL			NO
Ag	26%	200	0.12	Yes		YES
Na	95%	53900	No SL	Yes	Yes	NO
Sr	100%	1021	No SL			NO
Tl	10%	1970	40	Yes		YES
Sn	100%	64	No SL			NO
Ti	41%	73.5	No SL			NO
U	36%	10	No SL			NO
V	22%	504	No SL	Yes		YES
Zn	98%	72000	42.1	Yes		YES
Zr	8%	64	No SL			NO

Retained COPCs	Frequency of Detection	Maximum Detection (ug/L)	Screening Level (ug/L)	Detect Frequency > 5% and Retained COPC
Al	67%	41140	87	YES
Sb	34%	202	30	YES
As	79%	6290	150	YES
Ba	99%	2050	No SL	YES
Be	7%	202	5.3	YES
Cd	65%	1230	0.15	YES
Cr	13%	200	No SL	YES
Co	41%	316	23	YES
Cu	88%	13400	4.1	YES
Fe	96%	212000	1000	YES
Pb	34%	20000	1.16	YES
Mn	96%	38100	120	YES
Hg	21%	0.65	0.65	YES
Ni	54%	196	24	YES
Se	4%	8.4	4.61	NO
Ag	26%	200	0.12	YES
Tl	10%	1970	40	YES
V	22%	504	No SL	YES
Zn	98%	72000	42.1	YES

Retained COCs for Basin OU2	Retained COCs for Upper Tenmile Creek
Al	Al
Sb	Sb
As	As
Ba	
Be	
Cd	Cd
Cr	
Co	Co
Cu	Cu
Fe	Fe
Pb	Pb
Mn	Mn
Hg	
Ni	Ni
Ag	Ag
Tl	
V	
Zn	Zn

No SL - No screening level identified.
Sample statistics from RI Site-wide database (CDM 2002)

COPC - chemical of potential concern
CLP - Contract Laboratory Program

TAL - Target Analyte List
COC - chemical of concern

ug/L - micrograms per liter

CDM

Table 10.1-2 Selection Process for Chemicals of Potential Concern - Sediment

Analyte		Number of Post-1990 Samples Collected	Number of Detects	Frequency of Detection	Maximum Detection (mg/kg)	Screening Level (mg/kg)	Exceeds SL and Retained COPC	Retained COPCs	Frequency of Detection	Maximum Detection (mg/kg)	Screening Level (mg/kg)	CLP Target Analyte	Essential Nutrient or Non-Toxic	CLP TAL Inorganic, Non-Nutrient, and Retained COPC	Retained COPCs	Frequency of Detection	Maximum Detection (mg/kg)	Screening Level (mg/kg)	Detect Frequency > 5% and Retained COPC	Retained COCs for Basin OU2	Retained COCs for Upper Tenmile Creek
Aluminum	Al	316	316	100%	110000	No SL	YES	Al	100%	110000	No SL	Yes		YES	Al	100%	110000	No SL	YES	Al	
Antimony	Sb	71	40	56%	69.9	2	YES	Sb	56%	69.9	2	Yes		YES	Sb	56%	69.9	2	YES	Sb	Sb
Arsenic	As	315	314	100%	8500	5.9	YES	As	100%	8500	5.9	Yes		YES	As	100%	8500	5.9	YES	As	As
Barium	Ba	317	317	100%	1100	200	YES	Ba	100%	1100	200	Yes		YES	Ba	100%	1100	200	YES	Ba	
Berylium	Be	289	256	89%	6	No SL	YES	Be	89%	6	No SL	Yes		YES	Be	89%	6	No SL	YES	Be	
Cadmium	Cd	299	190	64%	88	0.59	YES	Cd	64%	88	0.59	Yes		YES	Cd	64%	88	0.59	YES	Cd	Cd
Calcium	Ca	317	317	100%	37000	No SL	YES	Ca	100%	37000	No SL	Yes	Yes	NO							
Cerium	Ce	244	244	100%	280	No SL	YES	Ce	100%	280	No SL			NO							
Chromium	Cr	301	288	96%	310	37.3	YES	Cr	96%	310	37.3	Yes		YES	Cr	96%	310	37.3	YES	Cr	
Cobalt	Co	315	292	93%	72	20	YES	Co	93%	72	20	Yes		YES	Co	93%	72	20	YES	Co	
Copper	Cu	316	316	100%	6600	18.7	YES	Cu	100%	6600	18.7	Yes		YES	Cu	100%	6600	18.7	YES	Cu	Cu
Galliium	Ga	244	241	99%	27	No SL	YES	Ga	99%	27	No SL			NO							
Iron	Fe	317	317	100%	300000	20000	YES	Fe	100%	300000	20000	Yes		YES	Fe	100%	300000	20000	YES	Fe	Fe
Lanthanum	La	243	243	100%	160	No SL	YES	La	100%	160	No SL			NO							
Lead	Pb	315	315	100%	19000	30.2	YES	Pb	100%	19000	30.2	Yes		YES	Pb	100%	19000	30.2	YES	Pb	Pb
Lithium	Li	244	244	100%	98	No SL	YES	Li	100%	98	No SL			NO							
Magnesium	Mg	316	316	100%	23000	No SL	YES	Mg	100%	23000	No SL	Yes	Yes	NO							
Manganese	Mn	317	317	100%	9600	460	YES	Mn	100%	9600	460	Yes		YES	Mn	100%	9600	460	YES	Mn	Mn
Mercury	Hg	71	15	21%	0.27	0.13	YES	Hg	21%	0.27	0.13	Yes		YES	Hg	21%	0.27	0.13	YES	Hg	Hg
Molybdenum	Mo	220	109	50%	30	10	YES	Mo	50%	30	10			NO							
Neodymium	Nd	243	243	100%	120	No SL	YES	Nd	100%	120	No SL			NO							
Nickel	Ni	315	299	95%	30	15.9	YES	Ni	95%	30	15.9	Yes		YES	Ni	95%	30	15.9	YES	Ni	Ni
Niobium	Nb	244	226	93%	74	No SL	YES	Nb	93%	74	No SL			NO							
Potassium	K	312	312	100%	37000	No SL	YES	K	100%	37000	No SL	Yes	Yes	NO							
Scandium	Sc	232	232	100%	37	No SL	YES	Sc	100%	37	No SL			NO							
Selenium	Se	73	22	30%	2.5	No SL	YES	Se	30%	2.5	No SL	Yes		YES	Se	30%	2.5	No SL	YES	Se	
Silver	Ag	296	149	50%	120	0.5	YES	Ag	50%	120	0.5	Yes		YES	Ag	50%	120	0.5	YES	Ag	Ag
Sodium	Na	304	303	100%	31000	No SL	YES	Na	100%	31000	No SL	Yes	Yes	NO							
Strontium	Sr	241	241	100%	840	No SL	YES	Sr	100%	840	No SL			NO							
Sulfur	S	7	7	100%	600	No SL	YES	S	100%	600	No SL			NO							
Thallium	Tl	71	1	1%	1.4	No SL	YES	Tl	1%	1.4	No SL	Yes		YES	Tl	1%	1.4	No SL	NO		
Thorium	Th	243	240	99%	73	No SL	YES	Th	99%	73	No SL			NO							
Tin	Sn	207	30	14%	14	No SL	YES	Sn	14%	14	No SL			NO							
Titanium	Ti	246	242	98%	13000	No SL	YES	Ti	98%	13000	No SL			NO							
Turbium	Tb	26	4	15%	1	No SL	YES	Tb	15%	1	No SL			NO							
Uranium	U	4	0	0%	-	No SL	NO														
Vanadium	V	311	311	100%	1300	No SL	YES	V	100%	1300	No SL	Yes		YES	V	100%	1300	No SL	YES	V	
Ytterbium	Yb	211	211	100%	7	No SL	YES	Yb	100%	7	No SL			NO							
Yttrium	Y	244	244	100%	82	No SL	YES	Y	100%	82	No SL			NO							
Zinc	Zn	315	315	100%	7300	110	YES	Zn	100%	7300	110	Yes		YES	Zn	100%	7300	110	YES	Zn	Zn

No SL - No screening level identified.
Sample statistics from RI Site-wide database (CDM 2002)

COPC - chemical of potential concern
CLP - Contract Laboratory Program

TAL - Target Analyte List
COC - chemical of concern

mg/kg - milligrams per kilogram

CDM

Table 10.1-3 Selection Process for Chemicals of Potential Concern - Soil

Analyte		Number of Post-1990 Samples Collected	Number of Detects	Frequency of Detection	Maximum Detection (mg/kg)	Screening Level (mg/kg)	Exceeds SL and Retained COPC
Aluminum	Al	606	606	100%	110000	50	YES
Antimony	Sb	533	353	66%	3182.87	3.5	YES
Arsenic	As	1047	1045	100%	96728.8	10	YES
Barium	Ba	903	903	100%	1329.25	165	YES
Berylium	Be	178	157	88%	6.7	1.1	YES
Bismuth	Bi	1	1	100%	37	No SL	YES
Cadmium	Cd	900	641	71%	1300	1.6	YES
Calcium	Ca	828	812	98%	72000	No SL	YES
Cerium	Ce	429	424	99%	200	No SL	YES
Chromium	Cr	686	538	78%	36.7	0.4	YES
Cobalt	Co	662	449	68%	970	20	YES
Copper	Cu	1037	1035	100%	9000	40	YES
Galliium	Ga	429	393	92%	25	No SL	YES
Iron	Fe	886	886	100%	210000	50	YES
Lanthanum	La	429	429	100%	170	No SL	YES
Lead	Pb	1093	1085	99%	93000	50	YES
Lithium	Li	429	429	100%	76	No SL	YES
Magnesium	Mg	606	605	100%	14000	No SL	YES
Manganese	Mn	816	816	100%	29598.3	100	YES
Mercury	Hg	261	226	87%	218	0.1	YES
Molybdenum	Mo	564	413	73%	74	2	YES
Neodymium	Nd	429	425	99%	210	No SL	YES
Nickel	Ni	684	485	71%	147	30	YES
Niobium	Nb	429	313	73%	40	No SL	YES
Potassium	K	789	789	100%	51000	No SL	YES
Rubidium	Rb	221	221	100%	468	No SL	YES
Scandium	Sc	429	424	99%	25	No SL	YES
Selenium	Se	183	67	37%	6.1	0.81	YES
Silver	Ag	720	574	80%	411.51	2	YES
Sodium	Na	606	591	98%	18000	No SL	YES
Strontium	Sr	645	645	100%	879.53	No SL	YES
Sulfur	S	197	173	88%	71800	No SL	YES
Terbium	Tb	1	1	100%	1	No SL	YES
Thallium	Tl	358	209	58%	300	1	YES
Thorium	Th	429	396	92%	50	No SL	YES
Tin	Sn	1	0	0%	-	50	NO
Titanium	Ti	651	651	100%	6700	No SL	YES
Uranium	U	261	61	23%	450	No SL	YES
Vanadium	V	606	603	100%	180	2	YES
Ytterbium	Yb	429	248	58%	20	No SL	YES
Yttrium	Y	429	417	97%	160	No SL	YES
Zinc	Zn	1102	1102	100%	28000	50	YES
Zirconium	Zr	222	222	100%	342.78	No SL	YES

Retained COPCs	Frequency of Detection	Maximum Detection (mg/kg)	Screening Level (mg/kg)	CLP Target Analyte	Essential Nutrient or Non-Toxic	CLP TAL Inorganic, Non-Nutrient, and Retained COPC
Al	100%	110000	50	Yes		YES
Sb	66%	3182.87	3.5	Yes		YES
As	100%	96728.8	10	Yes		YES
Ba	100%	1329.25	165	Yes		YES
Be	88%	6.7	1.1	Yes		YES
Bi	100%	37	No SL			NO
Cd	71%	1300	1.6	Yes		YES
Ca	98%	72000	No SL	Yes	Yes	NO
Ce	99%	200	No SL			NO
Cr	78%	36.7	0.4	Yes		YES
Co	68%	970	20	Yes		YES
Cu	100%	9000	40	Yes		YES
Ga	92%	25	No SL			NO
Fe	100%	210000	50	Yes		YES
La	100%	170	No SL			NO
Pb	99%	93000	50	Yes		YES
Li	100%	76	No SL			NO
Mg	100%	14000	No SL	Yes	Yes	NO
Mn	100%	29598.3	100	Yes		YES
Hg	87%	218	0.1	Yes		YES
Mo	73%	74	2			NO
Nd	99%	210	No SL			NO
Ni	71%	147	30	Yes		YES
Nb	73%	40	No SL			NO
K	100%	51000	No SL	Yes	Yes	NO
Rb	100%	468	No SL			NO
Sc	99%	25	No SL			NO
Se	37%	6.1	0.81	Yes		YES
Ag	80%	411.51	2	Yes		YES
Na	98%	18000	No SL	Yes	Yes	NO
Sr	100%	879.53	No SL			NO
S	88%	71800	No SL			NO
Tb	100%	1	No SL			NO
Tl	58%	300	1	Yes		YES
Th	92%	50	No SL			NO
Ti	100%	6700	No SL			NO
U	23%	450	No SL			NO
V	100%	180	2	Yes		YES
Yb	58%	20	No SL			NO
Y	97%	160	No SL			NO
Zn	100%	28000	50	Yes		YES
Zr	100%	342.78	No SL			NO

Retained COPCs	Frequency of Detection	Maximum Detection (mg/kg)	Screening Level (mg/kg)	Detect Frequency > 5% and Retained COPC	Retained COCs for Basin OU2	Retained COCs for Upper Tenmile Creek
Al	100%	110000	50	YES	Al	
Sb	66%	3182.87	3.5	YES	Sb	Sb
As	100%	96728.8	10	YES	As	As
Ba	100%	1329.25	165	YES	Ba	Ba
Be	88%	6.7	1.1	YES	Be	
Cd	71%	1300	1.6	YES	Cd	Cd
Cr	78%	36.7	0.4	YES	Cr	Cr
Co	68%	970	20	YES	Co	Co
Cu	100%	9000	40	YES	Cu	Cu
Fe	100%	210000	50	YES	Fe	Fe
Pb	99%	93000	50	YES	Pb	Pb
Mn	100%	29598.3	100	YES	Mn	Mn
Hg	87%	218	0.1	YES	Hg	Hg
						Mo
Ni	71%	147	30	YES	Ni	
Se	37%	6.1	0.81	YES	Se	
Ag	80%	411.51	2	YES	Ag	Ag
Tl	58%	300	1	YES	Tl	
V	100%	180	2	YES	V	
Zn	100%	28000	50	YES	Zn	Zn

No SL - No screening level identified.
Sample statistics from RI Site-wide database (CDM 2002)

COPC - chemical of potential concern
CLP - Contract Laboratory Program

TAL - Target Analyte List
COC - chemical of concern

mg/kg - millograms per kilogram

CDM

Table 10.1-4 Toxcity Reference Values for Soil COCs

COPC	Soil/Solid Media Toxicity Reference Values (TRVs, mg/kg)									Selected TRV (9) (number or range)	
	Phytotoxicity TRV						Earthworm TRV (7)	Microorganism TRV (7)	Interim Remediation Criteria (agricultural use) (8)		
	(1)	(2)	(3)	(4)	(5)	(6)					
Aluminum	**NA**	**NA**	**NA**	**50**	**NA**	**NA**	**NA**	**600**	**NA**	**50**	
Antimony	NA	NA	NA	5	NA	NA	NA	NA	20	20	
Arsenic	135 - 315	224 - 315	100	10	200	15 - 50	60	100	20	60	315
Barium	NA	NA	NA	500	NA	NA	NA	3,000	750	3,000	
Beryllium	**NA**	**NA**	**NA**	**10**	**NA**	**NA**	**NA**	**NA**	**NA**	**10**	
Cadmium	5.1 - 20	8.6 - 40	100	4	5	3 - 5	20	20	3	5.1	20
Chromium	NA	NA	NA	1	NA	NA	0.4	10	750	0.4	10
Cobalt	NA	NA	NA	20	NA	NA	NA	1,000	40	1,000	
Copper	236 - 750	1,062 - 1,636	100	100	400	60 - 125	50	100	150	50	750
Iron	NA	NA	NA	NA	NA	NA	NA	50	NA	50	
Lead	94 - 250	179 - 250	1000	50	NA	100 - 400	500	900	375	94	500
Manganese	NA	NA	NA	500	NA	NA	NA	100	NA	100	
Mercury	NA	NA	5	0.3	NA	NA	0.1	30	0.8	0.1	30
Molybdenum	NA	NA	NA	2	NA	NA	NA	200	5	200	
Selenium	**NA**	**NA**	**NA**	**1**	**NA**	**NA**	**70**	**100**	**NA**	**1**	**100**
Silver	NA	NA	NA	2	NA	NA	NA	50	20	50	
Thalium	**NA**	**NA**	**NA**	**1**	**NA**	**NA**	**NA**	**NA**	**NA**	**1**	
Vanadium	**NA**	**NA**	**NA**	**2**	**NA**	**NA**	**NA**	**20**	**NA**	**2**	**20**
Zinc	196 - 240	379 - 500	500	50	NA	70 - 400	200	100	600	196	240

Notes:
1 - CDM 1996 (pH <6.5)
2 - CDM 1996 (pH >6.5)
3 - CH2M Hill 1987a and 1987b
4 - Efroymson, Will, Suter, and Wooten 1997
5 - Rice and Ray 1984
6 - Kabata-Pendias and Pendias 1992
7 - Efroymson, Will, and Suter 1997
8 - Canadian Council of Ministers of the Environment (CCME) 1991
9 - Selected TRV primarily based on ERA work completed for Upper Tenmile Creek (CDM 2001). Selected TRV used to derive HQs.
NA – Not available (no value established or derived)
Bold - indicates those analytes that were not considered in the Upper Tenmile Creek ERA (CDM 2001)
COC - chemical of concern
TRV - toxicity reference value
mg/kg - milligrams per kilogram

Table 10.1-5 Toxicity Reference Values for Sediment COCs

COC	Sediment Toxicity Reference Values (TRVs, mg/kg)								Selected TRVs [10] (number or range)	
	Ingersoll NOAEL TRV [1]	Ingersoll LOAEL TRV [2]	Regional NOAEL TRV [3]	Regional LOAEL TRV [4]	EPA ARCS TEC [5]	EPA ARCS PEC [6]	OME LEL [7]	EPA Region IV SV [9]		
Aluminum	**14000**	**58000**	**NA**	**NA**	**NA**	**58030**	**NA**	**NA**	**14000**	**58000**
Antimony	NA	NA	NA	NA	NA	NA	NA	12	12	
Arsenic	13	50	115	230	12.1	57	6	7.24	13	50
Barium	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**No TRV**	
Beryllium	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**No TRV**	
Cadmium	0.7	3.9	4.93	9.86	0.592	11.7	0.6	1	0.7	3.9
Chromium	**39**	**270**	**NA**	**NA**	**56**	**159**	**26**	**52.3**	**39**	**270**
Cobalt [11]	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**50000**	
Copper	41	190	1,125	2,250	28	77.7	16	18.7	41	190
Iron	NA	NA	NA	NA	NA	NA	20,000 (2%)	NA	20,000	
Lead	53	99	86.5	173	34.2	396	31	30.2	53	99
Manganese	NA	NA	NA	NA	NA	NA	460	NA	460	
Mercury	NA	NA	NA	NA	NA	NA	0.2	0.13	0.13	0.2
Nickel	NA	NA	NA	NA	NA	NA	16	15.9	15.9	16
Selenium	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**No TRV**	
Silver	NA	NA	NA	NA	NA	NA	0.5 [8]	2	0.5	2
Vanadium	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**No TRV**	
Zinc	110	550	1,385	2,770	159	1,532	120	124	110	550

1 - NOAEL-based sediment TRV (Effects Range-Low or ERL) derived by Ingersoll et al. (1996)
2 - LOAEL-based sediment TRV (Effects Range-Median or ERM) derived by Ingersoll et al. (1996)
3 - NOAEL-based sediment TRV using the results of Hyalella toxicity tests, from the Clark Fork River ERA (EPA 1999b)
4 - LOAEL-based sediment TRV using the results of Hyalella toxicity tests, from the Clark Fork River ERA (EPA 1999b)
5 - Threshold effects Concentration (TEC), Assessment and Remediation of Contaminated Sediments Program (EPA 1996 in Jones, Suter, and Hull 1997)
6 - Probable effects concentration (PEC), Assessment and Remediation of Contaminated Sediments Program (EPA 1996 in Jones, Suter, and Hull 1997)
7 - Ontario Ministry of Environment Lowest Effect Level (Persaud et al. 1993)
8 - Ontario Ministry of Environment Open Water Disposal Guideline (Persaud et al. 1993)
9 - EPA Region IV Screening Value (EPA Region IV 1995 in Jones, Suter, and Hull 1997)
10 - Selected TRV primarily based on ERA work completed for Upper Tenmile Creek (CDM 2001). Selected TRV used to derive HQs.
11 - EPA Region V EDQL for cobalt of 50,000 mg/kg
NA – Not available (no value established or derived)
Bold - indicates those analytes that were not considered in the Upper Tenmile Creek ERA (CDM 2001)
COC - chemical of concern
TRV - toxicity reference value
mg/kg - milligrams per kilogram

Table10.1-6 Toxicity Reference Values for Surface Water COCs

COPC	Surface Water Toxicity Reference Values (TRVs, ug/l)						Selected TRVs [6] (number or range)
	Chronic AWQC [1]	Secondary Chronic AWQC [2]	Lowest EC20 Fish [3]	Lowest EC20 Daphnids [3]	Rainbow Trout Chronic TRV [4]	Daphnid Chronic TRV [5]	
Aluminum	87	NA	4,700	540	NA	NA	87
Antimony	NA	30	2,310	1,900	NA	NA	30
Arsenic	150	NA	2,130 (As III) 1,500 (As V)	633 (As III) > 932 (As V)	2,953	914	914
Barium	**NA**	**4**	**NA**	**NA**	**NA**	**NA**	**4**
Beryllium	**NA**	**0.66**	**148**	**3.8**	**NA**	**NA**	**0.66 3.8**
Cadmium	0.17	NA	1.8	1	2.7	0.8	0.17 0.8
Chromium [7]	**11**	**NA**	**51**	**0.5**	**NA**	**NA**	**11 51**
Cobalt	NA	23	810	< 4.4	NA	NA	23
Copper	5.6	NA	810	0.205	20 estimated	7	5.6 7
Iron	1,000	NA	NA	NA	NA	NA	1,000
Lead	1.49	NA	22	NA	71	23	23
Manganese	NA	120	1,270	< 1,100	NA	NA	120
Mercury	**0.91**	**1.3**	**0.87**	**0.87**	**NA**	**NA**	**0.87 1.3**
Nickel	31.5	NA	62	45	NA	NA	31.5
Selenium	**5**	**NA**	**40**	**25**	**NA**	**NA**	**5**
Silver	NA	0.36	0.2	< 0.56	NA	NA	0.36
Thalium	**NA**	**12**	**81**	**64**	**NA**	**NA**	**12**
Vanadium	**NA**	**20**	**41**	**430**	**NA**	**NA**	**20**
Zinc	72.2	NA	47	NA	343	51	51

Notes: 1 - State of Montana WQB-7 (2002). Equivalent or more stringent than Federal Ambient water quality criteria (AWAC). Total (not dissolved) criteria, hardness = 55 mg/L CaCO3 (average hardness for Basin Watershed OU2) (Except aluminum - dissolved criteria). It is recognized that hardness varies substantially across the site. Mean subarea specific hardness values range from 20 to 85 mg CaCO3/L. Average site-wide hardness (55-mg/L) is used because subarea-specific values are expected to vary significantly both spatially and temporally.

2 - Alternative chronic AWQC (Suter and Tsao 1996)

3 - Highest tested concentration causing less than 20% reduction in growth or reproductive endpoints (Suter and Tsao 1996)

4 - Species-specific TRV (dissolved), adjusted to hardness of 50 mg/L, Clark Fork River Ecological Risk Assessment (EPA 1999b) (Cu values based on CFR Water Effects Ratios)

5 - Species-specific TRV (dissolved), adjusted to hardness of 50 mg/L, Clark Fork River Ecological Risk Assessment (EPA 1999b) (Cu values based on revised EPA database which resulted in chronic value for daphnids exceeding acute value at some hardness levels. Chronic value for copper therefore considered unacceptable.)

6 - Selected TRV primarily based on ERA work completed for Upper Tenmile Creek (CDM 2001). Selected TRV used to derive HQs.

7 - Used chromium (VI) standard with is more stringent between the Cr (III) and Cr (VI) analytes.

NA – Not available (no value established or derived)

Bold - indicates those analytes that were not considered in the Upper Tenmile Creek ERA (CDM 2001)

COC - chemical of concern

TRV - toxicity reference value

ug/L - micrograms per liter

Table 10.1-7 Complete Exposure Pathways, Basin Mining Area Site OU2

Contaminant Source	Exposure Route	Ecological Receptor	Comments
Metals-contaminated mine waste, tailings, surface soil	Inhalation of wind-blown particulates	Terrestrial vertebrates	Minor - eliminated (not included on SCEM)
	Direct contact/uptake/incidental ingestion	Terrestrial plants, invertebrates and vertebrates	Minor - retained for evaluation as surface soil (SS) exposure
Metals-contaminated streambank soil/sediment	Direct contact/uptake/incidental ingestion (streambank)	Terrestrial plants, invertebrates and vertebrates	Minor - retained for evaluation as surface soil (SS) exposure
	Direct contact/uptake/incidental ingestion (instream following erosion)	Rooted aquatic plants, aquatic invertebrates and vertebrates	Major - retained for evaluation as instream sediment (SED) exposure
Metals-contaminated instream sediments	Direct contact/incidental ingestion	Aquatic invertebrates and vertebrates	Major - retained for evaluation as instream sediment (SED) exposure
Metals-contaminated seep/adit water	Direct contact/ingestion (at seeps/adits)	Terrestrial invertebrates and vertebrates	Major - retained for evaluation as surface water (SW) exposure
	Direct contact/uptake/ingestion (instream following entry into creek)	Aquatic plants, invertebrates and vertebrates	Major - retained for evaluation as surface water (SW) exposure
Metals-contaminated surface water	Direct contact/ingestion	Aquatic plants, invertebrates and vertebrates	Major - retained for evaluation as surface water (SW) exposure
Metals-contaminated biota	Ingestion of prey	Terrestrial, semi-aquatic and aquatic invertebrates and vertebrates	Major - retained for evaluation (Hg only)

SCEM - site conceptual exposure model
SS - surface soil/solid media
SED - sediment
SW - surface water

Table 10.1-8 Assessment and Measurement Endpoints, Basin Mining Area Site OU2

Assessment Endpoint	Measurement Endpoint	Comments
protection of benthic macroinvertebrate population and community structure and function	benthic macroinvertebrate abundance and diversity	directly measured - data will support BERA
	water quality (toxicity)	directly measured – SERA and BERA
	sediment quality (toxicity)	directly measured – SERA and BERA
protection of fish population and community structure and function	fish abundance and diversity	directly measured - data will support BERA
	water quality (toxicity)	directly measured – SERA and BERA
	sediment quality (toxicity)	directly measured – SERA and BERA
protection of wetland function	abundance and diversity of wetland plants and animals	data are lacking
	water quality (toxicity)	directly measured – SERA and BERA
	sediment quality (toxicity)	directly measured – SERA and BERA
protection of terrestrial macrophytes, small mammals, and birds	abundance and diversity of terrestrial plants and animals	data are lacking
	surface soil quality (toxicity)	directly measured – SERA and BERA

This page intentionally left blank.

Table 10.1-9 Summary Statistics of COC Concentration Data for Surface Water

Constituents of Concern			Units	Upper Basin Creek			South Fork Basin Creek			Jack Creek			Middle Basin Creek			Lower Basin Creek		
				Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect
Aluminum	Al	Dissolved	ug/L	1178.77	927.11	41140	81.5	-	81.5	1653.75	1296.05	30400	26	-	41	38.46	54.03	379
Antimony	Sb	Dissolved	ug/L	1.44	4.29	7	0.12	-	-	1.33	1.17	26.6	2.55	-	3.1	0.77	0.9	1.3
Aresenic	As	Dissolved	ug/L	19.21	25.25	441	2.15	-	-	155.81	61.19	6290	4.78	-	7.4	4.68	6.87	14.5
Barium	Ba	Dissolved	ug/L	11.08	13.3	41.1	14.4	-	14.4	17.38	21.12	46.1	23.75	-	24.4	24.74	27.93	60
Beryllium	Be	Dissolved	ug/L	0.62	0.81	6.3	0.12	-	-	1.31	1.24	2.9	0.12	-	-	0.4	0.56	-
Cadmium	Cd	Dissolved	ug/L	5.38	5.6	144.4	0.01	-	-	49.44	138.21	636	0.82	-	0.98	0.86	0.99	5.9
Chromium	Cr	Dissolved	ug/L	0.86	1.06	3.3	0.28	-	-	1.81	2.13	17	1.04	-	1.8	0.68	0.8	3.2
Cobalt	Co	Dissolved	ug/L	1.83	3	25	0.08	-	-	15.48	40.22	308	0.34	-	0.59	0.46	0.56	0.6
Copper	Cu	Dissolved	ug/L	75.53	40.14	2900	0.68	-	0.68	792.72	2297.24	13400	10.25	-	15.5	7.16	10.4	56.7
Iron	Fe	Dissolved	ug/L	3952.83	1656.73	137000	48.6	-	48.6	9446.66	5405.27	212000	108.85	-	124	71.79	136.86	490
Lead	Pb	Dissolved	ug/L	377.17	124.67	20000	0.1	-	-	39.06	59.35	801	0.39	-	0.57	0.62	0.74	1.4
Manganese	Mn	Dissolved	ug/L	1446.06	5230.44	38100	1.7	-	1.7	2137.55	19277.01	30100	29.75	-	49.8	14.75	26.63	55
Mercury	Hg	Dissolved	ug/L	0.04	0.06	0.18	0.02	-	-	0.14	0.14	0.19	0.02	-	-	0.05	0.07	0.12
Nickel	Ni	Dissolved	ug/L	2.51	2.95	27.2	0.22	-	0.22	11.87	14.6	180	0.94	-	0.99	0.9	1.06	3.5
Selinium	Se	Dissolved	ug/L	2.25	-	-	2.25	-	-	2.9	3.84	8.7	2.25	-	-	2.25	-	-
Silver	Ag	Dissolved	ug/L	0.85	1.55	21	0.07	-	0.07	2.01	2.75	45	0.07	-	0.08	0.41	0.73	0.09
Thallium	Tl	Dissolved	ug/L	1.55	-	-	1.55	-	-	8.42	25.92	58.52	1.55	-	-	1.84	2.51	3.3
Vanadium	V	Dissolved	ug/L	2.5	4.65	22	0.34	-	-	6.38	8.82	34	0.87	-	1.4	2.09	4.86	5.8
Zinc	Zn	Dissolved	ug/L	934.24	799.9	25000	2.5	-	2.5	5134.68	34050.03	72000	101.55	-	113	84.26	113.52	447
Hardness			mg/L as CaCO3	33.37	38.27	121	19.6	-	19.6	76.95	89.17	346	41.05	-	42.1	32.59	39.1	67.8

Constituents of Concern			Units	Upper Cataract Creek			Uncle Sam Gulch			Middle Cataract Creek			Lower Cataract Creek			Upper Boulder River			Lower Boulder River		
				Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect
Aluminum	Al	Dissolved	ug/L	562.77	2310.54	6640	1811.83	11239.04	21620	296.16	153.53	15300	84.29	66.94	1890	43.25	60.35	426	17.46	34.33	117
Antimony	Sb	Dissolved	ug/L	0.63	1.32	1.1	1.52	1.99	4	0.62	0.9	3.2	6.52	2.07	202	0.47	0.6	0.6	0.97	1.12	2.5
Aresenic	As	Dissolved	ug/L	7.51	14.68	62.8	48.53	36.81	1270	29.79	14.07	1839	46.51	7.25	1910	3.56	3.89	7.4	10.41	13.33	38.3
Barium	Ba	Dissolved	ug/L	31.32	57.09	110	19.42	27.21	48	17.69	21.73	187	73.48	42.6	2000	16.45	19.83	57.4	23.96	26.27	39
Beryllium	Be	Dissolved	ug/L	0.7	1.42	2	0.44	0.73	2.1	0.34	0.43	0.82	6.63	2.04	202	0.45	0.59	-	0.49	0.58	-
Cadmium	Cd	Dissolved	ug/L	24.46	4328.06	127	93.46	499.53	939	14.72	10.47	1230	6.95	14.97	198	0.66	1.39	0.7	1.75	2.75	7.5
Chromium	Cr	Dissolved	ug/L	0.75	0.97	0.91	3	4.72	31	1.14	1.19	18	5.84	2.36	194	1.81	2.12	16	0.59	0.65	1.6
Cobalt	Co	Dissolved	ug/L	4.75	29.98	38	18.24	332.14	249	1.83	2.12	43.2	7.1	3.28	201	0.45	0.64	0.25	0.57	0.71	2
Copper	Cu	Dissolved	ug/L	241.54	18101.43	2620	1035.66	4248.13	12000	171.57	36.95	12000	26.4	75.4	190	6.14	8.66	27	7.53	8.99	25.8
Iron	Fe	Dissolved	ug/L	968.68	2740.35	17900	6383.84	63467.95	108000	3174.1	1436.38	189600	116.17	152.92	1150	125.91	162.27	470	65.94	126.47	310
Lead	Pb	Dissolved	ug/L	79.46	1073.96	1227	8.6	7.01	149	5.91	3.75	191.2	5.65	1.73	208	0.46	0.59	0.36	0.54	0.6	1.6
Manganese	Mn	Dissolved	ug/L	779.83	571022.42	3580	1699.44	31773.03	13700	921.22	3733.66	31600	196.41	243.18	7240	14.78	21.04	68	181.3	432.17	915
Mercury	Hg	Dissolved	ug/L	0.08	0.15	0.17	0.05	0.12	0.19	0.07	0.1	0.42	0.06	0.08	0.65	0.05	0.1	0.12	0.14	0.44	-
Nickel	Ni	Dissolved	ug/L	6.74	30.72	26	10.31	19.94	133	3.29	3.43	47	7.29	5.06	192	2.63	4.16	3	1.05	1.24	4
Selinium	Se	Dissolved	ug/L	1.54	2.4	1	2.25	-	-	2.21	2.62	4.8	92.45	16.61	1880	1.86	3.69	-	1.59	4.15	-
Silver	Ag	Dissolved	ug/L	0.35	1.33	0.18	2.66	7.03	42	0.63	1.28	12	5.56	2.67	197	1.53	4.19	17	0.44	0.68	0.06
Thallium	Tl	Dissolved	ug/L	1.55	-	-	2.52	4.45	9.3	2.28	2.58	6	272.7	8193.09	1910	1.55	-	-	1.91	2.31	-
Vanadium	V	Dissolved	ug/L	1.84	3.45	0.9	5.3	10.22	61	2.11	2.96	20	21.31	9.99	504	4.3	14	18	1.92	7.41	3.9
Zinc	Zn	Dissolved	ug/L	3127.82	1621518.77	22300	6165.68	40575.05	64160	1087.59	1033.65	48000	283.2	1051.88	2190	24.59	50.46	159	527.04	1513.48	2360
Hardness			mg/L as CaCO3	77.31	137.2	219	84.1	106.42	450	60.26	70.47	242	83.66	103.13	464	48.41	54.66	160	85.29	102.51	189

Notes:
ug/L - micrograms per liter
U95 - 95% upper confidence limit of the mean
Max - maximum
mg/L - milligrams per liter
CaCO3 - calcium carbonate
COC - Chemical of Concern

Table 10.1-10 Summary Statistics of COC Concentration Data for Sediment

Constituents of Concern			Units	Upper Basin Creek			South Fork Basin Creek			Jack Creek			Middle Basin Creek			Lower Basin Creek			Upper Cataract Creek			Uncle Sam Gulch			Middle Cataract Creek			Lower Cataract Creek			Upper Boulder River			Lower Boulder River		
				Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect
Aluminum	Al	Total	mg/kg	63228	129481	96000	69917	178385	86000	64344	86810	88000	66924	156562	85000	35364	587379	76000	24522	542003	88000	59825	130771	92000	32756	159969	86000	49995	541306	96000	60330	88937	92000	63631	157704	110000
Antimony	Sb	Total	mg/kg	8	53	70	0.6	-	-	7	353	13	4	-	5	4	52	8	0.6	3	-	16	89	29	2	6	8	3	2396	9	0.7	2	1	1	3	2
Arsenic	As	Total	mg/kg	414	638	4500	24	35	44	743	1557	5600	108	242	340	137	244	269	18	63	35	1779	6070	6400	95	195	714	365	9034	980	235	482	1600	1126	3588	8500
Barium	Ba	Total	mg/kg	497	935	850	597	1157	790	489	649	1100	635	1373	800	351	2421	750	166	4825	610	418	691	650	293	734	920	409	2130	710	703	827	1100	562	849	850
Beryllium	Be	Total	mg/kg	2	3	6	4	6	6	2	2	3	3	5	4	1	6	3	0.6	33	2	3	5	4	0.9	3	3	1	22	2	1	2	2	2	3	3
Cadmium	Cd	Total	mg/kg	2	3	8	1	2	2	7	20	41	2	3	8	6	11	12	0.2	1156	0.08	29	39	88	1	8	4	12	117	26	2	3	11	15	24	58
Chromium	Cr	Total	mg/kg	38	62	310	18	34	24	52	74	170	29	53	95	18	171	43	16	139	47	18	26	60	43	211	220	30	161	64	24	92	100	48	124	170
Cobalt	Co	Total	mg/kg	13	15	25	10	13	15	22	32	55	14	17	25	14	21	28	12	21	20	28	38	72	10	18	39	19	45	35	8	18	20	18	24	35
Copper	Cu	Total	mg/kg	68	85	530	18	29	42	303	479	1280	57	116	180	109	205	222	30	65	51	1982	9032	6600	107	221	1100	355	11455	749	295	477	1100	323	502	1600
Iron	Fe	Total	mg/kg	40883	49306	300000	25899	33583	42000	57355	67353	150000	34056	45355	91000	24386	59076	47000	30400	109410	70000	48783	65787	91000	49429	114633	220000	38415	97692	66000	30396	36846	96000	53997	82492	180000
Lead	Pb	Total	mg/kg	282	377	2200	60	102	94	640	838	12000	88	114	210	124	205	170	19	72	36	628	1142	1900	129	279	911	274	1807	640	150	251	470	1360	2944	19000
Manganese	Mn	Total	mg/kg	827	1062	2940	658	875	1400	1319	1861	4300	943	1279	2200	1051	1301	1500	829	2479	1800	1859	2625	6600	1208	2786	4600	1663	2772	4200	661	946	3030	2162	2984	9600
Mercury	Hg	Total	mg/kg	0.04	0.04	0.08	0.03	-	-	0.07	0.2	0.3	0.03	-	-	0.03	0.03	-	0.03	0.03	-	0.05	0.1	0.1	0.07	0.1	0.3	0.04	0.06	0.06	0.04	0.05	0.08	0.05	0.09	0.1
Nickel	Ni	Total	mg/kg	14	18	28	10	17	13	19	24	29	13	17	20	6	15	15	9	20	16	12	15	18	9	21	29	10	19	19	9	15	28	17	23	30
Silver	Ag	Total	mg/kg	2	2	17	0.9	1	0.6	5	5	72	1	1	2	1	2	3	0.9	3	2	5	8	40	3	6	20	4	20	12	6	11	22	12	26	120
Vanadium	V	Total	mg/kg	150	217	1300	68	122	92	181	237	590	101	162	350	55	393	160	66	378	180	68	94	190	171	730	940	104	533	220	85	105	310	148	266	650
Zinc	Zn	Total	mg/kg	321	404	960	104	141	150	844	1148	3800	281	398	1100	636	1015	1140	161	4905	600	1824	2671	6080	249	424	610	1204	5045	2600	351	447	1100	2302	3913	7300

Notes:
mg/kg - milligrams per kilogram
U95 - 95% upper confidence limit of the mean
Max - maximum
COC - Chemical of Concern

Table 10.1-11 Summary Statistics of COC Concentration Data for Soil/Solid Material

Constituents of Concern			Units	Upper Basin Creek			South Fork Basin Creek			Jack Creek			Middle Basin Creek			Lower Basin Creek			Upper Cataract Creek			Uncle Sam Gulch			Middle Cataract Creek			Lower Cataract Creek			Upper Boulder River			Lower Boulder River		
				Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect	Mean	U95	Max Detect
Aluminum	Al	Total	mg/kg	62208	106409	110000	-	-	-	47452	56850	97000	-	-	-	6307	10313	57000	4003	5829	8400	37291	164698	81000	9943	11946	87000	4156	3967	66000				-	-	-
Antimony	Sb	Total	mg/kg	207	1088	3183	-	-	-	125	449	1081	-	-	-	8	8	132	12	37	84	77	663	398	81	196	1153	13	37	88	70	165	329	-	-	-
Arsenic	As	Total	mg/kg	5752	18916	96729	-	-	-	2958	7207	79500	-	-	-	60	102	190	991	6695	5380	1954	5559	11100	2258	3561	92500	215	341	539	1014	5290	5128	-	-	-
Barium	Ba	Total	mg/kg	471	702	990	-	-	-	328	391	1329	-	-	-	109	175	541	110	185	388	380	624	868	226	327	1190	221	395	1062	396	662	1044	-	-	-
Beryllium	Be	Total	mg/kg	0.4	0.8	2	-	-	-	0.2	0.8	1	-	-	-	0.2	1	0.5	0.4	0.6	0.7	0.5	0.8	0.9	0.4	0.5	7	0.2	0.3	0.5				-	-	-
Cadmium	Cd	Total	mg/kg	34	102	370	-	-	-	16	20	1300	-	-	-	10	21	71	9	80	154	18	76	161	12	25	197	10	173	132	63	1898	214	-	-	-
Chromium	Cr	Total	mg/kg	8	12	32	-	-	-	5	6	31	-	-	-	4	6	20	3	5	6	4	5	27	4	5	37	2	4	13	8	653	12	-	-	-
Cobalt	Co	Total	mg/kg	8	6	970	-	-	-	5	4	245	-	-	-	6	27	18	19	24	366	12	16	60	5	9	37	3	15	11	45	35286	205	-	-	-
Copper	Cu	Total	mg/kg	212	217	4800	-	-	-	317	321	9000	-	-	-	291	393	1540	233	374	1327	305	469	1600	220	251	4350	109	256	515	309	464	963	-	-	-
Iron	Fe	Total	mg/kg	27411	29567	93118	-	-	-	24771	26385	210000	-	-	-	29618	37748	70600	27156	33291	66942	29205	34479	130000	25112	27227	83000	24505	30727	74500	18210	20721	34606	-	-	-
Lead	Pb	Total	mg/kg	4155	7539	93000	-	-	-	2220	5154	16000	-	-	-	3751	9770	39900	2687	27967	6770	1153	2693	6858	2579	4280	24300	2890	15489	29200	1724	8676	11900	-	-	-
Manganese	Mn	Total	mg/kg	509	506	14265	-	-	-	281	300	5000	-	-	-	1603	2705	5276	589	982	1940	1462	2256	6200	2491	4883	29598	903	3032	3300	2403	7052	12199	-	-	-
Mercury	Hg	Total	mg/kg	7	3	218	-	-	-	0.4	1	2	-	-	-	0.9	2	3	0.2	0.3	0.7	0.1	0.2	0.5	0.3	0.4	1	0.4	0.6	3	0.7	7	2	-	-	-
Nickel	Ni	Total	mg/kg	6	8	23	-	-	-	5	5	37	-	-	-	5	10	13	4	6	10	5	7	16	6	7	147	3	6	13	6	22	11	-	-	-
Selenium	Se	Total	mg/kg	0.6	0.8	1	-	-	-	2	6	5	-	-	-	0.5	0.6	1	0.7	0.9	2	0.4	0.5	0.6	0.8	1	6	0.5	0.6	2	1	1	1	-	-	-
Silver	Ag	Total	mg/kg	30	54	290	-	-	-	33	59	207	-	-	-	14	35	83	18	72	72	46	334	143	49	177	412	27	91	160	130	150	208	-	-	-
Thallium	Tl	Total	mg/kg	13	55	60	-	-	-	27	93	83	-	-	-	4	7	31	10	41	49	15	93	49	17	37	300	5	9	23	13	73	25	-	-	-
Vanadium	V	Total	mg/kg	67	109	180	-	-	-	75	86	180	-	-	-	24	32	89	14	19	26	36	75	120	19	24	105	10	15	46				-	-	-
Zinc	Zn	Total	mg/kg	598	498	28000	-	-	-	582	501	18000	-	-	-	1822	3832	11600	666	980	13500	756	992	8000	1118	1186	23700	485	1178	2460	2694	8839	12500	-	-	-

Notes: mg/kg - milligrams per kilogram
U95 - 95% upper confidence limit of the mean
Max - maximum
COC - Chemical of Concern

Table 10.1-12 Hazard Quotients for Surface Water Media

COC		Upper Basin Creek			South Fork Basin Creek			Jack Creek			Middle Basin Creek			Lower Basin Creek		
		HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values
Aluminum	Al	13.6		472.9	0.9		0.9	19		349.4	0.3		0.5		0.6	
Antimony	Sb		0.1		No Detections			0		0.9	0.1		0.1		0	
Aresenic	As		0		No Detections			0.2		6.9	0		0		0	
Barium	Ba		3.3		3.5		3.5		5.3		6		6		7	
Beryllium	Be		0.2 - 1.2		No Detections			0.3 - 1.7		0.8 - 4.5	No Detections			No Detections		
Cadmium	Cd		7.5 - 35.3		No Detections				172.5 - 811.8		1 - 4.7		1.3 - 5.9		1.3 - 5.9	
Chromium	Cr		0 - 0.1		No Detections			0 - 0.2		0.3 - 1.5	0 - 0.1		0 - 0.2		0 - 0.1	
Cobalt	Co		0.1		No Detections				1.7		0		0	No Detections		
Copper	Cu	10.9 - 13.6		414.3 - 517.9	0.1 - 0.1		0.1 - 0.1		328.1 - 410.2		1.4 - 1.8		2.3 - 2.9		1.4 - 1.8	
Iron	Fe	4		137	0		0	9.4		212	0.1		0.1		0.1	
Lead	Pb	16.4		869.6	No Detections				2.6		0		0		0	
Manganese	Mn		43.6		0		0		160.6		0.3		0.4		0.2	
Mercury	Hg		0 - 0.1		No Detections			0.1 - 0.1		0.2 - 0.2	No Detections				0.1 - 0.1	
Nickel	Ni	0.1		0.9	0		0		0.5		0		0		0	
Selenium	Se	No Detections			No Detections				0.8		No Detections				0 - 0	
Silver	Ag		5.6		0.2		0.2		8.3		0.2		0.2	1.1		0.3
Thallium	Tl	No Detections			No Detections				2.2		No Detections			No Detections		
Vanadium	V		0.3		No Detections				0.5		0		0.1		0.3	
Zinc	Zn	18.3		490.2	0		0		667.6		2		2.2		2.2	
Primary COCs (HQ>100)		Al, Cu, Fe, Pb, Zn			None			Al, Cd, Cu, Fe, Mn, Zn			None			None		

COC		Upper Cataract Creek			Uncle Sam Gulch			Middle Cataract Creek			Lower Cataract Creek			Upper Boulder River			Lower Boulder River		
		HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values
Aluminum	Al		26.6			129.2		3.4		175.9	1		21.7		0.7			0.4	
Antimony	Sb	0		0		0.1			0		0.2		6.7	0		0	0		0.1
Aresenic	As		0		0.1		1.4	0		2	0.1		2.1	0		0		0	
Barium	Ba		14.3			6.8			5.5		18.3		500		5			6.5	
Beryllium	Be		0.3 - 1.5			0.2 - 1.1			0.1 - 0.6		1.8 - 10.6		53.2 - 306.1	No Detections			No Detections		
Cadmium	Cd	30 - 141.2		158.8 - 747.1		625 - 2941.2		18.8 - 88.2		1537.5 - 7235.3		18.8 - 88.2		0.9 - 4.1		0.9 - 4.1		3.8 - 17.6	
Chromium	Cr	0 - 0.1		0 - 0.1		0.1 - 0.5		0 - 0.1		0.4 - 1.6	0.1 - 0.5		3.8 - 17.6	0 - 0.2		0.3 - 1.5		0 - 0.1	
Cobalt	Co		1.3		0.8		10.8	0.1		1.9	0.3		3.7	0		0		0	
Copper	Cu	34.6 - 43.2		374.3 - 467.9		806.9 - 758.6		24.6 - 30.7		1714.3 - 2142.9		10.7 - 13.4			1.3 - 1.6			1.3 - 1.6	
Iron	Fe		2.7			63.5		3.2		189.6		0.2			0.2			0.1	
Lead	Pb		46.7		0.4		6.5	0.3		8.3	0.3		9	0		0		0	
Manganese	Mn	6.5		29.8	14.2		114.2		31.1			2			0.2			3.6	
Mercury	Hg	0.1 - 0.1		0.2 - 0.2		0.1 - 0.1			0.1 - 0.1			0.1 - 0.1		0 - 0.1		0.1 - 0.1	No Detections		
Nickel	Ni	0.2		0.8		0.6		0.1		1.5	0.2		6.1	0.1		0.1	0		0.1
Selenium	Se	0.4		0.2		No Detections			0.6		18.4		376	No Detections			No Detections		
Silver	Ag	1.1		0.6		19.4			2.8		16.7		547.2		11.1		1.1		0.2
Thallium	Tl	No Detections				0.3			0.3		22.8		159.2	No Detections			No Detections		
Vanadium	V	0.1		0		0.5			0.2		1.1		25.2		0.7		0.1		0.2
Zinc	Zn	61.3		437.3		795.6		21.3		941.2		20.6			1			29.7	
Primary COCs (HQ>100)		Cd, Cu, Zn			Al, Cd, Cu, Mn, Zn			Al, Cd, Cu, Fe, Zn			Ba, Be, Se, Ag, Tl			None			None		

Notes: COC - chemical of concern
HQ - hazard quotient
U95 - 95% upper confidence limit of the mean
Max - maximum
TRV - toxicity reference value

HQ greater than 10, less than 500
HQ greater than 500

Table 10.1-13 Hazard Quotients for Sediment Media

COC		Upper Basin Creek			South Fork Basin Creek			Jack Creek			Middle Basin Creek		
		HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values
Aluminum	Al	1.1 - 4.5		1.7 - 6.9	1.2 - 5		1.5 - 6.1		1.5 - 6.2		1.2 - 4.8		1.5 - 6.1
Antimony	Sb		4.4		No Detections			0.6		1.1	0.3		0.4
Arsenic	As		12.8 - 49.1			0.7 - 2.7			31.1 - 119.8			4.8 - 18.6	
Barium	Ba		No TRV			No TRV			No TRV			No TRV	
Beryllium	Be		No TRV			No TRV			No TRV			No TRV	
Cadmium	Cd		0.8 - 4.3		0.3 - 1.4		0.5 - 2.9		5.1 - 28.6			0.8 - 4.3	
Chromium	Cr		0.2 - 1.6		0.1 - 0.5		0.1 - 0.6		0.3 - 1.9			0.2 - 1.4	
Cobalt	Co		0			0			0			0	
Copper	Cu		0.4 - 2.1			0.2 - 0.7			2.5 - 11.7			0.6 - 2.8	
Iron	Fe		2.5			1.7			3.4			2.3	
Lead	Pb		3.8 - 7.1		0.6 - 1.1		0.9 - 1.8		8.5 - 15.8			1.2 - 2.2	
Manganese	Mn		2.3			1.9			4			2.8	
Mercury	Hg	0.2 - 0.3		0.4 - 0.6	No Detections				1 - 1.5		No Detections		
Nickel	Ni		1.1 - 1.1		0.6 - 0.6		0.8 - 0.8		1.5 - 1.5			1.1 - 1.1	
Selenium	Se		No TRV			No TRV			No TRV			No TRV	
Silver	Ag	1.1 - 4.2		8.5 - 34	0.5 - 1.8		0.3 - 1.2	2.6 - 10.2		36 - 144	0.6 - 2.2		1 - 4
Vanadium	V		No TRV			No TRV			No TRV			No TRV	
Zinc	Zn		0.7 - 3.7			0.3 - 1.3			2.1 - 10.4			0.7 - 3.6	
Primary COCs (HQ>10)		As, Ag			None			As, Cd, Cu, Pb, Ag, Zn			As		

COC		Lower Basin Creek			Upper Cataract Creek			Uncle Sam Gulch			Middle Cataract Creek		
		HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values
Aluminum	Al	0.6 - 2.5		1.3 - 5.4	0.4 - 1.8		1.5 - 6.3	1 - 4.3		1.6 - 6.6	0.6 - 2.3		1.5 - 6.1
Antimony	Sb	0.3		0.7	No Detections			1.3		2.4		0.5	
Arsenic	As		4.9 - 18.8		0.4 - 1.4		0.7 - 2.7		121.4 - 466.9			3.9 - 15	
Barium	Ba		No TRV			No TRV			No TRV			No TRV	
Beryllium	Be		No TRV			No TRV			No TRV			No TRV	
Cadmium	Cd		2.8 - 15.7		0.1 - 0.3		0 - 0.1		10 - 55.7		0.3 - 1.4		1 - 5.7
Chromium	Cr	0.1 - 0.5		0.2 - 1.1	0.1 - 0.4		0.2 - 1.2		0.1 - 0.7			0.8 - 5.4	
Cobalt	Co		0		0		0		0			0	
Copper	Cu		1.1 - 5		0.2 - 0.7		0.3 - 1.2	10.4 - 46.3		34.7 - 161		1.2 - 5.4	
Iron	Fe	1.2		2.4	1.5		3.5		3.3			5.7	
Lead	Pb	1.3 - 2.3		1.7 - 3.2	0.2 - 0.4		0.4 - 0.7		11.5 - 21.5			2.8 - 5.3	
Manganese	Mn		2.8		1.8		3.9		5.7			6.1	
Mercury	Hg	No Detections			No Detections			0.3 - 0.4		0.5 - 0.8		0.5 - 0.8	
Nickel	Ni	0.5 - 0.5		0.9 - 0.9	0.6 - 0.6		1 - 1		0.9 - 0.9			1.3 - 1.3	
Selenium	Se	No TRV and No Detections				No TRV			No TRV			No TRV	
Silver	Ag		1 - 4		0.5 - 1.8		1 - 4		4 - 16			3 - 12	
Vanadium	V		No TRV			No TRV			No TRV			No TRV	
Zinc	Zn		1.8 - 9.2		0.3 - 1.5		1.1 - 5.5		4.9 - 24.3			0.8 - 3.9	
Primary COCs (HQ>10)		As, Cd			None			As, Cd, Cu, Pb, Ag, Zn			As, Ag		

COC		Lower Cataract Creek			Upper Boulder River			Lower Boulder River		
		HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values
Aluminum	Al	0.9 - 3.6		1.7 - 6.9		1.5 - 6.4		1.1 - 4.5		1.9 - 7.9
Antimony	Sb	0.3		0.8	0.1		0.1	0.1		0.2
Arsenic	As	7.3 - 28.1		19.6 - 75.4		9.6 - 37.1			71.8 - 276	
Barium	Ba		No TRV			No TRV			No TRV	
Beryllium	Be		No TRV			No TRV			No TRV	
Cadmium	Cd	3.1 - 17.1		6.7 - 37.1		0.8 - 4.3			6.2 - 34.3	
Chromium	Cr	0.1 - 0.8		0.2 - 1.6		0.3 - 2.4			0.5 - 3.2	
Cobalt	Co	0		0		0			0	
Copper	Cu	1.9 - 8.7		3.9 - 18.3		2.5 - 11.6			2.6 - 12.2	
Iron	Fe	1.9		3.3		1.8			4.1	
Lead	Pb	2.8 - 5.2		6.5 - 12.1		2.5 - 4.7			29.7 - 55.5	
Manganese	Mn		6			2.1			6.5	
Mercury	Hg	0.2 - 0.3		0.3 - 0.5		0.3 - 0.4			0.5 - 0.7	
Nickel	Ni	0.6 - 0.6		1.2 - 1.2		0.9 - 0.9			1.4 - 1.4	
Selenium	Se		No TRV		No TRV and No Detections				No TRV	
Silver	Ag	2 - 8		6 - 24		5.5 - 22			13 - 52	
Vanadium	V		No TRV			No TRV			No TRV	
Zinc	Zn	2.2 - 10.9		4.7 - 23.6		0.8 - 4.1			7.1 - 35.6	
Primary COCs (HQ>10)		As, Cd, Cu, Pb, Ag, Zn			As, Cu, Ag			As, Cd, Cu, Pb, Ag, Zn		

Notes: COC - chemical of concern
HQ - hazard quotient
U95 - 95% upper confidence limit of the mean
Max - maximum
TRV - toxicity reference value

HQ greater than 1, less than 10
HQ greater than 10

Table 10.1-14 Hazard Quotients for Soil Media

COC		Upper Basin Creek			South Fork Basin Creek			Jack Creek			Middle Basin Creek			Lower Basin Creek		
		HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values
Aluminum	Al		2128.2			No Data			1137			No Data			206.3	
Antimony	Sb		54.4			No Data			22.5			No Data		0.4		6.6
Aresenic	As		60.1 - 315.3			No Data			22.9 - 120.1			No Data			0.3 - 1.7	
Barium	Ba		0.2			No Data			0.1			No Data			0.1	
Beryllium	Be	0		0.2		No Data			0.1			No Data		0		0.1
Cadmium	Cd	17 - 66.7		18.5 - 72.5		No Data			1 - 3.9			No Data			1.1 - 4.1	
Chromium	Cr		1.2 - 30			No Data			0.6 - 15			No Data			0.6 - 15	
Cobalt	Co	0		1		No Data		0		0.2		No Data		0		0
Copper	Cu		0.3 - 4.3			No Data			0.4 - 6.4			No Data			0.5 - 7.9	
Iron	Fe		591.3			No Data			527.7			No Data			755	
Lead	Pb		15.1 - 80.2			No Data			10.3 - 54.8			No Data			19.5 - 103.9	
Manganese	Mn	5.1		142.7		No Data			3			No Data			27.1	
Mercury	Hg	0.2 - 70		6.2 - 2180		No Data			0 - 10			No Data			0.1 - 20	
Nickel	Ni		0			No Data		0		0.2		No Data			0.1	
Selenium	Se		0 - 0.8			No Data		0 - 2		0.1 - 5		No Data			0 - 0.6	
Silver	Ag		1.1			No Data			1.2			No Data			0.7	
Thallium	Tl		55			No Data		27		83		No Data			7	
Vanadium	V		5.5 - 54.5			No Data			4.3 - 43			No Data			1.6 - 16	
Zinc	Zn	2.5 - 3.1		116.7 - 142.9		No Data		2.4 - 3		75 - 91.8		No Data			16 - 19.6	
Primary COCs (HQ>100)		**Al, As, Fe, Mn, Hg, Zn**			**None**			**Al, As, Fe**			**None**			**Al, Fe, Pb**		

COC		Upper Cataract Creek			Uncle Sam Gulch			Middle Cataract Creek			Lower Cataract Creek			Upper Boulder River			Lower Boulder River		
		HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values	HQs for Mean Values	HQs for U95 Values	HQs for Max Values
Aluminum	Al		116.6		745.8		1620		238.9		83.1		1320		No Data			No Data	
Antimony	Sb		1.9		3.9		19.9		9.8			1.9			8.3			No Data	
Aresenic	As	3.1 - 16.5		17.1 - 89.7		17.6 - 92.7			11.3 - 59.4			1.1 - 5.7		3.2 - 16.9		16.3 - 85.5		No Data	
Barium	Ba		0.1			0.2			0.1			0.1			0.2			No Data	
Beryllium	Be		0.1			0.1			0.1			0			No Data			No Data	
Cadmium	Cd		4 - 15.7			3.8 - 14.9			1.3 - 4.9		0.5 - 2		6.6 - 25.9	3.2 - 12.4		10.7 - 42		No Data	
Chromium	Cr		0.5 - 12.5			0.5 - 12.5			0.5 - 12.5			0.4 - 10		0.8 - 20		1.2 - 30		No Data	
Cobalt	Co		0			0			0		0		0	0		0.2		No Data	
Copper	Cu		0.5 - 7.5			0.6 - 9.4			0.3 - 5			0.3 - 5.1			0.6 - 9.3			No Data	
Iron	Fe		665.8			689.6			544.5			614.5			414.4			No Data	
Lead	Pb	5.4 - 28.6		13.5 - 72		5.4 - 28.6			8.6 - 45.5			31 - 164.8			17.4 - 92.3			No Data	
Manganese	Mn		9.8			22.6			48.8			30.3			70.5			No Data	
Mercury	Hg		0 - 3			0 - 2			0 - 4			0 - 6		0 - 7		0.1 - 20		No Data	
Nickel	Ni		0			0			0			0		0		0.1		No Data	
Selenium	Se		0 - 0.9			0 - 0.5			0 - 1			0 - 0.6		0 - 1.1		0 - 1.1		No Data	
Silver	Ag	0.4		1.4	0.9		2.9		3.5			1.8			3			No Data	
Thallium	Tl		41		15		49		37			9		13		25		No Data	
Vanadium	V		1 - 9.5			3.8 - 37.5			1.2 - 12			0.8 - 7.5			No Data			No Data	
Zinc	Zn		4.1 - 5			4.1 - 5.1			4.9 - 6.1			4.9 - 6			36.8 - 45.1			No Data	
Primary COCs (HQ>100)		**Al, Fe**			**Al, Fe**			**Al, Fe**			**Al, Fe, Pb**			**Fe**			**None**		

Notes: COC - chemical of concern
HQ - hazard quotient
U95 - 95% upper confidence limit of the mean
Max - maximum
TRV - toxicity reference value

HQ greater than 100, less than 500
HQ greater than 500

Table10.1-15 Estimated Risks (Total Dietary Dose/Ingestion TRV) for Representative Birds and Mammals, Basin Watershed OU2

Receptors	COCs	Upper Basin Creek			South Fork Basin Creek			Jack Creek			Middle Basin Creek		
		Dose (mg/kg-d)	TRV (mg/kg-d)	HQ	Dose (mg/kg-d)	TRV (mg/kg-d)	HQ	Dose (mg/kg-d)	TRV (mg/kg-d)	HQ	Dose (mg/kg-d)	TRV (mg/kg-d)	HQ
Mink	Copper	0.0029	3.6	<1	0.0000	3.6	<1	0.0303	3.6	<1	0.0004	3.6	<1
	Cadmium	0.0004	0.028	<1	0.0000	0.028	<1	0.0041	0.028	<1	0.0001	0.028	<1
	Lead	0.0104	0.32	<1	0.0000	0.32	<1	0.0011	0.32	<1	0.0000	0.32	<1
	Zinc	0.0216	470	<1	0.0000	470	<1	0.1187	470	<1	0.0024	470	<1
Belted Kingfisher	Copper	0.0716	6	<1	0.0007	6	<1	0.7472	6	<1	0.0094	6	<1
	Cadmium	0.0082	0.68	<1	0.0000	0.68	<1	0.0803	0.68	<1	0.0013	0.68	<1
	Lead	0.1809	1.32	<1	0.0000	1.32	<1	0.0187	1.32	<1	0.0002	1.32	<1
	Zinc	0.3942	39	<1	0.0008	39	<1	2.1673	39	<1	0.0431	39	<1
Marsh Wren	Copper	1.3262	6	<1	0.0122	6	<1	13.8375	6	**2.3**	0.1745	6	<1
	Cadmium	0.7761	0.13	**6.0**	0.0016	0.13	<1	7.6060	0.13	**58.5**	0.1242	0.13	<1
	Lead	26.2222	1.32	**19.9**	0.0070	1.32	<1	2.7126	1.32	**2.1**	0.0278	1.32	<1
	Zinc	49.5706	39	**1.3**	0.1061	39	<1	272.5322	39	**7.0**	5.4135	39	<1

Receptors	COCs	Lower Basin Creek			Upper Cataract Creek			Uncle Sam Gulch			Middle Cataract Creek		
		Dose (mg/kg-d)	TRV (mg/kg-d)	HQ	Dose (mg/kg-d)	TRV (mg/kg-d)	HQ	Dose (mg/kg-d)	TRV (mg/kg-d)	HQ	Dose (mg/kg-d)	TRV (mg/kg-d)	HQ
Mink	Copper	0.0003	3.6	<1	0.0093	3.6	<1	0.0396	3.6	<1	0.0066	3.6	<1
	Cadmium	0.0001	0.028	<1	0.0020	0.028	<1	0.0395	0.028	**1.4**	0.0066	0.028	<1
	Lead	0.0000	0.32	<1	0.0022	0.32	<1	0.0002	0.32	<1	0.0002	0.32	<1
	Zinc	0.0019	470	<1	0.0723	470	<1	0.1425	470	<1	0.0252	470	<1
Belted Kingfisher	Copper	0.0066	6	<1	0.2280	6	<1	0.9762	6	<1	0.1621	6	<1
	Cadmium	0.0015	0.68	<1	0.0393	0.68	<1	0.9755	0.68	**1.4**	0.1620	0.68	<1
	Lead	0.0003	1.32	<1	0.0379	1.32	<1	0.0043	1.32	<1	0.0029	1.32	<1
	Zinc	0.0355	39	<1	1.3202	39	<1	2.6024	39	<1	0.4592	39	<1
Marsh Wren	Copper	0.1221	6	<1	4.2228	6	<1	18.0777	6	**3.0**	3.0013	6	<1
	Cadmium	0.1397	0.13	**1.1**	3.7254	0.13	**28.7**	18.0552	0.13	**138.9**	2.9976	0.13	**23.1**
	Lead	0.0417	1.32	<1	5.4948	1.32	**4.2**	0.6260	1.32	<1	0.4173	1.32	<1
	Zinc	4.4582	39	<1	166.0138	39	**4.3**	327.2509	39	**8.4**	57.7439	39	**1.5**

Receptors	COCs	Lower Cataract Creek			Upper Boulder River			Lower Boulder River		
		Dose (mg/kg-d)	TRV (mg/kg-d)	HQ	Dose (mg/kg-d)	TRV (mg/kg-d)	HQ	Dose (mg/kg-d)	TRV (mg/kg-d)	HQ
Mink	Copper	0.0010	3.6	<1	0.0002	3.6	<1	0.0003	3.6	<1
	Cadmium	0.0010	0.028	<1	0.0002	0.028	<1	0.0003	0.028	<1
	Lead	0.0002	0.32	<1	0.0000	0.32	<1	0.0000	0.32	<1
	Zinc	0.0065	470	<1	0.0006	470	<1	0.0122	470	<1
Belted Kingfisher	Copper	0.0245	6	<1	0.0057	6	<1	0.0075	6	<1
	Cadmium	0.0245	0.68	<1	0.0056	0.68	<1	0.0075	0.68	<1
	Lead	0.0029	1.32	<1	0.0002	1.32	<1	0.0002	1.32	<1
	Zinc	0.1194	39	<1	0.0106	39	<1	0.2224	39	<1
Marsh Wren	Copper	0.4537	6	<1	0.1047	6	<1	0.1396	6	<1
	Cadmium	0.4532	0.13	**3.5**	0.1046	0.13	<1	0.1395	0.13	**1.1**
	Lead	0.4173	1.32	<1	0.0348	1.32	<1	0.0348	1.32	<1
	Zinc	15.0198	39	<1	1.3268	39	<1	27.9697	39	<1

Table 10.2-1 Summary of Chemicals of Potential Concern for Town of Basin OU1 and Upper Tenmile Creek

Summary of COPCs for Town of Basin OU1

Chemical	Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment
Antimony	YES			YES	
Arsenic	YES	YES	YES	YES	YES
Cadmium	YES			YES	
Copper				YES	
Iron	YES	YES			
Lead	YES	YES	YES	YES	YES
Manganese	YES			YES	
Mercury	YES		YES	YES	YES
Thallium				YES	
Zinc	YES	YES			

Summary of COPCs for Upper Tenmile Creek

Chemical	MEDIA			
	Surface Soil	Groundwater	Surface Water	Sediment
Aluminum			YES	
Antimony	YES		YES	YES
Arsenic	YES	YES	YES	YES
Cadmium		YES	YES	
Copper			YES	
Iron	YES		YES	YES
Lead	YES	YES	YES	YES
Manganese	YES	YES	YES	YES
Mercury	YES	YES	YES	YES
Thallium			YES	
Zinc			YES	

Note: Surface soil includes waste rock and surface water includes adit discharges.

Table 10.2-2 Summary of Town of Basin OU1 and Upper Tenmile Creek Exposure Pathway Analysis

Exposure Pathways and Receptors of Concern for Town of Basin OU1

Exposure Pathway	Residents	Workers	Recreationists
Air	Inhalation[a]		Inhalation
Soil/Mine Waste	Ingestion	Ingestion	Ingestion
Subsurface Soil		Ingestion	
Interior Dust	Ingestion	Ingestion	
Surface Water, Recreational Purposes	Ingestion[a]		Ingestion
Surface Water, Domestic Purposes	Ingestion		
Sediments	Ingestion[a]		Ingestion
Groundwater	Ingestion		

[a]Although the pathway is potentially complete for residents who may recreate in the Town of Basin OU1, exposure assumptions are expected to be similar to those used to evaluate out of town recreationists. The pathway is quantitatively evaluated for recreationists and the result may be applied to residents as appropriate.

Exposure Pathways and Receptors of Concern for Upper Tenmile Creek

Exposure Medium	Exposure Route
RESIDENTS	
Air (suspended particulates)	Inhalation
Soil/Mine Waste	Incidental Ingestion
Interior Dust	Incidental Ingestion
Surface Water (domestic purposes)	Ingestion
Groundwater (domestic purposes)	Ingestion
WORKERS	
Air (suspended particulates)	Inhalation
Soil/Mine Waste	Incidental Ingestion
Interior Dust	Incidental Ingestion
Surface Water (domestic purposes)	Ingestion
Groundwater (domestic purpose)	Ingestion
RECREATIONISTS	
Soil/Mine Waste	Incidental Ingestion
Air (suspended particulates)	Inhalation
Surface Water	Incidental Ingestion
Sediments	Incidental Ingestion

Table 10.2-3 Summary of Cancer and Noncancer Risk Estimates for Town of Basin OU1 and Upper Tenmile Creek

Town of Basin OU1 Summary of Cancer Risk Estimates

	Receptor Population					
	Resident		Commercial Worker		Recreationist	
Exposure Pathway	**CTE**	**RME**	**CTE**	**RME**	**CTE**	**RME**
Ingestion of Soil/Mine Waste	3E-06	2E-04	8E-07	3E-05	4E-07	3E-05
Inhalation of House Dust	2E-06	1E-04	4E-07	3E-05		
Ingestion of Groundwater	1E-05	1E-04				
Ingestion of Surface Water (Potable Purposes)	1E-05	5E-04	5E-07	2E-05		
Ingestion of Subsurface Soil						
Ingestion of House Dust Derived Form Subsurface Soil			2E-07	1E-05		
Ingestion of Sediment					4E-07	2E-05
Ingestion of Surface Water					1E-07	3E-06
Inhalation of Air					3E-06	3E-04

Town of Basin OU1 Summary of Hazard Indices

	Receptor Population					
	Resident		Commercial Worker		Recreationist	
Exposure Pathway	**CTE**	**RME**	**CTE**	**RME**	**CTE**	**RME**
Ingestion of Soil/Mine Waste	0.1	1	0.03	0.3	0.01	0.2
Ingestion of House Dust	0.1	0.9	0.02	0.2	-	-
Ingestion of Groundwater	0.2	0.6	-	-	-	-
Ingestion of Surface Water (Potable Purposes)	21	22	-	-	-	-
Ingestion of Subsurface Soil	-	-	0.02	0.2	-	-
Ingestion of House Dust Derived Form Subsurface Soil	-	-	0.01	0.1	-	-
Ingestion of Sediment	-	-	-	-	0.01	0.1
Ingestion of Surface Water	-	-	-	-	0.08	0.14
Inhalation of Air	-	-	-	-	1	19

Table 10.2-4 Risk-Based Preliminary Goals(a) for Receptors of Concern Exposed to Chemicals of Potential Concern through Soils and Interior Dust (b), Town of Basin OU1

RESIDENTIAL PRELIMINARY REMEDIATION GOALS, SURFACE SOIL																		
Screening Level Based on Risk	Antimony PRGs (mg/kg)		Arsenic PRGs (mg/kg)		Cadmium PRGs (mg/kg)		Copper PRGs (mg/kg)		Iron[c] PRGs (mg/kg)		Lead[d] PRGs (mg/kg)		Manganese[c] PRGs (mg/kg)		Mercury PRGs (mg/kg)		Zinc[c] PRGs (mg/kg)	
Carcinogenic Risk	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
1.00E-06	NA	NA	0.6	12	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.00E-05	NA	NA	6.0	120	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.00E-04	NA	NA	60	1,200	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Screening Level Based on Noncarcinogenic Effects (HQ = 1)[d]																		
	132	449	124	674	165	562	12,222	41,555	99,099	336,929	400[e]	1,000[f]	7,928	26,954	99	337	99,099	336,929

Residential PRG Equations:

Carcinogenic PRG (mg/kg) = (TR x AT) / (CF x EF x SFo) x (((IRchild x EDchild)/BWchild) + ((IRadult x EDadult)/BWadult)) x [(FS x BAFs) + (C x FD x (BAFd)]

Non-carcinogenic PRG (mg/kg) = (HQ x AT x RfD)/((EFx CF) x (((IRchild x EDchild)/BWchild) + ((IRadult x EDadult)/BWadult)) x ((FS x BAFs) + (C x FD x BAFd)))

COMMERCIAL WORKER PRELIMINARY REMEDIATION GOALS, SURFACE AND SUBSURFACE SOIL																		
Screening Level Based on Risk	Antimony PRGs (mg/kg)		Arsenic PRGs (mg/kg)		Cadmium PRGs (mg/kg)		Copper PRGs (mg/kg)		Iron[c] PRGs (mg/kg)		Lead[g] PRGs (mg/kg)		Manganese[c] PRGs (mg/kg)		Mercury PRGs (mg/kg)		Zinc[c] PRGs (mg/kg)	
Carcinogenic Risk	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
1.00E-06	NA	NA	2.9	49	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.00E-05	NA	NA	29	490	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.00E-04	NA	NA	290	4,900	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Screening Level Based on Noncarcinogenic Effects (HQ = 1)[e]																		
	502	1,390	471	2,090	628	1,740	46,500	129,000	377,000	1,000,000	NA	NA	30,000	74,000	377	1,050	377,000	1,000,000

Commercial Worker PRG Equations:

Carcinogenic PRG (mg/kg) = (TR x AT) / ((CF x EF x SFo) x ((IRadult x EDadult)/BWadult) x ((FS x BAFs) + (C x FD x BAFd)))

Non-carcinogenic PRG (mg/kg) = (HQ x AT x RfD)/((EF x CF) x ((IRadult x EDadult)/BWadult)) x ((FS x BAFs) + (C x FD x BAFd)))

RECREATIONAL USER PRELIMINARY REMEDIATION GOALS, SURFACE SOIL																		
Screening Level Based on Risk	Antimony PRGs (mg/kg)		Arsenic PRGs (mg/kg)		Cadmium PRGs (mg/kg)		Copper PRGs (mg/kg)		Iron[c] PRGs (mg/kg)		Lead[g] PRGs (mg/kg)		Manganese[c] PRGs (mg/kg)		Mercury PRGs (mg/kg)		Zinc[c] PRGs (mg/kg)	
Carcinogenic Risk	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
1.00E-06	NA	NA	7.2	144	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.00E-05	NA	NA	72	1,440	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.00E-04	NA	NA	720	14,400	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Screening Level Based on Noncarcinogenic Effects (HQ = 1)[d]																		
	1,490	11,100	1,390	8,330	1,860	13,900	137,000	1,030,000	1,110,000	8,330,000	NA	NA	89,100	666,000	1,110	8,330	1,110,000	8,330,000

Recreationist PRG Equations:

Carcinogenic PRG (mg/kg) = (TR x AT) / ((CF x EF x SFo) x ((((IRchild x EDchild)/BWchild) + ((IRadult x EDadult)/BWadult)) x BAFs))

Non-carcinogenic PRG (mg/kg) = (HQ x AT x RfD) / (CF x EF) x ((((IRchild x EDchild)/BWchild) + ((IRadult x EDadult)/BWadult)) x BAFs))

[a] PRGs = Risk-based concentrations in media (e.g., surface soils)

[b] PRGs for recreational visitors are based on ingestion of mine waste and soil only; ingestion of interior dust is an incomplete exposure pathway.

[c] These chemicals are essential nutrients.

[d] Lead PRGs are estimated using the IEUBK model for estimating blood lead concentrations for young children in residential settings. The model was run iteratively, using exposure parameters described in Section 6.2, until a soil concentration associated with a 5 percent chance of blood lead exceeding 10 mg/dL was established. This soil concentration was the intial estimate of a PRG for lead in soil.

[e] Default soil screening concentration from EPA(1994)

[f] Value dervived as explained in Section 6.2

[g] Lead is not evaluated for industrial/commercial workers or recreational users.

RME = reasonable maximum exposure

CTE = central tendancy exposure

HQ = hazard quotient

NA = not applicable

PRG Equation Definitions:

TR =Target Risk

IR = Soil Ingestion Rate (mg/day)

CF = Conversion Factor (Kg/mg)

EF =Exposure Frequency (days/year)

ED = Exposure Duration (years)

HQ = Hazard Quotient

FD = Fraction Attributed to Dust

FS = Fraction Attributed to Soil

BAFd = Bioavailability Factor in Dust

BAFs = Bioavailability Factor in Soil

Table 10.2-5 Risk-Based Prelimanry Remediation Goals(a) for Residents Exposed to Chemicals of Potential Concern through Ingestion of Drinking Water, Town of Basin OU1

RESIDENTIAL PRELIMINARY REMEDIATION GOALS, DRINKING WATER (SURFACE WATER AND/OR GROUNDWATER)																
Screening Level Based on Risk	Antimony PRGs (ug/L)		Arsenic PRGs (ug/L)		Cadmium PRGs (ug/L)		Copper PRGs (ug/L)		Lead PRGs (ug/L)		Manganese[b] PRGs (ug/L)		Mercury PRGs (ug/L)		Thallium PRGs (ug/L)	
Carcinogenic Risk	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
1.00E-06	**NA**	**NA**	**0.04**	**0.3**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
1.00E-05	NA	NA	0.4	3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.00E-04	**NA**	**NA**	**4**	**30**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Screening Level Based on Noncarcinogenic Effects (HQ = 1)[c]	9	22	7	17	11	28	846	2,060	4[c]	4[c]	549	1,330	7	17	2	4

PRG Equations:

Carcinogenic PRG (ug/L) = (TR x AT) / [(EF x SFo) x (((IRwchild x Edchild)/Bwchild) + ((IRwadult x Edadult)/Bwadult) x BAF)]

Non-carcinogenic PRG (ug/L) = (HQ x AT x BW x RfD)/[EF x ED x (((IRwchild x Edchild)/Bwchild) + ((IRwadult x Edadult)/Bwadult) x BAF)]

Where:

TR =Target Risk

IRw = Water Ingestion Rate (L/day)

EF =Exposure Frequency (days/year)

ED = Exposure Duration (years)

SFo = Oral Cancer Slope Factor

HQ = Hazard Quotient

BW = Body Weight (Kg)

AT = Averaging Time (days)

BAF = Bioavailability Factor

[a] PRGs = Risk-based concentrations in media (surface water and/or groundwater)

[b] These chemicals are essential nutrients.

[c] The Integrated Exposure Uptake Biokinetic (IEUBK) model uses a default value of 4 ug/L for lead in drinking water; this value was also adopted as a PRG for drinking water. used as the drinking water PRG. Soil PRGs would decrease if drinking water values were greater than this PRG.

RME = reasonable maximum exposure

CTE = central tendancy exposure

HQ = hazard quotient

NA = not applicable

Table 10.2-6 Risk-Based Prelimanry Remediation Goals(a) for Recreationists Exposed to Chemicals of Potential Concern through Ingestion of Surface Water, Town of Basin OU1

PRELIMINARY REMEDIATION GOALS, RECREATIONAL EXPOSURE TO SURFACE WATER																
Screening Level Based on Risk	Antimony PRGs (ug/L)		Arsenic PRGs (ug/L)		Cadmium PRGs (ug/L)		Copper PRGs (ug/L)		Leadc PRGs (ug/L)		Manganeseb PRGs (ug/L)		Mercury PRGs (ug/L)		Thallium PRGs (ug/L)	
Carcinogenic Risk	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
1.00E-06	**NA**	**NA**	**5.8**	**74**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
1.00E-05	NA	NA	58	740	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.00E-04	**NA**	**NA**	**580**	**7,400**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Screening Level Based on Noncarcinogenic Effects (HQ = 1)	1,490	5,690	1,120	4,270	1,860	7,120	138,000	527,000	NA	NA	89,500	342,000	1,120	4,270	261	996

PRG Equations:

Carcinogenic PRG (ug/L) = (TR x AT x 1000ug/mg) / (EF x SFo) x((((IRwchild x ET x EDchild)/BWchild) + ((IRwadult x ET x EDadult)/BWadult)) x BAF)

Non-carcinogenic PRG (ug/L) = (HQ x AT x RfD x 1000ug/mg)/(EF x ((((IRwchild x ET x EDchild)/BWchild) + ((IRwadult x ET x EDadult)/BWadult) x BAF)

Where:

TR =Target Risk
IRw = Water Ingestion Rate (L/hour)
ET = Exposure Time (hours/day)
EF =Exposure Frequency (days/year)
ED = Exposure Duration (years)
HQ = Hazard Quotient
BW = Body Weight (Kg)
AT = Averaging Time (days)
BAF = Bioavailability Factor
SFo = Oral Cancer Slope Factor

[a] PRGs = Risk-based concentrations in media (surface water)

[b] These chemicals are essential nutrients.

[c] Lead is assumed to be addressed through application of residential soil and drinking water PRGs.

RME = reasonable maximum exposure

CTE = central tendancy exposure

HQ = hazard quotient

Table 10.2-7 Risk-Based Prelimanry Remediation Goals(a) for Recreationists Exposed to Chemicals of Potential Concern through Ingestion of Sediment, Town of Basin OU1

PRELIMINARY REMEDIATION GOALS, RECREATIONAL EXPOSURE TO SEDIMENTS						
Screening Level Based on Risk	Arsenic PRGs (mg/kg)		Lead PRGs (mg/kg)		Mercury PRGs (mg/kg)	
Carcinogenic Risk	RME	CTE	RME	CTE	RME	CTE
1.00E-06	**9.4**	**374**	**NA**	**NA**	**NA**	**NA**
1.00E-05	94	3,740	NA	NA	NA	NA
1.00E-04	**940**	**37,400**	**NA**	**NA**	**NA**	**NA**
Screening Level Based on Noncarcinogenic Effects (HQ = 1)	1,810	21,600	400b	1000c	115,846,267	865,993,677

PRG Equations:

Carcinogenic PRG (mg/kg) = (TR x AT) / (CF x EF x SFo) x ((((IRsedchild x EDchild)/BWchild) + ((IRsedadult x EDadult)/BWadult)) x BAF))

Non-carcinogenic PRG (mg/kg) = (HQ x AT x BW x RfD)/[(EF x ED x CF) x ((((IRsedchild x EDchild)/BWchild) + ((IRsedadult x EDadult)/BWadult)) x BAF]

Where:

TR =Target Risk
IRsed = Sediment Ingestion Rate (mg/day)
CF = Conversion Factor (Kg/mg)
EF =Exposure Frequency (days/year)
ED = Exposure Duration (years)
HQ = Hazard Quotient
BW = Body Weight (Kg)
AT = Averaging Time (days)
BAF = Bioavailability Factor
SFo = Oral Cancer Slope Factor

[a] PRGs = Risk-based concentrations in media (sediments)

[b] Default soil screening concentration from EPA(1994)

[c] Value dervived as explained in Section 6.2

RME = reasonable maximum exposure

CTE = central tendancy exposure

HQ = hazard quotient

NA = not applicable

Table 10.2-8 Risk-Based Prelimanry Remediation Goals(a) for Recreationists Exposed to Chemicals of Potential Concern through Inhalation of Windblown Particulates from Erosion of Soil, Town of Basin OU1

RECREATIONAL PRELIMINARY REMEDIATION GOALS, SURFACE SOIL																
Screening Level Based on Risk	Antimony PRGs (mg/kg)		Arsenic PRGs (mg/kg)		Cadmium PRGs (mg/kg)		Iron[b] PRGs (mg/kg)		Lead[c] PRGs (mg/kg)		Manganese[b] PRGs (mg/kg)		Mercury PRGs (mg/kg)		Zinc[b] PRGs (mg/kg)	
Carcinogenic Risk	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
1.00E-06	**NA**	**NA**	**0.7**	**17**	**1.8**	**41**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
1.00E-05	NA	NA	7.4	174	17.5	414	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.00E-04	**NA**	**NA**	**740**	**1,740**	**175**	**4,140**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Screening Level Based on Noncarcinogenic Effects (HQ = 1)[c]	NA	NA	NA	NA	NA	NA	NA	NA	400[d]	1,000[e]	66	469	407	2,880	NA	NA

PRG Equations:

Carcinogenic PRG (mg/kg) = (TR x AT) / (DLF x EF x SFo) x ((((INHairchild x ET x EDchild)/BWchild) + ((INHairadult x ET x EDadult)/BWadult)) x BAF))

Non-carcinogenic PRG (mg/kg) = (HQ x AT x RfD)/[(DLF x EF) x ((((INHairchild x Edchild x ET)/BWchild) + ((INHairadult x Edadult x ET)/BWadult)) x BAF)]

Where:

TR =Target Risk
DLF = Dust Loading Factor Factor (Kg/m^3)
INHair = Inhalation Rate (m^3/hour)
ET =Exposure Time (hr/day)
EF =Exposure Frequency (days/year)
SFo = Oral Cancer Slope Factor
HQ = Hazard Quotient
ED = Exposure Duration (years)
BW = Body Weight (Kg)
AT = Averaging Time (days)
BAF= Bioavailability Factor for airborne particulates

[a] PRGs = Risk-based concentrations in media (e.g., surface soils)
[b] These chemicals are essential nutrients.
[c] Lead is assumed to be addressed through application of residential soil PRGs.
[d] Default soil screening concentration from EPA(1994)
[e] Value dervived as explained in Section 6.2
RME = reasonable maximum exposure
CTE = central tendancy exposure
HQ = hazard quotient
NA = not applicable

Table 10.2-9 Risk-Based Preliminary Remediation Goals (a) for Receptors of Concern Exposed to Chemicals of Potential Concern through Ingestion of Solid Media (Waste Rock, Surface Soil, Interior Dust) (b), Upper Tenmile Creek Watershed

RESIDENTIAL PRELIMINARY REMEDIATION GOALS, SURFACE SOIL												
Screening Level Based on Risk	Antimony PRGs (mg/kg)		Arsenic PRGs (mg/kg)		Iron[c] PRGs (mg/kg)		Lead PRGs (mg/kg)		Manganese[c] PRGs (mg/kg)		Mercury PRGs (mg/kg)	
Carcinogenic Risk	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
1.00E-06	**NA**	**NA**	**0.6**	**12**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
1.00E-05	NA	NA	6.0	120	NA	NA	NA	NA	NA	NA	NA	NA
1.00E-04	**NA**	**NA**	**60**	**1200**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Screening Level Based on Noncarcinogenic Effects (HQ = 1)[d]												
	132	449	124	674	99099	336929	400	950	6607	22462	99	337

Residential PRG Equations:

Carcinogenic PRG (mg/kg) = (TR x AT) / (CF x EF x Sfo) x (((IRchild x EDchild)/BWchild) + ((IRadult x EDadult)/BWadult)) x [(FS x BAFs) + (C x FD x (BAFd)]

Non-carcinogenic PRG (mg/kg) = (HQ x AT x RfD)/((EFx CF) x (((IRchild x EDchild)/BWchild) + ((IRadult x EDadult)/BWadult)) x ((FS x BAFs) + (C x FD x BAFd)))

INDUSTRIAL WORKER PRELIMINARY REMEDIATION GOALS, SURFACE AND SUBSURFACE SOIL												
Screening Level Based on Risk	Antimony PRGs (mg/kg)		Arsenic PRGs (mg/kg)		Iron[c] PRGs (mg/kg)		Lead PRGs (mg/kg)		Manganese[c] PRGs (mg/kg)		Mercury PRGs (mg/kg)	
Carcinogenic Risk	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
1.00E-06	**NA**	**NA**	**2.9**	**49**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
1.00E-05	NA	NA	29	490	NA	NA	NA	NA	NA	NA	NA	NA
1.00E-04	**NA**	**NA**	**290**	**4900**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Screening Level Based on Noncarcinogenic Effects (HQ = 1)[e]												
	502	1394	471	2092	3776627	1045884	See Note		25108	69725	377	1045

Industrial Worker PRG Equations:

Carcinogenic PRG (mg/kg) = (TR x AT) / ((CF x EF x Sfo) x ((IRadult x EDadult)/BWadult) x ((FS x BAFs) + (C x FD x BAFd)))

Non-carcinogenic PRG (mg/kg) = (HQ x AT x RfD)/((EF x CF) x ((IRadult x EDadult)/BWadult)) x ((FS x BAFs) + (C x FD x BAFd)))

RECREATIONAL USER PRELIMINARY REMEDIATION GOALS, SURFACE SOIL												
Screening Level Based on Risk	Antimony PRGs (mg/kg)		Arsenic PRGs (mg/kg)		Iron[c] PRGs (mg/kg)		Lead PRGs (mg/kg)		Manganese[c] PRGs (mg/kg)		Mercury PRGs (mg/kg)	
Carcinogenic Risk	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
1.00E-06	**NA**	**NA**	**7.2**	**144**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
1.00E-05	NA	NA	72	1440	NA	NA	NA	NA	NA	NA	NA	NA
1.00E-04	**NA**	**NA**	**720**	**14400**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Screening Level Based on Noncarcinogenic Effects (HQ = 1)[d]												
	1490	5553	1397	8330	1118107	4165257	NA	NA	74540	277683	1118	4165

Recreationist PRG Equations:

Carcinogenic PRG (mg/kg) = (TR x AT) / ((CF x EF x Sfo) x ((Irchild x Edchild/Bwchild) + (Iradult x Edadult/Bwadult)) x BAFs)

Non-carcinogenic PRG (mg/kg) = (HQ x AT x RfD) / ((CF x EF) x ((Irchild x Edchild/Bwchild) + (Iradult x Edadult/Bwadult)) x BAFs)

[a] PRGs = Risk-based concentrations in media (e.g., surface soils)

[b] PRGs for recreational visitors are based on ingestion of mine waste and soil only; ingestion of interior dust is an incomplete exposure pathway.

[c] These chemicals are essential nutrients.

[d] Lead is evaluated using the Integrated Exposure Uptake Biokinetic (IEUBK) model for residential receptors.

[e] Lead is evaluated for industrial/commercial workers using the adult lead model as described in Section 5.2.4.
Depending on assumption made for GSD, PRGs for RME (default) assumptions range from 773 to 1,545 mg/kg.
This range is 1,854 to 5,636 mg/kg when using regional data for bioavailability and soil-to-dust transfer.
No PRGs are calculated for lead for recreational exposures (see Section 5.2.4.2)

RME = reasonable maximum exposure

CTE = central tendancy exposure

HQ = hazard quotient

NA = not applicable

PRG Equation Definitions:

TR =Target Risk
IR = Soil Ingestion Rate (mg/day)
CF = Conversion Factor (Kg/mg)
EF =Exposure Frequency (days/year)
ED = Exposure Duration (years)
BW = Body Weight (Kg)
AT = Averaging Time (days)

HQ = Hazard Quotient
FD = Fraction Attributed to Dust
FS = Fraction Attributed to Soil
BAFd = Bioavailability Factor in Dust
BAFs = Bioavailability Factor in Soil
C (Soil to Dust Transfer Coefficient)

Table 10.2-10 Risk-Based Preliminary Remediation Goals (a) for Residents Exposed to Chemicals of Potential Concern through Ingestion of Drinking Water (Surface Water or Groundwater) (b), Upper Tenmile Creek Watershed

RESIDENTIAL PRELIMINARY REMEDIATION GOALS, DRINKING WATER (SURFACE WATER AND/OR GROUNDWATER)																						
Screening Level Based on Risk	Aluminum PRGs (ug/L)		Antimony PRGs (ug/L)		Arsenic PRGs (ug/L)		Cadmium PRGs (ug/L)		Copper PRGs (ug/L)		Iron PRGs (ug/L)		Lead PRGs (ug/L)		Manganese[b] PRGs (ug/L)		Mercury PRGs (ug/L)		Thallium PRGs (ug/L)		Zinc PRGs (ug/L)	
Carcinogenic Risk	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
1.00E-06	**NA**	**NA**	**NA**	**NA**	**0.04**	**0.3**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
1.00E-05	NA	NA	NA	NA	0.4	3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.00E-04	**NA**	**NA**	**NA**	**NA**	**4**	**30**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Screening Level Based on Noncarcinogenic Effects (HQ = 1)[c]	22856	55600	9	22	7	17	11	28	846	2057	6857	16680	4[c]	4[c]	457	1112	7	17	2	4	6857	16680

PRG Equations:

Carcinogenic PRG (mg/kg) = (TR x AT) / (EF x Sfo) x (((Irchild x Edchild)/Bwchild) + ((Iradult x Edadult)/Bwadult))

Non-carcinogenic PRG (mg/kg) = (TR x AT x RfD)/(EF x ED x (((Irchild x Edchild)/Bwchild) + ((Iradult x Edadult)/Bwadult))

Where: TR =Target Risk HQ = Hazard Quotient

IRw = Water Ingestion Rate (L/day)

EF =Exposure Frequency (days/year)

ED = Exposure Duration (years)

BW = Body Weight (Kg)

AT = Averaging Time (days)

BAF = Bioavailability Factor

[a] PRGs = Risk-based concentrations in media (surface water and/or groundwater)

[b] These chemicals are essential nutrients.

[c] The Integrated Exposure Uptake Biokinetic (IEUBK) model uses a default value of 4 ug/L for lead in drinking water. This value was used to calculate soil PRGs and is therefore used as the drinking water PRG. Soil PRGs would decrease if drinking water values were greater than this PRG.

RME = reasonable maximum exposure

CTE = central tendancy exposure

HQ = hazard quotient

NA = not applicable

Table 10.2-11 Risk-Based Preliminary Remediation Goals (a) for Residents and Recreational Visitors Exposed to Chemicals of Potential Concern through Incidental Ingestion of Surface Water (including Adit Discharges and Seeps) during Recreational Activities, Upper Tenmile Creek Watershed

PRELIMINARY REMEDIATION GOALS, RESIDENTIAL AND RECREATIONAL EXPOSURE TO SURFACE WATER																						
Screening Level Based on Risk	Aluminum PRGs (ug/L)		Antimony PRGs (ug/L)		Arsenic PRGs (ug/L)		Cadmium PRGs (ug/L)		Copper PRGs (ug/L)		Iron PRGs (ug/L)		Leadc PRGs (ug/L)		Manganeseb PRGs (ug/L)		Mercury PRGs (ug/L)		Thallium PRGs (ug/L)		Zinc PRGs (ug/L)	
Carcinogenic Risk	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
1.00E-06	**NA**	**NA**	**NA**	**NA**	**5.8**	**74**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
1.00E-05	NA	NA	NA	NA	58	740	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.00E-04	**NA**	**NA**	**NA**	**NA**	**580**	**7400**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Screening Level Based on Noncarcinogenic Effects (HQ = 1)	3728234	14231476	1491	5693	1118	4269	1864	7116	137945	526565	1118470	4269443	NA	NA	74565	284630	1118	4269	261	996	1118470	4269443

[a] PRGs = Risk-based concentrations in media (surface water)

[b] These chemicals are essential nutrients.

[c] Lead is assumed to be addressed through application of soil and drinking water PRGs.

RME = reasonable maximum exposure

CTE = central tendancy exposure

HQ = hazard quotient

NA = not applicable

Table 10.2-12 Risk-Based Preliminary Remediation Goals (a) for Recreational Visitors Exposed to Chemicals of Potential Concern through Incidental Ingestion of Sediments, Upper Tenmile Creek Watershed

PRELIMINARY REMEDIATION GOALS, RECREATIONAL EXPOSURE TO SEDIMENTS												
Screening Level Based on Risk	Antimony PRGs (mg/kg)		Arsenic PRGs (mg/kg)		Iron PRGs (mg/kg)		Lead PRGs (mg/kg)b		Manganese PRGs (mg/kg)		Mercury PRGs (mg/kg)	
Carcinogenic Risk	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
1.00E-06	**NA**	**NA**	**9.4**	**374**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
1.00E-05	NA	NA	94	3740	NA	NA	NA	NA	NA	NA	NA	NA
1.00E-04	**NA**	**NA**	**940**	**37400**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Screening Level Based on Noncarcinogenic Effects (HQ = 1)	1931	14433	1810	21650	1448078	10824921	1000	1000	96539	721661	1448	10825

Carcinogenic PRG (mg/kg) = (TR x AT) / (CF x EF x Sfo) x ((((Irchild x Edchild)/Bwchild) + ((Iradult x Edadult)/Bwadult)) x BAFas))

Non-carcinogenic PRG (mg/kg) = (TR x AT x BW x RfD)/((EF x CF1) x ((IRchild x EDchild/BWchild) + (IRadult x EDadult/BWadult)) x BAFas)

Where:
TR =Target Risk HQ = Hazard Quotient
IRsed = Sediment Ingestion Rate (mg/day)
CF = Conversion Factor (Kg/mg)
EF =Exposure Frequency (days/year)
ED = Exposure Duration (years)
BW = Body Weight (Kg)
AT = Averaging Time (days)
BAF = Bioavailability Factor

[a] PRGs = Risk-based concentrations in media (sediments)

[b]Quantitative analysis of lead exposure to sediments in recreational situations was not performed (see Section 5.2.4.2).

RME = reasonable maximum exposure

CTE = central tendancy exposure

HQ = hazard quotient

NA = not applicable

Table 10.2-13 Risk-Based Preliminary Remediation Goals (a) for Receptors of Concern Exposed to Chemicals of Potential Concern through Inhalation of Windblown Particulates from Erosion of Soil, Upper Tenmile Creek Watershed

RESIDENTIAL PRELIMINARY REMEDIATION GOALS, SURFACE SOIL												
Screening Level Based on Risk	Antimony PRGs (mg/kg)		Arsenic PRGs (mg/kg)		Iron[b] PRGs (mg/kg)		Lead[c] PRGs (mg/kg)		Manganese[b] PRGs (mg/kg)		Mercury PRGs (mg/kg)	
Carcinogenic Risk	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
1.00E-06	**NA**	**NA**	**599**	**3625**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
1.00E-05	NA	NA	5990	36250	NA	NA	NA	NA	NA	NA	NA	NA
1.00E-04	**NA**	**NA**	**59900**	**362500**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Screening Level Based on Noncarcinogenic Effects (HQ = 1)[c]	NA	NA	NA	NA	NA	NA	400	950	55091	99983	331319	601296

PRG Equations:

Carcinogenic PRG (mg/kg) = (TR x AT) / (DLF x EF x Sfo) x ((((INHairchild x ET x EDchild)/BWchild) + ((INHairadult x ET x EDadult)/BWadult)) x BAF))

Non-carcinogenic PRG (mg/kg) = (HQ x AT x RfD)/[(DLF x EF) x ((((INHairchild x Edchild x ET)/BWchild) + ((INHairadult x Edadult x ET)/BWadult)) x BAF)]

INSDUSTRIAL WORKER PRELIMINARY REMEDIATION GOALS, SURFACE SOIL												
Screening Level Based on Risk	Antimony PRGs (mg/kg)		Arsenic PRGs (mg/kg)		Iron[b] PRGs (mg/kg)		Lead[c] PRGs (mg/kg)		Manganese[b] PRGs (mg/kg)		Mercury PRGs (mg/kg)	
Carcinogenic Risk	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
1.00E-06	**NA**	**NA**	**6601**	**53015**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
1.00E-05	NA	NA	66010	530150	NA	NA	NA	NA	NA	NA	NA	NA
1.00E-04	**NA**	**NA**	**660100**	**5301500**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Screening Level Based on Noncarcinogenic Effects (HQ = 1)[c]	NA	NA	NA	NA	NA	NA	See Table 6-1		505749	1072201	3041568	6448204

Carcinogenic PRG (mg/kg) = (TR x AT) / ((DLF x EF x Sfo) x (INHairadult x ET x EDadult/BWadult) x BAF)

Non-carcinogenic PRG (mg/kg) = (HQ x AT x RfD)/((DLF x EF) x (INHairadult x Edadult x ET/BWadult) x BAF)

RECREATIONISTS PRELIMINARY REMEDIATION GOALS, SURFACE SOIL												
Screening Level Based on Risk	Antimony PRGs (mg/kg)		Arsenic PRGs (mg/kg)		Iron[b] PRGs (mg/kg)		Lead[c] PRGs (mg/kg)		Manganese[b] PRGs (mg/kg)		Mercury PRGs (mg/kg)	
Carcinogenic Risk	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
1.00E-06	**NA**	**NA**	**7753**	**182861**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
1.00E-05	NA	NA	77530	1828610	NA	NA	NA	NA	NA	NA	NA	NA
1.00E-04	**NA**	**NA**	**775300**	**18286100**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Screening Level Based on Noncarcinogenic Effects (HQ = 1)[c]	NA	NA	NA	NA	NA	NA	NA	NA	7127421	5043046	4286421	3028813

Carcinogenic PRG (mg/kg) = (TR x AT) / (DLF x EF x ET x Sfo) x ((((INHairchild x ET x EDchild)/BWchild) + ((INHairadult x ET x EDadult)/BWadult)) x BAF))

Non-carcinogenic PRG (mg/kg) = (HQ x AT x RfD)/[(DLF x Ef x ET) x ((((INHairchild x Edchild x ET)/BWchild) + ((INHairadult x Edadult x ET)/BWadult)) x BAF)]

PRG Equation Defintions: TR =Target Risk HQ = Hazard Quotient

DLF = Dust Loading Factor Factor (Kg/m^3)

INHair = Inhalation Rate (m^3/hour)

ET =Exposure Time (hr/day)

EF =Exposure Frequency (days/year)

ED = Exposure Duration (years)

BW = Body Weight (Kg)

AT = Averaging Time (days)

BAF= Bioavailability Factor for airborne particulates

[a] PRGs = Risk-based concentrations in media (e.g., surface soils)

[b] These chemicals are essential nutrients.

[c] Lead is evaluated using using EPA models for children and adults (Section 5.2.4). Air exposure is assumed to be adequately addressed in these models

RME = reasonable maximum exposure

CTE = central tendancy exposure

HQ = hazard quotient

NA = not applicable

Table 11.3-1 Summary of Mine Sites by Potential to Impact the Environment, Basin Watershed OU2

Site Name	Area of Concern	Environmental Impact Potential	Site Name	Area of Concern	Environmental Impact Potential
Potential to Impact the Environment Based on ABA and Relative Total Zinc					
Bullion Smelter	Basin Creek	High	Meyers Gulch	Basin Creek	Medium
Aurora	Basin Creek	High	First Shot / Last Shot	Basin Creek	Medium
Adelaide	Basin Creek	High	Se Nw Section 30	Basin Creek	Medium
Columbus	Basin Creek	High	Hawkeye Mine	Basin Creek	Medium
Dew Drop	Basin Creek	High	Enterprise Mine	Basin Creek	Medium
Rti Recon: P	Basin Creek	High	Morning	Basin Creek	Medium
Lady Hennessey	Basin Creek	High	Basin Belle	Basin Creek	Medium
Rti Recon: R	Basin Creek	High	Hector - Lower	Basin Creek	Medium
Se Se Section 35	Basin Creek	High	Jumbo	Cataract Creek	Medium
Lady Leith	Basin Creek	High	Ida May	Cataract Creek	Medium
Doris	Basin Creek	High	Unnamed 004	Cataract Creek	Medium
Vindicator	Basin Creek	High	Mike #14	Cataract Creek	Medium
Daily West	Basin Creek	High	Fourth Of July	Cataract Creek	Medium
Hector	Basin Creek	High	Edna	Cataract Creek	Medium
Bullion Mine	Basin Creek	High	Snowbird	Cataract Creek	Medium
Buckeye Mine	Basin Creek	High	Bakama	Cataract Creek	Medium
Eldorado And Plateau	Cataract Creek	High	Garfield	Cataract Creek	Medium
Sylvan	Cataract Creek	High	Overland Creek	Cataract Creek	Medium
Sirius	Cataract Creek	High	Morning Marie	Cataract Creek	Medium
Hattie Ferguson	Cataract Creek	High	Unnamed 002	Cataract Creek	Medium
Timberline	Cataract Creek	High	Manhattan	Cataract Creek	Medium
Middle Snowdrift Creek	Cataract Creek	High	Evening Star	Cataract Creek	Medium
Lizzie Osborne	Cataract Creek	High	Cataract Tails	Cataract Creek	Medium
Mary Anne	Cataract Creek	High	Vera And Marie	Cataract Creek	Medium
New Cottage	Cataract Creek	High	Waldy	Cataract Creek	Medium
Cartwright Cabins 2	Cataract Creek	High	Cataract	Cataract Creek	Medium
Unnamed 001	Cataract Creek	High	Mantle	Cataract Creek	Medium
Klondyke	Cataract Creek	High	Rocker Wetland	Cataract Creek	Medium
Corbitt	Cataract Creek	High	Molly Snow	Basin Creek	Low
Clipper / Edna	Cataract Creek	High	Boulder Vestal	Cataract Creek	Low
Ne Se Section 14	Cataract Creek	High	Uncle Sam	Cataract Creek	Low
Apollo	Cataract Creek	High	Sw Se Section 4	Cataract Creek	Low
Phantom	Cataract Creek	High	Vogel	Cataract Creek	Low
North Ada - Piermont	Cataract Creek	High	Big Medicine	Cataract Creek	Low
Boston	Cataract Creek	High	Alpine	Cataract Creek	Low
Cracker	Cataract Creek	High	Ruth	Cataract Creek	Low
Morning Glory	Cataract Creek	High	Gold Flake	Cataract Creek	Low
Gray Lead	Cataract Creek	High	Ne Nw Section 17	Cataract Creek	Low
Eva May	Cataract Creek	High	Grub Creek Station	Basin Creek	Very Low
Blue Diamond / Occidental	Cataract Creek	High	Magdelena Group	Basin Creek	Very Low
Seattle	Cataract Creek	High	Adit, Mine, Waste Rock Dump	Basin Creek	Very Low
Black Bear	Cataract Creek	High	Placer	Basin Creek	Very Low
Saturday Night	Cataract Creek	High	Basin Creek Placer	Basin Creek	Very Low
Crystal	Cataract Creek	High	Bm-So-004	Basin Creek	Very Low
Boulder Chief	Cataract Creek	High	Perry Parks	Basin Creek	Very Low
Double Shaft	Basin Creek	Medium	Smelter Creek Adit	Basin Creek	Very Low
24Jf0524	Basin Creek	Medium	Lady Ricker	Cataract Creek	Very Low
Morning Star	Basin Creek	Medium	Bing Hampton	Cataract Creek	Very Low
Josephine	Basin Creek	Medium	Quartz Creek	Cataract Creek	Very Low
Jessie	Basin Creek	Medium	Holland	Cataract Creek	Very Low
Dorothy Snow	Basin Creek	Medium	Rocker	Cataract Creek	Very Low
Neptune	Basin Creek	Medium	Sw Nw Section 29	Cataract Creek	Very Low
Potential to Impact the Environment Inferred Based on Vein Grouping					
Moccason	Basin Creek	High	Regalia	Cataract Creek	High
California	Cataract Creek	High	Saginaw	Cataract Creek	High
Cataract Creek Placer	Cataract Creek	High	Unnamed 003	Cataract Creek	High
Cataract Meadows Corral	Cataract Creek	High	Virginia	Cataract Creek	High
Cataract Placer	Cataract Creek	High	Billie T.	Cataract Creek	High

Table 11.3-1 Summary of Mine Sites by Potential to Impact the Environment, Basin Watershed OU2

Site Name	Area of Concern	Environmental Impact Potential	Site Name	Area of Concern	Environmental Impact Potential
Potential to Impact the Environment Inferred Based on Vein Grouping (continued)					
Cateract Flats Placer	Cataract Creek	High	Pen Yan	Cataract Creek	High
Clipper	Cataract Creek	High	Joe Bower'S Mine	Basin Creek	Medium
Deer Lodge Area 2	Cataract Creek	High	Winter'S Camp Area 2	Basin Creek	Medium
Deer Lodge Main	Cataract Creek	High	Winter'S Camp Main	Basin Creek	Medium
Free Silver	Cataract Creek	High	Redwing	Cataract Creek	Medium
Ida M. Area 2	Cataract Creek	High	Saint Nick	Cataract Creek	Medium
Ida M. Main	Cataract Creek	High	Independence Mine	Cataract Creek	Low
Laplate	Cataract Creek	High	24JF0240	Cataract Creek	Low
Mammoth	Cataract Creek	High	24JF0241	Cataract Creek	Low
Red Bird	Cataract Creek	High			
Potential to Impact the Environment Based on Historical Scoring					
Ada	Cataract Creek	High	John T.	Cataract Creek	Low
Alsace	Cataract Creek	High	Lincoln	Cataract Creek	Low
Crescent	Cataract Creek	High	Log Cabin And Stone Fireplace	Cataract Creek	Low
Jack Creek Tailings	Basin Creek	High	Lula Bell	Basin Creek	Low
Rocker Extension	Cataract Creek	Medium	Penn Placer	Basin Creek	Low
Basin Creek Placer 1	Basin Creek	Low	Placer Ditch	Basin Creek	Low
Basin Creek Placer 2	Basin Creek	Low	Se Sw Section 32	Basin Creek	Low
Basin Creek Placer 3	Basin Creek	Low	Sw Nw Section 7	Basin Creek	Low
Creden Mines	Basin Creek	Low	Sw Se Section 1	Basin Creek	Low
Delgate	Basin Creek	Low	Unnamed Fire Clay	Basin Creek	Low
Golden Glow	Basin Creek	Low	Unnamed Placer	Basin Creek	Low
Hidden Treasure	Basin Creek	Low	Unnamed Quarry	Basin Creek	Low
Highland	Basin Creek	Low	Venus	Basin Creek	Low
Jack Mtn. Iron	Basin Creek	Low	Obelisk	Boulder River	Low
Joe Metesh Lessee	Basin Creek	Low	Silica Quartz Mine	Boulder River	Low
Lady Lane	Basin Creek	Low	West Mount Thompson	Cataract Creek	Low
Last Shot	Basin Creek	Low	Ne Se Section 28	Cataract Creek	Low
Lower Ditch	Basin Creek	Low	Nw Sw Section 27	Cataract Creek	Low
Lula	Basin Creek	Low	Ousley	Cataract Creek	Low
Cataract City	Boulder River	Low	Placer 2313	Cataract Creek	Low
American Eagle	Cataract Creek	Low	Protection	Cataract Creek	Low
Bazzer Claim	Cataract Creek	Low	Redemption	Cataract Creek	Low
Bee Claim	Cataract Creek	Low	Redemption	Cataract Creek	Low
Cartwright Cabins	Cataract Creek	Low	Rocky Point	Cataract Creek	Low
Father Murphy	Cataract Creek	Low	Saint Lawrence*	Cataract Creek	Low
Golden Assets Mine	Cataract Creek	Low	Nw Sw Section 29	Cataract Creek	Low
Great Shield	Cataract Creek	Low	Sw Se Section 29	Cataract Creek	Low
Hanna	Cataract Creek	Low	Totten Mine	Cataract Creek	Low
James	Cataract Creek	Low			
Unknown Characteristics in Basin Creek					
24Jf0520	Basin Creek	Unknown	Lyons Prospect	Basin Creek	Unknown
24Jf0525	Basin Creek	Unknown	Mayflower	Basin Creek	Unknown
24Jf0890	Basin Creek	Unknown	Midnight	Basin Creek	Unknown
Alma No. 2	Basin Creek	Unknown	N462471	Basin Creek	Unknown
Basin Creek Mine Area 2	Basin Creek	Unknown	Ne Ne Section 13	Basin Creek	Unknown
Basin Creek Mine Main	Basin Creek	Unknown	Neptune Cabins	Basin Creek	Unknown
Basin Historic District	Basin Creek	Unknown	Old Baldy Group	Basin Creek	Unknown
Big Chief	Basin Creek	Unknown	Pearl	Basin Creek	Unknown
Buster	Basin Creek	Unknown	Rti Recon: A	Basin Creek	Unknown
Cleveland/Delbert Claims	Basin Creek	Unknown	Rti Recon: E	Basin Creek	Unknown
Cullen Claim	Basin Creek	Unknown	Rti Recon: O	Basin Creek	Unknown
Dimon	Basin Creek	Unknown	Ruby Diggings	Basin Creek	Unknown
Dumortierite Prospect	Basin Creek	Unknown	Se Se Section 25	Basin Creek	Unknown
Golden Glow	Basin Creek	Unknown	Solar Main	Basin Creek	Unknown
Hope	Basin Creek	Unknown	Solar Area 2	Basin Creek	Unknown
Jack Creek Ridge Area 2	Basin Creek	Unknown	T&B	Basin Creek	Unknown
Jack Creek Ridge Main	Basin Creek	Unknown	Unnamed Silver; Lead; & Zinc	Basin Creek	Unknown

Table 11.3-1 Summary of Mine Sites by Potential to Impact the Environment, Basin Watershed OU2

Site Name	Area of Concern	Environmental Impact Potential	Site Name	Area of Concern	Environmental Impact Potential
Unknown Characteristics in Basin Creek (continued)					
Keller'S Hematite	Basin Creek	Unknown	Upper Ditch	Basin Creek	Unknown
Last Chance	Basin Creek	Unknown			
Unknown Characteristics in Boulder River					
24Jf0188	Boulder River	Unknown	Basin Jibe	Boulder River	Unknown
24Jf0185	Boulder River	Unknown	Basin Millsite	Boulder River	Unknown
Last Chance	Boulder River	Unknown	Basin Street Tailings	Boulder River	Unknown
24Jf0516	Boulder River	Unknown	Confidence	Boulder River	Unknown
24Jf0183	Boulder River	Unknown	Finn'S Cabin And Sauna	Boulder River	Unknown
24Jf0179	Boulder River	Unknown	Jib Shaft (Main)	Boulder River	Unknown
24Jf0515	Boulder River	Unknown	Jib Shaft (Mill)	Boulder River	Unknown
24Jf0178	Boulder River	Unknown	Jib Shaft (Mill Flume)	Boulder River	Unknown
24Jf0517	Boulder River	Unknown	Katie Extension	Boulder River	Unknown
24Jf0177	Boulder River	Unknown	Merry Widow	Boulder River	Unknown
Attwater Mill	Boulder River	Unknown			
Unknown Characteristics in Cataract Creek					
24JF0131	Cataract Creek	Unknown	Lizzie	Cataract Creek	Unknown
24JF0132	Cataract Creek	Unknown	Louise	Cataract Creek	Unknown
24JF0134	Cataract Creek	Unknown	Marguerite Area 2	Cataract Creek	Unknown
24JF0141	Cataract Creek	Unknown	Marguerite Main	Cataract Creek	Unknown
24JF0142	Cataract Creek	Unknown	Marshall-Changes Mines	Cataract Creek	Unknown
24JF0247	Cataract Creek	Unknown	Mantle South	Cataract Creek	Unknown
24JF0249	Cataract Creek	Unknown	Minneapolis Area 2	Cataract Creek	Unknown
24JF0250	Cataract Creek	Unknown	Minneapolis Main	Cataract Creek	Unknown
24JF0444	Cataract Creek	Unknown	Minneapolis Placer & Prospect	Cataract Creek	Unknown
24JF0489	Cataract Creek	Unknown	Montana	Cataract Creek	Unknown
24JF0490	Cataract Creek	Unknown	Mountain Chief Area 2	Cataract Creek	Unknown
24JF0676	Cataract Creek	Unknown	Mountain Chief Main	Cataract Creek	Unknown
24JF0683	Cataract Creek	Unknown	Mt. Thompson	Cataract Creek	Unknown
24JF0696	Cataract Creek	Unknown	Ne Basin	Cataract Creek	Unknown
24JF0833	Cataract Creek	Unknown	Ne Ne Section 28	Cataract Creek	Unknown
Alturas	Cataract Creek	Unknown	Ne Nw Section 16 (51)	Cataract Creek	Unknown
Atlantic	Cataract Creek	Unknown	Ne Nw Section 3	Cataract Creek	Unknown
Basin Gold & Silver	Cataract Creek	Unknown	Ne Three Brothers	Cataract Creek	Unknown
Basin Quartz Mass	Cataract Creek	Unknown	Near Boulder Vestal	Cataract Creek	Unknown
Big Lumber Gulch	Cataract Creek	Unknown	Near Quartz Creek	Cataract Creek	Unknown
Bluebird	Cataract Creek	Unknown	Nw Ne Section 32	Cataract Creek	Unknown
Bluebird	Cataract Creek	Unknown	Nw Se Section 14	Cataract Creek	Unknown
Buckeye Mine (Cataract)	Cataract Creek	Unknown	Ousley	Cataract Creek	Unknown
Captain Cook	Cataract Creek	Unknown	Pirate	Cataract Creek	Unknown
Custer Main	Cataract Creek	Unknown	Placer 2623	Cataract Creek	Unknown
Custer Area 2	Cataract Creek	Unknown	Robie Burns	Cataract Creek	Unknown
Elephant	Cataract Creek	Unknown	Rose Mine Main	Cataract Creek	Unknown
Elmer	Cataract Creek	Unknown	Rose Mine Area 2	Cataract Creek	Unknown
Gold Hill	Cataract Creek	Unknown	Se Ne Section 28	Cataract Creek	Unknown
Golden Reef	Cataract Creek	Unknown	Se Se Section 21	Cataract Creek	Unknown
Hanson	Cataract Creek	Unknown	Se Sw Section 2	Cataract Creek	Unknown
Hiawatha	Cataract Creek	Unknown	Se Sw Section 28	Cataract Creek	Unknown
Hogback	Cataract Creek	Unknown	Self - Riser	Cataract Creek	Unknown
Huot	Cataract Creek	Unknown	Lady Nell	Cataract Creek	Unknown
Silver Reef	Cataract Creek	Unknown	Victory	Cataract Creek	Unknown
Sparking Water Area 2	Cataract Creek	Unknown	Viola	Cataract Creek	Unknown
Sparking Water Main	Cataract Creek	Unknown	Waldy North	Cataract Creek	Unknown
Sw Nw Section 28	Cataract Creek	Unknown	White Pine Main	Cataract Creek	Unknown
Unnamed Lead & Silver	Cataract Creek	Unknown	White Pine Area 2	Cataract Creek	Unknown
Vandalia	Cataract Creek	Unknown			

Notes: * - Potentially has a higher impact due to other unevaluated mechanisms

This page intentionally left blank.

Plates

NOTICE

SDMS Number: 1165450

This item is not suitable for scanning, but is available for review at the U.S. Environmental Protection Agency (EPA), Region 8 Superfund Records Center, Helena, Montana

Document Date: DEC. 2002

Title: DRAFT BASIN MINING AREA OU 2 RI VOLUME 1 TEXT, TABLES AND FIGURES

Item Description: MAP Plate 1-1 DOCUMENTED HISTORIC MINE SITE LOCATIONS – Basin Watershed Operable Unit 2, Jefferson County, Montana

NOTICE

SDMS Number: 1165450

This item is not suitable for scanning, but is available for review at the U.S. Environmental Protection Agency (EPA), Region 8 Superfund Records Center, Helena, Montana

Document Date: DEC. 2002

Title: DRAFT BASIN MINING AREA OU 2 RI VOLUME 1 TEXT, TABLES AND FIGURES

Item Description: MAP Plate 2-2 - FALL 2001 SAMPLE LOCATIONS – Basin Watershed Operable Unit 2, Jefferson County, Montana

NOTICE

SDMS Number: 1165450

This item is not suitable for scanning, but is available for review at the U.S. Environmental Protection Agency (EPA), Region 8 Superfund Records Center, Helena, Montana

Document Date: DEC. 2002

Title: DRAFT BASIN MINING AREA OU 2 RI VOLUME 1 TEXT, TABLES AND FIGURES

Item Description: MAP Plate 6-1 - RELATIVE CONCENTRATION RATIOS FOR ZINC IN BASIN CREEK SURFACE WATER AND SEDIMENT DURING NON-STORM AND STORM FLOW CONDITIONS – Basin Watershed Operable Unit 2, Jefferson County, Montana

NOTICE

SDMS Number: 1165450

This item is not suitable for scanning, but is available for review at the U.S. Environmental Protection Agency (EPA), Region 8 Superfund Records Center, Helena, Montana

Document Date: DEC. 2002

Title: DRAFT BASIN MINING AREA OU 2 RI VOLUME 1 TEXT, TABLES AND FIGURES

Item Description: MAP Plate 10-1 – DISTRIBUTION OF RISK BASED ON HAZARD QUOTIENTS FOR SURFACE WATER AND SEDIMENT – Basin Watershed Operable Unit 2, Jefferson County, Montana

NOTICE

SDMS Number: 1165450

This item is not suitable for scanning, but is available for review at the U.S. Environmental Protection Agency (EPA), Region 8 Superfund Records Center, Helena, Montana

Document Date: DEC. 2002

Title: DRAFT BASIN MINING AREA OU 2 RI VOLUME 1 TEXT, TABLES AND FIGURES

Item Description: MAP Plate 11-1 – MINE SITE CATEGORIZATION OF RELATIVE POTENTIAL IMPACTS TO OU2 COMBINED WITH SURFACE WATER AND SEDIMENT HQs – Basin Watershed Operable Unit 2, Jefferson County, Montana

NOTICE

SDMS Number: 1165450

This item is not suitable for scanning, but is available for review at the U.S. Environmental Protection Agency (EPA), Region 8 Superfund Records Center, Helena, Montana

Document Date: DEC. 2002

Title: DRAFT BASIN MINING AREA OU 2 RI VOLUME 1 TEXT, TABLES AND FIGURES

Item Description: MAP Plate 11-3 – MINE SITE CATEGORIZATION OF RELATIVE POTENTIAL IMPACTS TO OU2 COMBINED WITH SURFACE WATER AND SEDIMENT QUALITY IN BASIN CREEK – Basin Watershed Operable Unit 2, Jefferson County, Montana