Boulder-Elkhorn Metals TMDLs and Framework Water Quality Improvement Plan

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ACRONYM LIST

Acronym	Definition
AAL	Acute Aquatic Life
AMB	Abandoned Mine Bureau (DEQ)
AML	Abandoned Mine Lands
ARD	Acid Rock Drainage
ARM	Administrative Rules of Montana
BHS	Boulder Hot Springs
BLM	Bureau of Land Management (Federal)
BMP	Best Management Practices
CAFO	Concentrated Animal Feeding Operation
CAL	Chronic Aquatic Life
CALA	Controlled Allocation of Liability Act
CECRA	[Montana] Comprehensive Environmental Cleanup and Responsibility Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CFS	Cubic Feet Per Second
CWA	Clean Water Act
DEM	Digital Elevation Model
DEQ	Department of Environmental Quality (Montana)
DNRC	Department of Natural Resources & Conservation (Montana)
EPA	Environmental Protection Agency (U.S.)
EQIP	Environmental Quality Initiatives Program
FWP	Fish, Wildlife, and Parks (Montana)
GIS	Geographic Information System
GWIC	Groundwater Information Center
HH	Human Health
ICIS	Integrated Compliance Information System
INFISH	Inland Native Fish Strategy
IR	Integrated Report
LA	Load Allocation
LULC	Land Use and Land Cover
MBMG	Montana Bureau of Mines and Geology
MCA	Montana Code Annotated
MCL	Maximum Contaminant Level
MDT	Montana Department of Transportation
MGPCS	Montana Ground Water Pollution Control System
MOS	Margin of Safety
MPDES	Montana Pollutant Discharge Elimination System
NAIP	National Agricultural Imagery Program
NHD	National Hydrography Data(set)
NLCD	National Land Cover Dataset
NOAA	National Oceanographic and Atmospheric Administration
NPL	National Priorities List
NPS	Nonpoint Source
NRCS	National Resources Conservation Service

NRIS	Natural Resource Information System (Montana)
NWIS	National Water Information System
OIT	Office of Information Technology (DEQ)
OSM	Office of Surface Mining Reclamation and Enforcement
OU	Operable Unit
PELs	Probable Effects Levels
PRISM	Parameter-elevation Regressions on Independent Slopes Model
RDG	Reclamation and Development Grants Program
RIT	Resource Indemnity Trust
SAP	Sampling and Analysis Plan
SILC	Satellite Image Land Cover
SMCRA	Surface Mining Control & Reclamation Act
STORET	EPA STOrage and RETrieval database
TIE	TMDL Implementation Evaluation
TMDL	Total Maximum Daily Load
TPA	TMDL Planning Area
TSS	Total Suspended Solids
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USLE	Universal Soil Loss Equation
USGS	United States Geological Survey
VCRA	Voluntary Cleanup and Redevelopment Act
WLA	Wasteload Allocation
WRP	Watershed Restoration Plan
WWTF	Wastewater Treatment Facility (used interchangeably with WWTP)
WWTP	Wastewater Treatment Plant (used interchangeably with WWTF)

DOCUMENT SUMMARY

This document presents a total maximum daily load (TMDL) and framework water quality improvement plan for 16 metal-impaired stream segments in the Boulder-Elkhorn TMDL planning area (TPA). **Figure DS-1** shows the locations of impaired streams within the TPA boundary. **Table DS-1** lists the stream segments and identifies the metal impairments and affected uses for each segment.

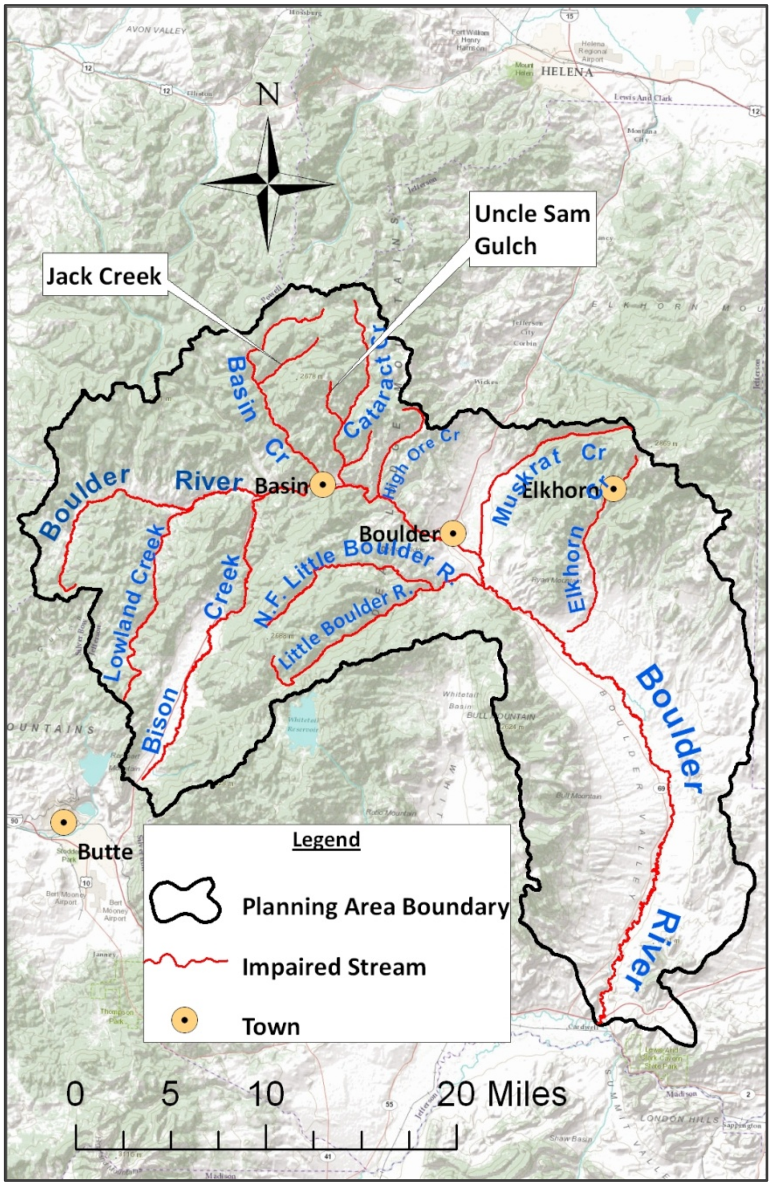

Figure DS-1. Streams in the Boulder-Elkhorn TPA impaired by metals.

The Montana Department of Environmental Quality (DEQ) develops TMDLs and submits them to the U.S. Environmental Protection Agency (EPA) for approval. The Montana Water Quality Act requires DEQ to develop TMDLs for streams and lakes that do not meet, or are not expected to meet, Montana water quality standards. A TMDL is the maximum amount of a pollutant a waterbody can receive and still meet water quality standards. TMDLs provide an approach to improve water quality so that streams and lakes can support and maintain their state-designated beneficial uses.

The Boulder-Elkhorn TPA is located in Jefferson County and coincides with the 1002006 fourth-code hydrologic basin that is the Boulder River watershed. The watershed originates along the continental divide on the northwest, the Elkhorn Mountains on the north and northeast, sedimentary uplands on the east, and the ridge of the Bull Mountains on the west. The watershed drainage area encompasses 487,142 acres, or approximately 760 square miles of mixed federal, state, and private land ownership.

The scope of the TMDLs in this document addresses water quality problems caused by metal pollutants (see **Table DS-1**). DEQ determined that 16 stream segments do not meet the applicable water quality standards for metals, requiring development of 70 metals TMDLs for these 16 stream segments. Metals concentrations are identified as impairing aquatic life and drinking water. Elevated water column metals concentrations are causing chronic and acute toxicity conditions for aquatic life, and exceeding drinking water standards. Water quality restoration goals are based on established numeric standards for dissolved and total recoverable concentrations in water and suggested guidelines for metals concentrations in sediment. Once water quality goals are met, all water uses currently affected by metals will be restored.

This document quantifies allowable metals loads from natural background sources (where possible) and mining sources. The most significant mining sources include metals-laden mine adit discharges, precipitation percolation through sulfide waste rock and tailings accumulations, and erosion of sediment or mine-related wastes directly into surface waters. The TMDLs indicate that a wide range in metal loading reductions is needed to satisfy the water quality restoration goals.

This document also presents broad recommendations for reducing metals loading. They include best management practices (BMPs) for:

- Active treatment of acidic adit discharges
- Removal of waste rock and mill tailings deposits from floodplain or near stream positions and disposal in approved waste repositories
- Reclamation and revegetation of waste rock or tailings deposits left in place.

In addition, BMPs for streambank stabilization and vegetation enhancement should be generally applied to minimize remobilization of historic tailings remnants that may be present in streambank sediments.

Implementation of most water quality improvement measures described in this plan is based on voluntary actions of watershed stakeholders. Ideally, local watershed groups and/or other watershed stakeholders will use this TMDL, and associated information, as a tool to guide local water quality improvement activities. Such activities can be documented within a watershed restoration plan consistent with DEQ and EPA recommendations.

TMDLs are prepared to address water quality impairment caused by elevated concentrations of one or more of the following trace metals: aluminum, arsenic, cadmium, copper, iron, lead, and zinc. A flexible approach to most nonpoint source TMDL implementation activities may be necessary as more knowledge is gained through implementation and future monitoring. The plan includes a monitoring strategy designed to track progress in meeting TMDL objectives and goals and to help refine the plan during its implementation.

Table DS-1. Metals-impaired waterbodies with completed metals TMDLs in this document

Waterbody & Location Description	TMDL Prepared	Impaired Uses*
BASIN CREEK, headwaters to mouth (Boulder River)	Aluminum Arsenic Cadmium Copper Lead Zinc	Aquatic Life Drinking Water
BISON CREEK, headwaters to mouth (Boulder River)	Arsenic Copper Iron	Aquatic Life Drinking Water
BOULDER RIVER, headwaters to Basin Creek	Copper Lead	Aquatic Life
BOULDER RIVER, Basin Creek to Town of Boulder	Arsenic Cadmium Copper Lead Zinc	Aquatic Life Drinking Water
BOULDER RIVER, Town of Boulder to Cottonwood Creek	Arsenic Cadmium Copper Iron Lead Zinc	Aquatic Life Drinking Water
BOULDER RIVER, Cottonwood Creek to the mouth (Jefferson Slough), T1N R3W S2	Arsenic Cadmium Copper Iron Lead Zinc	Aquatic Life Drinking Water
CATARACT CREEK, headwaters to mouth (Boulder River)	Aluminum Arsenic Cadmium Copper Lead Zinc	Aquatic Life Drinking Water
ELKHORN CREEK, headwaters to Wood Gulch	Arsenic Cadmium Copper Iron Lead	Aquatic Life Drinking Water
ELKHORN CREEK, Wood Gulch to the mouth (Unnamed Canal/Ditch), T5N R3W S21	Arsenic Cadmium Lead	Aquatic Life Drinking Water

Table DS-1. Metals-impaired waterbodies with completed metals TMDLs in this document

Waterbody & Location Description	TMDL Prepared	Impaired Uses*
HIGH ORE CREEK, headwaters to mouth (Boulder River)	Arsenic Cadmium Copper Lead Zinc	Aquatic Life Drinking Water
JACK CREEK, headwaters to mouth (Basin Creek)	Aluminum Arsenic Cadmium Copper Iron Lead Zinc	Aquatic Life Drinking Water
LITTLE BOULDER RIVER, headwaters to mouth (Boulder River)	Aluminum Copper Iron Lead	Aquatic Life
LOWLAND CREEK, headwaters to mouth (Boulder River)	Aluminum Copper Lead	Aquatic Life
MUSKRAT CREEK, headwaters to mouth (Boulder River)	Iron	Aquatic Life
NORTH FORK LITTLE BOULDER RIVER, headwaters to mouth (Little Boulder)	Aluminum Copper	Aquatic Life
UNCLE SAM GULCH, headwaters to mouth (Cataract Creek)	Aluminum Arsenic Cadmium Copper Lead Zinc	Aquatic Life Drinking Water

* Only the uses impaired by metals are identified; information is based on updated metals impairment and use support determinations presented within this document.

1.0 INTRODUCTION

This document presents an analysis of water quality information and establishes total maximum daily loads (TMDLs) for metal pollutants in the Boulder-Elkhorn TMDL Planning Area (TPA)(**Appendix A**). This document also presents a general framework for resolving these problems. **Figure DS-1,** found above in the document summary shows a map of waterbodies in the Boulder-Elkhorn TPA with metals pollutant listings.

1.1 BACKGROUND

In 1972, the U.S. Congress passed the Water Pollution Control Act, more commonly known as the Clean Water Act (CWA). The CWA's goal is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The CWA requires each state to designate uses of their waters and to develop water quality standards to protect those uses. Each state must monitor their waters to track if they are supporting their designated uses.

Montana's water quality designated use classification system includes the following uses:

- aquatic life
- wildlife
- recreation
- agriculture
- industry
- drinking water

Each waterbody has a set of designated uses. Montana has established water quality standards to protect these uses. Waterbodies that do not meet one or more standards are called impaired waters. Every two years DEQ must file a Water Quality Integrated Report (IR), which lists all impaired waterbodies and their identified impairment causes. Impairment causes fall within two main categories: pollutant and non-pollutant.

Montana's biennial IR identifies all the state's impaired waterbody segments. The 303(d) list portion of the IR includes all of those waterbody segments impaired by a pollutant, which require a TMDL. TMDLs are not required for non-pollutant impairments. **Table B-1** in **Appendix B** identifies impaired waters for the Boulder-Elkhorn TPA from Montana's 2012 303(d) List, as well as non-pollutant impairment causes included in Montana's "2012 Water Quality Integrated Report." **Table B-1** provides the current status of each impairment cause, identifying whether it has been addressed by TMDL development.

Both Montana state law (Section 75-5-701 of the Montana Water Quality Act) and section 303(d) of the federal CWA require the development of total maximum daily loads for all impaired waterbodies when water quality is impaired by a pollutant. A TMDL is the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards.

Developing TMDLs and water quality improvement strategies includes the following components, which are further defined in **Section 4.0**:

- Determining measurable target values to help evaluate the waterbody's condition in relation to the applicable water quality standards
- Quantifying the magnitude of pollutant contribution from their sources

- Determining the TMDL for each pollutant based on the allowable loading limits for each waterbody-pollutant combination
- Allocating the total allowable load (TMDL) into individual loads for each source

In Montana, restoration strategies and monitoring recommendations are also incorporated in TMDL documents to help facilitate TMDL implementation.

Basically, developing a TMDL for an impaired waterbody is a problem-solving exercise: The problem is excess pollutant loading that impairs a designated use. The solution is developed by identifying the total acceptable pollutant load (the TMDL), identifying all the significant pollutant-contributing sources, and identifying where pollutant loading reductions should be applied to achieve the acceptable load.

1.2 Water Quality Impairments and TMDLs Addressed by this Document

This document addresses beneficial use impairments caused by elevated metal concentrations. **Table 1-1** below lists all of the metals impairment causes from the "2012 Water Quality Integrated Report" that are addressed in this document. **Table 1-1** also lists 25 new metals impairment causes for 14 waterbody segments identified during this project by the assessment of recent data. These impairment causes are identified in **Table 1-1** as not being on the 2012 303(d) List (within the integrated report). The data assessment also concluded that 18 metals impairments on the 2012 303(d) List were no longer causing impairments on 12 different stream segments.

TMDLs are completed for each waterbody – pollutant combination, and this document contains 70 TMDLs (**Table 1-1**). There are several non-pollutant types of impairment that are affecting the water quality of streams discussed in this document. Although TMDLs are not required for non-pollutants, in many situations the solution to one or more metal pollutant problems will also provide the solution for one or more non-pollutant problems. The overlap between the pollutant TMDLs and non-pollutant impairment causes is discussed in **Section 6**. **Section 6** also provides some basic water quality solutions to address those non-pollutant causes not specifically addressed by TMDLs in this document.

There are a number of non-metal pollutant listings for the Boulder-Elkhorn TPA that are addressed in other TMDL documents and not included in **Table 1-1**. These impairment causes are included in **Appendix B**, **Table B-1**. DEQ sometimes develops separate TMDL documents for specific pollutant categories. Nutrient, sediment, and temperature TMDLs are presented in a separate document entitled "Boulder-Elkhorn Sediment, Nutrient, and Temperature TMDLs and Framework Water Quality Improvement Plan." **Table B-1** in **Appendix B** lists the impairment causes for all pollutant categories, as well as non-pollutant impairment causes.

Table 1-1. Water quality impairment causes in the Boulder-Elkhorn TPA addressed in this document

Waterbody & Location Description*	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impairment Cause Status	Included in the 2012 Integrated Report**
BASIN CREEK, headwaters to mouth (Boulder River)	MT41E002_030	Aluminum	Metal	Aluminum TMDL Completed	No
		Arsenic	Metal	Arsenic TMDL Completed	Yes
		Cadmium	Metal	Cadmium TMDL Completed	No
		Copper	Metal	Copper TMDL Completed	Yes
		Lead	Metal	Lead TMDL Completed	Yes
		Mercury	Metal	Not impaired based on updated assessment	Yes
		Zinc	Metal	Zinc TMDL Completed	Yes
BIG LIMBER GULCH, headwaters to mouth (Cataract Creek-Boulder River)	MT41E002_140	Lead	Metal	Not impaired based on updated assessment	Yes
		Mercury	Metal	Not impaired based on updated assessment	Yes
BISON CREEK, headwaters to mouth (Boulder River)	MT41E002_070	Arsenic	Metal	Arsenic TMDL Completed	No
		Copper	Metal	Copper TMDL Completed	Yes
		Iron	Metal	Iron TMDL Completed	Yes
BOULDER RIVER, headwaters to Basin Creek	MT41E001_010	Cadmium	Metal	Not impaired based on updated assessment	Yes
		Copper	Metal	Copper TMDL Completed	Yes
		Iron	Metal	Not impaired based on updated assessment	Yes
		Lead	Metal	Lead TMDL Completed	Yes
		Zinc	Metal	Not impaired based on updated assessment	Yes
BOULDER RIVER, Basin Creek to Town of Boulder	MT41E001_021	Arsenic	Metal	Arsenic TMDL Completed	No
		Cadmium	Metal	Cadmium TMDL Completed	Yes
		Copper	Metal	Copper TMDL Completed	Yes
		Iron	Metal	Not impaired based on updated assessment	Yes
		Lead	Metal	Lead TMDL Completed	Yes
		Silver	Metal	Not impaired based on updated assessment	Yes
		Zinc	Metal	Zinc TMDL Completed	Yes
BOULDER RIVER, Town of Boulder to Cottonwood Creek	MT41E001_022	Arsenic	Metal	Arsenic TMDL Completed	No
		Cadmium	Metal	Cadmium TMDL Completed	No
		Copper	Metal	Copper TMDL Completed	Yes
		Iron	Metal	Iron TMDL Completed	Yes
		Lead	Metal	Lead TMDL Completed	Yes
		Silver	Metal	Not impaired based on updated assessment	Yes
		Zinc	Metal	Zinc TMDL Completed	Yes

Table 1-1. Water quality impairment causes in the Boulder-Elkhorn TPA addressed in this document

Waterbody & Location Description*	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impairment Cause Status	Included in the 2012 Integrated Report**
BOULDER RIVER, Cottonwood Creek to the mouth (Jefferson Slough), T1N R3W S2	MT41E001_030	Arsenic	Metal	Arsenic TMDL Completed	Yes
		Cadmium	Metal	Cadmium TMDL Completed	Yes
		Copper	Metal	Copper TMDL Completed	Yes
		Iron	Metal	Iron TMDL Completed	No
		Lead	Metal	Lead TMDL Completed	Yes
		Zinc	Metal	Zinc TMDL Completed	Yes
CATARACT CREEK, headwaters to mouth (Boulder River)	MT41E002_020	Aluminum	Metal	Aluminum TMDL Completed	No
		Arsenic	Metal	Arsenic TMDL Completed	Yes
		Cadmium	Metal	Cadmium TMDL Completed	Yes
		Copper	Metal	Copper TMDL Completed	Yes
		Lead	Metal	Lead TMDL Completed	Yes
		Mercury	Metal	Not impaired based on updated assessment	Yes
		Zinc	Metal	Zinc TMDL Completed	Yes
ELKHORN CREEK, headwaters to Wood Gulch	MT41E002_061	Arsenic	Metal	Arsenic TMDL Completed	Yes
		Cadmium	Metal	Cadmium TMDL Completed	Yes
		Copper	Metal	Copper TMDL Completed	Yes
		Iron	Metal	Iron TMDL Completed	No
		Lead	Metal	Lead TMDL Completed	Yes
		Zinc	Metal	Not impaired based on updated assessment	Yes
ELKHORN CREEK, Wood Gulch to the mouth (Unnamed Canal/Ditch), T5N R3W S21	MT41E002_062	Arsenic	Metal	Arsenic TMDL Completed	No
		Cadmium	Metal	Cadmium TMDL Completed	Yes
		Copper	Metal	Not impaired based on updated assessment	Yes
		Lead	Metal	Lead TMDL Completed	Yes
		Zinc	Metal	Not impaired based on updated assessment	Yes
HIGH ORE CREEK, headwaters to mouth (Boulder River)	MT41E002_040	Arsenic	Metal	Arsenic TMDL Completed	Yes
		Cadmium	Metal	Cadmium TMDL Completed	Yes
		Copper	Metal	Copper TMDL Completed	Yes
		Lead	Metal	Lead TMDL Completed	Yes
		Mercury	Metal	Not impaired based on updated assessment	Yes
		Zinc	Metal	Zinc TMDL Completed	Yes

Table 1-1. Water quality impairment causes in the Boulder-Elkhorn TPA addressed in this document

Waterbody & Location Description*	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impairment Cause Status	Included in the 2012 Integrated Report**
JACK CREEK, headwaters to mouth (Basin Creek)	MT41E003_010	Aluminum	Metal	Aluminum TMDL Completed	No
		Arsenic	Metal	Arsenic TMDL Completed	No
		Cadmium	Metal	Cadmium TMDL Completed	No
		Copper	Metal	Copper TMDL Completed	No
		Iron	Metal	Iron TMDL Completed	No
		Lead	Metal	Lead TMDL Completed	No
		Zinc	Metal	Zinc TMDL Completed	No
LITTLE BOULDER RIVER, headwaters to mouth (Boulder River)	MT41E002_080	Aluminum	Metal	Aluminum TMDL Completed	No
		Copper	Metal	Copper TMDL Completed	Yes
		Iron	Metal	Iron TMDL Completed	No
		Lead	Metal	Lead TMDL Completed	No
		Zinc	Metal	Not impaired based on updated assessment	Yes
LOWLAND CREEK, headwaters to mouth (Boulder River)	MT41E002_050	Aluminum	Metal	Aluminum TMDL Completed	Yes
		Copper	Metal	Copper TMDL Completed	Yes
		Lead	Metal	Lead TMDL Completed	No
		Silver	Metal	Not impaired based on updated assessment	Yes
MUSKRAT CREEK, headwaters to mouth (Boulder River)	MT41E002_100	Copper	Metal	Not impaired based on updated assessment	Yes
		Iron	Metal	Iron TMDL Completed	No
		Lead	Metal	Not impaired based on updated assessment	Yes
NORTH FORK LITTLE BOULDER RIVER, headwaters to mouth (Little Boulder)	MT41E002_090	Aluminum	Metal	Aluminum TMDL Completed	No
		Copper	Metal	Copper TMDL Completed	No
UNCLE SAM GULCH, headwaters to mouth (Cataract Creek)	MT41E002_010	Aluminum	Metal	Aluminum TMDL Completed	No
		Arsenic	Metal	Arsenic TMDL Completed	Yes
		Cadmium	Metal	Cadmium TMDL Completed	Yes
		Copper	Metal	Copper TMDL Completed	Yes
		Lead	Metal	Lead TMDL Completed	Yes
		Zinc	Metal	Zinc TMDL Completed	Yes

*All waterbody segments within Montana's water quality integrated report are indexed to the National Hydrography Dataset.

**Impairment causes not in the 2012 Water Quality Integrated Report were recently identified and will be included in the 2014 Integrated Report.

1.3 DOCUMENT LAYOUT

This document addresses all of the required components of a TMDL and includes an implementation and monitoring strategy. The TMDL components are summarized within the main body of the document. Additional technical details are contained in the appendices. In addition to this introductory section, this document includes:

Section 2.0 Boulder-Elkhorn Watershed Description:
Describes the physical characteristics and social profile of the watershed.

Section 3.0 Montana Water Quality Standards
Discusses the water quality standards that apply to the Boulder-Elkhorn planning area.

Section 4.0 Defining TMDLs and Their Components
Defines the components of TMDLs and how each is developed.

Sections 5.0 Metals TMDL Components:
The section includes (a) a discussion of the affected waterbodies and the pollutant's effect on designated beneficial uses, (b) the information sources and assessment methods used to evaluate stream health and pollutant source contributions, (c) water quality targets and existing water quality conditions, (d) the quantified pollutant loading from the identified sources, (e) the determined TMDL for each waterbody, (f) the allocations of the allowable pollutant load to the identified sources.

Section 6.0 Other Impairment Causes and Metals TMDLs:
Discusses other impairment causes and linkages to metals TMDLs, possible solutions to non-metal impairment causes, and additional TMDLs pending in the planning area.

Section 7.0 Metals Restoration Objectives and Implementation Plan:
Discusses water quality restoration objectives and presents a framework for implementing a strategy to meet the identified objectives and TMDLs.

Section 8.0 Monitoring for Effectiveness:
Describes a water quality monitoring plan for evaluating the long-term effectiveness of the "Boulder-Elkhorn Metals TMDLs and Framework Water Quality Improvement Plan".

Section 9.0 Stakeholder Outreach, Public Participation, & Public Comments:
Describes other agencies and stakeholder groups who were involved with the development of the plan and the public participation process used to review the draft document. Addresses comments received during the public review period.

2.0 Boulder River Watershed Description

This section describes the physical, ecological, and cultural characteristics of the Boulder River watershed. The characterization establishes a context for impaired waters to support TMDL planning. The area described is known as the Boulder-Elkhorn TPA.

DEQ has identified 16 impaired (Category 5) waterbody segments within the Boulder-Elkhorn TPA: Basin Creek, Bison Creek, four segments of the Boulder River, Cataract Creek, two segments of Elkhorn Creek, High Ore Creek, Jack Creek, Little Boulder River, North Fork Little Boulder River, Lowland Creek, Muskrat Creek, and Uncle Sam Gulch. The impairments are detailed in DEQ's Integrated 305(b)/303(d) Water Quality Report (Montana Department of Environmental Quality, 2012), and are not discussed in this report. For the reader's convenience, listings extracted from the report are contained in **Appendix B Table B-1.** Streams on the 303(d) list are shown in **Appendix A**, **Figures A-1** to **A-17**. A total of 199.4 miles of streams in the TPA are listed as impaired.

2.1 Physical and Biological Characteristics

The following sections describe the physical and biological characteristics of the Boulder-Elkhorn TPA including climate, topography, hydrology, geology, vegetation, and landcover conditions.

2.1.1 Location

The Boulder-Elkhorn TPA is within Jefferson County. The total extent is 487,142 acres, or approximately 760 square miles. The TPA is located in the Missouri Headwaters Basin (Accounting Unit 100200) of southwestern Montana, as shown in **Appendix A**, **Figure A-1**. The TPA is coincident with the 1002006 fourth-code watershed.

The TPA is located in the Middle Rockies Level III Ecoregion. Three Level IV Ecoregions are mapped within the TPA (Woods et al., 2002), as shown in **Appendix A**, **Figure A-2**. These include: Elkhorn Mountains-Boulder Batholith (17ai), Townsend Basin (17w), and Townsend-Horseshoe-London Sedimentary Hills (17y). The TPA is bounded by the continental divide to the west, Boulder Hill to the north, the Elkhorn Mountains to the northeast, and Bull Mountain to the southwest.

2.1.2 Climate

Climate in the area is typical of mid-elevation intermontane valleys in western Montana. Precipitation is most abundant in May and June. Annual average precipitation ranges from 11-45 inches in the Boulder-Elkhorn TPA. The mountains receive most of the moisture, and the Boulder Valley below Elkhorn Creek receives the least. The precipitation data (**Appendix A, Figure A-8**) is mapped by Oregon State University's PRISM Group, using records from NOAA stations (PRISM Group, 2004).

National Oceanographic and Atmospheric Administration (NOAA) currently operates one weather station in the TPA. The USDA Natural Resources Conservation Service (NRCS) operates three SNOTEL snowpack monitoring stations within the TPA. **Appendix A**, **Figure A-8** shows the locations of the NOAA and SNOTEL stations, in addition to average annual precipitation. Climate data are provided by the Western Regional Climate Center, operated by the Desert Research Institute of Reno, Nevada. **Table 2-1** contains climate summaries; **Appendix A**, **Figure A-8** shows the distribution of average annual precipitation.

Table 2-1. Monthly Climate Summary: Boulder, Montana (241008), 7/1/1948 to 12/31/2005

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Ave. Max. Temp (°F)	33.2	38.6	44.7	54.9	64.2	72.7	82.5	82.0	71.1	59.4	42.9	34.9	56.7
Ave. Min. Temp. (F)	9.3	14.1	19.0	27.1	35.2	42.5	47.7	45.9	36.9	28.2	18.3	11.5	28.0
Ave. Total. Precip. (in.)	0.46	0.32	0.50	0.79	1.78	2.05	1.37	1.24	1.02	0.56	0.51	0.44	11.03
Ave. Snowfall (in.)	7.3	3.6	6.3	3.8	0.4	0.1	0.0	0.0	0.1	0.4	3.9	5.3	31.2
Ave. Snow Depth (in.)	3	1	1	0	0	0	0	0	0	0	1	2	1

Streamflows are at their highest between May and June. These are also the months with the greatest amount of precipitation and snowmelt runoff. Streamflows begin to decline in late June or early July, reaching minimum flow levels in September when many streams go dry. The decrease in streamflow correlates with a dwindling water supply and increasing water demands for irrigation and other uses. About 42,000 acres, or 9%, of the total Boulder River watershed area is irrigated. Streamflow begins to rebound in October and November when irrigation has ended and fall storms supplement the base-flow levels.

2.1.3 Topography

Elevations in the Boulder-Elkhorn TPA range from approximately 1,304 to 2,868 meters (4,275 - 9,415 feet) above mean sea level (**Appendix A**, **Figure A-3**). The lowest point is the confluence of the Boulder and Jefferson Rivers. The highest point is Crow Peak in the Elkhorn Mountains at the northeast corner of the planning area. Much of the Boulder-Elkhorn TPA is rugged and mountainous, with three distinct mountain valleys.

Elk Park is a long, narrow, fault-bound valley extending along the upper 10 miles of Bison Creek. The Boulder River valley is physically divided into an upper and lower portion by a shallow bedrock constriction about two miles upstream of the mouth of Elkhorn Creek. The upper valley is bounded by the Boulder Batholith on the west and Elkhorn Mountains to the east. The lower valley extends for about 25 miles from the south flank for the Elkhorn Mountains, southward to the Jefferson River near Cardwell, Montana. The planning area topography consists of rugged alpine terrain at the highest elevations, gently sloping ridgelines and peaks in the uplands, and steep-sided valleys grading to nearly level valley floors.

2.1.4 Hydrology

The TPA includes the entire Boulder River watershed. The river flows a distance of approximately 70 miles. The planning area hydrography is illustrated in **Appendix A**, **Figure A-7**. The National Hydrography Dataset (NHD) medium resolution data (United States Department of Interior, Geological Survey, 1999) includes 374 miles of named streams, with a total of 1,042 miles of streams mapped in the TPA. This data is compiled at 1:100,000. The United States Geological Survey (USGS) maintains two gaging stations within the TPA that are illustrated in **Appendix A**, **Figure A-7** and described below in **Table 2-2**.

Table 2-2. Active Stream Gages in the Boulder-Elkhorn TPA

Station Name	Station Number	Drainage Area	Agency	Period of Record
Cataract Creek near Basin, MT	06031950	30.6 $miles^2$	USGS	1973-2008*
Boulder River near Boulder, MT	06033000	381 $miles^2$	USGS	1929-1972; 1985-2009

* Annual peak data

Mean monthly streamflow data for the Boulder River near Boulder (station 06033000) are illustrated in the **Figure 2-1** hydrograph**.**

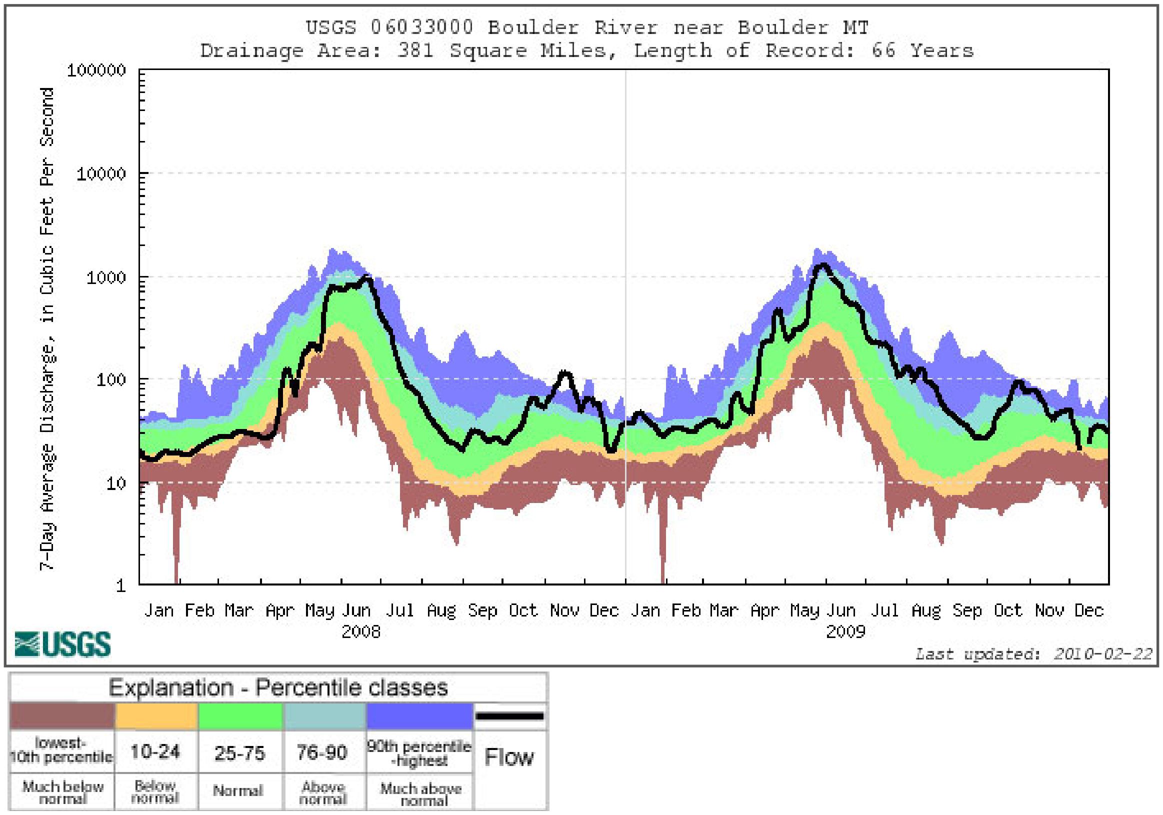

Figure 2-1. Mean monthly streamflow (cfs) and percentile flow classes for UGGS station 06033000 on the Boulder River near Boulder, Montana

Over a 75-year record, the average peak flow is 456 cfs occurring in May. The highest recorded flow is 7,000 cfs measured in May, 1981. Annual peak flows have not occurred earlier than April 23, nor later than July 7. Mean low flow occurs in January (26 cfs). Mean flows in October and November have been slightly higher at 35-36 cfs. Surface water flow from snowmelt and precipitation recharges local alluvial and bedrock groundwater aquifers during high flows and shallow alluvial aquifers maintain base flow conditions in streams during late summer through winter periods.

Flood irrigation is an additional source of recharge to the valley aquifers, particularly on the benches adjacent to floodplains. Mainstem as well as tributary streams have been historically straightened, or channelized, to accommodate a variety of land uses and/or transportation networks. These alterations can significantly affect sediment transport dynamics of streams and may affect streambank stability.

2.1.5 Geology and Soils

Appendix A, Figure A-4 provides an overview of the planning area geology, based on a geologic map of Montana by Ross and others (1955). Geologic descriptions of bedrock and basin sediments are based on more recent investigations by O'Neill and others (O'Neill et al., 2004). The descriptions of soil properties affecting water quality are based on attributes developed by the USGS (Schwarz and Alexander, 1995) from the USDA, NRCS STATSGO soil database.

The bedrock of the TPA includes a sequence of partially metamorphosed and highly folded and faulted Precambrian (*i.e.* Belt Series) basement rocks and overlying Paleozoic and early Mesozoic limestones, shales and quartzite sedimentary formations. These older formations were later crosscut by the Cretaceous age Elkhorn Mountain Volcanics. These volcanics were in turn intruded by a series of igneous plutons. The largest of these is the Boulder Batholith that extends from near Butte, Montana, northeastward to the Helena Valley. Although the mineralogy of the granitic batholith is variable, it generally trends from fine textured basic minerals near the surface, to coarser and more quartz-rich material at depth. The batholith contains extensive fracture systems that formed during placement and later cooling. The fracture systems are commonly occupied by quartz veins containing metals sulfide minerals that are the focus of mine development. A second volcanic episode produced the Lowland Creek Volcanics most common in the western and northwestern portions of the watershed.

Basin sediments are Tertiary and Quaternary deposits occupying Elk Park and both areas of the Boulder River valley. The Tertiary sediments are commonly fine-grained with isolated bodies of coarser material. Tertiary sediments commonly occur in benches or dry terraces. Quaternary sediments include fluvial, colluvial, and glacial deposits.

Erodibility and slope are the soil attributes considered in this general description. STATSGO soil data are intended for use at the 1:250,000 or smaller. Each STATSGO soil map unit in the data may include up to 21 soil components. Soil erodibility is based on the Universal Soil Loss Equation (USLE) K-factor attribute (Wischmeier and Smith, 1978) that ranges from 0 to 1, with higher values corresponding to greater erosion potential. **Appendix A**, **Figure A-5** is a map of soil erosion susceptibility. Most (57%) of the planning area is mapped as having moderate to low soils erosion susceptibility, 19.5 percent has moderate to high susceptibility, and 23.5 percent has low susceptibility. Soils with low erosion susceptibility generally correspond to the materials weathered from the granitic Boulder Batholith. Soils developed from volcanic rocks exhibit moderate to low erosion susceptibility. Soils developed from sedimentary materials are the most erodible.

Appendix A, Figure A-6a is a map of soil slope for broad STATSGO map units, with the majority of the TPA having slopes ranging between 31° and 40°. **Appendix A**, **Figure A-6b** depicts land surface slope interpreted from a 30-meter digital elevation model (DEM). The planning area has locally very steep slopes along valley margins, generally rounded mountaintops, and level valley bottoms.

2.1.6 Vegetation

Conifer forest the primary upland vegetation cover in the TPA. Principal species are lodgepole pine and Douglas fir with lesser amounts of subalpine fir, white pine, and western juniper. The valley floors are perennial grasslands and irrigated hay lands, with deciduous trees and shrubs in riparian corridors. Foothill areas are a mosaic of perennial grass and shrub cover. Landcover is shown in **Appendix A**, **Figures A-9** and **A-10**. Data sources include the University of Montana's Satellite Imagery Land Cover (SILC) project (University of Montana, 2002), and USGS National Land Cover Dataset (NLCD) mapping (Montana State Library, 1992).

2.1.7 Aquatic Life

Native fish species present in the TPA include: westslope cutthroat trout, mountain whitefish, mottled scuplin, longnose dace and longnose sucker. Westslope cutthroat trout are a designated "Species of Concern" by Montana Department of Fish, Wildlife and Parks (FWP). Introduced fish species include brook trout, rainbow trout, brown trout, and Yellowstone cutthroat trout. Data on fish species distribution are collected, maintained and provided by FWP (2006). Fish species distribution is shown in **Appendix A, Figure A-11.**

2.1.8 Wildfire

The United States Forest Service (USFS) Region 1 office and the USFS remote sensing applications center provided data on fire locations from 1940 to the present. Two fires are identified for this period, both of which burned in 2000. The High Ore fire burned 7,824 acres of the TPA north of Boulder. The Boulder Hill fire burned 1,830 acres northeast of Boulder (**Appendix A**, **Figure A-12**).

2.2 Cultural Characteristics

The following information describes the cultural profile of the Boulder-Elkhorn TPA.

2.2.1 Population

An estimated 2,245 persons lived within the TPA in 2000 (Montana Department of Natural Resources and Conservation, 2008). Population estimates are derived from census data (United States Census Bureau, 2010), based upon the populations reported from census blocks within and intersecting the TPA boundary. Basin and Boulder had reported populations of 255 and 1,300 in the 2010 census, respectively. The remainder of the population is sparsely distributed. Much of the mountainous portion of the TPA is unpopulated. Census data are mapped in **Appendix A**, **Figure A-13**.

2.2.2 Land Ownership

Land ownership data are provided by the State of Montana CAMA database via the NRIS website (Montana Department of Natural Resources and Conservation, 2008). Slightly more than one-half of the TPA is administered by the USFS, and eight percent by the BLM. Private lands comprise 37 percent of the TPA. Montana State Trust Lands occupy five percent of the TPA. The details for each land ownership category are provided in **Table 2-3**. Land ownership is illustrated in **Appendix A**, **Figure A-14**.

Table 2-3. Land Ownership in the Boulder-Elkhorn TPA

Owner	Acres	Square Miles	Percent of Total
Private	180,448	281.9	37
US Forest Service	249,016	389.1	51
US Bureau of Land Management	41,362	64.6	8
State Trust Land	14,876	23.2	5
State Department of Corrections	1,393	2.2	0.3
Total	487,142	761.2	—

2.2.3 Land Use and Cover

Land use within the TPA is dominated by silviculture and agriculture (**Table 2-4**). Agriculture in the lowlands is primarily related to the cattle industry, with irrigated hay production and both dry-land and irrigated grazing.

Table 2-4. Land Use and Cover in the Boulder-Elkhorn TPA

Land Use	Acres	Square Miles	% of Total
Evergreen Forest	256,516.6	400.8	52.66%
Grasslands/Herbaceous	154,348.5	241.2	31.68%

Table 2-4. Land Use and Cover in the Boulder-Elkhorn TPA

Land Use	Acres	Square Miles	% of Total
Shrubland	52,338.7	81.8	10.74%
Pasture/Hay	8,680.3	13.6	1.78%
Small Grains	3,843.4	6.0	0.79%
Transitional	2,999.3	4.7	0.62%
Deciduous Forest	2,223.5	3.5	0.46%
Woody Wetlands	2,177.9	3.4	0.45%
Fallow	1,096.2	1.7	0.23%
Commercial/Industrial/Transportation	981.6	1.5	0.20%
Row Crops	849.5	1.3	0.17%
Emergent Herbaceous Wetlands	474.1	0.7	0.10%
Low Intensity Residential	145.4	0.2	0.030%
Urban/Recreational Grasses	136.8	0.2	0.028%
Open Water	112.2	0.2	0.023%
High Intensity Residential	98.7	0.2	0.020%
Bare Rock/Sand/Clay	95.4	0.1	0.020%
Mixed Forest	16.0	0.0	0.003%
Perennial Ice/Snow	6.3	0.0	0.001%
Quarries/Strip Mines/Gravel Pits	0.4	0.0	0.000%

Information on land use is based on land use and land cover (LULC) mapping completed by the USGS in the 1980s. The data are at 1:250,000 scale, and are based upon manual interpretation of aerial photographs. Agricultural land use is illustrated on **Appendix A**, **Figure A-15**. Potential sources of human-caused water quality impacts (abandoned mines, timber harvest, livestock feeding areas) are illustrated on **Appendix A**, **Figure A-16**.

2.2.4 Metal Mining

Mining remains an important economic activity within Jefferson County. Mining and ore processing occurred widely within the TPA but were focused in the communities of Basin and Elkhorn. Waste rock and tailings deposits from historic mining, milling, and smelting operations persist in many locations. Like many Montana mining districts, much of the metal production began in the 1860s with gold-bearing placers. Later, significant lode deposits of lead, zinc, gold and silver were developed. Iron-bearing ore was mined in the Elkhorn district to provide flux to the East Helena smelter.

The environmental impacts of abandoned and inactive mines in the TPA have been widely studied (Metesh et al., 1994; Metesh et al., 1995; Metesh et al., 1998; Nimick et al., 2004). The influences of historic mining are most concentrated in the Basin and Cataract Creek drainages. The Environmental Protection Agency (EPA) added the Basin Mining Area to the Superfund National Priorities List (NPL) in 1999. Pollutant exposure risks are caused by mine waste accumulations in the town of Basin and surrounding watersheds. The NPL site includes the watersheds of Basin, Cataract, and High Ore creeks and portions of the Boulder River below the confluence with these heavily impacted streams. Listing makes the site eligible for federal cleanup funds. The EPA seeks to recover costs from the parties responsible for the contamination, or proceeds to complete reclamation work if no parties are found. The NPL designation also allows EPA to cooperate with other agencies (such as the US Forest Service) in the cleanup. Under Superfund, affected communities are eligible to receive Technical Assistance Grants from EPA to provide a technical advisor for independent review of the proposed work. DEQ Remediation Division data on abandoned mine locations are plotted on **Appendix A**, **Figure A-16**. The Basin Creek

Mine property, located on the Continental Divide between Basin and Tenmile Creeks, is now owned by Montana DEQ, and is operated as the Luttrell Depository. This facility provides encapsulated disposal for mine and mill waste from former mining sites in the region.

Elkhorn Goldfields, Inc. is developing an underground ore deposit for gold recovery (operating permit number 000173) near the historic mining town of Elkhorn. The operation plans a continuous discharge of process wastewater to groundwater through a subsurface drainfield at a rate of from 150 to 300 gallons per minute.

2.2.5 Permitted Wastewater Discharges

DEQ is required to administer permit programs for discharges of pollutants to surface and groundwater. The Montana Pollutant Discharge Elimination System (MPDES) program issues permits for discharges to surface water. Dischargers may operate under an individual permit tailored for a specific process, or operate under one of several general permits applied to broader discharge categories. There are 12 facilities in the Boulder-Elkhorn TPA that hold MPDES discharge permits. The town of Boulder and Boulder Hot Springs hold individual permits for discharges of domestic wastewater. Four general permits are held by portable suction operators. Five general permits are issued for stormwater discharges from construction activity (building sites and gravel pits). In addition to a mine operating permit, Elkhorn Goldfields, Inc. holds a general stormwater discharge permit for mining activity. The MPDES permits in the planning area are summarized in **Table 2-5**.

Table 2-5. Active MPDES Permits Issued in the Boulder-Elkhorn TPA

Facility Name	Facility Type	Permit Number	Permit Type	Receiving Stream
TOWN OF BOULDER WWTF (also referred to as Boulder WWTP in this document)	Municipal	MT0023078	MPDES Individual Permit	BOULDER RIVER
BOULDER HOT SPRINGS WWTP	Private Facility	MT0023639	MPDES Individual Permit	LITTLE BOULDER RIVER
PARKER SUCTION DRDGE	Private Facility	MTG370269	General Permit, Suction Dredge	LOWLAND CREEK
CARLSON RANCH SUCTION DREDGE	Private Facility	MTG370313	General Permit, Suction Dredge	LOWLAND CREEK
SNOWDRIFT DREDGE MINING	Private Facility	MTG370320	General Permit, Suction Dredge	SNOWDRIFT CREEK
BOULDER RIVER MIDSUMMER DREAM	Private Facility	MTG370322	General Permit, Suction Dredge	BOULDER RIVER
GILMAN EXCAVATING - CARLSON PIT	Private Facility	MTR103333	General Permit, Construction Stormwater	RED ROCK CREEK
MDOT ELKHORN ROAD SOUTH	State Government	MTR103698	General Permit, Construction Stormwater	BOULDER RIVER, LITTLE BOULDER RIVER
AM WELLES - COMPTON SITE	Private Facility	MTR103724	General Permit, Construction Stormwater	BOULDER RIVER
PUMCO - MDT CAREY BORROW	State Government	MTR103727	General Permit, Construction Stormwater	MURPHY IRRIGATION DITCH
MCALVAIN CONSTRUCTION	Private Facility	MTR103757	General Permit, Construction Stormwater	BOULDER RIVER
ELKHORN GOLDFIELDS INC	Private Facility	MTR300264	General Permit, Mining Stormwater	ELKHORN CREEK

Discharges of pollutants to groundwater are permitted by the Montana Groundwater Pollution Control System (MGWPCS) program at DEQ. The town of Basin is sewered and discharges domestic wastewater to groundwater for infiltration cells located south of Highway I-15. O.T. Mining, Inc. holds a MGWPCS permit number MTX000014 for discharges to groundwater from its custom mill tailings pond near the town of Basin.

Wastewater treatment for other communities and rural residences is provided by on-site septic tanks and drainfields. Septic system density is estimated from the 2010 census block data, based on the assumption of one septic tank and drainfield for each 2.5 persons (Montana Department of Natural Resources and Conservation, 2008). Septic system density is classified as low (<50 per square mile), moderate (51-300 per square mile) or high (>300 per square mile). Nearly all of the TPA is mapped as having low density. Moderate density occurs on 215 acres; high density occurs on 47 acres. The high and moderate density locations are around the towns of Boulder and Basin. The community sewer system at Boulder is mapped on 727 acres. The Basin system is unmapped. Septic system density is illustrated in **Appendix A**, **Figure A-16**.

The MPDES program does not report regulated concentrated animal feeding operations (CAFOs) within the Boulder-Elkhorn TPA. Three facilities that may be livestock feeding areas (**Appendix A**, **Figure A-16)** with potential for discharges to surface waters are identified from aerial imagery.

3.0 Montana Water Quality Standards

The federal Clean Water Act provides for the restoration and maintenance of the chemical, physical, and biological integrity of the nation's surface waters so that they support all designated uses. Water quality standards are used to determine impairment, establish water quality targets, and to formulate the TMDLs and allocations.

Montana's water quality standards include four main parts:

1. Stream classifications and designated uses
2. Numeric and narrative water quality criteria designed to protect designated uses
3. Nondegradation provisions for existing high-quality waters
4. Prohibitions of practices that degrade water quality

Those components that apply to this document are reviewed briefly below. More detailed descriptions of Montana's water quality standards that apply to the Boulder-Elkhorn TPA streams can be found in **Appendix C**.

3.1 Boulder-Elkhorn TPA Stream Classifications and Designated Beneficial Uses

Waterbodies are classified based on their designated uses. All Montana waters are classified for multiple uses. All streams and lakes within the Boulder-Elkhorn TPA, except for Basin Creek, are classified as B-1, which specifies that the water must be maintained suitable to support all of the following uses (Administrative Rules of Montana (ARM) (17.30.623(1)):

drinking, culinary, and food processing purposes, after conventional treatment
bathing, swimming, and recreation
growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers
agricultural and industrial water supply

Basin Creek is designated as A-1, which specifies that the water must be maintained suitable for the same uses as described for B-1 above, with the following exception (Administrative Rules of Montana (ARM) (17.30.622(1)):

drinking, culinary, and food processing purposes, after conventional treatment for removal of naturally present impurities

While some of the waterbodies might not actually be used for a designated use (e.g., drinking water supply), their water quality must be maintained suitable for that use. More detailed descriptions of Montana's surface water classifications and designated uses are provided in **Appendix C**

Based on the 2012 Water Quality Integrated Report, 15 waterbody segments in the Boulder-Elkhorn TPA are not fully supporting one or more designated uses because of metals impairments (**Table 3-1** and **Figure 3-1**). The metals data collection and assessment process for this project identified new metals impairment causes and use support limitations for Jack Creek and the North Fork of the Little Boulder River. Recent data assessed in this project removed metals impairment causes for Big Limber Gulch.

Table 3-1. Metals Impaired Waterbodies in the Boulder-Elkhorn TPA and their Designated Use Support Status* on the 2012 Water Quality Integrated Report

Waterbody & Location Description	Waterbody ID	Use Class	Agriculture	Aquatic Life	Drinking Water	Primary Contact Recreation
BASIN CREEK, headwaters to mouth (Boulder River)	MT41E002_030	A-1**	P	N	N	F
BIG LIMBER GULCH, headwaters to mouth (Cataract Creek-Boulder River)	MT41E002_140	B-1	F	X	N	X
BISON CREEK, headwaters to mouth (Boulder River)	MT41E002_070	B-1	F	N	F	F
BOULDER RIVER, headwaters to Basin Creek	MT41E001_010	B-1	F	P	N	F
BOULDER RIVER, Basin Creek to Town of Boulder	MT41E001_021	B-1	F	N	N	F
BOULDER RIVER, Town of Boulder to Cottonwood Creek	MT41E001_022	B-1	P	N	N	P
BOULDER RIVER, Cottonwood Creek to the mouth (Jefferson Slough), T1N R3W S2	MT41E001_030	B-1	P	N	N	P
CATARACT CREEK, headwaters to mouth (Boulder River)	MT41E002_020	B-1	P	N	N	F
ELKHORN CREEK, headwaters to Wood Gulch	MT41E002_061	B-1	P	N	N	P
ELKHORN CREEK, Wood Gulch to the mouth (Unnamed Canal/Ditch), T5N R3W S21	MT41E002_062	B-1	P	N	N	N
HIGH ORE CREEK, headwaters to mouth (Boulder River)	MT41E002_040	B-1	P	N	N	F
LITTLE BOULDER RIVER, headwaters to mouth (Boulder River)	MT41E002_080	B-1	F	N	F	P
LOWLAND CREEK, headwaters to mouth (Boulder River)	MT41E002_050	B-1	F	N	F	F
MUSKRAT CREEK, headwaters to mouth (Boulder River)	MT41E002_100	B-1	F	N	N	F
UNCLE SAM GULCH, headwaters to mouth (Cataract Creek)	MT41E002_010	B-1	P	N	N	F

F = Fully Supporting, P = Partially Supporting, N = Not Supporting, X = Not Assessed
* Not all use support limitations are linked to metals impairment causes. Use support limitations linked to metals impairment causes will be updated in the 2014 Water Quality Integrated Report based on recent assessment work summarized within this document (**Section 5.5.1**)
**Basin Creek appears in the 2012 Integrated Report as B-1, but the use class designation will be corrected to A-1 for the 2014 IR.

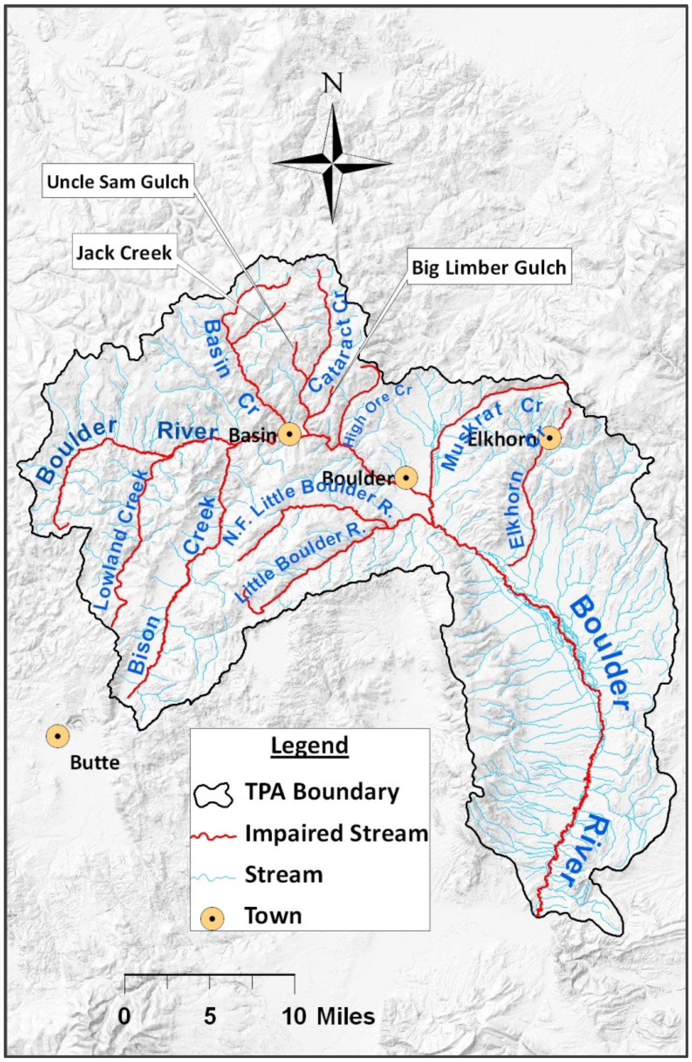

Figure 3-1. Metal-impaired streams in the Boulder-Elkhorn TPA addressed in this document

Waterbodies that are “not supporting” or “partially supporting” a designated use are impaired and require a TMDL. DEQ describes impairment as either partially supporting or not supporting, based on assessment results. Not supporting is applied to noncompliance with drinking water standards and severe impairment of aquatic life. A non-supporting level of impairment does not equate to complete elimination of the use. Detailed information about Montana’s use support categories can be found in DEQ’s water quality assessment methods (Montana Department of Environmental Quality, 2011).

3.2 Boulder-Elkhorn Water Quality Standards

In addition to the use classifications described above, Montana’s water quality standards include numeric and narrative criteria that protect the designated uses. Numeric criteria define the allowable concentrations of specific pollutants so as not to impair designated uses. Numeric standards apply to pollutants that are known to have adverse effects on human health or aquatic life (e.g., metals, organic chemicals, and other toxic constituents). Human health standards are set at levels that protect against long-term (lifelong) exposure, as well as short-term exposure through direct contact such as swimming. Numeric standards for aquatic life include chronic and acute values. Numeric criteria for both chronic and acute values are used for metals TMDL development in the Boulder-Elkhorn TPA. The chronic aquatic life criteria are based on a 96-hour exposure. Chronic criteria are intended to be protective under long-term and low level pollutant exposure. Acute aquatic life standards are protective of short-term exposures to a parameter and are not to be exceeded.

Narrative criteria are statements describing unacceptable conditions. **Appendix C** defines both the numeric and narrative water quality criteria for the Boulder-Elkhorn TPA. Narrative standards are developed when there is insufficient information to develop specific numeric standards. Narrative standards describe either the allowable condition or an allowable increase of a pollutant above "naturally occurring" conditions. DEQ uses the naturally occurring condition, called a "reference condition," to determine whether or not narrative standards are being met (see **Appendix C**). Reference defines the condition a waterbody could attain if all reasonable land, soil, and water conservation practices were put in place. Reasonable land, soil, and water conservation practices usually include, but are not limited to, best management practices (BMPs) applied to pollutant sources.

4.0 DEFINING TMDLS AND THEIR COMPONENTS

A Total Maximum Daily Load (TMDL) is a quantitative tool for implementing water quality standards and expressing the relationship between pollutant sources and acceptable water quality conditions. More specifically, a TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive from all sources and still meet water quality standards.

Pollutant sources are generally defined as two categories: point sources and nonpoint sources. Point sources are discernible, confined and discrete conveyances, such as pipes, ditches, wells, containers, or concentrated animal feeding operations, from which pollutants are being, or may be, discharged. Some sources such as return flows from irrigated agriculture are not included in this definition. All other pollutant loading sources are considered nonpoint sources. Nonpoint sources are diffuse and are typically associated with runoff, streambank erosion, most agricultural activities, atmospheric deposition, and groundwater seepage. Natural background loading is a type of nonpoint source.

As part of TMDL development, the allowable load is divided among all significant contributing point and nonpoint sources. For point sources, the allocated loads are called “wasteload allocations” (WLAs). For nonpoint sources, the allocated loads are called “load allocations” (LAs).

A TMDL is expressed by the equation: TMDL = ΣWLA + ΣLA, where:

ΣWLA is the sum of the wasteload allocation(s) (point sources)
ΣLA is the sum of the load allocation(s) (nonpoint sources)

TMDL development must include a margin of safety (MOS), which can be explicitly incorporated into the above equation. Alternatively, the MOS can be implicit, such as an analysis assumption that would conservatively overestimate human-caused pollutant loading. A TMDL must also ensure that the waterbody will be able to meet and maintain water quality standards for all applicable seasonal variations (e.g., flow volume).

Development of each TMDL has four major components:

1. Determining water quality targets
2. Quantifying pollutant sources
3. Establishing the total allowable pollutant load
4. Allocating the total allowable pollutant load to the sources

Although the way a TMDL is expressed can vary by pollutant, these four components are common to all TMDLs, regardless of pollutant. Each component is described in further detail in the following subsections.

Figure 4-1 illustrates how numerous sources contribute to the existing load and how the TMDL is defined. The existing load can be compared to the allowable load to determine the amount of pollutant reduction needed.

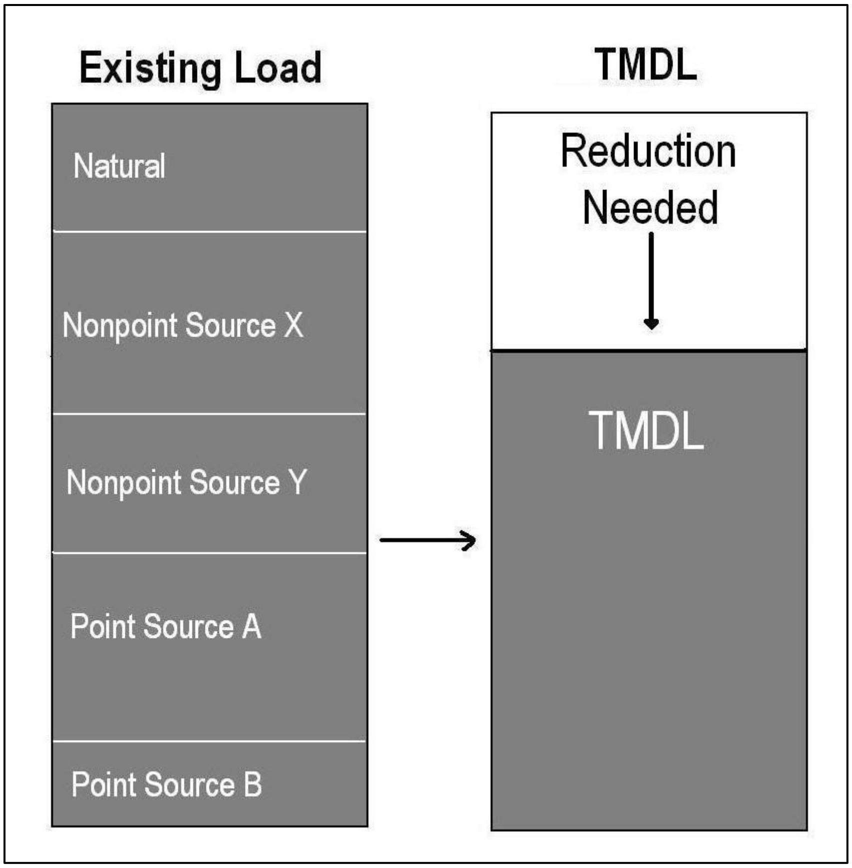

Figure 4-1. Schematic Example of TMDL Development

4.1 Developing Water Quality Targets

TMDL water quality targets are a translation of the applicable water quality standard(s) for each pollutant. For pollutants with established numeric water quality standards, the numeric value(s) are used as the TMDL targets. For pollutants with narrative water quality standard(s), the targets provide a waterbody-specific interpretation of the narrative standard(s).

Water quality targets are typically developed for multiple parameters that link directly to the impaired beneficial use(s) and applicable water quality standard(s). Therefore, the targets provide a benchmark by which to evaluate attainment of water quality standards. Furthermore, comparing existing stream conditions to target values allows for a better understanding of the extent and severity of the problem.

4.2 Quantifying Pollutant Sources

All significant pollutant sources, including natural background loading, are quantified so that the relative pollutant contributions can be determined. Because the effects of pollutants on water quality can vary throughout the year, assessing pollutant sources must include an evaluation of the seasonal variability of the pollutant loading. The source assessment helps to define the extent of the problem by linking the pollutant load to specific sources in the watershed.

A pollutant load is usually quantified for each point source permitted under the Montana Pollutant Discharge Elimination System (MPDES) program. Nonpoint sources are commonly quantified by source categories (e.g., natural background loading). Nonpoint source categories and land uses can be divided further by ownership, such as federal, state, or private. Pollutant sources can also be quantified geographically, such as the loading contribution from a sub-watershed or other explicit source area.

Because all potentially significant sources of the water quality problems must be evaluated, source assessments are conducted on a watershed scale. The source quantification approach may produce reasonably accurate estimates or gross allotments, depending on the data available and the techniques used for predicting the loading (40 CFR Section 130.2(I)). Montana TMDL development often includes a combination of approaches, depending on the desired level of certainty for setting allocations and guiding implementation of load reductions.

4.3 Establishing the Total Allowable Load

Identifying the TMDL requires a determination of the total allowable load over the appropriate time period necessary to comply with the applicable water quality standard(s). Although "TMDL" implies "daily load," determining a daily loading may not be consistent with the applicable water quality standard(s), or may not be practical from a water quality management perspective. Therefore, the TMDL will ultimately be defined as the total allowable loading during an appropriate time period for applying water quality standards. Since the water quality criteria for metals are numeric, and daily stream discharge data is commonly available, metals TMDLs are expressed in units of pounds per day.

In cases of high uncertainty in the link between the target values and actual loading conditions, the TMDL may be expressed as a percent reduction in total loading. The magnitude of target exceedances can be numerically expressed as a needed percent reduction in current loading. The nature of the pollutant sources and likelihood of achieving needed reductions with available technology may influence the value of the TMDL when the link between loading and beneficial-use support is uncertain.

4.4 Determining Pollutant Allocations

Once the allowable load (the TMDL) is determined, that total must be divided among the contributing sources. In addition to basic technical and environmental analysis, DEQ also considers economic and social costs and benefits when developing allocations. The allocations are often determined by quantifying feasible and achievable load reductions through application of a variety of best management practices and other reasonable conservation practices.

Under the current regulatory framework (40 CFR 130.2) for developing TMDLs, flexibility is allowed in allocations in that "TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure." Allocations are typically expressed as a numeric portion of the allowable load, a percent reduction (from the current load), or as a measure of a surrogate parameter strongly linked to pollutant loading (e.g., a percent increase in canopy density for temperature TMDLs).

Figure 4-2 illustrates how TMDLs are allocated to different sources using WLAs for point sources and LAs for natural and nonpoint sources. Although some flexibility in allocations is possible, the sum of all allocations must meet the water quality standards in all segments of the waterbody.

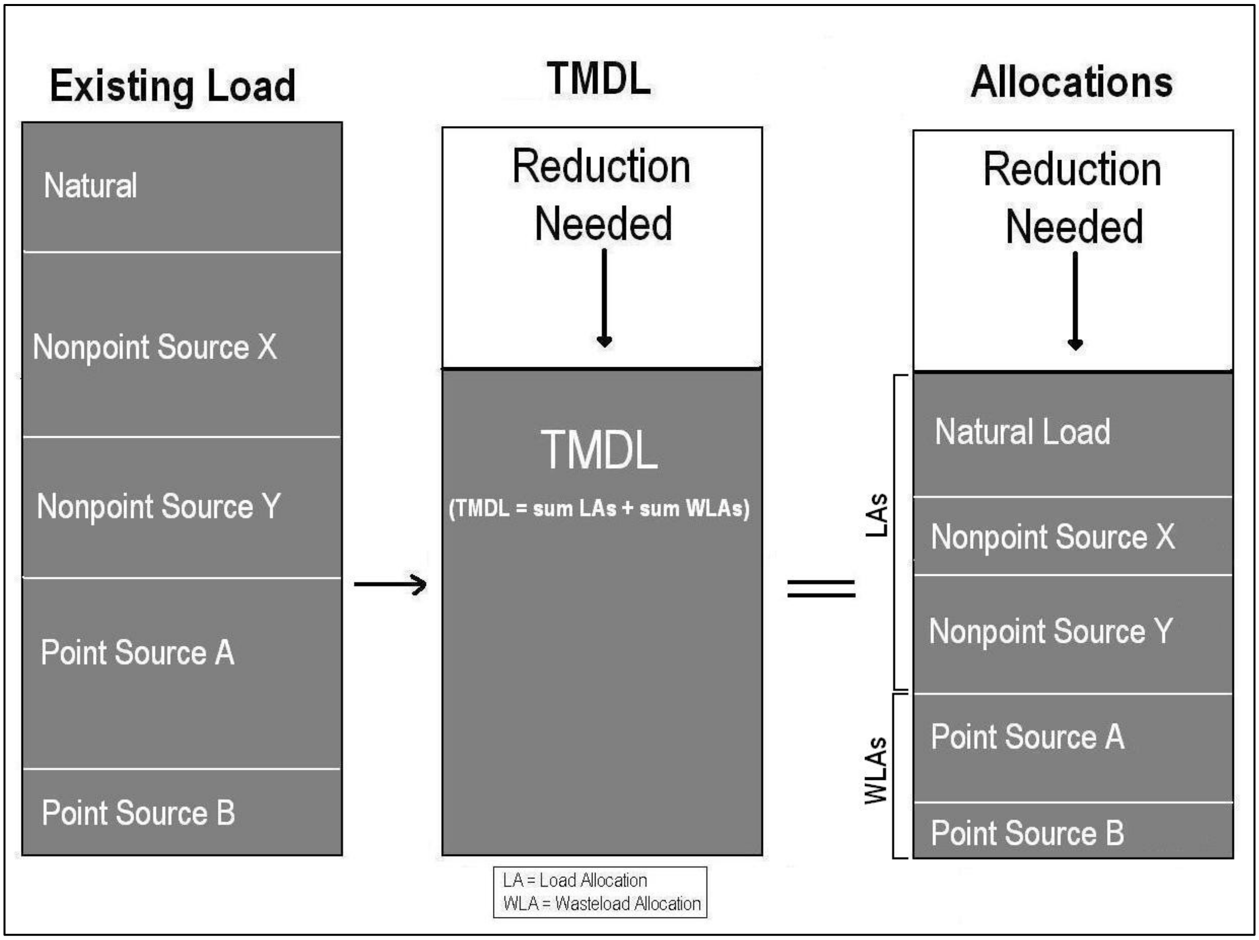

Figure 4-2. Schematic Diagram of a TMDL and its Allocations

TMDLs must also incorporate a margin of safety. The margin of safety accounts for the uncertainty, or any lack of knowledge, about the relationship between the pollutant loads and the quality of the receiving waterbody. The margin of safety may be applied implicitly by using conservative assumptions in the TMDL development process, or explicitly by setting aside a portion of the allowable loading (i.e., a TMDL = WLA + LA + MOS) (U.S. Environmental Protection Agency, 1999). The margin of safety is a required component to help ensure that water quality standards will be met when all allocations are achieved. In Montana, TMDLs typically incorporate implicit margins of safety.

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions. For TMDLs in this document where there is a combination of nonpoint sources and one or more permitted point sources discharging into an impaired stream reach, the permitted point source WLAs are not dependent on implementation of the LAs. Instead, DEQ sets the WLAs and LAs at levels necessary to achieve water quality standards throughout the watershed. Under these conditions, the LAs are developed independently of the permitted point source WLA such that they would satisfy the TMDL target concentration within the stream reach immediately above the point source. In order to ensure that the water quality standard or target concentration is achieved below the point source discharge, the WLA is based on the point source's discharge concentration set equal to the standard or target concentration for each pollutant.

4.5 Implementing TMDL Allocations

The Clean Water Act (CWA) and Montana state law (Section 75-5-703 of the Montana Water Quality Act) require wasteload allocations to be incorporated into appropriate discharge permits, thereby providing a regulatory mechanism to achieve load reductions from point sources. Nonpoint source reductions linked to load allocations are not required by the CWA or Montana statute, and are primarily implemented through voluntary measures. This document contains several key components to assist stakeholders in implementing nonpoint source controls. **Section 7.0** discusses a restoration and implementation strategy and **Section 7.3** discusses potential funding sources. Other site-specific pollutant sources are discussed throughout the document, and can be used to target implementation activities. DEQ's Watershed Protection Section helps to coordinate nonpoint implementation throughout the state and provides resources to stakeholders to assist in nonpoint source BMPs. Montana's Nonpoint Source Management Plan (available at http://www.deq.mt.gov/wqinfo/nonpoint/nonpointsourceprogram.mcpx) further discusses nonpoint source implementation strategies at the state level.

DEQ uses an adaptive management approach to implementing TMDLs to ensure that water quality standards are met over time (outlined in **Sections 5.9 and 8**). This includes a monitoring strategy and an implementation review that is required by Montana statute. TMDLs may be refined as new data become available, land uses change, or as new sources are identified.

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5.0 METALS TMDL COMPONENTS

This section focuses on impairment of water quality caused by metals. It describes: 1) the mechanisms by which metals impair beneficial uses, 2) the specific stream segments of concern, 3) the presently available data pertaining to metals impairment in the watershed, 4) the various contributing sources of metals based on recent data and studies, and 5) the metals TMDLs and allocations.

5.1 EFFECTS OF ELEVATED METALS ON BENEFICIAL USES

Elevated metals concentrations in the Boulder-Elkhorn TPA are related to metal mining which has caused rapid and extensive exposure of metal sulfide minerals to weathering. Examples of these minerals include iron sulfides such as pyrite (FeS_2), lead sulfides such as galena (PbS), and copper sulfides such as chalcocite (Cu_2S). Exposure of metal sulfide minerals to oxygen (O_2) and water (H_2O) produces sulfuric acid and metal oxide precipitates. The following equation describes the oxidation of pyrite, a common sulfide mineral at planning area mines:

$$FeS_2 + 7/2\ O_2 + H_2O \rightarrow Fe^{+2} + 2\ SO4^{2-} + 2\ H^{+}$$

Oxidizing bacteria, such as *Thiobacillus ferrooxidans*, accelerate sulfide oxidation and commonly occur in surface water and groundwater. Sulfuric acid (H_2SO_4) lowers soil and water pH and increases the dissolved concentrations of iron and other metals (e.g. copper, lead, and arsenic) to levels toxic to aquatic life. Metal oxide precipitates often cause turbidity in surface water and coat stream substrates with fine sediment that degrades aquatic habitat.

The acid generation and metal contamination caused by mining-related metal sulfide oxidation are commonly referred to as “acid rock drainage” or ARD. **Figure 5-1** shows the effects of ARD-related iron oxide precipitation on water quality in the discharge from the lower adit at the Crystal Mine in Uncle Sam Gulch.

Figure 5-1. The iron oxide precipitation effects of ARD at the lower Crystal Mine adit discharge

Waterbodies with metals concentrations exceeding the aquatic life and/or human health standards can impair numerous beneficial uses including aquatic life, drinking water, and agriculture. Elevated metals concentrations can have toxic, carcinogenic, or bioconcentrating effects on aquatic organisms. Humans and wildlife can suffer acute and chronic health problems from consuming metal contaminated drinking water or fish tissue. Because elevated metals can be toxic to plants and animals, metal contamination may damage agricultural irrigation or water used for livestock.

5.2 Stream Segments of Concern

Table 5-1 lists the 15 waterbody segments in the Boulder-Elkhorn TPA that are impaired by metals-related causes based on the 2012 Montana 303(d) List (see also **Figure 3-1** and **Appendix A** figures). Jack Creek and North Fork Little Boulder River, though not included on the 2012 303(d) List and **Table 5-1**, are included within the scope of metals TMDL development in this document because a review of recent water quality data indicates beneficial uses for both streams are impaired by elevated metal concentrations. Jack Creek is a headwater tributary to Basin Creek and North Fork Little Boulder River is a tributary to the Little Boulder River. All 2012 303(d) impairment causes as well as new impairment determinations are included in **Table 1-1.** Metals-related impairment causes include aluminum, arsenic, cadmium, copper, iron, lead, mercury, silver, and zinc.

Table 5-1. Waterbody segments in the Boulder-Elkhorn TPA with metals-related impairments on the 2012 303(d) List

Waterbody ID	Stream Segment	Probable Causes of Impairment*
MT41E002_030	BASIN CREEK, headwaters to mouth (Boulder River)	Arsenic, Copper, Lead, Mercury, Zinc
MT41E002_140	BIG LIMBER GULCH, headwaters to mouth (Cataract Creek-Boulder River)	Lead, Mercury

Table 5-1. Waterbody segments in the Boulder-Elkhorn TPA with metals-related impairments on the 2012 303(d) List

Waterbody ID	Stream Segment	Probable Causes of Impairment*
MT41E002_070	BISON CREEK, headwaters to mouth (Boulder River)	Copper, Iron
MT41E001_010	BOULDER RIVER, headwaters to Basin Creek	Cadmium, Copper, Iron, Lead, Zinc
MT41E001_021	BOULDER RIVER, Basin Creek to town of Boulder	Cadmium, Copper, Iron, Lead, Silver, Zinc
MT41E001_022	BOULDER RIVER, town of Boulder to Cottonwood Creek	Copper, Iron, Lead, Silver, Zinc
MT41E001_030	BOULDER RIVER, Cottonwood Creek to the mouth (Jefferson Slough), T1N R3W S2	Arsenic, Cadmium, Copper, Lead, Zinc
MT41E002_020	CATARACT CREEK, headwaters to mouth (Boulder River)	Arsenic, Cadmium, Copper, Lead, Mercury, Zinc
MT41E002_061	ELKHORN CREEK, headwaters to Wood Gulch	Arsenic, Cadmium, Copper, Lead, Zinc
MT41E002_062	ELKHORN CREEK, Wood Gulch to the mouth (Unnamed Canal/Ditch), T5N R3W S21	Cadmium, Copper, Lead, Zinc
MT41E002_040	HIGH ORE CREEK, headwaters to mouth (Boulder River)	Arsenic, Cadmium, Copper, Lead, Mercury, Zinc
MT41E002_080	LITTLE BOULDER RIVER, headwaters to mouth (Boulder River)	Copper, Zinc
MT41E002_050	LOWLAND CREEK, headwaters to mouth (Boulder River)	Aluminum, Copper, Silver
MT41E002_100	MUSKRAT CREEK, headwaters to mouth (Boulder River)	Copper, Lead
MT41E002_010	UNCLE SAM GULCH, headwaters to mouth (Cataract Creek)	Arsenic, Cadmium, Copper, Lead, Zinc

* Impairment causes have been modified based on the information presented within this document and summarized below.

5.3 Information Sources and Assessment Methods

DEQ used the following information sources for describing water quality and metals loading conditions in the planning area:

- The monitoring and assessment database compiled by DEQ for the Boulder-Elkhorn TPA
- United States Geological Survey (USGS), National Water Information System (NWIS) database of surface water chemistry and discharge
- United States Environmental Protection Agency (EPA) STORET database of surface water chemistry and stream discharge
- State agency databases and GIS layers of inventoried mining properties and mining and milling disturbances
- DEQ discharge permit program files for active mines and mine-related facilities
- EPA remedial investigations and feasibility studies identifying remediation and removal action options for metal mining sources in the Boulder River watershed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
- Federal and state government agency geographical information system (GIS) data for geology, topography, land cover, and land-use layers
- 2011 National Agricultural Imagery Program (NAIP) Aerial photos
- DEQ historical narratives of mining and milling activities

DEQ's monitoring and assessment record (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2010) is the principal basis for stream impairment listings. Most of the metals impairments are based on water column chemistry data collected by DEQ or its contractors from 2009 through 2011. Sediment chemistry data, collected by DEQ monitoring and assessment field crews during 2009 and 2010, is available from 36 samples collected from metals-listed streams or their tributaries under low flow conditions. Sediment chemistry data from four sites on Uncle Same Gulch are available from a 1997 USGS investigation. DEQ assessment data was supplemented by STORET and NWIS data collected between 2001 and 2011.

DEQ's Office of Information Technology (OIT) has compiled a host of GIS layer files representing the approximate locations of potential metals loading sources inventoried by various state and federal natural resource agencies. These include inventoried abandoned mines, mills, and ore processing sites, priority abandoned mines, and Montana Pollutant Discharge Elimination Systems permit sites. In addition, OIT maintains a GIS directory of physical and cultural land features that include topography, hydrography, land cover categories, transportation infrastructure, and land ownership, These layers, combined with interpretation of 2011 NAIP aerial imagery, are used to help identify significant sources of metals loading from mining and other sources.

DEQ's Permitting and Compliance Division administers two programs for discharges of process wastewater and stormwater to state surface waters and groundwater. The Montana Pollutant Discharge Elimination System (MPDES) program issues both individual and general permits for discharges to surface water; the Montana Ground Water Pollution Control System (MGWPCS) program issues permits for discharges to groundwater. Both programs maintain compliance monitoring databases and inspection records. Hardrock mines and mill operations which are not exempted as small miners are required to obtain an operating permit from DEQ's Environmental Management Bureau. The permits typically contain wastewater treatment specifications and surface water and groundwater monitoring requirements for permitted facilities with wastewater discharges.

Projects carried out under CERCLA authority are described in remediation feasibility assessments and periodic project updates describing the nature and scope of pollutant removal and disposal actions. EPA listed the Basin Mining Area on the Superfund National Priorities List on October 22, 1999, because of the exposure risk from mining wastes within the town of Basin and mine drainage and waste problems in the Basin Creek and Cataract Creek watersheds. CERCLA support documents provide details of major mining-related loading sources, remediation options, and continued environmental risks.

DEQ's Remediation Division has compiled historical narratives of metal mine developments describing the timing, nature, and production levels of mining and milling properties in Montana's mining districts. The narratives are used to describe the level of disturbance and likely pollutant sources at specific properties.

Based on the review of water quality data, geographic information, and project reports and narratives, potential sources of metals loading in the Boulder Elkhorn TPA include:

- natural background sources from mineralized bedrock
- abandoned mine adit discharges
- runoff erosion and precipitation seepage from sulfide waste rock and tailings accumulations at abandoned mines
- sulfide sediment deposits in stream channels and floodplains from abandoned mines
- point source discharges from permitted facilities.

5.3.1 Natural Background Loading

Natural background loading of metals is influenced by flow rate, and to a lesser degree, by bedrock geology. The quality of runoff water reflects the influences of a melting snowpack and the entrainment of suspended sediment from hillslope and streambank erosion that accompanies high flows. Variability in the bedrock geology (**Appendix A**, **Figure A-4**) affects the degree of exposure and weathering rate of sulfide minerals that lowers pH and increases surface water metals concentrations. The sampling and analysis plan developed for stream assessments in 2009 (Montana Department of Environmental Quality, 2009) identified a number of sampling sites remote from mining sources. Subsequent sampling in 2010 revisited these sites, and in some cases, adjusted the locations to better describe loading with minimal mining influence. Sixteen sites are selected as representing natural background conditions. These sites occur within two broad geologic settings: those on the granitic intrusive bedrock of the Boulder Batholith and sites on volcanic bedrock. **Table 5-2** lists median values for metal pollutant parameters measured in samples from sites representing natural background concentrations. Water quality data from the 16 sites are stratified in **Table 5-2** by geologic setting and flow condition. Complete water column chemistry results for selected natural background sites are contained in **Appendix E** by stream segment.

Table 5-2 Median metal concentrations for natural background sites stratified by geology and flow condition

Geology/Flow Condition	Site Identification Codes	Al (µg/L)	As (µg/L)	Cd (µg/L)	Cu (µg/L)	Fe (µg/L)	Pb (µg/L)	Hg (µg/L)	Zn (µg/L)
Boulder Batholith/High Flow	M07BASNC01 M07BASNC02 BE-36 BE-53 BE-74 M07BISNC01 M07BLMBG01 M07JACKC02 M07LBLDR01 M07LBNFR02 M07LOWLC04 M07UCLSG01	**110**	3	**< 0.08**	**4**	235	**< 0.5**	< 0.005	**< 10**
Boulder Batholith/Low Flow		30	3	**< 0.08**	**2**	265	**< 0.5**	< 0.005	< 10
Volcanics/High Flow	BE-28 M07ELKHC01 M07MSKRC01 M07MSKRC02	40	3	< 0.08	2	245	< 0.5	< 0.005	< 10
Volcanics/Low Flow		30	4	< 0.08	1	50	< 0.5	< 0.005	< 10

The bolded values in **Table 5-2** correspond to the metal parameters where at least one target exceedance occurred in the data set. Regardless of flow condition, no water quality analysis results exceed metals targets among the background sites on volcanic bedrock. Areas underlain by volcanic bedrock occur in the Lowland Creek watershed, in the portion of the Boulder River drainage upstream of Lowland Creek, and in Elkhorn, and Muskrat creeks.

Exceedances of aluminum and copper targets are common during high streamflow at background sites on the granitic batholith. With the exceptions of aluminum and copper, median metal concentrations during high flows are within target values. Although, exceedances of cadmium, iron, and lead targets also occur on granitic terrain under both flow conditions, they are less frequent than those for aluminum and copper and median values are less than the most restrictive target. No samples from background sites exceeded arsenic, mercury, or zinc targets. The data suggest that natural background concentrations of aluminum and copper in surface waters draining the granitic Boulder Batholith may periodically exceed numeric water quality standards. Further monitoring of high-flow aluminum and copper concentrations is needed to confirm whether natural background concentrations routinely exceed targets in granitic watersheds.

The locations of the 16 natural background sites are highlighted in green in **Figure 5-2**. The sites occur in headwater reaches that are generally upstream of mining sources and are selected to represent a condition of minimal human-caused metals loading. Until disproven by future monitoring, loading from natural background sources is assumed to be within water quality standards.

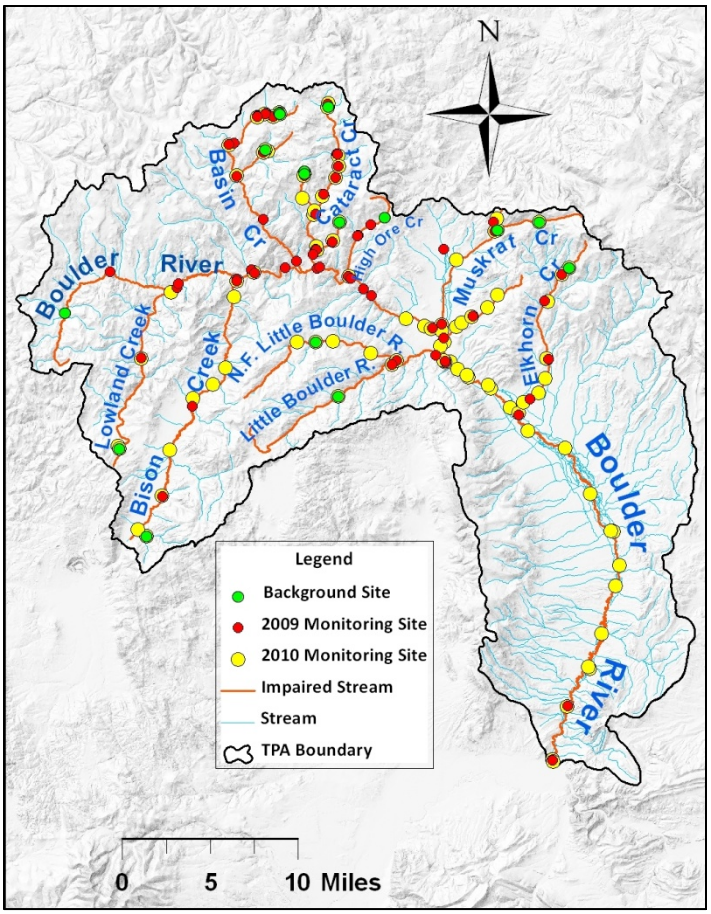

Figure 5-2. Stream monitoring sites during 2009, 2010, and selected natural background sites in the Boulder-Elkhorn TPA

When possible, background loading is accounted for separately from human-caused sources. The selected monitoring sites on which the background loading is based are identified in the allocation discussion for each stream. Median values for water column metals concentrations from selected background sites are used to develop load allocations for natural background sources when several values are available for a given metal parameter. Single values for metal concentration are also used to calculate natural background loads when they constitute the entire data set for a metal parameter. Because past mining for metals has affected nearly the entire length of metals impaired streams, load allocations to natural background sources cannot always be expressed separately from human caused sources. Regardless of the allocation scheme, the underlying assumption is that natural background sources alone would not exceed the target metals concentrations in the water column, or the PELs in sediment. If future monitoring disproves this assumption, metals loading analyses may need revision per the adaptive management strategy described in **Section 5.9**

5.3.2 Loading from Mining Sources

The following information provides a general summary of mining history and associated metals loading throughout the watershed. A stream-by-stream review of metals loading sources is contained in **Appendix F**.

Mining in the Boulder-Elkhorn TPA began with the discovery of placer gold deposits in a number of streams draining from the continental divide, southward, to the Boulder River near the town of Basin. Placer mining in Basin Creek, Cataract Creek, High Ore Creek, and the Boulder River began in the early 1860s (Wolle, 1963). Placer operations also occurred during the same period on Elkhorn and Lowland creeks.

When placer deposits were depleted, the 1880s saw development of polymetallic vein lode deposits along geologic contacts, faults, and shear zones. Significant lode discoveries coincided with the arrival of the Northern Pacific Railroad which aided in constructing several large smelters and the development of larger mines. The largest producers include the Eva May, Morning Glory, and Grey Eagle mines in Cataract Creek; the Bullion and Crystal mines in Jack Creek and Uncle Sam Gulch; and the Comet Mine in High Ore Creek. Construction of several smelters in the Colorado District near the town of Wickes resulted in a local mining boom that lasted a decade until the silver panic of 1893 forced many of the mines to close (Becraft et al., 1963). Since 1900, most mining in the area consisted of small-scale operations with limited capital and equipment working old tailings and waste dumps. The Comet district was an exception to this trend. With joint development of the Comet and Grey Eagle mines, ore concentrates were shipped to the smelter at Wickes, and later to the smelter at East Helena. At its peak during the 1920s and 1930s, the Comet Mine was second in size only to the Anaconda Copper operations at Butte. The Comet Mine and mill have been abandoned since the 1940s (Anderson and Sommer, 1990).

During the above periods, tailings were often impounded in and adjacent to stream courses. Breached tailings impoundments have delivered tens of thousands of cubic yards of tailings to downstream reaches and floodplain areas of Jack Creek, Basin, Cataract, High Ore Creek, and Elkhorn creeks, and the lowest three segments of the Boulder River. Large flood events have also contributed to the downstream channel and floodplain distribution of contaminated tailings and other mine wastes throughout the Boulder River watershed.

From 1989 through 1991, the Pegasus Gold Corporation operated a cyanide heap leach process for gold recovery at the Basin Creek Mine in the headwaters of Basin Creek. When mining ceased, the Luttrell Pit portion of the mine was used as a repository for mining wastes removed from other inactive mines in the area. The repository consists of several cells, each with its own liner and leachate collection system (Smith et al., 2004). To date, approximately 650,000 cubic yards of mine wastes have been placed in the Luttrell Repository. Capacity remains for an additional 300,000 cubic yards.

DEQ and the Montana Bureau of Mines and Geology databases for abandoned and inactive mines identify about 370 abandoned mine sites within the Boulder-Elkhorn TPA. DEQ's, Mine Waste Cleanup Bureau classified 29 as "priority" mines, which means they are a source of high public concern because of severe environmental degradation caused by heavy metal and mineral processing reagent contamination of surface water and groundwater (Montana Department of State Lands, 1995).

Environmental data describing individual loading contributions from abandoned mines is typically insufficient to guide allocations for each individual abandoned mine. Where data is adequate, wastewater discharges from abandoned mines are assigned wasteload allocations (WLA). Contributions from other abandoned mine sources are more commonly included in composite WLAs for mining sources associated with a specific property or drainage area. These allocation approaches assume that reductions in metals loading can be accomplished by treating the discharges and remediating or removing solid waste sources at abandoned mines.

5.3.3 Loading from Permitted Surface and Groundwater Point Sources

The Integrated Compliance Information System (ICIS) is an EPA database for reporting and tracking federal environmental enforcement cases and tracking the compliance records of permitted discharging facilities. **Table 5-3** contains information on the 12 permitted facilities, with conceivable discharges to surface water, listed in the ICIS database for the Boulder-Elkhorn TPA. The discharges include private and municipal sewage disposal and stormwater from mining and construction activities.

Table 5-3. Permitted point sources in the Boulder-Elkhorn TPA

Permit ID	Facility Name	Permit Type	Nearest Waterbody (Waterbody ID)	Number of Outfalls	Disturbed Acres
MT0023078	TOWN OF BOULDER WWTF	Individual MPDES	Boulder River (MT41E001_022)	1	NA
MT0023639	BOULDER HOT SPRINGS WWTP	Individual MPDES	Little Boulder River (MT41E002_080)	1	NA
MTG370313	CARLSON RANCH SUCTION DREDGE	GPSD[1]	Lowland Creek (MT41E002_050)	1	< 5
MTG370269	PARKER SUCTION DREDGE	GPSD	Lowland Creek (MT41E002_050)	1	< 5
MTG370320	SNOWDRIFT DREDGE MINING	GPSD	Snowdrift Creek (tributary to Cataract Creek MT41E002_020)	1	< 5
MTG370322	MIDSUMMER DREAM BOULDER RIVER	GPSD	Boulder River (MT41E001_021)	1	< 5
MTR103333	GILMAN EXCAVATING - CARLSON PIT	SGPCA[2]	Red Rock Creek (tributary to Boulder River MT41E001_010)	1	8
MTR103698	MDOT ELKHORN ROAD SOUTH ARRA 69 1 27 22	SGPCA	Boulder River (MT41E001_022)	2	< 5
MTR103724	AM WELLES - COMPTON SITE	SGPCA	Boulder River (MT41E001_022)	1	16
MTR103727	PUMCO - MDT CAREY BORROW	SGPCA	Boulder River (MT41E001_022)	1	12
MTR103757	MCALVAIN CONSTRUCTION - BIG BOULDER RESIDENCES	SGPCA	Boulder River (MT41E001_022)	1	< 5
MTR300264	ELKHORN GOLDFIELDS INC ELKHORN MINE SITE	SGPMA[3]	Upper Elkhorn Cr. (MT41E002_061)	2	

[1] GPSD = General Permit, Suction Dredge
[2] SGPCA = Stormwater General Permit, Construction Activity
[3] SWGPMA = Stormwater General Permit, Mining Activity

In addition to the permitted facilities identified in **Table 5-3**, Elkhorn Goldfields holds operating permit number 00173, issued by DEQ's, Environmental Management Bureau for an underground gold mine near the town of Elkhorn. The mine operation plan proposes to discharge from 150 - 300 gallons per minute from three mine dewatering wells to groundwater through a subsurface drainfield. Analysis of groundwater samples from the proposed dewatering wells indicates the possibility of elevated arsenic, copper, and nitrogen concentrations in the discharge. The operating permit contains both surface water and groundwater monitoring requirements on a variable frequency during the first 8 weeks of the discharge and quarterly thereafter. The parameter list includes standard field parameters, common ions, metals, and nutrients. Elkhorn Goldfields, Inc. also holds a general stormwater permit for mining activity for its Elkhorn Mine (No. MTR300264 in **Table 5-3**). The permit covers two stormwater outfalls to Elkhorn Creek.

Also in addition to the **Table 5-3** permitted facilities, the O.T. Mining Corporation holds MGWPCS permit number MTX000014 to discharge wastewater from its floatation mill tailings impoundment to groundwater. The permit grants a groundwater mixing zone that extends 150 feet down-gradient (southwest) of the source. The permit contains effluent concentration limits for specific conductance, NO_3+NO_2-N, and metal parameters. Groundwater monitoring is required during mill operation, although the mill has not operated since 1989. **Figure 5-3** shows the locations of permitted point sources in the Boulder-Elkhorn TPA.

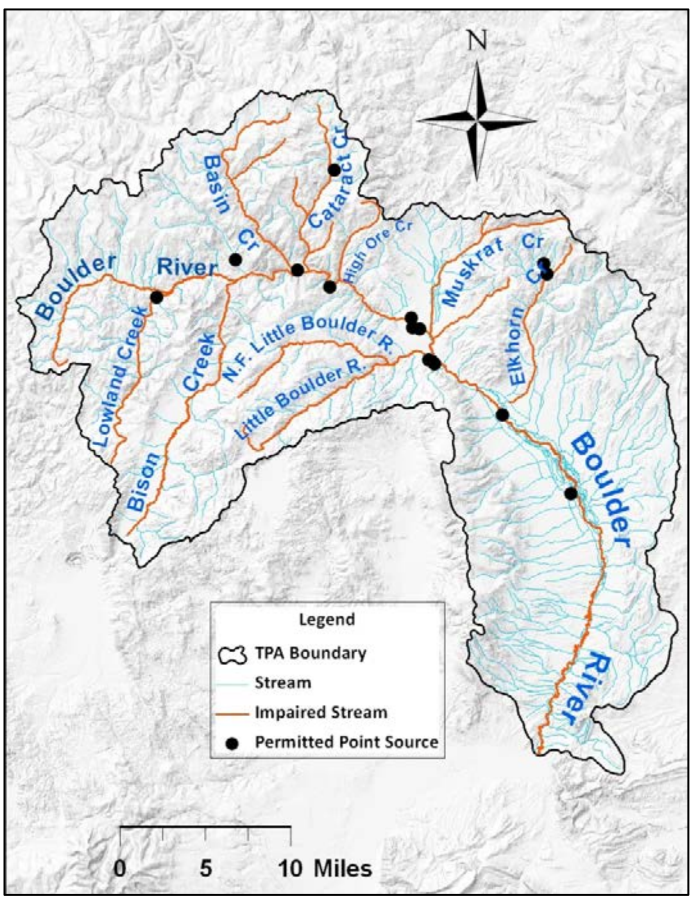

Figure 5-3. Permitted point sources in the Boulder-Elkhorn TPA

Permitted point source discharges with reasonable potential to affect surface water quality for metals are provided a wasteload allocation if they discharge directly to surface water, and a load allocation if the discharge is to groundwater and any potential loading to surface water would be via diffuse groundwater loading pathways. As an example, the wasteload allocation under a specific discharge flow to surface water is calculated using the following formula:

WLA_{MPDES} = (X) (Y) (k)

Where:

WLA= Wasteload Allocation to MPDES (Montana Pollutant Discharge Elimination System) permitted discharges

X= the lowest applicable (most restrictive) instream metals water quality target in ug/l

Y= discharge flow in gallons per day

k = conversion factor

The above equation and resulting wasteload allocations are consistent with the reasonable assurance approach defined within **Section 4.4**. More details regarding the two **Table 5-3** MPDES permitted facility wasteload allocations are provided in **Sections 5.7.11** and **5.7.15**.

A suction dredge facility operated under a general permit is given a zero wasteload allocation for all metals pollutants based on the assumption that dredge operations performed according to the conditions of the general permit will not be a source of metals loading to the nearest stream. Similarly, a facility with construction activity covered by a stormwater general permit will also be given a zero wasteload allocation based on the assumption that meeting the conditions of the stormwater permit will effectively eliminate metals loading to nearby streams during storm events.

Appendix F also includes discussion of permitted point sources within each applicable watershed.

5.4 Water Quality Targets and Supplemental Indicators

Montana's established criteria for numeric water quality are adopted as the water quality targets for metal pollutants in this document. These values are published in Circular DEQ-7 (Montana Department of Environmental Quality, 2010a). Circular DEQ-7 contains acute aquatic life and chronic aquatic life criteria (designed to protect aquatic life uses) and the human health criteria (designed to protect drinking water uses. TMDLs are calculated using the most stringent target value to ensure protection of all designated beneficial uses.

DEQ has established an assessment method for determining water quality impairment caused by elevated metals concentrations (Montana Department of Environmental Quality,2011). The method includes guidelines for making use-support decisions based on water column metals data. Numeric metals criteria established to protect aquatic life are different from those established to protect human health. In general, an exceedance rate of 10 % or less of the chronic aquatic life criteria represents compliance with the numeric criteria and support for aquatic life. The 10 % guideline is not applied for datasets containing a result that is more than twice the acute aquatic life criteria. A single exceedance of this magnitude warrants a conclusion of aquatic life impairment. No exceedances are allowed when assessing compliance with human health criteria. Thus, the drinking water use for a waterbody can be impaired while full support remains for aquatic life uses. Compliance with chronic aquatic life criteria is based on an average water quality metals concentration during a 96 hour period. The 1-hour average concentration in surface water may not exceed the a*cute* aquatic life water quality criteria more than once in any 3- year period. The presence of human-caused loading sources is critical to making impairment conclusions.

The metals assessment method recommends that impairment decisions be based on a minimum of eight samples collected from within the same assessment reach. An impairment decision may be based on fewer samples, but caution should be taken against false use support conclusions. In general, data from the last 10 years is considered when making attainment decisions for aquatic life and drinking water uses. Older data may be useful for developing a historical reference or for loading analysis when more recent dataset is unavailable. Although samples can be taken any time of the year, 33 % of the dataset should be from samples collected during high-flow conditions, with the remaining samples collected during base-flow conditions. At a minimum, a metals sampling suite should include analysis for total recoverable metals and dissolved aluminum. Although not required for making use-attainment decisions, dissolved concentrations for metals other than aluminum and sediment metal concentrations may be useful for identifying sources.

To summarize, the metals assessment method specifies that the maximum allowable exceedance rate for the chronic aquatic life criteria is 10 % of samples collected using a sound monitoring design that includes representative and independent samples under both high and low flow conditions. No human health exceedances or exceedances greater than twice the acute aquatic life criteria are allowed. Where the numeric criteria apply to protection of both aquatic life and human health, the most restrictive value is adopted as the water quality target. Some of the aquatic life criteria for metals are dependent on water hardness and adjust with changes in hardness. The presence of human-caused sources is required to conclude impairment.

5.4.1 Water Column Metals Concentration Targets

Water column metals concentration targets are the acute aquatic life (AAL), chronic aquatic life (CAL) and human health (HH) criteria. The criteria are dissolved concentrations of aluminum, and total recoverable concentrations of all other metal parameters (Montana Department of Environmental Quality, 2010a). The acute and chronic aquatic life criteria for cadmium, copper, lead, silver, and zinc increase with increasing hardness. **Table C2-2,** in **Appendix C** contains the aquatic life and human health criteria for these metals at hardness values of 25 and 100 mg/L. **Appendix C**, **Table C2-2** also contains the aquatic life and human health criteria for those metals not affected by water hardness, including aluminum, arsenic, mercury, and iron.

The human health criteria given in Circular DEQ-7 for iron (300 µg/L) and manganese (50 µg/L) are based on secondary maximum contaminant levels (MCL) established by EPA to prevent unwanted tastes, odors, or staining. These values provide a guide for determining interference with the specified uses after conventional water treatment. DEQ assumes that the concentrations of iron and manganese present in listed waterbodies after conventional treatment would not consistently exceed the MCLs. Therefore, the chronic aquatic life criterion of 1,000 µg/L is the water quality target for iron. Since there are no aquatic life criteria for manganese and no manganese impairment in the Boulder-Elkhorn TPA, manganese targets are not developed in this document.

5.4.2 Supplemental Indicators

Compared with established numeric criteria for metals, selecting the value of a supplemental indicator that denotes use impairment is more uncertain. Therefore, exceedance of a selected maximum value for a supplemental indicator does not automatically equate to use impairment. The number and magnitude of supplemental indicator exceedances are considered together with those for numeric target criteria when evaluating use support. In most cases, a combination of target departure analysis, meaningful qualitative observations, and sound professional judgment is applied in each assessment of TMDL development needs.

The general prohibitions in Montana's water quality standards (ARM 17.30.637) apply to additions of pollutants in sediment at harmful or toxic concentrations. Sediment chemistry data are available for 40 samples from the planning area and sediment concentration guidelines are used here as supplemental indicators of water quality problems. Sediment metals concentration data are contained in **Appendix D**. The National Oceanic and Atmospheric Administration (NOAA) has developed Screening Quick Reference Tables that contain metals concentration guidelines for freshwater and marine sediments (Buchman, 2008). The screening criteria, developed from a variety of toxicity studies, are expressed as Probable Effects Levels (PELs) in **Table 5-4**.

Table 5-4. Screening criteria for sediment metals concentrations used as supplemental indicators

Metal Parameter	PEL (µg/g dry weight)
Arsenic	17
Cadmium	3.53
Copper	197
Lead	91.3
Mercury	0.486
Zinc	315

PELs represent the sediment concentrations above which toxic effects frequently occur. PELs are used here as a screening tool to identify potential impacts to aquatic life.

5.4.3 Targets, Supplemental Indicators, and the Need for TMDLs

The following discussion describes the decision factors, together with targets, used to determine whether current water quality conditions require TMDL development. The metals targets and supplemental indicators are summarized in **Table 5-5**.

Table 5-5. Targets and Supplemental Indicators for the Boulder-Elkhorn TPA

Target Parameter	Criterion
Water Column Metal Pollutant Concentration	Montana Water Quality Standards, Circular DEQ 7 (Montana Department of Environmental Quality, 2010a)
Supplemental Indicators	**Criterion**
NOAA Quick Reference Table for Inorganics in Freshwater Sediment	Probable Effects Limits (PELs) (Buchman, 2008)

The need to develop metals TMDLs is based on the assumption that naturally occurring metals concentrations in surface water are less than the most restrictive numeric standard under both high- and low- flow conditions. Where available background data suggests that targets may be exceeded under naturally occurring conditions, additional monitoring may be needed to better distinguish between natural background and human-caused loading. Adaptive management can direct future refinement of a broadly allocated TMDL.

TMDL development decisions are guided by the following factors:

- the clear presence of human-caused metal loading sources
- the number and age of available metal analysis results obtained for each stream segment
- the rate and magnitude of target and supplemental indicator exceedances
- the status of the impairment listing as either current for 2012 or as a new listing.

The current method of assessing metals impairment for surface waters (Montana Department of Environmental Quality, Water Quality Planning Bureau, Montioring and Assessment Section, 2012) recommends a minimum of eight recent analytical results. Recent data are those obtained for samples collected within the past 10 years. Current pollutant causes are those that appear in the Water Quality Integrated Report for 2012 (Montana Department of Environmental Quality, 2012). New pollutant causes are those that are absent from the 2012 Integrated Report (Montana Department of Environmental Quality, 2012), but are identified after review of recent data from an adequate dataset. New pollutant causes will appear in the Water Quality Integrated Report for 2014.

The following scenarios apply to current pollutant causes for streams with known human-caused sources. Each scenario describes how the rate and magnitude of target exceedances are interpreted to determine the need for metals TMDLs:

Greater than 10 % of recent analytical results exceed CAL concentration targets (AAL is used for Silver since Silver does not have a CAL).

- The 10 % target exceedance threshold is not met, but the available dataset has fewer than 8 recent results.
- At least one analytical result in a recent dataset exceeds the HH target.
- At least one analytical result in a recent dataset is greater than twice the AAL target.
- Although targets are not exceeded, water column metals concentrations are elevated under both high and low flows and sediment metals concentrations greatly exceed PELs.

Despite the presence of human-caused sources, metals TMDLs are not developed for currently listed streams if targets and supplemental indicators are met by an adequate and recent dataset. Metals TMDLs are developed for streams without current metals impairment causes when known human-caused sources are present and compliance thresholds for aquatic life and human health targets are exceeded in a recent and adequately sized dataset.

Additional monitoring is recommended in lieu of TMDL development, for either listed or unlisted streams, if fewer than 2 target exceedances occur for any parameter among a dataset containing less than 8 results for that parameter. Additional monitoring may also be recommended in lieu of TMDLs for unlisted streams if background conditions appear to exceed water quality targets and a clear link cannot be made to known human-caused sources.

5.5 Existing Condition and Comparison with Water Quality Targets

The decision factor analysis and TMDL conclusions are summarized below for each stream segment in **Tables 5-6 - 5-22**. The water quality and sediment data on which TMDL decisions are based are given by stream segment in **Appendices D and E.** The recent water quality record for each pollutant impaired stream segment in the planning area is compared with the metal targets and supplemental indicators listed above in **Table 5-5**. The results of the comparison are stated in terms of the TMDL development decision factors described in **Section 5.4.3**.The stream-by-stream review of metals loading sources and comparison of water quality data with targets and supplemental indicators is contained in **Appendix F**.

Table 5-6. Metals decision factors and TMDL conclusions for Basin Creek

Pollutant Parameter	CAL Exceedance Rate > 10%*	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded	Parameter Listing in 2012	TMDL Conclusion
Aluminum	Y	N	NA	Y	Na	N	Al TMDL
Arsenic	N	N	Y	Y	Y	Y	As TMDL
Cadmium	Y	N	N	Y	Y	N	Cd TMDL
Copper	Y	Y	N	Y	Y	Y	Cu TMDL
Iron	N	NA	NA	Y	NA	N	No TMDL
Lead	Y	N	N	Y	Y	Y	Pb TMDL
Mercury	N	N	N	Y	Y	Y	No TMDL
Silver	N	N	N	Y	NA	N	No TMDL
Zinc	Y	Y	N	Y	Y	Y	Zn TMDL

* AAL is used for Silver since Silver does not have a CAL

Table 5-7. Metals decision factors and TMDL conclusions for Big Limber Gulch

Pollutant Parameter	CAL Exceedance Rate > 10%*	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded	Parameter Listing in 2012	TMDL Conclusion
Aluminum	N	N	NA	Y	NA	N	No TMDL
Arsenic	N	N	N	Y	Y	N	No TMDL
Cadmium	N	N	N	Y	N	N	No TMDL
Copper	N	N	N	Y	N	N	No TMDL
Iron	N	NA	NA	Y	NA	N	No TMDL
Lead	N	N	N	Y	N	Y	No TMDL
Mercury	N	N	N	Y	N	Y	No TMDL
Silver	N	N	N	Y	NA	N	No TMDL
Zinc	N	N	N	Y	Y	N	No TMDL

* AAL is used for Silver since Silver does not have a CAL

Table 5-8. Metals decision factors and TMDL conclusions for Bison Creek

Pollutant Parameter	CAL Exceedance Rate > 10%*	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded	Parameter Listing in 2012	TMDL Conclusion
Aluminum	N	N	NA	Y	NA	N	No TMDL
Arsenic	N	N	Y	Y	Y	N	As TMDL
Cadmium	N	N	N	Y	N	N	No TMDL
Copper	Y	N	N	Y	N	Y	Cu TMDL
Iron	Y	NA	NA	Y	NA	Y	Fe TMDL
Lead	N	N	N	Y	N	N	No TMDL
Mercury	N	N	N	Y	Y	N	No TMDL
Silver	N	N	N	Y	N	N	No TMDL
Zinc	N	N	N	Y	N	N	No TMDL

* AAL is used for Silver since Silver does not have a CAL

Table 5-9. Metals decision factors and TMDL conclusions for the Boulder River, headwaters to Basin Creek

Pollutant Parameter	CAL Exceedance Rate > 10%*	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded	Parameter Listing in 2012	TMDL Conclusion
Aluminum	Y	N	NA	Y	NA	N	No TMDL
Arsenic	N	N	N	Y	Y	N	No TMDL
Cadmium	N	N	N	Y	N	Y	No TMDL
Copper	Y	N	N	Y	N	Y	Cu TMDL
Iron	N	NA	NA	Y	NA	Y	No TMDL
Lead	Y	N	N	Y	N	Y	Pb TMDL
Mercury	N	N	N	Y	Y	N	No TMDL
Silver	N	N	N	Y	N	N	No TMDL
Zinc	N	N	N	Y	N	Y	No TMDL

* AAL is used for Silver since Silver does not have a CAL

Table 5-10. Metals decision factors and TMDL conclusions for the Boulder River, Basin Creek to town of Boulder

Pollutant Parameter	CAL Exceedance Rate > 10%*	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded	Parameter Listing in 2012	TMDL Conclusion
Aluminum	N	N	NA	Y	NA	N	No TMDL
Arsenic	N	N	Y	Y	Y	N	As TMDL
Cadmium	Y	N	N	Y	Y	Y	Cd TMDL
Copper	Y	Y	N	Y	Y	Y	Cu TMDL
Iron	N	NA	NA	Y	NA	Y	No TMDL
Lead	Y	N	N	Y	Y	Y	Pb TMDL
Mercury	N	N	N	Y	Y	N	No TMDL
Silver	N	N	N	Y	N	Y	No TMDL
Zinc	Y	Y	N	Y	Y	Y	Zn TMDL

* AAL is used for Silver since Silver does not have a CAL

Table 5-11. Metals decision factors and TMDL conclusions for the Boulder River, town of Boulder to Cottonwood Creek

Pollutant Parameter	CAL Exceedance Rate > 10%*	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded	Parameter Listing in 2012	TMDL Conclusion
Aluminum	Y	N	NA	Y	NA	N	No TMDL
Arsenic	N	N	Y	Y	Y	N	As TMDL
Cadmium	Y	N	N	Y	Y	N	Cd TMDL
Copper	Y	Y	N	Y	Y	Y	Cu TMDL
Iron	Y	NA	NA	Y	NA	Y	Fe TMDL
Lead	Y	N	Y	Y	Y	Y	Pb TMDL
Mercury	N	N	N	Y	Y	N	No TMDL
Silver	N	N	N	Y	NA	Y	No TMDL
Zinc	Y	N	N	Y	Y	Y	Zn TMDL

* AAL is used for Silver since Silver does not have a CAL

Table 5-12. Metals decision factors and TMDL conclusions for the Boulder River, Cottonwood Creek to mouth

Pollutant Parameter	CAL Exceedance Rate > 10%*	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded	Parameter Listing in 2012	TMDL Conclusion
Aluminum	N	N	NA	Y	NA	N	No TMDL
Arsenic	N	N	Y	Y	Y	Y	As TMDL
Cadmium	Y	N	N	Y	Y	Y	Cd TMDL
Copper	Y	Y	N	Y	N	Y	Cu TMDL
Iron	Y	NA	NA	Y	NA	N	Fe TMDL
Lead	Y	N	N	Y	N	Y	Pb TMDL
Mercury	N	N	N	Y	Y	N	No TMDL
Silver	N	N	N	Y	NA	N	No TMDL
Zinc	Y	N	N	Y	Y	Y	Zn TMDL

* AAL is used for Silver since Silver does not have a CAL

Table 5-13. Metals decision factors and TMDL conclusions for Cataract Creek

Pollutant Parameter	CAL Exceedance Rate > 10%*	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded	Parameter Listing in 2012	TMDL Conclusion
Aluminum	Y	N	NA	Y	NA	N	Al TMDL
Arsenic	N	N	Y	Y	Y	Y	As TMDL
Cadmium	Y	Y	N	Y	Y	Y	Cd TMDL
Copper	Y	Y	N	Y	Y	Y	Cu TMDL
Iron	N	NA	NA	Y	NA	N	No TMDL
Lead	Y	N	Y	Y	Y	Y	Pb TMDL
Mercury	N	N	N	Y	Y	Y	No TMDL
Silver	N	N	N	Y	NA	N	No TMDL
Zinc	Y	Y	N	Y	Y	Y	Zn TMDL

* AAL is used for Silver since Silver does not have a CAL

Table 5-14. Metals decision factors and TMDL conclusions for Elkhorn Creek, headwaters to Wood Gulch

Pollutant Parameter	CAL Exceedance Rate > 10%*	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded	Parameter Listing in 2012	TMDL Conclusion
Aluminum	N	N	NA	NA	NA	N	No TMDL
Arsenic	N	N	Y	Y	NA	Y	As TMDL
Cadmium	Y	N	N	Y	NA	Y	Cd TMDL
Copper	Y	N	N	Y	NA	Y	Cu TMDL
Iron	Y	NA	NA	Y	NA	N	Fe TMDL
Lead	Y	N	N	Y	NA	Y	Pb TMDL
Mercury	N	N	N	Y	NA	N	No TMDL
Silver	N	N	N	Y	NA	N	No TMDL
Zinc	N	N	N	Y	NA	Y	No TMDL

* AAL is used for Silver since Silver does not have a CAL

Table 5-15. Metals decision factors and TMDL conclusions for Elkhorn Creek, Wood Gulch to mouth

Pollutant Parameter	CAL Exceedance Rate > 10%*	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded	Parameter Listing in 2012	TMDL Conclusion
Aluminum	N	N	NA	Y	NA	N	No TMDL
Arsenic	N	N	Y	Y	Y	N	As TMDL
Cadmium	Y	N	N	Y	Y	Y	Cd TMDL
Copper	N	N	N	Y	N	Y	No TMDL
Iron	N	NA	NA	Y	NA	N	No TMDL
Lead	Y	N	Y	Y	Y	Y	Pb TMDL
Mercury	N	N	N	Y	N	N	No TMDL
Silver	N	N	N	Y	NA	N	No TMDL
Zinc	N	N	N	Y	Y	Y	No TMDL

* AAL is used for Silver since Silver does not have a CAL

Table 5-16. Metals decision factors and TMDL conclusions for High Ore Creek

Pollutant Parameter	CAL Exceedance Rate > 10%*	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded	Parameter Listing in 2012	TMDL Conclusion
Aluminum	N	N	NA	Y	NA	N	No TMDL
Arsenic	N	N	Y	Y	Y	Y	As TMDL
Cadmium	Y	N	Y	Y	Y	Y	Cd TMDL
Copper	Y	N	N	Y	Y	Y	Cu TMDL
Iron	N	NA	NA	Y	NA	N	No TMDL
Lead	Y	N	Y	Y	Y	Y	Pb TMDL
Mercury	N	N	N	Y	Y	Y	No TMDL
Silver	N	N	N	Y	NA	N	No TMDL
Zinc	Y	Y	N	Y	Y	Y	Zn TMDL

* AAL is used for Silver since Silver does not have a CAL

Table 5-17. Metals decision factors and TMDL conclusions for Jack Creek

Pollutant Parameter	CAL Exceedance Rate > 10%*	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded	Parameter Listing in 2012	TMDL Conclusion
Aluminum	Y	N	NA	Y	NA	NA	Al TMDL
Arsenic	N	N	Y	Y	NA	NA	As TMDL
Cadmium	Y	Y	N	Y	NA	NA	Cd TMDL
Copper	Y	Y	N	Y	NA	NA	Cu TMDL
Iron	N	NA	NA	Y	NA	NA	Fe TMDL**
Lead	Y	N	Y	Y	NA	NA	Pb TMDL
Mercury	N	N	N	Y	NA	NA	No TMDL
Silver	N	N	N	Y	NA	NA	No TMDL
Zinc	Y	Y	N	Y	NA	NA	Zn TMDL

* AAL is used for Silver since Silver does not have a CAL
* As noted in **Section F2.2.2** in **Appendix F**, iron was considered impaired based on the magnitude of the exceedance in relation to the CAL and because of the number of samples at concentrations just below the CAL.

Table 5-18. Metals decision factors and TMDL conclusions for Little Boulder River, headwaters to mouth

Pollutant Parameter	CAL Exceedance Rate > 10%*	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded	Parameter Listing in 2012	TMDL Conclusion
Aluminum	Y	N	NA	Y	NA	N	Al TMDL
Arsenic	N	N	N	Y	Y	N	No TMDL
Cadmium	N	N	N	Y	N	N	No TMDL
Copper	Y	Y	N	Y	N	Y	Cu TMDL
Iron	Y	NA	NA	Y	NA	N	Fe TMDL
Lead	Y	N	N	Y	N	N	Pb TMDL
Mercury	N	N	N	Y	Y	N	No TMDL
Silver	N	N	N	Y	NA	N	No TMDL
Zinc	N	N	N	Y	N	Y	No TMDL

* AAL is used for Silver since Silver does not have a CAL

Table 5-19. Metals decision factors and TMDL conclusions for Lowland Creek

Pollutant Parameter	CAL Exceedance Rate > 10%*	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded	Parameter Listing in 2012	TMDL Conclusion
Aluminum	Y	N	N	Y	NA	Y	Al TMDL
Arsenic	N	N	N	Y	Y	N	No TMDL
Cadmium	N	N	N	Y	N	N	No TMDL
Copper	Y	Y	N	Y	N	Y	Cu TMDL
Iron	N	NA	NA	Y	NA	N	No TMDL
Lead	Y	N	N	Y	N	N	Pb TMDL
Mercury	N	N	N	Y	N	N	No TMDL
Silver	N	N	N	Y	NA	Y	No TMDL
Zinc	N	N	N	Y	N	N	No TMDL

* AAL is used for Silver since Silver does not have a CAL

Table 5-20. Metals decision factors and TMDL conclusions for Muskrat Creek

Pollutant Parameter	CAL Exceedance Rate > 10%*	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded	Parameter Listing in 2012	TMDL Conclusion
Aluminum	N	N	NA	Y	NA	N	No TMDL
Arsenic	N	N	N	Y	NA	N	No TMDL
Cadmium	N	N	N	Y	NA	N	No TMDL
Copper	N	N	N	Y	NA	Y	No TMDL
Iron	Y	NA	NA	Y	NA	N	Fe TMDL
Lead	N	N	N	Y	NA	Y	No TMDL
Mercury	N	N	N	Y	NA	N	No TMDL
Silver	N	N	N	Y	NA	N	No TMDL
Zinc	N	N	N	Y	NA	N	No TMDL

* AAL is used for Silver since Silver does not have a CAL

Table 5-21. Metals decision factors and TMDL conclusions for North Fork Little Boulder River

Pollutant Parameter	CAL Exceedance Rate > 10%*	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded	Parameter Listing in 2012	TMDL Conclusion
Aluminum	Y	N	NA	Y	NA	N	Al TMDL
Arsenic	N	N	N	Y	N	N	No TMDL
Cadmium	N	N	N	Y	N	N	No TMDL
Copper	Y	N	N	Y	N	N	Cu TMDL
Iron	N	NA	NA	Y	NA	N	No TMDL
Lead	N	N	N	Y	N	N	No TMDL
Mercury	N	N	N	Y	N	N	No TMDL
Silver	N	N	N	Y	NA	N	No TMDL
Zinc	N	N	N	Y	N	N	No TMDL

* AAL is used for Silver since Silver does not have a CAL

Table 5-22. Metals decision factors and TMDL conclusions for Uncle Sam Gulch

Pollutant Parameter	CAL Exceedance Rate > 10%*	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded	Parameter Listing in 2012	TMDL Conclusion
Aluminum	Y	N	NA	Y	NA	N	Al TMDL
Arsenic	N	N	Y	Y	Y	Y	As TMDL
Cadmium	Y	Y	Y	Y	Y	Y	Cd TMDL
Copper	Y	Y	Y	Y	Y	Y	Cu TMDL
Iron	N	NA	NA	Y	NA	N	No TMDL
Lead	Y	Y	Y	Y	Y	Y	Pb TMDL
Mercury	N	N	N	Y	N	N	No TMDL
Silver	N	N	N	Y	NA	N	No TMDL
Zinc	Y	Y	Y	Y	Y	Y	Zn TMDL

* AAL is used for Silver since Silver does not have a CAL

5.5.1 TMDL Development Summary

Sixteen stream segments in the Boulder-Elkhorn TPA require development of 70 TMDLs for metals (**Table 5-23**). The metals of concern are aluminum, arsenic, cadmium, copper, iron, lead, mercury, and zinc.

Table 5-23. Metal pollutants requiring TMDLs for streams in the Boulder-Elkhorn TPA

Waterbody Segment ID	Waterbody Segment	Metals Listings in the 2012 Integrated Report	Verified Target Exceedances and TMDL Developed
MT41E002_030	Basin Creek	Arsenic, Copper, Lead, Mercury, Zinc	Aluminum, Arsenic, Cadmium, Copper, Lead, Zinc
MT41E002_140	Big Limber Gulch	Lead, Mercury	None
MT41E002_070	Bison Creek	Copper, Iron	Arsenic, Copper, Iron
MT41E001_010	Boulder River, headwaters to Basin Creek	Cadmium, Copper, Iron, Lead, Zinc	Copper, Lead
MT41E001_021	Boulder River, Basin Creek to Boulder	Cadmium, Copper, Iron, Lead, Silver, Zinc	Arsenic, Cadmium, Copper, Lead, Zinc
MT41E001_022	Boulder River, Boulder to Cottonwood Creek	Copper, Iron, Lead, Silver, Zinc	Arsenic, Cadmium, Copper, Iron, Lead, Zinc

Table 5-23. Metal pollutants requiring TMDLs for streams in the Boulder-Elkhorn TPA

Waterbody Segment ID	Waterbody Segment	Metals Listings in the 2012 Integrated Report	Verified Target Exceedances and TMDL Developed
MT41E001_030	Boulder River, Cottonwood Creek to mouth	Arsenic, Cadmium, Copper, Lead, Zinc	Arsenic, Cadmium, Copper, Iron, Lead, Zinc
MT41E002_020	Cataract Creek	Arsenic, Cadmium, Copper, Lead, Mercury, Zinc	Aluminum, Arsenic, Cadmium, Copper, Lead, Zinc
MT41E002_061	Elkhorn Creek, headwaters to Wood Gulch	Arsenic, Cadmium, Copper, Lead, Zinc	Arsenic, Cadmium, Copper, Iron, Lead
MT41E002_062	Elkhorn Creek, Wood Gulch to mouth	Cadmium, Copper, Lead, Zinc	Arsenic, Cadmium, Lead
MT41E002_040	High Ore Creek	Arsenic, Cadmium, Copper, Lead, Mercury, Zinc	Arsenic, Cadmium, Copper, Lead, Zinc
MT41E003_010	Jack Creek	None	Aluminum, Arsenic, Cadmium, Copper, Iron, Lead, Zinc
MT41E002_080	Little Boulder River, headwaters to mouth	Copper, Zinc	Aluminum, Copper, Iron, Lead,
MT41E002_050	Lowland Creek, headwaters to mouth (Boulder River)	Aluminum, Copper, Silver	Aluminum, Copper, Lead
MT41E002_100	Muskrat Creek, headwaters to mouth (Boulder River)	Copper, Lead	Iron
MT41E002_090	North Fork Little Boulder River, headwaters to mouth (Little Boulder River)	None	Aluminum, Copper
MT41E002_010	Uncle Sam Gulch, headwaters to mouth (Cataract Creek)	Arsenic, Cadmium, Copper, Lead, Zinc	Aluminum, Arsenic, Cadmium, Copper, Lead, Zinc

The recent data support most of the metal pollutant causes reported on the 2012 303(d) List. However, the data support TMDLs for 25 new pollutant-waterbody combinations and removal from the list of 18 others. All seven of the metals listings in Jack Creek and two in the North Fork of the Little Boulder River are new listings. The recent data for Big Limber Gulch do not support the 2012 listings for lead and mercury, thus metals TMDLs are not required for Big Limber Gulch.

For all streams and stream segments except Big Limber Gulch, aquatic life is considered an impaired use due to one or more metals causes. Drinking water is considered an impaired use due to one or more metals causes only for those stream segments with a human health exceedance noted within **Tables 5-6** through **5-22**. Streams and stream segments with no drinking water use impairment linked to metals are Big Limber Gulch, the upper segment of the Boulder River (headwaters to Basin Creek), Little Boulder River, Lowland Creek, Muskrat Creek, and North Fork Little Boulder River.

5.6 TMDLs

TMDLs for metals represent the maximum amount (lbs/day) of each metal that a stream can receive without exceeding water quality standards. A stream's capacity to assimilate metal pollutants is a function of the diluting effect of stream discharge and, in some cases, water hardness. Increasing water hardness reduces the toxicity of several metals (cadmium, copper, lead, silver, and zinc) and so is a factor in determining numeric water quality criteria. Because stream discharge and water hardness vary seasonally, the TMDLs must be applied seasonally to protect beneficial uses over a range of flow and hardness conditions. All TMDLs must contain a margin of safety (MOS) to ensure beneficial-use support in light of the uncertainty in deriving load estimates. All metals TMDLs developed for the Boulder-Elkhorn contain an implicit margin of safety described in **Section 5.8**. Metals TMDLs are calculated using the following equation:

TMDL = (X) (Y) (k)

Where:

TMDL = Total Maximum Daily Load in lbs/day

X = lowest applicable (most restrictive) metals target concentration (µg/L) adjusted for hardness

Y = streamflow in cubic feet per second (cfs)

k = unit conversion factor of 0.0054.

All metals TMDLs are calculated using the most restrictive target value to ensure that the TMDLs protect all designated beneficial uses. The most restrictive target is commonly the chronic aquatic life criterion. Exceptions are arsenic and mercury, where the human health criteria are the most restrictive (**Appendix C, Table C2-2**). Circular DEQ-7 (Montana Department of Environmental Quality, 2010b) specifies that compliance with the chronic aquatic life criteria is based on an average water quality metals concentration occurring over a 96 hour (4-day) period (**Section 5.4**). Calculating an allowable daily load from the chronic criteria that are based on a 4-day exposure duration provides an implicit margin of safety in the TMDL.

Although the TMDL is often derived from the chronic standards, acute aquatic life standards are also established as water quality targets, and are applied as an instantaneous instream pollutant concentration that is not to be exceeded. The TMDL will ultimately be defined as the total allowable loading using a time period consistent with the application of the most appropriate numeric water quality criterion. Remediation required to eliminate pollutant loading that exceeds the chronic standards will often mitigate more extreme short-duration exceedances of acute criteria.

5.6.1 TMDLS for Non-Hardness Dependent Metals

The toxicity of several metal elements is independent of water hardness. The TMDLS for these substances can be illustrated graphically using the TMDL equation in **Section 5.6**, with the most restrictive water quality criterion substituted for the value of “X,” and stream discharge (cfs) substituted for the value of “Y.” **Figure 5-4** shows the graphs of the TMDLs for aluminum, arsenic, iron, and mercury based on the most restrictive water quality criterion for each parameter over a common range of stream discharge for the Boulder-Elkhorn TPA.

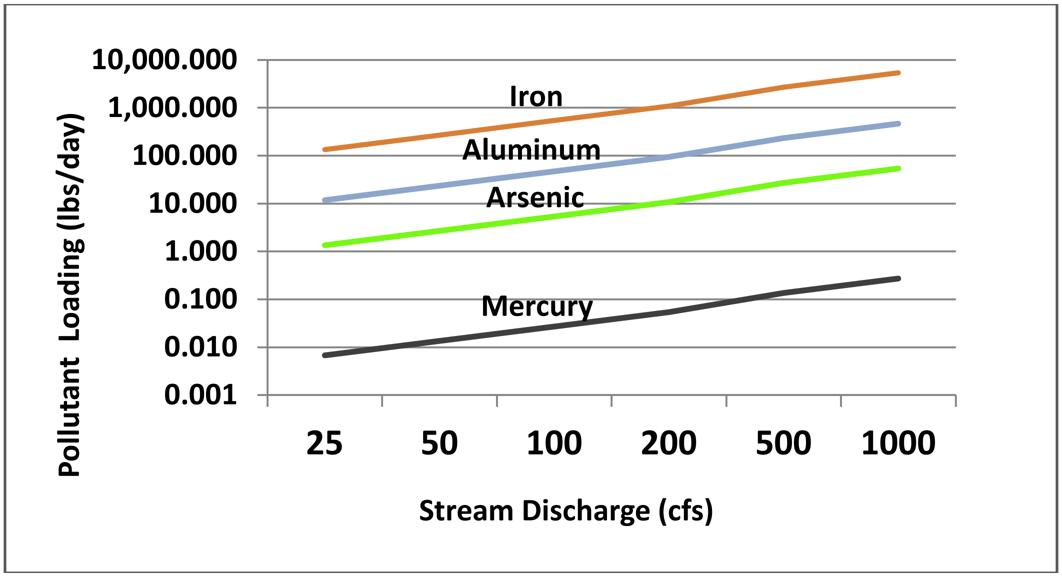

Figure 5-4. Graphs of TMDLs (lbs/day) for iron, aluminum, arsenic, and mercury with increasing stream discharge.

The **Figure 5-4** graphs are based on the chronic criteria for iron (1,000 µg/L) and aluminum (87 µg/L) and the human health criteria for arsenic (10 µg/L,) and mercury (0.05 µg/L). The TMDL graphs in **Figure 5-4** apply to all aluminum, arsenic, iron, and mercury TMDLs in this document.

5.6.2 Example Metals TMDLS for Listed Streams

Table 5-24 gives seasonal discharge rates, hardness values, target values, example TMDLs, and load reduction needed for the 16 waterbody segments in the Boulder-Elkhorn TPA requiring metals TMDLs. The examples are calculated based on high- and low-flow sampling events. For ungaged streams, flow measurements made during the second calendar quarter (April –June) are assumed as high flows; flows measured during the remaining three quarters are assumed as low flows. For gaged streams, high-flow values in **Table 5-24** are medians of flow measurements greater than the 50th percentile flow for the site. Low flows for gaged streams are medians of flow measurements less than the 50th percentile. The current loads, percent reductions, and TMDL components contained in this document should not be considered as rigid numbers but rather as reasonable approximations portraying the inherent loading variability.

Example TMDLs are shown in **Table 5-24** for the 16 waterbody segments requiring metals TMDLs. The example high- and low-flow TMDLs apply at a selected monitoring station on each stream. The hardness values, used to calculate the hardness-dependent metals targets, are mean values for each flow condition. The water quality targets are the most restrictive among the CAL, AAL, and HH criteria. Example TMDLs in the **Table 5-24** are in units of pounds per day. Selection of the monitoring stations is guided by the availability of flow and hardness data and also reflects loading from significant sources. The calculated example TMDLs represent the maximum load (lbs/day) of each pollutant that each waterbody can receive without exceeding applicable water quality standards for the specified flow and hardness. The raw data for the metals of concern are included in **Appendix D**. **Table 5-24** also contains the calculated percent reductions in loading needed for each stream to meet metals TMDLs under high and low flows.

The existing loads and corresponding load reductions for each stream and flow condition are calculated from the largest target exceedance among the data set of the most restrictive water quality target for that parameter. Load reductions are not required for datasets that contain no target exceedances. A value of zero is entered in **Table 5-24** in these instances.

Table 5-24. Example metals TMDLs for waterbodies in the Boulder-Elkhorn TPA

Stream Segment (Segment ID)	Station	Discharge (cfs) High flow	Discharge (cfs) Low flow	Hardness (mg/L) High flow	Hardness (mg/L) Low flow	Metal	Target Concentration (µg/L) High flow	Target Concentration (µg/L) Low flow	TMDL (lbs/day) High flow	TMDL (lbs/day) Low flow	Needed Load Reduction (%) High flow	Needed Load Reduction (%) Low flow
Basin Creek (MT41E002_030)	USGS 06031600	75	4.2	25	37	Cadmium	0.10	0.13	0.041	0.003	93	89
						Copper	2.85	3.99	1.15	0.090	95	88
						Lead	0.54	0.90	0.22	0.020	98	90
						Zinc	37.02	51.6	15.0	1.17	83	57
				NA		Aluminum	87	87	35.24	1.97	79	0
						Arsenic	10	10	4.05	0.23	77	45
Bison Creek (MT41E002_070)	BE-15	342	28.6	39	49	Copper	4.17	5.07	7.70	0.78	54	37
				NA		Arsenic	10	10	18.47	1.54	0	94
						Iron	1,000	1,000	1847	154.44	56	76
Boulder River, headwaters to Basin Creek (MT41E001_010)	BE-21	288	14	27	50	Copper	3.05	5.16	4.74	0.39	98	0
						Lead	0.60	1.32	0.93	0.10	63	0
Boulder River, Basin Creek to Boulder (MT41E001_021)	USGS 06032400	397	24	25	55	Cadmium	0.10	0.17	0.21	0.022	94	86
						Copper	2.85	5.60	6.12	0.73	82	63
						Lead	0.54	1.49	1.16	0.19	97	20
						Zinc	37.02	72.20	79.36	9.36	71	48
				NA		Arsenic	10	10	21.44	1.30	45	0
Boulder River, Boulder to Cottonwood (MT41E001_022)	M07BOLDR03	1,249	76	31	53	Cadmium	0.11	0.17	0.74	0.07	93	53
						Copper	3.43	5.42	23.13	2.22	98	51
						Lead	0.72	1.42	4.86	0.58	98	8
						Zinc	44.42	69.97	299.60	28.72	82	0.05
				NA		Arsenic	10	10	67.45	4.10	70	42
						Iron	1,000	1,000	6745.0	410.40	75	0
Boulder River, Cottonwood to mouth (MT41E001_030)	BE-27	238	78	61	136	Cadmium	0.19	0.34	0.24	0.14	65	0
						Copper	6.11	12.13	7.85	5.11	86	0
						Lead	1.70	4.71	2.18	1.98	85	0
						Zinc	78.82	155.48	101.30	65.49	22	0
				NA		Arsenic	10	10	12.85	4.21	45	26
						Iron	1,000	1,000	1,285.2	421.2	45	0

Table 5-24. Example metals TMDLs for waterbodies in the Boulder-Elkhorn TPA

Stream Segment (Segment ID)	Station	Discharge (cfs)		Hardness (mg/L)		Metal	Target Concentration (µg/L)		TMDL (lbs/day)		Needed Load Reduction (%)	
		High flow	Low flow	High flow	Low flow		High flow	Low flow	High flow	Low flow	High flow	Low flow
Cataract Creek (MT41E002_020)	USGS 06031960	435	85	46	57	Cadmium	0.15	0.18	0.35	0.08	96	96
						Copper	4.80	5.77	11.28	2.65	95	71
						Lead	1.18	1.56	2.77	0.72	94	0
						Zinc	62.05	74.42	145.76	34.16	83	80
						Arsenic	10	10	23.50	4.59	66	0
						Aluminum	87	87	204.36	39.93	33	0
Elkhorn Creek (MT41E002_061)	BE-48	20	5	38	61	Cadmium	0.13	0.19	0.014	0.005	83	79
						Copper	4.08	6.11	0.44	0.165	90	73
						Lead	0.93	1.70	0.10	0.046	94	76
				NA		Arsenic	10	10	1.08	0.27	60	32
						Iron	1,000	1,000	108	27	42	1
Elkhorn Creek (MT41E002_062)	BE-50	7	0.08	46	65	Cadmium	0.15	0.20	0.006	0.00009	86	88
						Lead	1.18	1.84	0.045	0.0008	94	84
						Arsenic	10	10	0.38	0.004	0	19
High Ore Creek (MT41E002_040)	BE-57	5	1	104	170	Cadmium	0.28	0.4	0.008	0.0022	96	> 99
						Copper	9.65	14.68	0.26	0.08	50	0
						Lead	3.34	6.25	0.09	0.034	95	64
						Zinc	123.87	187.83	3.34	1.01	95	90
				NA		Arsenic	10	10	0.27	0.054	90	73
Jack Creek (MT41E003_010)	USGS 462047112201901	12	1	25	38	Cadmium	0.10	0.13	0.0065	0.0007	98	97
						Copper	2.85	4.08	0.185	0.022	98	94
						Lead	0.54	0.93	0.035	0.005	98	24
						Zinc	37.02	52.78	24.0	0.285	27	90
				NA		Aluminum	87	87	5.64	0.47	21	0
						Arsenic	10	10	0.65	0.054	84	13
						Iron	1,000	1,000	64.80	5.40	60	0
Little Boulder River (MT41E002_080)	BE-59	363	22	31	42	Copper	3.43	4.45	6.72	0.529	57	0
						Lead	0.72	1.05	1.41	0.125	90	0
				NA		Aluminum	87	87	170.54	10.34	21	0
						Iron	1,000	1,000	1,960	118.80	44	0

Table 5-24. Example metals TMDLs for waterbodies in the Boulder-Elkhorn TPA

Stream Segment (Segment ID)	Station	Discharge (cfs)		Hardness (mg/L)		Metal	Target Concentration (µg/L)		TMDL (lbs/day)		Needed Load Reduction (%)	
		High flow	Low flow	High flow	Low flow		High flow	Low flow	High flow	Low flow	High flow	Low flow
Lowland Creek (MT41E002_050)	BE-65	77	11	31	51	Copper	3.34	5.25	1.39	0.31	58	0
				31	51	Lead	0.72	1.35	0.30	0.08	14	0
				NA		Aluminum	87	87	36.17	5.17	73	43
Muskrat Creek (MT41E002_100	BE-68	19	8	NA		Iron	1,000	1,000	102.60	43.20	60	23
North Fork Little Boulder River (MT41E002_090)	BE-62	32	5	29	46	Copper	3.24	4.80	0.56	0.13	54	4
				NA		Aluminum	87	87	15.03	2.35	3	0
Uncle Sam Gulch MT41E002_010	USGS 461904 112144 401	4	0.5	37	58	Cadmium	0.13	0.18	0.003	0.005	>99	99
						Copper	3.99	5.86	0.086	0.016	>99	>99
						Lead	0.90	1.59	0.02	0.0043	99	96
						Zinc	51.60	75.52	1.11	0.20	97	>99
				NA		Aluminum	87	87	1.88	0.235	51	0
						Arsenic	10	10	0.22	0.027	96	92

5.7 Loading Summaries and Allocations

The following sections provide a loading summary and source allocation for each pollutant-waterbody combination with a TMDL. It is helpful to review the loading sections on each segment with the corresponding source descriptions and target departure discussions in **Appendix F**. Loading summaries are based on the sample data contained in **Appendix D** and **Appendix E.** The order in which the stream segments are discussed begins with those having the highest concentrations of inactive mine sources. These are the Basin, Cataract, and High Ore creek watersheds, located north of the town of Basin. The order will then be downstream from the Boulder River headwaters to the mouth of the river on the Jefferson Slough near Cardwell. The aim of the loading summaries is to identify contributing sources, illustrate loading trends, and discuss seasonal fluctuations and pathways. Loads are expressed in units of pounds per day. While units of pounds per day are appropriate for expressing TMDLs, the most appropriate means of evaluating compliance with metals TMDLs is measurement of the surface water contaminant concentration and comparison of the results with metals targets.

As discussed in **Section 4.0**, a TMDL is the sum of all the load allocations (LAs), wasteload allocations (WLAs), and an MOS. LAs are allowable pollutant loads assigned to nonpoint sources and may include the pollutant load from naturally occurring sources, plus allowable human caused loading. When possible, LAs to human sources are provided separately from naturally occurring sources. WLAs are allowable pollutant loads that are assigned to permitted and non-permitted point sources. Mining-related waste sources (e.g. adit discharges, tailings accumulations, and waste rock deposits) are non-permitted point sources subject to WLAs. TMDLs are expressed by the following general equation:

$$TMDL = LA_{NB} + WLA_{MS} + MOS$$

The prevailing human-caused source of metals loading in the Boulder-Elkhorn TPA is from inactive mines. Where adequate data are available to evaluate loading from individual mining sources, these non-permitted point sources will be given separate WLAs. Where data from discrete mining sources is unavailable, loading contributions from inactive mines are grouped into composite WLAs. The adaptive management process discussed in **Section 5.9** is recommended where more detail is needed for future refinement and adjustment of composite WLAs to mining sources.

TMDLs must incorporate an MOS. All metals TMDLs in this document apply an implicit MOS by adopting a variety of conservative assumptions in calculating TMDLs and estimating pollutant loads. These assumptions are described in more detail in **Section 5.8.** Therefore, the implicit MOS is applied in the TMDL equations developed below and not repeated in each developed equation.

The TMDL and allocation tables in the following sections give the TMDLs for each metal pollutant parameter under both high- and low-flow conditions for each stream segment. These TMDL values are brought forward from **Table 5-24**. The column following the “TMDL” column (in **Table 5-25** for example) gives values for the “Existing Metal Concentration” in units of µg/L. These are the highest values from the water quality monitoring data for each flow condition. The “Existing Loads” are calculated by multiplying these concentrations times the flow values (also brought forward from **Table 5-24**) times a unit conversion factor. For example, **Table 5-25** for Basin Creek gives values of 68.85 lbs/day and 1.81 lbs/day for existing high- and low-flow aluminum loading. The median high flow in Basin Creek of 75 cfs (from **Table 5-24**) is multiplied by the highest aluminum concentration measured in Basin Creek during high flows (170 µg/L). The product of flow multiplied by concentration is, in turn, multiplied by the unit conversion factor of 0.0054 to give the existing high flow aluminum load of 68.85 lbs/day.

(75 cfs X 170 µg/L X 0.0054 = 68.85 lbs/day)

The “Existing Load” column in the tables is followed by “LA” and “WLA” columns that contain the allowable load allocations for nonpoint sources and the allowable wasteload allocations for permitted or unpermitted point sources. In most cases, the last column in the tables contains values for the percent reductions in current human-caused loading needed to meet the TMDLs. The needed reductions are calculated by subtracting the natural background loading from existing loading to obtain a value for the existing load contributed by human-caused sources. The difference between the human-caused component of existing loading and the allowable human-caused load is divided by the human-caused component of existing loading to obtain a value for the needed reduction.

Using high-flow aluminum loading in Basin Creek (**Table 5-25**) as an example, the needed reduction in human-cause loading is calculated in the following steps:

1. The natural background aluminum load of 26.33 lbs/day is subtracted for the existing high-flow load of 68.85 lbs/day to obtain 42.52 lbs/day as the human-caused component of existing loading.
2. The allowable human-caused load of 8.91 lbs/day is subtracted from the current human-caused load of 42.52 lbs/day to obtain the needed daily reduction of 33.61 pounds of aluminum.
3. The need reduction of 33.61 pounds is divided by the current human-caused load of 42.52.
4. The ratio of the needed daily reduction to the current human-caused load is multiplied by 100 to convert the ratio into a 79 percent reduction in human-caused loading.

In cases of high uncertainty in the degree of natural background loading, composite wasteload allocations are proposed that combine natural background and human-caused sources. In these cases, the final column in the allocation tables quantifies the reduction in total pollutant load needed to meet the TMDL.

5.7.1 Basin Creek (MT41E002_030)

Loading Summary

Metals target exceedances in Basin Creek result from mine-related acid rock drainage entering its northern headwater reaches and the Clear Creek and Grub Gulch tributaries. Principal sources in the upper reaches of the watershed include acid-generating tailings and waste rock accumulations at the Buckeye-Enterprise abandoned mine complex, an adit discharge from the abandoned Josephine Mine in Clear Creek, and active hillslope erosion from sparsely vegetated and newly regarded portions of the former Basin Creek Mine in the Grub Gulch drainage. Significant sources farther downstream include the waste rock, tailings, and adit drainage sources associated with the Bullion Mine in Jack Creek. The TMDLs and allocations for Jack Creek are identified separately in **Section 5.7.2**.

Natural background loading is calculated by multiplying high and low stream discharge (cfs) by median metal concentrations at selected natural background sites. In Basin Creek, natural background is represented by water analysis results from sites BE-1 and M07BASNC01 located up-gradient of both the abandoned Buckeye-Enterprise mine complex and sources related to the Josephine and Basin Creek mines along the Continental Divide.

The difference between high-flow and low-flow loading of aluminum and arsenic indicated a significant sediment-bound source of these two pollutants. Sediment metals concentrations measured in a sample collected at the mouth of Clear Creek (site BE-44) were all within the PEL values. However, the sediment sample from Basin Creek just below the Clear Creek mouth (site BE-04) has metals concentrations two orders of magnitude higher than those at site BE-44 (**Appendix F, Table F-2**). This difference suggests that significant sediment-bound aluminum and arsenic have source areas at the Buckeye-Enterprise complex, in the Grub Gulch drainage, or from both areas. The Grub Gulch drainage receives runoff from a large area of steep and sparsely vegetated slopes at the former Basin Creek Mine. Downstream of site BE-04, sediment metals concentrations either decrease or remain constant until site BE-07, located below the mouth of Jack Creek. At BE-07 sediment concentrations of arsenic, cadmium, copper, lead, and zinc increase from five times those measured upstream at site BE-04. Thus, Jack Creek sources introduce a second significant pulse of metals loading to Basin Creek.

TMDLs and Allocations

The metals TMDLs and allocations for high- and low-flow conditions in Basin Creek are summarized below and in **Table 5-25**. The allocations for aluminum, arsenic, cadmium, copper, lead, and zinc include load allocations to natural background concentrations (**$LA_{BSN\ CR\ NB}$**) and a wasteload allocation to unpermitted mining sources of these four metals (**$WLA_{BSN\ CR\ MS}$**). Natural background loading is calculated using the median metal concentrations for aluminum, arsenic, cadmium, copper, lead, and zinc from the two Basin Creek background sites BE-1 and M07BASNC01 located upstream of mining sources. The Basin Creek TMDL is summarized by the following equation:

$$TMDL_{BSN\ CR} = LA_{BSN\ CR\ NB} + WLA_{BSN\ CR\ MS}$$

Where background sample analysis results are less than method detection limits (MDLs,) one half of the MDL is the assumed background concentration. The wasteload allocation to mining sources is obtained by subtracting the calculated background load from the TMDL. The allocation scheme assumes that natural background loading rates do not exceed water quality standards. The allocations also assume that further applying best management practices (BMPs) to mining sources will reduce loading so that TMDLs and water quality standards are met.

Additional monitoring at background and current condition sites, with sufficiently low MDLs applied during both high- and low-flow conditions is recommended to better refine the metals allocations. High- and low-flow monitoring of sediment and water column metals concentrations in Grub Gulch are needed to confirm the Basin Creek Mine area as a significant high-flow loading source.

Table 5-25. Example metal TMDLs and load- and wasteload allocation examples for Basin Creek at USGS Station 06031600 near the town of Basin

Metal	Flow Condition*	TMDL (lbs/day)	Existing Metal Concentration (µg/L)	Existing Load (lbs/day)	LA_{NB} (lbs/day)	WLA_{MS} (lbs/day)	Needed Reduction (%)
Aluminum	High flow	35.24	170	68.85	26.33	8.910	79
	Low flow	1.97	80	1.81	0.74	1.230	0
Arsenic	High flow	4.05	38.2	15.47	0.61	3.440	77
	Low flow	0.230	17.2	0.390	0.0340	0.196	45
Cadmium	High flow	0.041	0.96	0.390	0.016	0.025	93
	Low flow	0.003	0.82	0.020	0.001	0.002	89
Copper	High flow	1.15	19.4	7.86	0.81	0.340	95
	Low flow	0.090	14	0.318	0.060	0.030	88

Table 5-25. Example metal TMDLs and load- and wasteload allocation examples for Basin Creek at USGS Station 06031600 near the town of Basin

Metal	Flow Condition*	TMDL (lbs/day)	Existing Metal Concentration (µg/L)	Existing Load (lbs/day)	LA_{NB} (lbs/day)	WLA_{MS} (lbs/day)	Needed Reduction (%)
Lead	High flow	0.22	14.6	5.91	0.10	0.120	98
	Low flow	0.020	6.37	0.14	0.006	0.014	90
Zinc	High flow	15.00	192	77.76	2.03	12.970	83
	Low flow	1.17	114	2.59	0.11	1.060	57

* Specific flow values provided in **Table 5-24**

Figure 5-5 is a bar graph of sediment metals concentration divided by the respective metals PEL target for samples collected at four sites on Basin Creek: BE-04 below Clear Creek, BE-06 below Joe Bowers Creek, site BE-07 below Jack Creek, and site BE-08 at the town of Basin. The sample locations are arranged in upstream-to-downstream order in the graph.

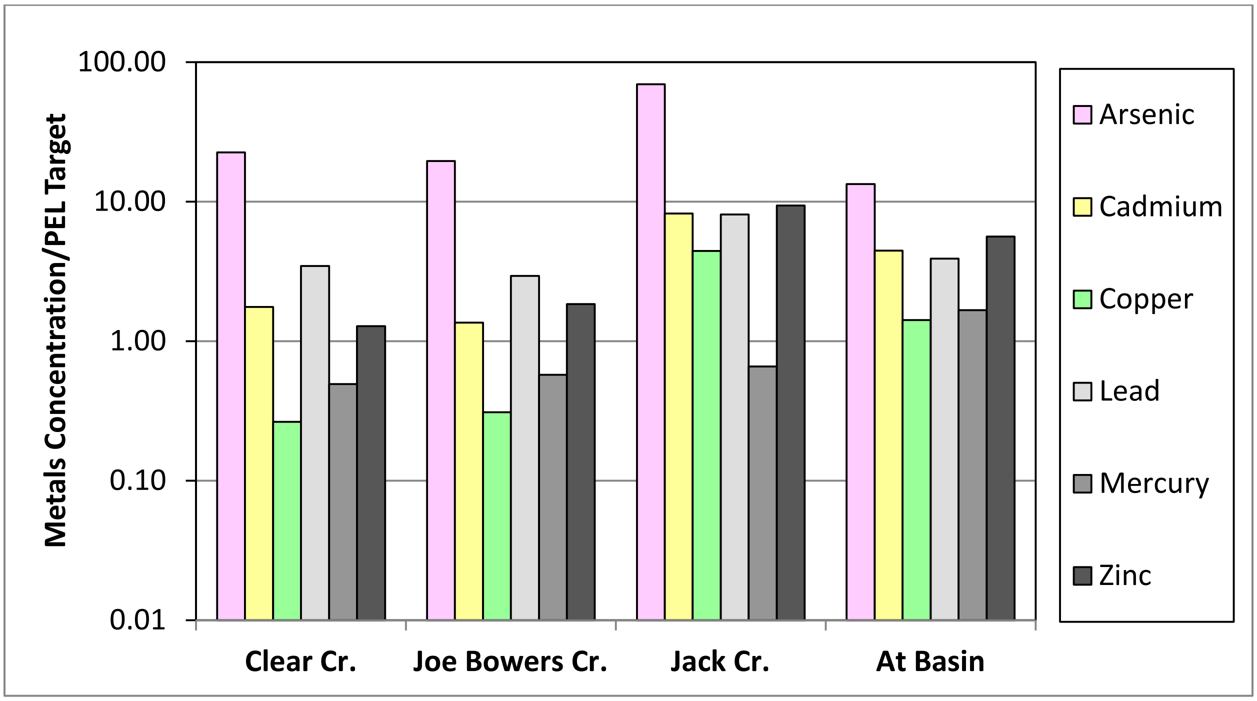

Figure 5-5. Sediment metals concentrations divided by PEL targets for four Basin Creek sample sites.

The vertical axis is the metals concentration in the sample divided by the target PEL for the specific metal parameter. Thus, for all values of 1 or less, the metal concentration measured in the sample meets or is less than the corresponding target PEL. The graph shows the significant (greater than 10 times the PEL) arsenic contamination throughout the stream, with a marked increase below the mouth of Jack Creek. A similar pattern exists for cadmium. The sediment copper concentrations meet the copper PEL target at the upper two sites, but, like arsenic and cadmium, are greatly increased by sources in Jack Creek. The graph suggests that remediation be focused on sources upstream of Clear Creek and sources in Jack Creek.

5.7.2 Jack Creek (MT41E003_010)

Loading Summary

Metals target exceedances in Jack Creek result almost exclusively from sources related to the Bullion Mine. A mine adit discharge and downstream tailings accumulations in the Jack Creek tributary of Jill Creek are compounded by a second streamside tailings accumulation about 0.5 mile below the mouth of Jill Creek. About 1 mile below Jill Creek an unnamed tributary entering Jack Creek from the south contains additional tailings from a smelter built to process the Bullion Mine ores (**Appendix F, Figure F-2**).

TMDLs and Allocations

Example TMDLs and allocations for Jack Creek are specified in **Table 5-26**. Two allocation schemes are developed for Jack Creek because of uncertainty regarding background aluminum and copper concentrations during high flow. For these two metals, the TMDL is a composite wasteload allocation to natural background and unpermitted mining sources. The composite WLA allocation for high-flow aluminum and copper is expressed by the following equation, which is inserted into **Table 5-26**:

$$TMDL_{JCK\ CR} = WLA_{(JCK\ CR\ NB\ +\ JCK\ CR\ MS)}$$

Table 5-26. Example metal TMDLs and load- and wasteload allocation examples for Jack Creek at USGS Station 462047112201901 near the mouth

Metal	Flow Condition*	TMDL (lbs/day)	Existing Metal Concentration (µg/L)	Existing Load (lbs/day)	LA_{NB} (lbs/day)	WLA_{MS} (lbs/day)	Needed Reduction (%)
Aluminum	High flow	5.64	110	7.12	TMDL = $WLA_{(JCK\ CR\ NB+JCK\ CR\ MS)}$ = 5.64 lbs/day		21
	Low flow	0.47	40	0.22	0.32	0.15	0
Arsenic	High flow	0.65	65	4.21	0.10	0.55	84
	Low flow	0.054	13	0.070	0.008	0.046	13
Cadmium	High flow	0.0065	4.61	0.3000	0.0026	0.0039	98
	Low flow	0.0007	4.43	0.0240	0.0002	0.0005	97
Copper	High flow	0.185	170	11.020	TMDL = $WLA_{(JCK\ CR\ NB\ +\ JCK\ CR\ MS)}$ = 0.185 lbs/day		98
	Low flow	0.022	76	0.410	0.011	0.011	94
Iron	High flow	64.80	2,500	162	1.62	63.18	60
	Low flow	5.40	970	5.24	0.14	5.26	0
Lead	High flow	0.035	26.4	1.71	0.020	0.015	98
	Low flow	0.0050	1.47	0.0080	0.0014	0.0036	24
Zinc	High flow	24.00	514	33.31	0.32	23.68	27
	Low flow	0.285	537	2.90	0.030	0.255	90

* Specific flow values provided in **Table 5-24**

Using a composite allocation, the sum of allowable aluminum loading from natural background, plus unpermitted mining sources, is equal to the TMDL of 5.64 lbs/day under high-flow conditions. The sum of allowable copper loading from natural background, plus mining sources is equal to the TMDL of 0.185 lb/day under high-flow conditions.

The allocations for low-flow aluminum and copper and for arsenic, cadmium, copper, iron, lead, and zinc under both flow conditions include load allocations to natural background concentrations (**$LA_{JCK\ CR\ NB}$**)

and a wasteload allocation to unpermitted mining sources (**WLA** $_{JCK\ CR\ MS}$). This allocation scheme is expressed in the following TMDL equation:

$$TMDL_{JCK\ CR} = LA_{(JCK\ CR\ NB)} + WLA_{(JCK\ CR\ MS)}$$

Natural background loading is calculated using the metal concentrations measured during high and low flows at site M07JACKC02, located in a headwater Jack Creek tributary without metal mine sources (**Appendix F**, **Figure F-2**). Where background sample analysis results are less than MDLs, one half of the MDL is the assumed background concentration. The wasteload allocation to mining sources is obtained by subtracting the calculated background load from the TMDL. The allocation scheme assumes that natural background loading rates do not exceed water quality standards and that further application of BMPs to mining sources in Jack Creek will reduce loading so that TMDLs and water quality standards are met.

Additional monitoring at background site M07JACKC02 is recommended under both high- and low-flow conditions to increase the sample size and obtain a better understanding of background aluminum and copper loading during high flows. Additional monitoring of sediment metals concentrations in Jack Creek would be helpful to quantify natural background conditions and separate the contributions from three main sources that include the Bullion Mine, the tailings accumulation about one half mile below the mine, and contributions from the smelter site in the unnamed tributary farther downstream.

With the current dataset it appears that neither aluminum nor iron require load reductions during low flow. Target values for these two metals are exceeded only during high flow. A single streambed sediment metals sample is available for Jack Creek at site M07JACKC03 located below the Bullion Mine (**Figure 5-6**).

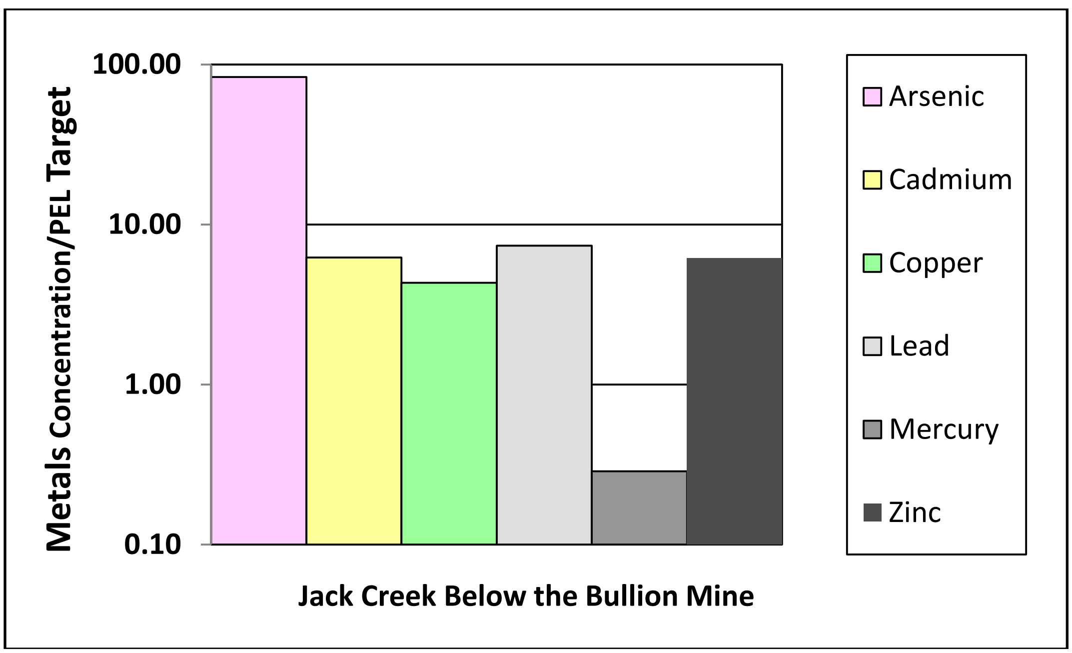

Figure 5-6. Sediment metals concentrations divided by PEL targets for site M07JACKC03 in Jack Creek.

The large exceedances of sediment PELs reflect the effects of loading from the Bullion Mine and the amount of streamside mine tailings remaining in the drainage.

5.7.3 Cataract Creek (MT41E002_020)

Loading Summary

Metal loading to Cataract Creek is largely influenced by sources in the Uncle Sam Gulch tributary. TMDLs and allocations for Uncle Sam Gulch are described in **Section 5.7.4**. Other Cataract Creek sources include several priority abandoned mine sites that include the Eva May and Morning Glory mines located adjacent to the Cataract Creek channel (**Appendix F, Figure F-3**). Both of these mines have large near-stream tailings accumulations. An adit at the Eva May site discharges about 5 gallons per minute that seeps into accumulated waste rock before reaching surface water. A diversion of surface water from Cataract Creek extends through accumulated waste rock and returns to Cataract Creek. The priority ranked Rocker-Ada Mine in Rocker Creek and the Boulder Chief Mine in an unnamed Cataract Creek tributary are also potential loading sources that include mine adit discharges and sulfide waste rock accumulations adjacent to stream channels.

A general discharge permit for operation of a portable suction dredge (permit number MTG370320) has been issued on Snowdrift Creek, an eastern tributary of Cataract Creek. The effluent limit in the general permit is no visible increase in stream turbidity at the downstream edge of the mixing zone. Dredge operation under the terms of the general permit is not anticipated to be a source of metals loading, and thus is provided a WLA of zero.

Natural background loading to Cataract Creek is represented by median values or, in the case of aluminum, single values from high- and low-flow analysis results from three sites located upstream of mining sources: BE-11 in the upper reach of Big Limber Gulch, BE-36 in upper Cataract Creek below the confluence of Nellie Grant Creek, and BE-74 in the headwaters of Uncle Sam Gulch upstream of the Crystal Mine disturbance.

TMDLs and Allocations

Example TMDLs and allocations for Cataract Creek are contained in **Table 5-27**. As with Jack Creek, two allocation schemes are developed for Cataract Creek because of uncertainty regarding background aluminum, cadmium, and copper concentrations measured during high flows. For these three metals, the TMDL is a composite wasteload allocation to natural background plus unpermitted mining sources of these pollutants, plus a WLA to the permitted suction dredge in Snowdrift Creek. The permitted suction dredge is given a WLA of zero. The composite allocation for high-flow aluminum, cadmium, and copper is expressed by the following equation:

$$TMDL_{CAT\ CR} = WLA_{(CAT\ CR\ NB\ +\ CAT\ CR\ MS)} + WLA_{(SD\ CR\ DREDGE)}$$

The equation for the composite WLA allocation to natural background and unpermitted mining sources has been inserted into the allocation columns for high-flow aluminum and cadmium in **Table 5-27.** The composite allocation scheme states that the sum of allowable aluminum loading from natural background, plus unpermitted mining sources, is equal to the TMDL of 204.36 lbs/day of aluminum and 0.35 lbs/day of cadmium under high-flow conditions. Operation of the permitted suction dredge is given a zero allocation for all pollutants with the assumption that dredge operations according to the conditions of the general permit will not be a source of metals loading to Cataract Creek.

Table 5-27. Example metal TMDLs and load- and wasteload allocation examples for Cataract Creek at USGS Station 06031960 near the mouth

Metal	Flow Conditions*	TMDL (lbs/day)	Existing Metal Concentration (µg/L)	Existing Load (lbs/day)	LA_{NB} (lbs/day)	WLA_{MS} (lbs/day)	$WLA_{S. Dredge}$ (lbs/day) MTG370320	Needed Reduction (%)
Aluminum	High flow	204.36	130	305.37	TMDL = $WLA_{(CAT CK NB + CAT CR MS)}$ = 204.36 lbs/day		0	33
	Low flow	39.93	30	13.77	6.89	33.04	0	0
Arsenic	High flow	23.5	30.6	71.88	3.52	19.98	0	66
	Low flow	4.59	5.5	2.52	1.26	3.33	0	0
Cadmium	High flow	0.35	4.02	9.44	TMDL = $WLA_{(CAT CK NB + CAT CR MS)}$ = 0.35 lbs/day		0	96
	Low flow	0.08	4.73	2.17	0.018	0.062	0	96
Copper	High flow	11.28	103	242	TMDL = $WLA_{(CAT CK NB + CAT CR MS)}$ = 11.28 lbs/day		0	95
	Low flow	2.65	21.6	9.91	0.69	1.96	0	71
Lead	High flow	2.77	19.7	46.28	1.01	1.76	0	94
	Low flow	0.72	1.44	0.66	0.115	0.605	0	0
Zinc	High flow	145.76	376	883.22	11.75	134.01	0	83
	Low flow	34.16	381	174.88	4.60	29.56	0	80

* Specific flow values provided in **Table 5-24**

The allocations for low-flow aluminum, cadmium, and copper, and for arsenic, lead, and zinc under both flow conditions include load allocations to natural background concentrations (**$LA_{CAT CR NB}$**), a wasteload allocation to unpermitted mining sources (**$WLA_{CAT CR MS}$**), and a wasteload allocation to suction dredge operations. This allocation scheme is reflected in the following TMDL equation:

$$TMDL_{CAT CR} = LA_{CAT CR NB} + WLA_{CAT MS} + WLA_{S. Dredge}$$

A value of zero is allocated to suction dredge operations (**$WLA_{S. Dredge}$**), assuming that operation is according to general permit stipulations and it will not result in metals loading to the creek.

Natural background loading is calculated using the median metal concentrations measured at sites BE-11, BE-36, and BE-74. Where background sample analysis results are less than MDLs, one half of the MDL is the assumed background concentration. The wasteload allocation to unpermitted mining sources is obtained by subtracting the calculated background load from the TMDL. The zero wasteload allocation to the permitted seasonal dredge operation assumes that operation according to the general permits does not contribute to metals loading. The allocation scheme assumes that natural background loading rates do not exceed water quality standards and that further application of BMPs to Cataract Creek mining sources will reduce loading so that TMDLs and water quality standards are met.

The current dataset indicates that low-flow reductions are not required for aluminum, arsenic, and lead. Target values for these three metals are exceeded only during high flow. Values for suspended sediment concentration average about 9,000 mg/L during runoff, compared with a base flow average of 1,200 mg/L.

Streambed sediment metals samples are available from four sites on Cataract Creek: BE-35 near the headwaters, BE-37 downstream of Rocker Creek, BE-39 below the Eva May Mine, and BE-41 below the Morning Glory tailings deposit. **Figure 5-7** is a bar graph of measured sediment metals concentrations divided by the respective PEL targets for the four sample sites.

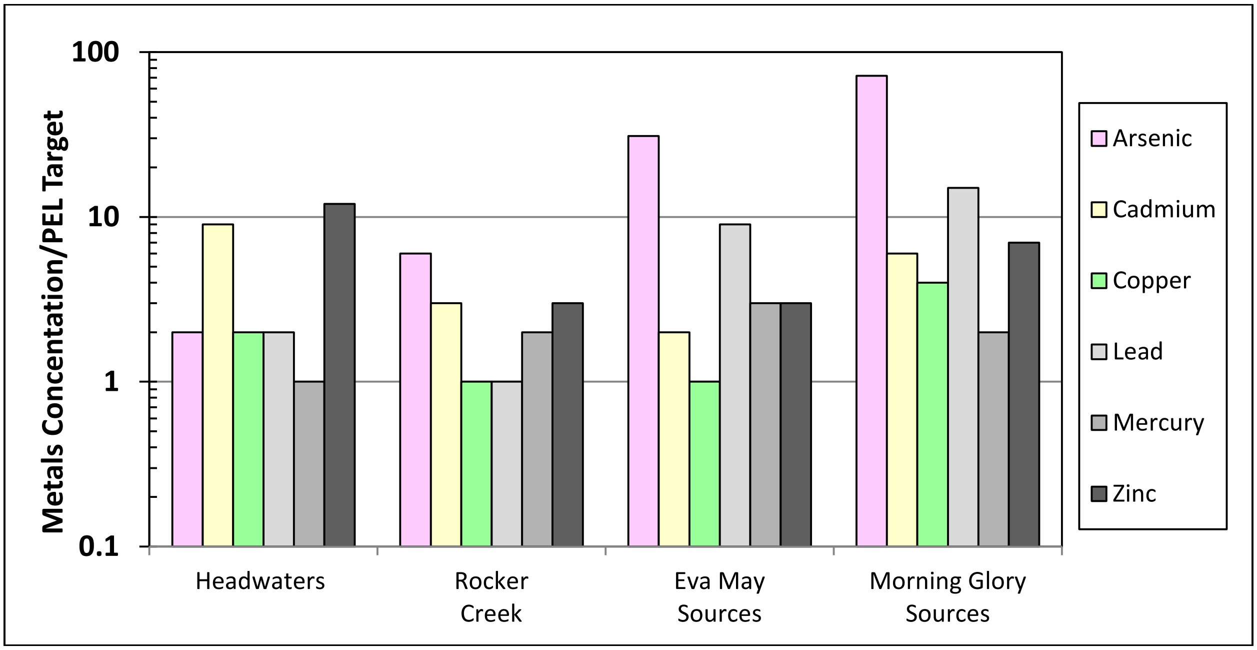

Figure 5-7. Sediment metals concentrations divided by PEL targets for four Cataract Creek sample sites.

The PEL targets are exceeded for all metal parameters except mercury in the headwaters sample. Sediment concentrations of arsenic and mercury increase below Rocker Creek. Notable increases in arsenic and lead occur below the Eva May Mine complex. Large increases in all sediment metals except mercury occur at site BE-41, which reflects additions from Uncle Sam Gulch and the Morning Glory tailings site. The degree of metals loading from sediment is likely related to the amount of streamside tailings remaining in the drainage.

5.7.4 Uncle Sam Gulch (MT41E002_010)

Loading Summary

Metals target exceedances in Uncle Sam Gulch result almost exclusively from sources related to the Crystal Mine. A mine adit discharge and streamside waste rock accumulations are the principal sources of ARD effects on surface water. Natural background loading is represented by median water analysis results from sites BE-74 and M07UCLSG01 located up-gradient of the adit discharge at the Crystal Mine (**Appendix F, Figure F-4**).

TMDLs and Allocations

Example TMDLs and allocations for Uncle Sam Gulch are contained in **Table 5-28**. Two allocation schemes are developed because of uncertainty regarding the high flow background concentration of lead. For lead during high flows, the TMDL is a composite wasteload allocation to natural background plus unpermitted mining sources. The composite allocation for high-flow lead is expressed by the following equation, which is inserted into the allocation columns for high-flow lead in **Table 5-28**:

$$TMDL_{USG} = WLA_{(USG\ NB\ +\ USG\ MS)}$$

The composite allocation scheme states that the sum of allowable high-flow lead loading from natural background, plus unpermitted mining sources, is equal to the TMDL of 0.02 lb/day.

Table 5-28. Example metal TMDLs and load- and wasteload allocation examples for Uncle Sam Gulch near the mouth at USGS Station 461904112144401

Metal	Flow Condition*	TMDL (lbs/day)	Existing Metal Concentration (µg/L)	Existing Load (lbs/day)	LA_{NB} (lbs/day)	WLA_{MS} (lbs/day)	Needed Reduction (%)
Aluminum	High flow	1.88	125	2.70	1.08	0.8	51
	Low flow	0.235	30	0.081	0.040	0.195	0
Arsenic	High flow	0.2200	239	5.1600	0.0324	0.1876	96
	Low flow	0.027	73.8	0.200	0.01	0.017	86
Cadmium	High flow	0.00300	22.5	0.48600	0.00086	0.00214	>99
	Low flow	0.00500	147	0.40000	0.00011	0.00489	99
Copper	High flow	0.0860	378	8.1600	0.0432	0.0428	> 99
	Low flow	0.016	1,900	5.13	0.0034	0.0126	>99
Lead	High flow	0.02	145	3.13	$TMDL_{USG} = (WLA_{(USG\ NB\ +\ USG\ MS)}) = 0.02$ lbs/day		99
	Low flow	0.0043	43.3	0.1170	0.0013	0.003	96
Zinc	High flow	1.110	1,870	40.400	0.108	1.002	97
	Low flow	0.20	12,100	32.67	0.02	0.18	> 99

* Specific flow values provided in **Table 5-24**

The allocations for low-flow lead and the remaining **Table 5-28** metal parameters under both flow conditions include load allocations to natural background concentrations (**$LA_{USG\ NB}$**) and wasteload allocations to unpermitted mining sources (**$WLA_{USG\ MS}$**). This allocation scheme is reflected in the following TMDL equation:

$$TMDL_{USG} = LA_{USG\ NB} + WLA_{USG\ MS}$$

Natural background loading is calculated using the median metal concentrations measured at sites BE-74 and M07UCLSG01. Where background sample analysis results are less than MDLs, one half of the MDL is the assumed background concentration. The wasteload allocation to mining sources is obtained by subtracting the calculated background load from the TMDL. The allocation scheme assumes that natural background loading rates do not exceed water quality standards and that further application of BMPs to Crystal Mine sources will reduce loading so that TMDLs and water quality standards are met.

The current dataset indicates that low-flow reductions are not required for aluminum, since the chronic aquatic life target is exceeded only during high flows. All other metal parameters generally require an order of magnitude reduction or greater under both flow conditions. The size of the reductions is reflected in the difference in sediment metals concentrations measured in samples collected above and below the Crystal Mine. Streambed sediment metals samples are available from four sites on Uncle Sam Gulch. **Appendix F, Figure 5-8** is a bar graph of measured sediment metals concentrations divided by the respective PEL targets for the four sites: one upstream of the Crystal Mine and three at increasing distances downstream.

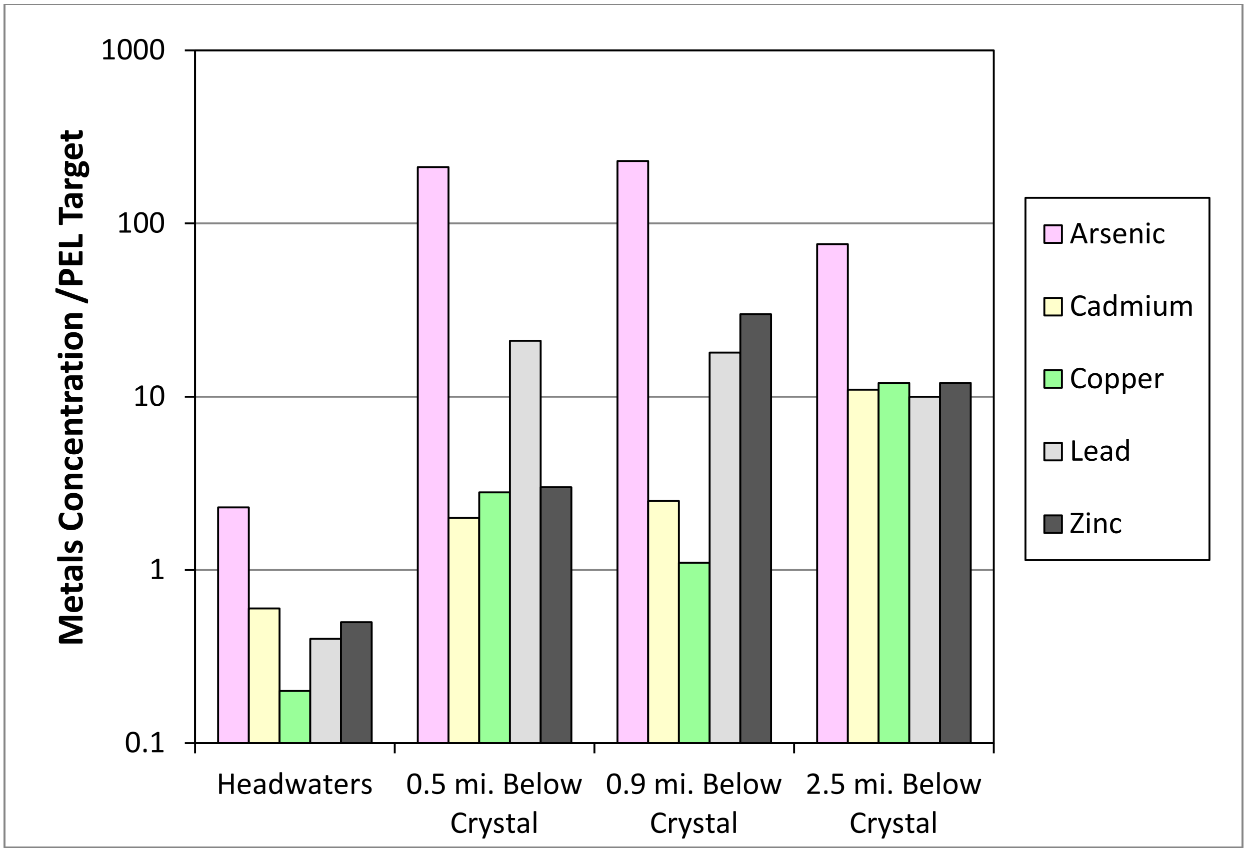

Figure 5-8. Sediment metals concentrations divided by PEL targets for four Uncle Sam Gulch sample sites.

The PEL target for arsenic is exceeded in all samples and increases by two orders of magnitude below the mine. The concentrations of the remaining three parameters in the headwater sample are less than the target PELs. The graph shows large increases in all metal concentrations in sediment below the Crystal Mine. Sediment concentrations of arsenic, lead, and zinc decrease somewhat between the mine and the sample site nearest the mouth, but the strong influence of the mine on sediment quality is clear.

5.7.5 Upper Boulder River (MT41E001_010)

Loading Summary

The upper-most segment of the Boulder River extends 24.4 miles from its headwaters to its confluence with Basin Creek near the town of Basin. Although 43 inactive mine sites have been inventoried in the upper Boulder River drainage, the properties consist largely of small-scale upland exploration prospects. The most significant mining sources of metals loading are associated with several mining and milling sources located near the town of Basin, just upstream of the mouth of Basin Creek. These include remaining streamside tailings deposits from the former Jib Mill on the western edge of Basin and milling wastes around the pits of the former Hope-Katie Mine complex. Farther to the west, an aggregate quarry in lower Red Rock Creek holds a general stormwater discharge permit for construction activity. Natural background loading is represented by water analysis results from 1 high-flow and 1 low-flow sample collected from site BE-28 located on the Boulder River up-gradient of inventoried mining sources (**Appendix F, Figure F-7**).

TMDLs and Allocations

Example TMDLs and allocations for the Boulder River above Basin are contained in **Table 5-29**. The allocations for copper and lead include load allocations to natural background concentrations (**LA** $_{\mathbf{UB\ RV\ NB}}$), a wasteload allocation to unpermitted mining sources of copper and lead (**WLA** $_{\mathbf{UBSN\ RV\ MS}}$) and a wasteload allocation to the permitted aggregate quarry in Red Rock Creek (**WLA** $_{\mathbf{QUARRY}}$). The upper Boulder River TMDL is summarized by the following equation:

$$TMDL_{UB\ RV} = LA_{UB\ RV\ NB} + WLA_{QUARRY} + WLA_{UB\ RV\ MS}$$

Table 5-29. Example copper and lead TMDLs and load- and wasteload allocation examples for upper Boulder River at site BE-21

Metal	Flow Condition*	TMDL (lbs/day)	Existing Metal Concentration (µg/L)	Existing Load (lbs/day)	LA_{NB} (lbs/day)	WLA_{Quarry} (lbs/day) MTR103333	WLA_{MS} (lbs/day)	Needed Reduction (%)
Copper	High flow	4.74	6	9.33	4.67	0	0.07	98
	Low flow	0.390	3.4	0.260	0.076	0	0.314	0
Lead	High flow	0.93	1.19	1.85	0.39	0	0.54	63
	Low flow	0.100	0.2	0.015	0.019	0	0.081	0

* Specific flow values provided in **Table 5-24**

Natural background loading is calculated using the reported high- and low-flow concentrations of copper and lead from site BE-28 located upstream of mining sources. Where background sample analysis results are less than MDLs, one half of the MDL is the assumed background concentration. The wasteload allocation to unpermitted mining sources is obtained by subtracting the calculated background load from the TMDL. The allocation scheme assumes that natural background loading rates do not exceed water quality standards. The allocations also assume that further application of BMPs to mining sources will reduce loading so that TMDLs and water quality standards are met. The permitted aggregate quarry is given an allocation of zero, since its operation according to permit specifications is not expected to contribute metals loading to the upper Boulder River.

The current dataset indicates that low-flow reductions are not required for either copper or lead since the chronic aquatic life targets are exceeded only during high flows. Loading of copper from mining sources during high flow requires a reduction of two orders of magnitude. A more modest reduction is required in high-flow lead loading.

Data for sediment metals chemistry is available for three sites on the upper Boulder River: BE-28 is in the headwaters, BE-30 is below the mouth of Bison Creek, and BE-21 is near the downstream end of the segment. **Figure 5-9** shows of measured sediment metals concentrations divided by the respective PEL targets for the three upper Boulder River sites.

Figure 5-9. Sediment metals concentrations divided by PEL targets for three upper Boulder River sample sites.

Except for arsenic in the sample from site BE-21, all sediment metals concentrations are less than the respective metals PEL targets.

5.7.6 Lowland Creek (MT41E002_050)

Loading Summary

Metals loading sources in Lowland Creek are most likely from past activities at the former Ruby Mine and milling operations located in the north-central portion of the watershed (**Appendix F, Figure F-8**). Two suction dredge operations operate along Lowland Creek under general discharge permits (MTG370313 and MTG370269). Lowland Creek has been placer mined for approximately four miles upstream from the mouth. The disturbance is a potential source of high-flow, sediment-bound metals loading. Natural background loading is represented by median concentrations values for sample from site M07LOWLC04, located in the headwaters upstream of mining sources and site M07LOWLC03, located on a headwater tributary having no discernible mining sources.

TMDLs and Allocations

Two allocation schemes are developed for Lowland Creek because of uncertainty regarding background aluminum and copper concentrations occurring during high flows. For high-flow aluminum and copper, the TMDL is a composite wasteload allocation to natural background sources and unpermitted mining sources. A separate composite WLA of zero is specified for operation of the permitted suction dredge operations. The composite allocation for high-flow aluminum and copper is expressed by the following equation, which is inserted into the allocations columns in **Table 5-30**:

$$TMDL_{LWLND\ CR} = WLA_{(LWLND\ CR\ NB\ +\ LWLND\ CR\ MS)} + WLA_{LWLND\ CR\ DREDGE}$$

The composite wasteload allocation scheme states that the sum of allowable aluminum loading from natural background and unpermitted mining sources, plus the wasteload allocation to the permitted source, is equal to the TMDL of 36.17 lbs/day of under high-flow conditions. A similar equation applies to high-flow copper loading and equals the TMDL of 1.39 lbs/day.

Table 5-30. Example aluminum, copper, and lead TMDLs and load- and wasteload allocation examples for Lowland Creek at site BE-65

Metal	Flow Condition*	TMDL (lbs/day)	Existing Metal Concentration (µg/L)	Existing Load (lbs/day)	LA_{NB} (lbs/day)	WLA_{MS} (lbs/day)	WLA_{DREDGE} (lbs/day) MTG370313	Needed Reduction (%)
Aluminum	High flow	36.17	320	133.06	$TMDL_{LWLND\ CR} = WLA_{(LWLND\ CR\ NB\ +\ LWLND\ CR\ MS)}$ = 36.17 lbs/day		0	73
	Low flow	5.17	130	7.72	1.78	3.39	0	43
Copper	High flow	1.39	8	3.33	$TMDL_{LWLND\ CR} = WLA_{(LWLND\ CR\ NB\ +\ LWLND\ CR\ MS)}$ = 1.39 lbs/day		0	58
	Low flow	0.31	5	0.30	0.30	0.01	0	0
Lead	High flow	0.300	0.8	0.333	0.104	0.196	0	14
	Low flow	0.080	0.25	0.015	0.015	0.065	0	0

* Specific flow values provided in **Table 5-24**

A second allocation scheme is proposed for low flow aluminum and copper and both high- and low-flow lead TMDLs. These TMDLs include load allocations to natural background sources (**$LA_{LWLND\ CR\ NB}$**), a wasteload allocation to unpermitted Lowland Creek mining sources (**$WLA_{LWLND\ CR\ MS}$**), and a composite wasteload allocation to the permitted Lowland Creek dredge operations (**$WLA_{LWLND\ CR\ DREDGE}$**). The TMDLs and allocations for low-flow aluminum and copper and both high and low-flow lead are reflected in the following equation:

$$TMDL_{LWLND\ CR} = LA_{LWLND\ CR\ NB} + WLA_{LWLND\ CR\ MS} + WLA_{LWLND\ CR\ DREDGE}$$

Natural background loading is calculated using the median metal concentrations measured at sites BE-63 and M07LOWC03 in the Lowland Creek headwaters. Where background sample analysis results are less than MDLs, one half of the MDL is the assumed background concentration. For low-flow aluminum and copper and for lead under both flow conditions, the wasteload allocation to mining sources is obtained by subtracting the calculated background load from the TMDL. The allocation scheme assumes that natural background loading rates do not exceed water quality standards. The zero allocation to the permitted suction dredge source assumes that operation according to the stipulations of the general permit will not be a source of metals loading to Lowland Creek. The allocations also assume that further application of BMPs to Lowland Creek mining sources will reduce loading so that TMDLs and water quality standards are met.

Since the chronic aquatic life targets for copper and lead are exceeded only during high flows, no low-flow load reductions of these metals are required. The respective high-flow reductions of aluminum, copper, and lead are 73%, 58%, and 14%. A 43 percent reduction in low-flow aluminum loading is needed to meet the TMDL.

Data for sediment metals chemistry is available for site BE-63 near the headwaters and site BE-65 near the mouth. **Figure 5-10** shows measured sediment metals concentrations divided by the respective PEL targets for the two Lowland Creek sites. Sediment concentration of arsenic at the headwaters is 3.4 times the arsenic PEL value (17,000 µg/kg). The mercury concentration in sediment collected near the mouth of Lowland Creek is 2.3 times the PEL of 486 µg/kg. The sediment-bound mercury could be a persistent condition from past placer mining. Low-level mercury analysis of water samples from Lowland Creek were less than the method detection limit of 0.05 µg/L. Sediment metals concentrations of parameters other than arsenic and mercury are all less than the corresponding PEL targets.

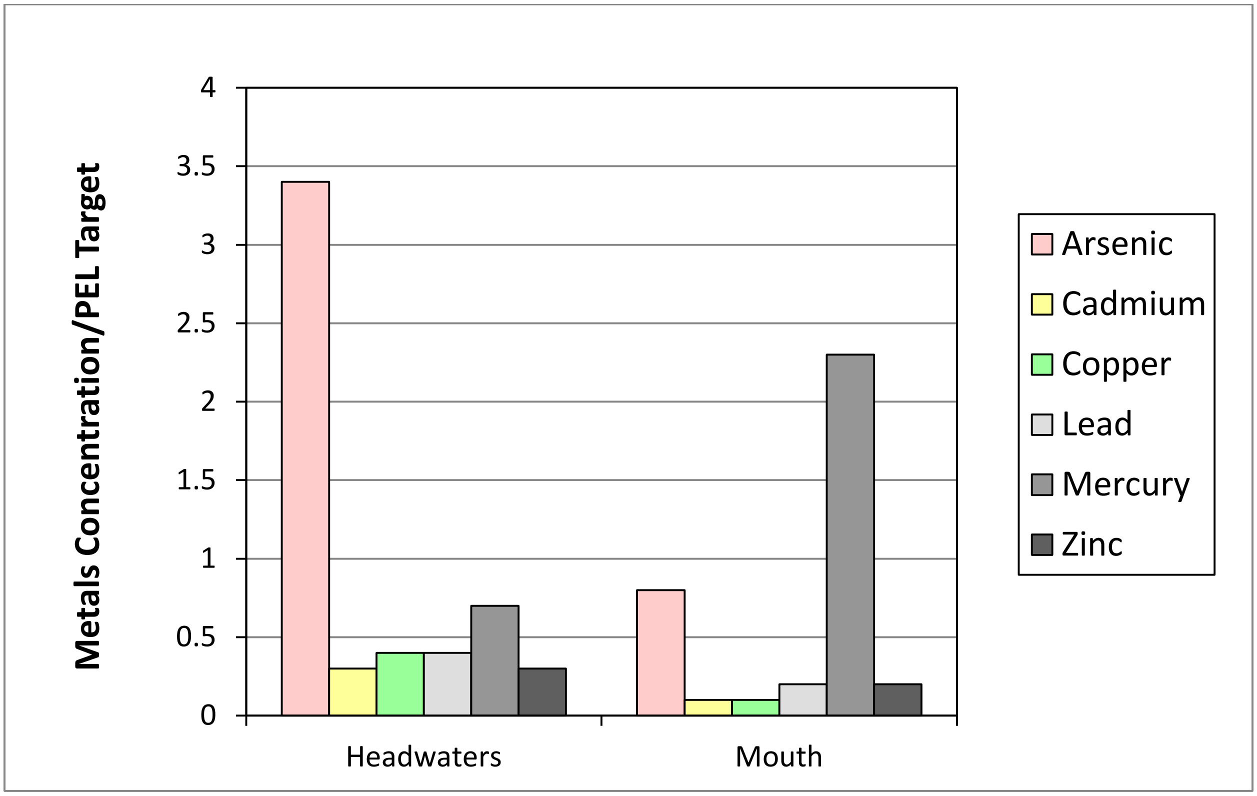

Figure 5-10. Sediment metals concentrations divided by PEL targets for sample sites at the headwaters and mouth of Lowland Creek

5.7.7 Bison Creek (MT41E002_070)

Loading Summary

The Bison Creek watershed contains minimal surface disturbances from mining development compared with watersheds downstream in the Basin Mining District. The 12 abandoned mine properties inventoried in the Bison Creek watershed are small upland disturbances remote from surface waters. Watershed residents have pointed out that the abandoned railroad grade in the Elk Park area of Bison Creek was constructed from mine wastes transported from Butte mines.

TMDLs and Allocations

As with Lowland Creek, two allocation schemes are developed for Bison Creek because of uncertainty in the background copper concentrations occurring during both high and low flows and uncertainty in low-flow concentrations of iron. For high- and low-flow copper and low-flow iron, the TMDL is a composite wasteload allocation to natural background sources and unpermitted mining sources. The composite copper and iron TMDLs and allocations are expressed by the following equation, which is inserted into the copper and low-flow iron allocation columns of **Table 5-31**:

$$TMDL_{LWLND\ CR} = WLA_{(BSN\ CR\ NB\ +\ BSN\ CR\ MS)}$$

The composite high-flow copper allocation states that the sum of allowable loading from natural background and mining sources is equal to the TMDL of 7.70 lbs/day. Similar composite allocations for low-flow copper and iron equal the respective TMDLs of 0.78 and 154.44 lbs/day.

Table 5-31. Example arsenic, copper, and iron TMDLs and load and wasteload allocation examples for Bison Creek at site BE-15

Metal	Flow Condition*	TMDL (lbs/day)	Existing Metal Concentration (µg/L)	Existing Load (lbs/day)	LA_{NB} (lbs/day)	WLA_{MS} (lbs/day)	Needed Reduction (%)
Arsenic	High flow	18.47	7	12.93	10.16	8.31	0
	Low flow	1.54	87	13.44	0.77	0.77	94
Copper	High flow	7.70	9	16.62	$TMDL_{BSN\ CR} = WLA_{(BSN\ CR\ NB\ +\ BSN\ CR\ MS)}$ = 7.70 lbs/day		54
	Low flow	0.78	8	1.24	$TMDL_{BSN\ CR} = WLA_{(BSN\ CR\ NB\ +\ BSN\ CR\ MS)}$ = 0.78 lbs/day		37
Iron	High flow	1,847	1,450	2,678	1,182	665	56
	Low flow	154	4,080	630	$TMDL_{BSN\ CR} = WLA_{(BSN\ CR\ NB\ +\ BSN\ CR\ MS)}$ = 154 lbs/day		76

* Specific flow values provided in **Table 5-24**

A second allocation scheme is proposed for arsenic and high-flow iron TMDLs. The allocations for arsenic and high-flow iron include load allocations to natural background concentrations (**$LA_{BSN\ CR\ NB}$**) and a wasteload allocation to Bison Creek mining sources (**$WLA_{BSN\ CR\ MS}$**). This allocation scheme is reflected in the following TMDL equation:

$$TMDL_{BSN\ CR} = LA_{BSN\ CR\ NB} + WLA_{BSN\ CR\ MS}$$

Natural background loading is calculated using the median metal concentrations measured at site BE-16 (**Appendix F, Figure F-9**). Where background sample analysis results are less than MDLs, one half of the MDL is the assumed background concentration. For arsenic and high-flow iron, the wasteload allocation to mining sources is obtained by subtracting the calculated background load from the TMDL. The allocation scheme assumes that natural background loading rates do not exceed water quality standards. The allocations also assume that further application of BMPs to mining sources will reduce loading so that TMDLs and water quality standards are met. Since the human health criterion for arsenic is exceeded only during low flows, no high-flow load reduction is required.

Data for sediment metals chemistry is available for sites BE-16 and M07BISNC01 in the Bison Creek headwaters and site BE-15 near the mouth of Bison Creek. **Figure 5-11** shows measured sediment metals concentrations divided by the respective PEL targets for the three sediment sample sites.

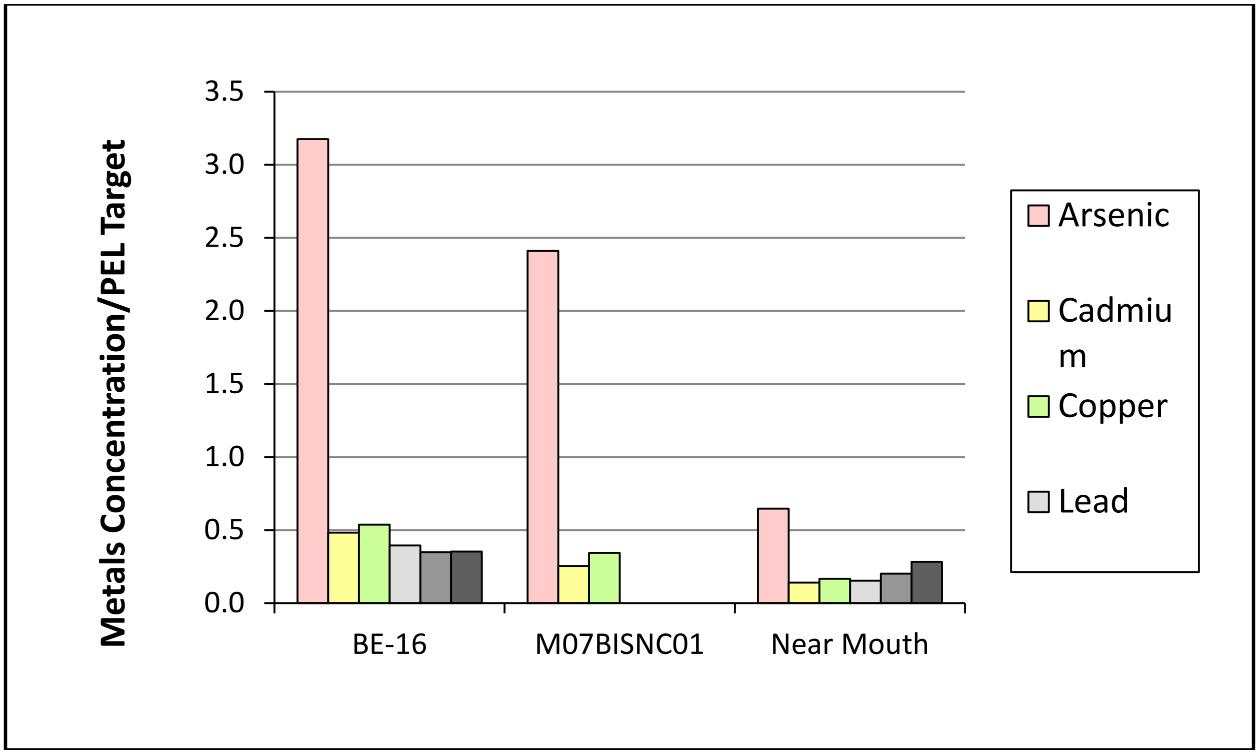

Figure 5-11. Sediment metals concentrations divided by PEL targets for two headwaters sample sites and one site at the mouth of Bison Creek.

Except for arsenic, all sediment metal concentrations at the three sites are less than the respective PEL values. Arsenic concentrations in sediment samples from the two headwater sites are 3.2 and 2.4 times the arsenic PEL value (17,000 µg/kg). Lead, mercury, and zinc concentration data are not available for the second headwater site. Sediment sampled near the Bison Creek mouth meets all PEL targets.

5.7.8 Boulder River, from Basin Creek to Town of Boulder (MT41E001_021)

Loading Summary

This segment of the Boulder River contains several streamside tailings deposits associated with the past operation of the Jib Mill, which was located just above the mouth of Basin Creek. They are part of the Basin Mining Area Superfund cleanup project. The Basin County Water and Sewer District operates an unpermitted wastewater treatment facility that includes infiltration/percolation ponds discharging to groundwater downstream of the mouth of Basin Creek. Past mining in and around the town of Basin and upstream within the Basin Creek watershed has increased metal concentrations in the local groundwater that is the source for the public water supply system for Basin. Elevated metals in the system source water contribute to elevated metals in the wastewater discharged to groundwater from the percolation ponds. Since historic mining is the ultimate source of the loading from the wastewater discharge, the facility's loading contributions is included in the allocation to unpermitted mining sources in the watershed, rather than receiving a separate load allocation.

The O. T. Mining Corporation owns a custom mill on the eastern side of the town of Basin. The facility has an MGWPCS permit (MTX000014) for discharges to groundwater from its tailings pond. Information in the permit file indicates that the pond has not been operated since 1989. A second permitted discharge to the Boulder River is a portable suction dredge (permit No. MTG370322) that operates seasonally in the Boulder River channel upstream of High Ore Creek. This segment of the Boulder River is also affected by significant metals loading from Basin, Cataract, and High Ore creek sources.

TMDLs and Allocations

Example TMDLs and allocations for the Boulder River between Basin Creek and the town of Boulder are contained in **Table 5-32**. Because of uncertainty in distinguishing the high flow copper concentrations in the data set from the natural background levels, the high flow copper allocation includes a composite WLA to natural background sources plus unpermitted mining sources(**$WLA_{(BLDR\ RIV\ NB\ +\ BLDR\ RIV\ MS)}$**). The composite WLA is inserted into **Table 5-32**. Since the local groundwater in the Basin area, including that supplying the Basin County Water and Sewer District, is affected by past mining sources, the unpermitted discharge from the Basin County Water and Sewer District's wastewater treatment system is included in the composite WLA to unpermitted mining sources. The allocations for high flow copper loading also include a load allocation to the Basin custom mill (**$LA_{CUST\ MILL}$**), owned by O.T. Mining, and a suction dredge permitted by DEQ (**WLA_{DREDGE}**). As noted in **Section 5.3.3**, the Basin custom mill is given a load instead of a wasteload allocation because potential metals loading to surface water would be via diffuse groundwater pathways. The high flow copper allocation scheme is expressed in the following TMDL equation:

$TMDL_{UB\ RV} = WLA_{(BLDR\ RIV\ NB\ +\ BLDR\ RIV\ MS)} + LA_{CUST\ MILL} + WLA_{DREDGE}$

Table 5-32. Example metal TMDLs and load- and wasteload allocation examples for the Boulder River at USGS Station 06032400 near the town of Boulder

Metal	Flow Condition	TMDL (lbs/day)	Existing Metal Concentration (µg/L)	Existing Load (lbs/day)	LA_{NB} (lbs/day)	WLA_{MS} (lbs/day)	$LA_{CUST\ MILL}$ (lbs/day) MTX000014	WLA_{DREDGE} (lbs/day) MTG370322	Needed Reduction (%)
Arsenic	High flow	21.44	17	36.44	3.22	18.22	0	0	45
	Low flow	1.30	8	1.04	0.19	1.11	0	0	0
Cadmium	High flow	0.21	0.95	2.04	0.086	0.124	0	0	94
	Low flow	0.022	0.97	0.126	0.005	0.017	0	0	86
Copper	High flow	6.11	17.9	38.37	$WLA_{(BLDR\ RIV\ NB\ +\ BLDR\ RIV\ MS)}$		0	0	82
	Low flow	0.73	11.7	1.52	0.26	0.47	0	0	63
Lead	High flow	1.16	10	21.44	0.54	0.62	0	0	97
	Low flow	0.19	1.80	0.230	0.032	0.158	0	0	20
Zinc	High flow	79.36	117	250.82	10.72	68.64	0	0	71
	Low flow	9.36	135	17.50	0.65	8.71	0	0	48

The allocations for low-flow copper and all other metal pollutants under both flow conditions include a load allocation to natural background concentrations (**$LA_{BLDR\ RV\ NB}$**), a LA to the permitted custom mill (**$LA_{CUST\ MILL}$**), a WLA to the permitted suction dredge (**WLA_{DREDGE}**), and a wasteload allocation to unpermitted mining sources in this segment of the Boulder River (**$WLA_{BLDR\ RV\ MS}$**). Under this allocation scheme, the TMDLs for the Boulder River from Basin Creek to the town of Boulder are expressed by the following equation:

$$TMDL_{UB\ RV} = LA_{BLDR\ RV\ NB} + WLA_{BLDR\ RV\ MS} + LA_{CUST\ MILL} + WLA_{DREDGE}$$

Natural background loading is calculated from the median metal pollutant concentrations from the following headwater sites: BE-01 and M07BASNC01 on Basin Creek, BE-11 on Big Limber Gulch, BE-28 on upper Boulder River, BE-36 on Cataract Creek, and BE-74 on Uncle Sam Gulch. The zero allocations to the permitted custom mill and dredge reflect the assumption that operation of these sources according to the stipulations of the individual groundwater permit for the mill and the general permit for portable suction dredges will not be a source of metals loading to the Boulder River.

The wasteload allocations to unpermitted mining sources are obtained by subtracting the calculated background loads from the TMDLs. The allocation scheme assumes that natural background loading rates do not exceed water quality standards. The allocations also assume that further application of BMPs to unpermitted mining sources will reduce loading so that TMDLs and water quality standards are met. Since the human health criterion for arsenic is exceeded only during high flows, no low-flow arsenic load reduction is required.

Data for sediment metals chemistry (**Figure 5-12**) is available for site BE-22 located below the mouth of Basin Creek, site BE-23 located below the mouth of Cataract Creek, and site BE-24 located below the mouth of High Ore Creek (**Appendix F, Figure F-10**).

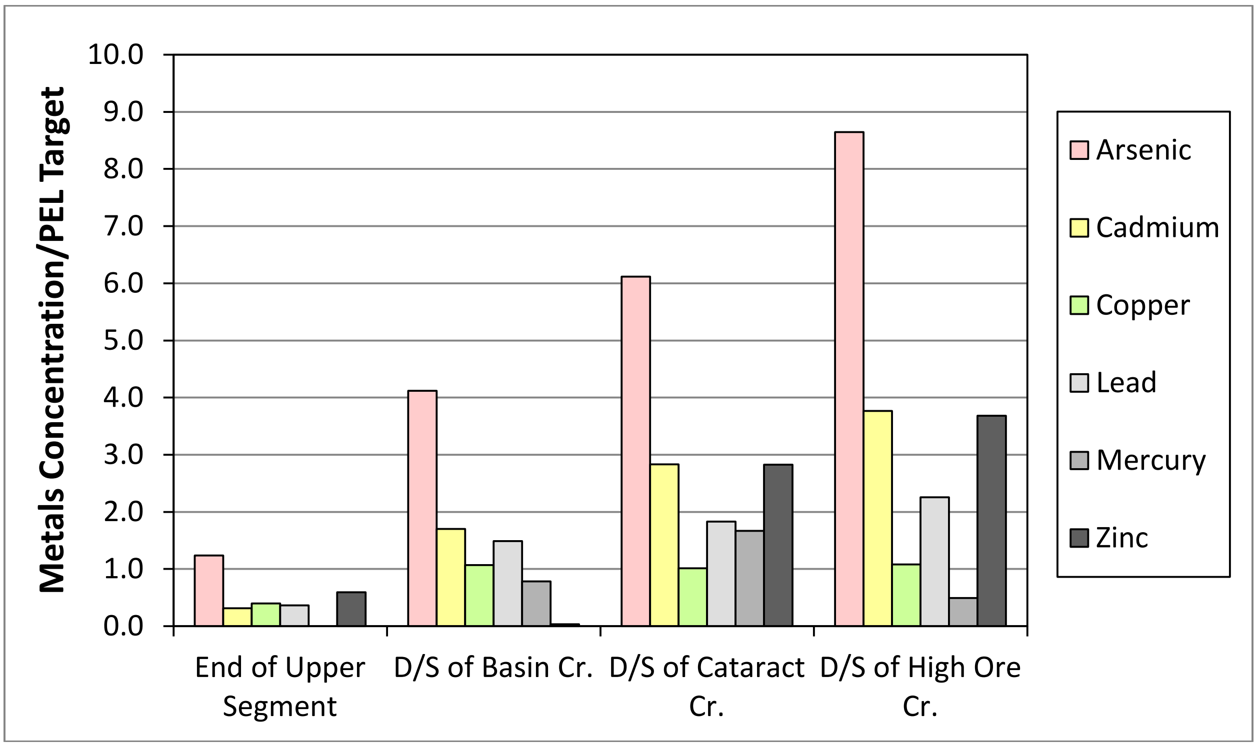

Figure 5-12. Sediment metals concentrations divided by PEL targets for Boulder River between Basin Creek and the town of Boulder

Data in the graph from the upstream segment is for site B-21 (**Appendix F, Figure F-7**). The graphs are arranged in upstream to downstream order. The graph shows large downstream increases in sediment concentrations of all metals except copper and illustrates the effects of Basin Area Superfund sources and sources in the Basin Creek, Cataract Creek and High Ore Creek drainages.

5.7.9 High Ore Creek (MT41E002_040)

Loading Summary

Metals loading to High Ore Creek is largely from sources related to the Comet Mine, located 4 miles above the mouth. The Grey Eagle Mine in the Bishop Creek tributary is another source, along with several small streamside lode and placer prospects (**Appendix F, Figure F-6**). Before reclamation during the 1990s the Comet Mine contained the largest volume of waste rock and tailings in the Basin Mining District. Natural background loading to High Ore Creek is represented by individual high- and low-flow water analysis results from site BE-53, upstream of the Comet Mine.

TMDLs and Allocations

Example TMDLs and allocations for High Ore Creek are contained in **Table 5-33**. Because of uncertainty regarding low-flow copper concentration measured at site BE-53, representing natural background conditions, the TMDL for low-flow lead loading is a composite WLA to natural background sources plus unpermitted mining sources (**WLA** $_{\text{H ORE CR NB + H ORE CR MS}}$). The TMDL equation containing the composite allocation is as follows:

$$TMDL_{\text{H ORE CR}} = WLA_{(\text{H ORE CR NB + H ORE CR MS})}$$

This equation is inserted into the allocation column of **Table 5-33** for low-flow lead loading. The allocations for all other metal pollutants under both flow conditions include a load allocation to natural background concentrations (**LA** $_{\text{H ORE CR NB}}$) and a wasteload allocation to unpermitted High Ore Creek mining sources (**WLA** $_{\text{H ORE CR MS}}$), as in the following equation:

$$TMDL_{\text{H ORE CR}} = LA_{\text{H ORE CR NB}} + WLA_{\text{H ORE CR MS}}$$

Table 5-33. Example metal TMDLs and load- and wasteload allocation examples for High Ore Creek at site BE-57

Metal	Flow Condition*	TMDL (lbs/day)	Existing Metal Concentration (µg/L)	Existing Load (lbs/day)	LA_{NB} (lbs/day)	WLA_{MS} (lbs/day)	Needed Reduction (%)
Arsenic	High flow	0.27	88	2.38	0.04	0.23	90
	Low flow	0.054	33	0.180	0.008	0.046	73
Cadmium	High flow	0.008	6.3	0.170	0.001	0.007	96
	Low flow	0.0022	41.7	0.2250	0.0020	0.0002	> 99
Copper	High flow	0.260	18.9	0.510	0.013	0.247	50
	Low flow	0.0800	8	0.0430	0.0054	0.0750	0
Lead	High flow	0.090	64.9	1.750	0.007	0.083	95
	Low flow	0.034	17.6	0.095	$TMDL_{\text{H ORE CR}} = WLA_{(\text{H ORE CR NB + H ORE CR MS})} = 0.034$		64
Zinc	High flow	3.34	1,800	48.60	1.19	2.15	95
	Low flow	1.01	1,270	6.86	0.38	0.63	90

* Specific flow values provided in **Table 5-24**

Natural background loading is represented by individual metal pollutant concentrations measured at site BE-53; wasteload allocations to mining sources are obtained by subtracting background loads from the target-based TMDLs. The allocation scheme assumes that natural background loading rates do not exceed water quality standards. The allocations also assume that additional BMPs applied to mining sources will reduce loading sufficiently to meet water quality standards. Since the chronic aquatic life criterion for copper is exceeded only during high flows, only high-flow reductions are needed to meet the TMDL.

Data for sediment metals chemistry is available from site BE-53 upstream of the Comet Mine, site BE-14 on Bishop Creek near its mouth, and site BE-57 at the mouth of High Ore Creek. **Figure 5-13** shows the ratios of metals concentrations measured in sediment, divided by the respective PEL targets. The sites are arranged downstream from left to right in the graph.

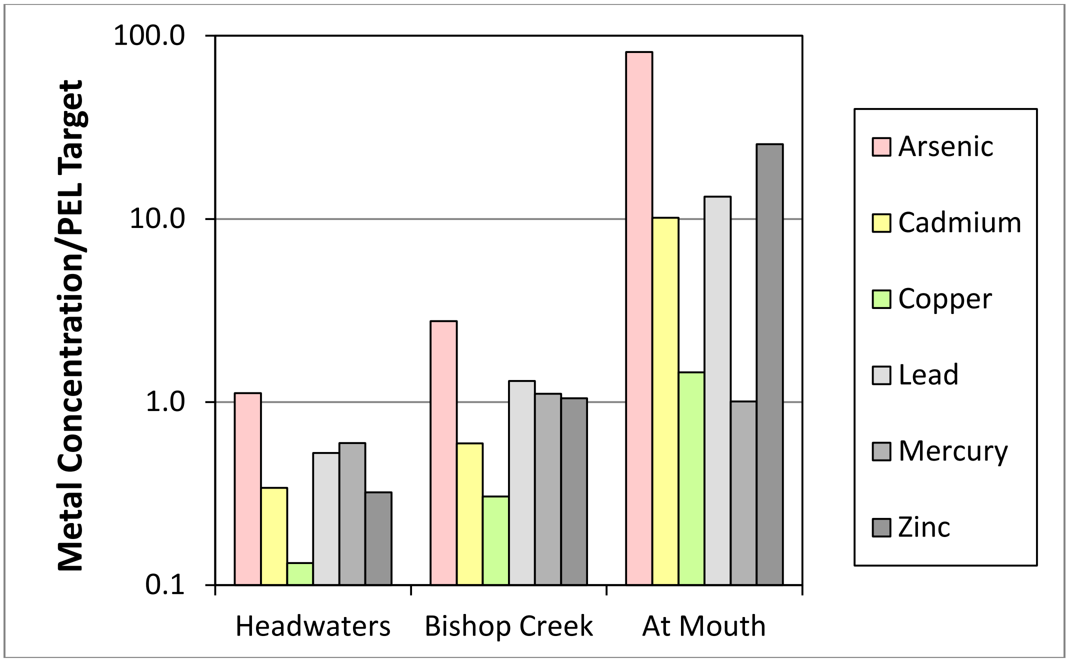

Figure 5-13. Sediment metals concentrations divided by PEL targets for a background site, a Bishop Creek site, and a site near the High Ore Creek Mouth

For the site above the Comet Mine, the arsenic exceedance is small, and all other metals are less than PELs. Bishop Creek contributes additional arsenic and amounts of lead, mercury, and zinc that slightly exceed PELs. Conditions at the mouth reflect Comet Mine sources.

5.7.10 Muskrat Creek (MT41E002_100)

Loading Summary

The Muskrat Creek drainage begins on the north slope of Elkhorn Peak (**Appendix F, Figure F-11**) and along the divide between the upper Boulder River valley and the Prickly Pear Creek watershed to the north. Sources are an iron mine in the Elkhorn Mountain headwaters and other mine disturbances in the Amazon Mining District in the northwestern part of the drainage. Natural background loading to Muskrat Creek is represented by water analysis results from headwaters sites M07MSKRC01 and BE-69 (**Appendix F, Figure F-11**).

TMDLs and Allocations

Example TMDLs and allocations for iron in Muskrat Creek are contained in **Table 5-34**. The allocations include a load allocation to natural background concentrations (**LA** $_{MSKRT\ CR\ NB}$) and a wasteload allocation to Muskrat Creek mining sources (**WLA** $_{MSKRT\ CR\ MS}$).

Table 5-34. Example iron TMDLs and load and wasteload allocation examples for Muskrat Creek at site BE-68

Metal	Flow Condition*	TMDL (lbs/day)	Existing Metal Concentration (µg/L)	Existing Load (lbs/day)	LA_{NB} (lbs/day)	WLA_{MS} (lbs/day)	Needed Reduction (%)
Iron	High flow	102.60	2,000	205.20	34.88	67.72	60
	Low flow	43.20	1,260	54.43	5.62	37.58	23

* Specific flow values provided in **Table 5-24**

The TMDLs are expressed by the following equation:

$$TMDL_{MSKRT\ CR} = LA_{MSKRT\ CR\ NB} + WLA_{MSKRT\ CR\ MS}$$

Natural background loading is calculated from low-flow median and individual high-flow metal pollutant concentrations measured at sites M07MSKRC01 and BE-69. Wasteload allocations to mining sources are obtained by subtracting background loads from the target-based TMDLs. The allocation scheme assumes that natural background loading rates do not exceed water quality standards. The allocations also assume that additional BMPs applied to mining sources will reduce loading sufficiently to meet water quality standards. The chronic aquatic life criterion for iron is exceeded under both flow conditions, so year round controls are needed to sufficiently reduce loading.

Data for sediment metals chemistry is not available for Muskrat Creek. The general location of iron loading sources may be inferred from the bar graph in **Figure 5-14**, showing median dissolved iron concentrations in samples from three surface water monitoring sites. The headwaters plot is from background site M07MSKRC01. The upper valley site is BE-69 and the site near the mouth is BE-68.

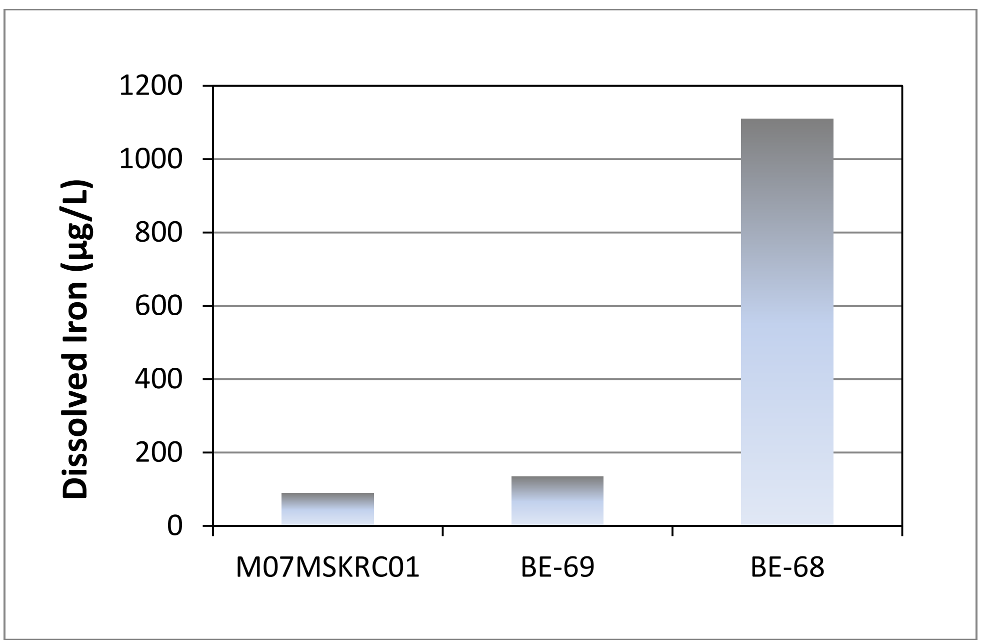

Figure 5-14 Median dissolved iron concentrations measured in samples from three Muskrat Creek monitoring sites

The chronic aquatic life criterion for dissolved iron in surface water is 1,000 µg/L. Loading appears greatest downstream of site BE-69 along the valley bottom reaches of the stream, or from sources in

Spencer Creek where a high flow iron concentration of 4,450 µg/L was measured in June 2009. Spencer Creek drains the northwestern portion of the watershed that contains several mining sources (**Appendix F, Figure F-11**).

5.7.11 Little Boulder River (MT41E002_080)

Loading Summary

Metals loading sources in the Little Boulder River watershed consist of small-scale hillside prospects in the upper drainage and Boulder valley placer mine areas farther downstream. Boulder Hot Springs has an MPDES permit (MT0023639) for a continuous domestic wastewater pond discharge of 0.1 cfs located about 1,700 feet upstream from the mouth on the mainstem Boulder River. Recent water quality monitoring of the Boulder Hot Springs wastewater treatment pond system outfall detected an arsenic concentration of 8 µg/L and a copper concentration of 3 µg/L. All other metal parameters in the discharge were less than method detection limits.

The Montana Department of Transportation has a general stormwater discharge permit for roadway construction activity near the mouth of the Little Boulder River. Natural background loading is represented by seasonal median values of water quality analysis results for site M07LBLDR01 in the central area of the watershed and site BE-59 located about 2,000 feet upstream of the confluence with the North Fork Little Boulder (**Appendix F, Figure F-12**).

TMDLs and Allocations

Two allocation schemes are developed for the Little Boulder River because of uncertainty regarding the background concentrations of aluminum, copper, and lead during high flows. For high-flow aluminum, copper, and lead the TMDL is a composite wasteload allocation to natural background sources, plus loading from unpermitted mining sources in the Little Boulder River water shed ($\mathbf{WLA}_{(LBLDR\ RV\ NB\ +\ LBLDR\ RN\ MS)}$).

In addition to the composite allocation, the TMDL includes a wasteload allocation to the permitted stormwater source ($\mathbf{WLA}_{LBLDR\ RV\ SW}$), and a wasteload allocation to the metal contributions from the permitted Boulder Hot Springs WWTP discharge ($\mathbf{WLA}_{BHS\ WWTP}$). The allocation to the stormwater source is set equal to zero, because operation of the source in compliance with the terms of the general permit is not expected to result in metals loading to the Little Boulder River. The allocations to Boulder Hot Springs are calculated from its discharge rate of 0.1 cfs multiplied by metals concentration measured in the outfall, and a unit conversion factor. One half of the detection limit is used in the allocation calculations for analysis results reported as less than the method detection limit. The composite high-flow aluminum, high-flow copper, and high-flow lead TMDLs and allocations to Little Boulder River sources are expressed by the following equation:

$$TMDL_{LBLDR\ RV} = WLA_{(LBLDR\ RV\ NB\ +\ LBLDR\ RV\ MS)} + WLA_{LBLDR\ RV\ SW} + WLA_{BHS\ WWTP}$$

For example, the allocation scheme for high-flow copper states that the sum of allowable loading from the composite of natural background and unpermitted mining sources stormwater sources, plus the stormwater and treatment plant sources is equal to the TMDL of 6.72 lbs/day. The composite allocation equations for high-flow aluminum, copper, and lead are inserted into the corresponding allocation columns of **Table 5-35**.

Table 5-35. Example high and low flow aluminum, copper, iron, and lead TMDLs and allocations for the Little Boulder River at site BE-59

Metal	Flow Condition*	TMDL (lbs/day)	Existing Metal Conc. (µg/L)	Existing Load (lbs/day)	LA_{NB} (lbs/day)	WLA_{MS} (lbs/day)	$WLA_{CNSTR\ SW}$ (lbs/day)	$WLA_{HSPRGS\ WWTP}$ (lbs/day)	Needed Reduction (%)
Aluminum	High flow	170.540	110	215.600	$TMDL_{LBLDR\ RV}$ = (WLA $_{(LBLDR\ RV\ NB\ +\ LBLDR\ RV\ MS)}$) = 170.493 (lbs/day)		0	0.047 (0.03% of TMDL)	21
	Low flow	10.340	15	1.780	1.780	8.513	0	0.047 (0.5% of TMDL	0
Copper	High flow	6.72	8	15.7	$TMDL_{LBLDR\ RV}$ = (WLA $_{(LBLDR\ RV\ NB\ +\ LBLDR\ RV\ MS)}$) = 6.718 (lbs/day)		0	0.002 (0.03% of TMDL)	57
	Low flow	0.529	3	0.360	0.360	0.167	0	0.002 (0.4% of TMDL)	0
Iron	High flow	1960.00	1,270	2,489.50	1,284.00	675.46	0	0.54 (0.03% of TMDL)	44
	Low flow	118.80	770	91.50	54.65	63.61	0	0.54 (0.4% of TMDL)	0
Lead	High flow	1.4100	7	13.700	$TMDL_{LBLDR\ RV}$ = (WLA $_{(LBLDR\ RV\ NB\ +\ BLDR\ RV\ MS)}$) = 1.4096 (lbs/day)		0	0.0004 (0.03% of TMDL)	90
	Low flow	0.1250	0.25	0.0300	0.0300	0.0944	0	0.0006 (0.5% of TMDL)	0

* Specific flow values provided in **Table 5-24**

A second allocation scheme is developed for low-flow loading of aluminum, copper, lead, and both low- and high-flow iron loading. These situations allow for an estimate of background loading that is within the TMDL. Therefore, the TMDL equals a load allocation to Little Boulder River natural background sources (**$LA_{LBLDR\ RV\ NB}$),** a wasteload allocation to unpermitted Little Boulder River mining sources (**$WLA_{LBLDR\ RV\ MS}$**), a wasteload allocation to the construction stormwater source (**$WLA_{CNSTR\ SW}$**), and a wasteload allocation to the Boulder Hot Springs WWTP (**$WLA_{BHS\ WWTP}$).** The TMDL is expressed in the following equation for year round iron loading and low flow loading of aluminum, copper, and lead:

$$TMDL_{LBLDR\ RV} = LA_{LBLDR\ RV\ NB} + WLA_{LBLDR\ RV\ MS} + WLA_{CNSTR\ SW} + WLA_{BHS\ WWTP.}$$

The wasteload allocation for construction stormwater source is set at zero. Loading from a permitted construction site, operated according to the requirement of the general stormwater control permit, is considered negligible. Wasteload allocations to unpermitted mining sources are obtained by subtracting the combined background loads plus WWTP loads from the target-based TMDLs. Both allocation schemes assume that natural background loading rates do not exceed water quality standards. The allocations also assume that additional BMPs applied to mining sources will sufficiently reduce loading to meet water quality standards. The chronic aquatic life criteria for all four metal parameters are exceeded only under high-flow conditions. Therefore, high-flow controls are needed to reduce loading. Low-flow loads of all four parameters are within the calculated TMDLs and do not require reductions.

The wasteload allocations to the Boulder Hot Springs WWTP are based on the existing discharge flow (estimated at 0.1 cfs) multiplied by the most restrictive target for each metal parameter; with hardness-dependent targets determined using the respective high and low flow average hardness values of 31 mg/L and 42 mg/L. Based on the limited available data, all metal parameters measured in the outfall are either less than the most restrictive target or less than the method detection limit. Therefore, it appears as though the $WLA_{BHS\ WWTP}$ is currently being met and no reductions are necessary. Under all flow conditions the facility will not cause or contribute to impairment of the Little Boulder River if the metal concentration in the discharge is less than or equal to the most restrictive metal target concentration for the Little Boulder River. For this reason, the allocations can also be interpreted and expressed as concentrations in units of mass per volume (µg/L), as opposed to loads in units of mass per time period (lbs/day). Thus, a concentration-based approach can be used for MPDES permit development, with the concentrations equaling the TMDL metals concentration target values applicable to the Little Boulder River. This approach may be desirable because there are no implicit or explicit loading caps over time and compliance can be based solely on the measured discharge concentration independent of discharge flow. A concentration-based approach is also consistent with reasonable assurance as defined within **Section 4.4**.

Additional monitoring of high-flow aluminum, copper, and lead concentrations in the Little Boulder River are needed to better refine estimates of natural background sources. An additional monitoring site higher in the watershed can avoid some of the mining sources that may be affecting water quality at site M07LBLDR01.

Results for sediment metals analysis are available for three sample sites in the Little Boulder River watershed. **Figure 5-15** shows the ratio of measured metal concentration in the samples over the target PELs.

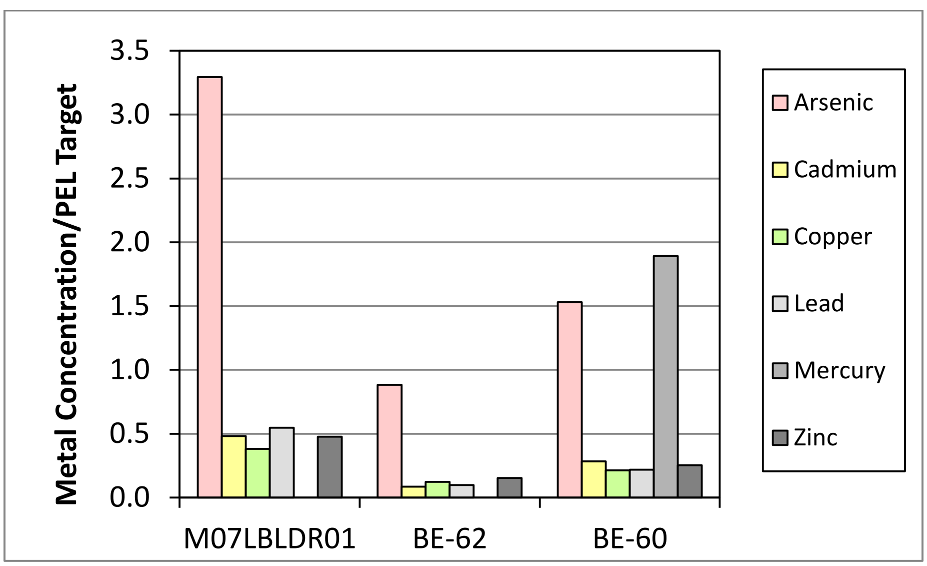

Figure 5-15. Sediment metals concentrations divided by PEL targets for three sample sites in the Little Boulder River Watershed

Site M07LBLDR01 is in the central part of the drainage, site M07LBNFR04 is at the mouth of the North Fork Little Boulder, and site BE-60 is at the mouth of the Little Boulder River. The graph suggests a large arsenic source in the central drainage and a source of mercury below the North Fork confluence. All other metals are within the respective PELs.

5.7.12 North Fork Little Boulder River (MT41E002_090)

Loading Summary

Metal loading sources in the North Fork Little Boulder River are small-scale mining and prospecting disturbances and related access roadways. A near stream access road extends for 6 miles from the mouth of the stream to site M07LBNFR02 in the central part of the drainage (**Appendix F, Figure F-12**).

TMDLs and Allocations

As in the Little Boulder River, composite allocations are used because of uncertainty regarding high-flow water column aluminum concentrations and copper concentrations under both flow conditions in samples from the background site (M07LBNFR02.) Separate allocations to natural background and mining sources apply to low-flow aluminum loading. For high-flow aluminum and both high- and low-flow copper, the TMDL is a composite wasteload allocation to natural background sources and unpermitted North Fork Little Boulder mining sources. The TMDL and composite allocations are expressed by the following equation:

$$TMDL_{NFLBLDR\ RV} = WLA_{(NFLBLDR\ RV\ NB\ +NFLBLDR\ RV\ MS}$$

The TMDL equations containing composite allocations are inserted into the allocation columns of **Table 5-36**. For example, the composite allocation scheme for high flow copper states that the sum of allowable loading from natural background and mining sources is equal to the TMDL of 0.56 lb/day.

Table 5-36. Example high- and low-flow aluminum and copper TMDL and allocation examples for North Fork Little Boulder River at site BE-62

<table>
<tr><th>Metal</th><th>Flow Condition*</th><th>TMDL (lbs/day)</th><th>Existing Metal Concentration (µg/L)</th><th>Existing Load (lbs/day)</th><th>LA_{NB} (lbs/day)</th><th>WLA_{MS} (lbs/day)</th><th>Needed Reduction (%)</th></tr>
<tr><td rowspan="2">Aluminum</td><td>High flow</td><td>15.03</td><td>90</td><td>15.55</td><td colspan="2">$TMDL_{NFLBLDR\ RV} = (WLA_{(NFLBLDR\ RV\ NB\ +NFLBLDR\ RV\ MS}) =$ 15.03 (lbs/day)</td><td>3</td></tr>
<tr><td>Low flow</td><td>2.35</td><td>80</td><td>2.16</td><td>2.16</td><td>0.19</td><td>0</td></tr>
<tr><td rowspan="2">Copper</td><td>High flow</td><td>0.56</td><td>7</td><td>1.21</td><td colspan="2">$TMDL_{NFLBLDR\ RV} = (WLA_{(NFLBLDR\ RV\ NB\ +NFLBLDR\ RV\ MS})$ =0.56 (lbs/day)</td><td>54</td></tr>
<tr><td>Low flow</td><td>0.130</td><td>5</td><td>0.135</td><td colspan="2">$TMDL_{NFLBLDR\ RV} = (WLA_{(NFLBLDR\ RV\ NB\ +NFLBLDR\ RV\ MS}) =$ 0.130 (lbs/day)</td><td>4</td></tr>
</table>

* Specific flow values provided in **Table 5-24**

A second allocation scheme applies to low-flow aluminum, where an estimate of background loading is within the TMDL. The TMDL for low-flow aluminum equals a load allocation to North Fork Little Boulder River natural background sources (**$LA_{NFLBLDR\ RV\ NB}$**), and a wasteload allocation to North Fork Little Boulder River mining sources (**$WLA_{NFLBLDR\ RV\ MS}$**). The TMDL is expressed in the following equation:

$$TMDL_{LBLDR\ RV} = LA_{LBLDR\ RV\ NB} + WLA_{LBLDR\ RV\ MS.}$$

Both allocation schemes assume that natural background loading rates do not exceed water quality standards. The allocations also assume that additional BMPs applied to mining sources will sufficiently reduce loading to meet water quality standards. Although the chronic aquatic life criterion for copper is exceeded under both flow conditions, water quality would improve more through BMPs that address high-flow loading. Additional monitoring of high-flow aluminum and copper are recommended to refine estimates of natural background sources.

Sediment metals chemistry data is available for site M07LBNFR04 located about one third of a mile above the mouth (**Figure 5-16**). Although high in arsenic compared to other metals, all sediment metal concentrations are less than the PELs. Thus, the North Fork does not appear to be the source of elevated sediment metals downstream in the Little Boulder River.

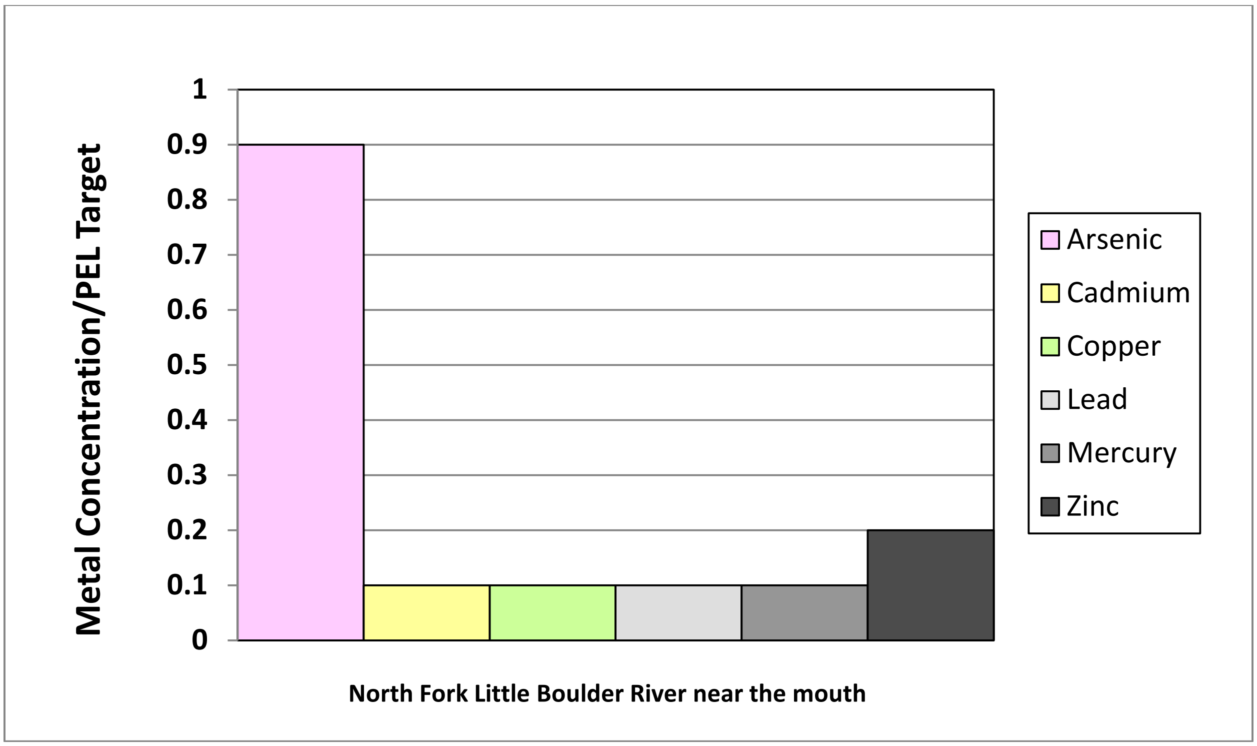

Figure 5-16. Sediment metals concentrations divided by PEL targets for a North Fork Little Boulder River sample from site M07LBNFR04

5.7.13 Upper Elkhorn Creek (MT41E002_061)

Loading Summary

Loading of metals to upper Elkhorn Creek is from mining and milling sources in the Elkhorn and Turnley creek watersheds, once part of the former Elkhorn Mining District. A permitted underground gold mine (operating permit number 000173) is located northwest of the Elkhorn town site. The mine operator plans to discharge 150-300 gpm (0.3-0.7 cfs) of treated wastewater to groundwater through a subsurface drainfield. The drainfield will be installed on hillsides draining to Slaughterhouse Gulch and Turnley Creek. Wastewater is treated for arsenic and nitrogen removal before discharge. If the reported average hardness of 164 mg/L is typical, reported values for hardness-dependent metal parameters are all below chronic aquatic life criteria. At expected arsenic concentrations in the discharge (8-25 µg/L), loading to local groundwater will range between 0.1 and 0.005 lb/day (concentration (µg/L) × Flow (cfs)

× 0.0054 = loading (lbs/day)). The discharge to groundwater is not expected to recharge local surface water in Slaughterhouse Gulch, Elkhorn Creek, or Turnley Creek. Groundwater and surface water quality monitoring of potential receiving waters is required by the permit. The mine also holds a general permit (MTR300264) for the discharge of stormwater from mining activity.

TMDLs and Allocations

Example TMDLs and allocations for upper Elkhorn Creek are contained in **Table 5-37**. The allocations include a load allocation to natural background concentrations (**LA** $_{\text{UPR ELKHN CR NB}}$), a load allocation to the permitted groundwater discharge (**LA** $_{\text{UPR ELKHN GRNDWTR}}$), a wasteload allocation to permitted stormwater (**WLA** $_{\text{UPR ELKHN CR STRMWTR}}$), and a wasteload allocation to unpermitted upper Elkhorn Creek mining sources (**WLA** $_{\text{UPR ELKHN CR MS}}$). As noted in **Section 5.3.3**, the permitted groundwater discharge is given a load instead of a wasteload allocation because potential metals loading to surface water would be via diffuse groundwater pathways. The TMDL is expressed in the following equation:

$$TMDL_{\text{UPR ELKHN CR}} = LA_{\text{UPR ELKHN CR NB}} + LA_{\text{UPR ELKHN GRNDWTR}} + WLA_{\text{UPR ELKHN CR STRMWTR}} + WLA_{\text{UPR ELKHN CR MS}}$$

Table 5-37. Example metal TMDLs and load- and wasteload allocation examples for upper Elkhorn Creek at site BE-48

Metal	Flow Condition*	TMDL (lbs/ day)	Existing Metal Concentration (µg/L)	Existing Load (lbs/day)	Permitted Groundwater Discharge	Permitted Stormwater Discharge	LANB (lbs/day)	WLAMS (lbs/day)	Needed Reduction (%)
Arsenic	High flow	1.08	19	2.05	0	0	0.43	0.65	60
	Low flow	0.27	14	0.378	0	0	0.04	0.23	32
Cadmium	High flow	0.0140	0.56	0.0600	0	0	0.0043	0.0097	83
	Low flow	0.0050	0.72	0.0200	0	0	0.0011	0.0039	79
Copper	High flow	0.440	35	3.780	0	0	0.054	0.386	90
	Low flow	0.1650	21	0.5670	0	0	0.0135	0.1515	73
Iron	High flow	108.0	1,710	184.7	0	0	2.7	105.3	42
	Low flow	27.00	1,010	27.30	0	0	0.68	26.32	1
Lead	High flow	0.100	10.7	1.156	0	0	0.027	0.073	94
	Low flow	0.0460	6.2	0.1670	0	0	0.0068	0.0392	76

* Specific flow values provided in **Table 5-24**

The wasteload allocations for the permitted groundwater discharge and permitted stormwater discharge from mining activity are set at zero. A discharge from the drainfield to surface water is not expected to occur, and the permit states that if it does, the operation will discontinue use of the drainfield and replace it with treatment and discharge options not resulting in a discharge of process water to surface water. A discharge from a facility operated according to the general permit for stormwater from mining activity is not expected to be a source of metals loading to surface water. Wasteload allocations to mining sources are obtained by subtracting background loads from the target-based TMDLs. Natural background water quality is represented by the individual water quality records for high- and low-flow loading at site BE-46 located on Elkhorn Creek upstream of the town of Elkhorn (**Appendix F, Figure F-13**). Allocations assume that natural background loading rates do not exceed water quality standards. The allocations also assume that additional BMPs applied to mining sources in upper Elkhorn Creek will sufficiently reduce loading to meet water quality standards.

The chronic aquatic life criterion for iron is exceeded under high-flow conditions and only slightly during low flows. Controls applied to high-flow loading will likely meet the TMDL under low-flow conditions. The remaining metal parameters require year round controls to meet the TMDLs.

Data for sediment metals chemistry is unavailable for upper Elkhorn Creek. The general location of metal loading sources may be inferred from **Figure 5-17**, which shows median metal concentrations in samples from three surface water monitoring sites. The red markers on the bars illustrate the target level for each metal impairment cause.

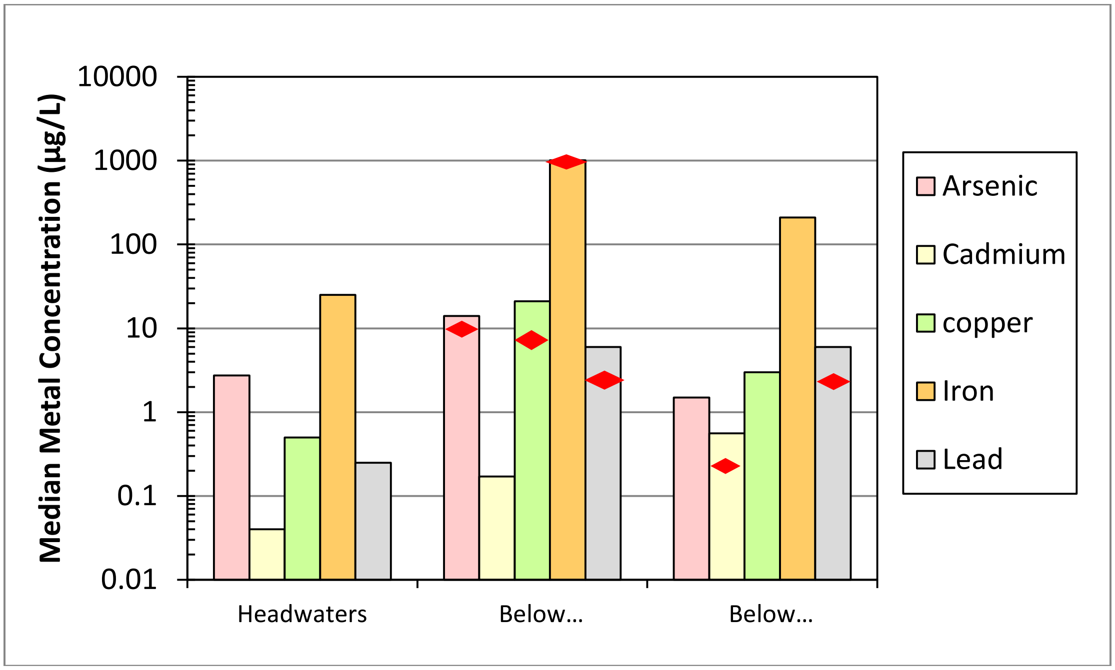

Figure 5-17. Median metal concentrations and target values (red markers) at three monitoring sites in Upper Elkhorn Creek

The headwaters plot is from background site BE-46, where all metals targets are met. The site below the Elkhorn Mine is BE-47, where targets are exceeded for arsenic, copper, iron, and lead. Site BE-47 is located below the confluence of Elkhorn Creek and Slaughterhouse Gulch and shows the influence on loading from tailings and waste rock accumulations in the area. The third site is below the confluence with Queen's Gulch (BE-48). Site BE-48 shows the influence of several tailings deposits in Elkhorn Creek and the influence of mining waste sources on Turnley Creek and its tributaries.

5.7.14 Lower Elkhorn Creek (MT41E002_062)

Loading Summary

Metals loading sources to lower Elkhorn Creek are those described above for the upper segment.

TMDLs and Allocations

Example TMDLs and allocations for lower Elkhorn Creek are contained in **Table 5-38**. The allocations include a load allocation to natural background concentrations (**$LA_{\text{LWR ELKHN CR NB}}$**) and a wasteload allocation to lower Elkhorn Creek mining sources (**$WLA_{\text{LWR ELKHN CR MS}}$**). The TMDL is expressed in the following equation:

$$TMDL_{\text{LWR ELKHN CR}} = LA_{\text{LWR ELKHN CR NB}} + WLA_{\text{LWR ELKHN CR MS}}$$

Natural background water quality is represented by the water quality record for site BE-46 located on Elkhorn Creek upstream of the town of Elkhorn (**Appendix F, Figure F-13**). Wasteload allocations to mining sources are obtained by subtracting background loads from the target-based TMDLs.

Table 5-38. Example metal TMDLs and load- and wasteload allocation examples for lower Elkhorn Creek at site BE-50

Metal	Flow Condition*	TMDL (lbs/day)	Existing Metal Concentration (µg/L)	Existing Load (lbs/day)	LA_{NB} (lbs/day)	WLA_{MS} (lbs/day)	Needed Reduction (%)
Arsenic	High	0.38	8	0.30	0.15	0.23	0
	Low	0.00400	11	0.00480	0.00065	0.00335	19
Cadmium	High	0.0060	0.9	0.0340	0.0015	0.0045	86
	Low	0.00009	1.39	0.00060	0.00002	0.00007	88
Lead	High	0.0450	16.6	0.6300	0.0095	0.0355	94
	Low	0.0008	10.3	0.0044	0.0001	0.0007	84

* Specific flow values provided in **Table 5-24**

Allocations assume that natural background loading rates do not exceed water quality standards. The allocations also assume that additional BMPs applied to mining sources affecting lower Elkhorn Creek will sufficiently reduce loading to meet water quality standards. An arsenic analysis result of 11 µg/L prompted the listing for lower Elkhorn Creek for arsenic. With the arsenic target equal to the 10 µg/L human health criteria, a small arsenic reduction is required during low flow. The large reductions required for the remaining metals reflect the magnitude of upstream tailings, waste rock, and adit discharge sources.

Data for sediment metals concentration is available for site BE-49, located near the upstream end of the lower Elkhorn Creek segment. The ratios of measured concentrations to PEL targets are found in **Figure 5-18**. Except for cadmium, sediment metal concentrations are at least 10 times the corresponding PEL target. The results show the strong influence of mine tailings on stream sediment chemistry.

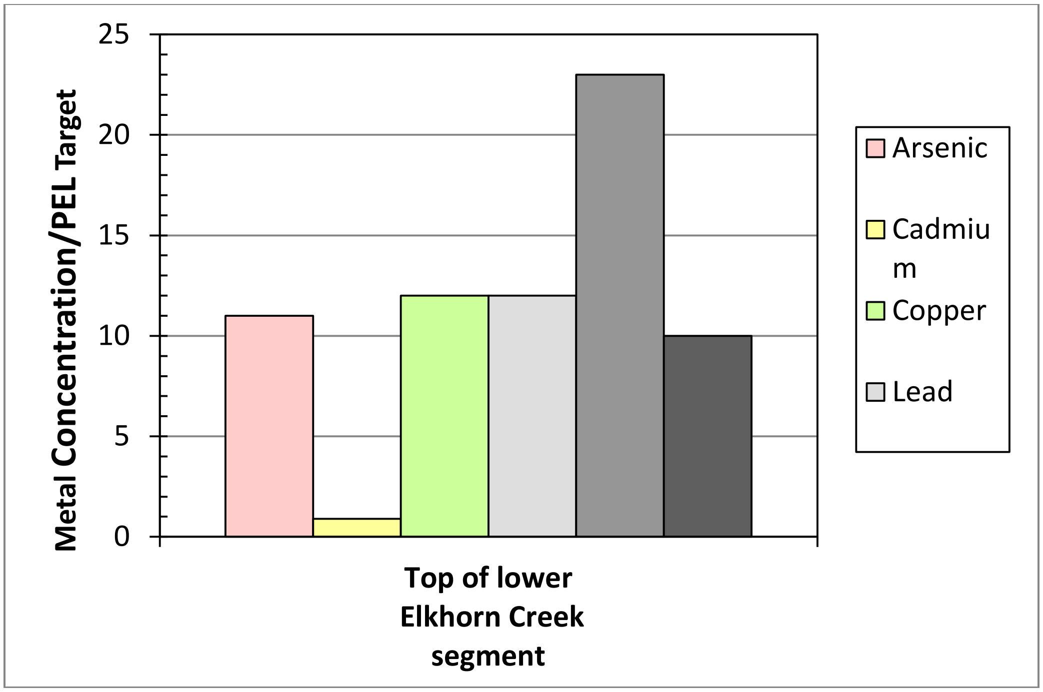

Figure 5-18. Bar graph of sediment metals concentrations divided by PEL targets for site BE-49 on lower Elkhorn Creek

5.7.15 Boulder River, Town of Boulder to Cottonwood Creek (MT41E001_022)

Loading Summary

Human-caused sources of metals loading to the Boulder River from the town of Boulder to the Cottonwood Creek confluence (**Appendix F, Figure F-14**) include several scattered mine and quarry properties on the east flank of Bull Mountain and around the Devil's Fence area along the east side of the Boulder River valley downstream of Elkhorn Creek. The sites contain small stockpiles of aggregate, metal ores, or waste rock that are sparsely vegetated. No portal discharges are described for the properties.

Seven general stormwater permits for construction activity are issued is this segment of the Boulder River. They include a residential building construction site in the city of Boulder, construction on Montana Highway 69 upstream of the mouth of the Little Boulder River, and aggregate quarries in the portion of the valley south of the Elkhorn Mountains. These existing sites, permitted under the stipulations of a general stormwater permit, do not represent significant sources of metals loading to the Boulder River if operating in compliance with the terms of the general permit.

The city of Boulder wastewater treatment plant (WWTP) holds permit number MT0022078) for its treated wastewater discharge to the Boulder River 1.2 miles below the upstream end of the segment. Treatment is provided by a three-celled pond system that discharges from the third cell to an unlined ditch connecting the outfall to the river channel. Permit discharge monitoring reports record flow rates that vary between 0.03 and 0.42 cfs, with a median discharge of 0.12 cfs. The permit for the facility requires semiannual metals monitoring for copper, iron, lead, silver, and zinc from 2010 through 2012. Lacking monitoring data for arsenic and cadmium, the outfall was sampled by DEQ in September, 2012, for the complete suite of metals pollutant causes affecting this segment of the river. The results of monitoring required by the permit and the results for the September, 2012, sample are contained in **Table 5-39**.

Table 5-39. Total recoverable metals monitoring results (mg/L) for the Boulder WWTP outfall 001 and total hardness values for the Boulder River*

Sample Period	Total Hardness	Arsenic	Cadmium	Copper	Iron	Lead	Silver	Zinc
Mar, 2010	43	--	--	**0.03**	0.58	< 0.01	< 0.005	0.02
July, 2010	54	--	--	< 0.02	0.29	< 0.01	< 0.005	< 0.01
Jan., 2011	28	--	--	**0.04**	0.04	< 0.01	< 0.005	**0.05**
July, 2011	61	--	--	**0.02**	0.09	< 0.01	< 0.005	< 0.01
Jan., 2012	28	--	--	**0.06**	0.72	**0.003**	< 0.001	0.04
July, 2012	40	--	--	**0.06**	0.72	**0.003**	< 0.001	0.04
Sept., 2012	48	< 0.003	0.00017	**0.063**	**1.66**	0.00042	< 0.0005	0.05

* The shaded cells identify analytical results for which the method detection limits were higher than the hardness-based aquatic life targets. Bolded values in the table identify actual target exceedances.

The shaded cells in **Table 5.39** identify analytical results for which the method detection limits exceed the hardness-based aquatic life targets. Bolded values in **Table 5-39** identify WWTP discharge concentrations measured at levels greater than Bolder River metal target values. The values for total hardness are those measured in the Boulder River upstream of the treatment pond outfall. The only available results for arsenic and cadmium are from the September, 2012, sample collected by DEQ. Arsenic in the outfall was less than the method detection limit and the cadmium result of 0.00017 mg/L was less than the hardness-dependent chronic aquatic life target of 0.00031 mg/L. From these limited results, arsenic and cadmium concentrations in the effluent appear to be less than the most restrictive Boulder River targets.

The method detection limit for copper used for permit monitoring (0.02 mg/L) exceeds both the acute and chronic aquatic life targets for copper. These targets for the lowest hardness value (28 mg/L) are 0.016 and 0.0006 mg/L respectively. The current permit monitoring for copper can only confirm whether the discharge concentration is less than the human health target of 1.3 mg/L. Despite the high method detection limits, 6 of the 7 copper results in **Table 5-39** are measured concentrations exceeding the chronic aquatic life targets for copper by an order of magnitude or more. As with copper, the method detection limit reported with the effluent monitoring results for lead in 2010 and 2011 exceed the chronic aquatic life targets. The 2 positive detections of 0.003 mg/L for lead in 2012 exceed the chronic aquatic life targets by an order of magnitude. However, the result of 0.00042 mg/L for the September, 2012, sample meets all water quality targets for lead. Silver was not detected in any effluent sample, though only the September, 2012, sample was reported with a detection limit low enough to assess compliance with the aquatic life target (0.00115 mg/L). The effluent does not appear to be a significant source of silver loading to the Boulder River. For both zinc and iron, 1 result in 7 exceeded the aquatic life criterion.

Discharge monitoring of the Boulder wastewater treatment facility includes the flow rate, ranging from 0.03 to 0.42 cfs. Higher discharge flows from the outfall generally correspond to higher flows in the Boulder River. This is likely due to infiltration into the wastewater collection system. The 50th percentile flow is 0.12 cfs. The average of flows greater than 0.12 cfs is 0.2 cfs; the average of flows less than the 50th percentile is 0.07 cfs. These average high- and low-flow values are used to calculate example high- and low-flow metal allocations to the treatment system for each metal parameter.

Results of sediment metals analysis are available for two sample sites in this segment of the Boulder River: site BE-26 is located just downstream of the Little Boulder River mouth; and site BE-34 is located just downstream of the Elkhorn Creek mouth. **Figure 5-19** shows the ratio of measured metal concentration in the samples to the target PELs.

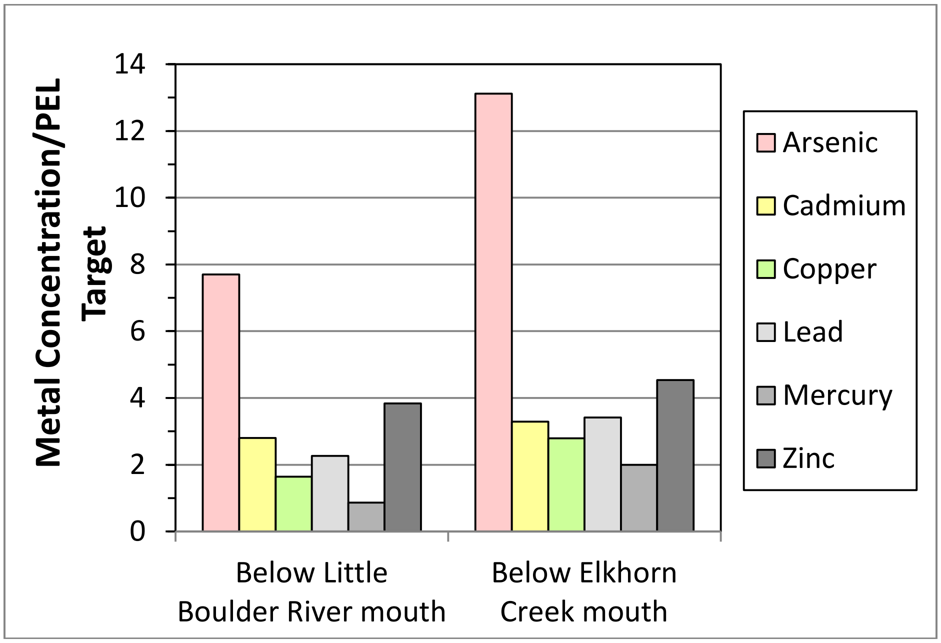

Figure 5-19. Bar graph of sediment metals concentrations divided by PEL targets for sites BE-26 and BE-36 on the Boulder River between the town of Boulder and Cottonwood Creek

The graph suggests a large arsenic source to the Boulder River between the mouth of the Little Boulder River and site BE-34 downstream of Elkhorn Creek. Downstream increases for other metals in sediment are less pronounced. Except for mercury in the sample from below the Little Boulder, all values exceed the corresponding PELs. The sediment-bound arsenic source is assumed as part of the unpermitted metal mining sources included in the composite WLA to these sources in the arsenic TMDL in **Table 5-40**.

TMDLs and Allocations

Example TMDLs and allocations for the Boulder River from the city of Boulder to Cottonwood Creek are contained in **Table 5-40**. The allocations include a load allocation to natural background sources (**LA** $_{BLDR\ RV\ NB}$), a wasteload allocation to the Boulder WWTP (WLA $_{BLDR\ WWTP}$), a composite wasteload allocation to the combined permitted general stormwater discharges from construction activity (**WLA** $_{GNRL\ STRMWTR}$), and a composite wasteload allocation to unpermitted Boulder River mining sources (**WLA**$_{BLDR\ RV\ MS}$). The TMDL is expressed in the following equation:

$$TMDL_{BLDR\ RV} = LA_{BLDR\ RV\ NB} + WLA_{BLDR\ WWTP} + WLA_{GNRL\ STRMWTR} + WLA_{BLDR\ RV\ MS}$$

Table 5-40. Example metal TMDLs and load- and wasteload allocation examples for the Boulder River (MT41E001_022) at site M07BOLDR03

Metal	Flow Condition*	TMDL (lbs/day)	Existing Metal Concentration (µg/L)	Existing Load (lbs/day)	LA_{NB} (lbs/day)	WLA $_{BLDR\ WWTP}$ (lbs/day) MT0023078	WLA $_{GNRL\ STRMWTR}$ (lbs/day)	WLA_{MS} (lbs/day)	Needed Reduction (%)
Arsenic	High	67.450	30	202.340	10.170	0.011	0	57.269	70
	Low	4.1000	16	6.5700	0.6200	0.0038	0	3.4762	42
Cadmium	High	0.74000	1.05	7.0800	0.27000	0.0001	0	0.4699	93
	Low	0.07000	0.32	0.1300	0.01600	0.0001	0	0.0539	53
Copper	High	23.13000	69	465.4000	13.5000	0.0034	0	9.6266	98
	Low	2.220	10	4.100	0.410	0.002	0	1.808	51
Lead	High	4.8600	31.2	210.4300	1.6900	0.0007	0	3.1693	98
	Low	0.5800	1.5	0.6200	0.1030	0.0005	0	0.4765	8
Iron	High	6745	3,010	20,301	2293	1	0	4451	75
	Low	410.400	320	131.330	53.350	0.378	0	356.672	0
Zinc	High	299.600	220	1,484.000	33.720	0.044	0	265.836	82
	Low	28.720	70	28.730	2.050	0.024	0	26.646	0.05

* Specific flow values provided in **Table 5-24**

Natural background loading is represented by the median values of water quality data for sites M07MSKRC01 and M07MSKRC02 on Muskrat Creek, site M07LBNFR02 on the North Fork Little Boulder River, and site BE-46 on Elkhorn Creek above the town of Elkhorn. The facilities operating under the conditions of the general stormwater discharge permit for construction activity are not assumed to be significant sources of metals loading to the river. Therefore, the composite allocation to permitted point sources operating under the general permit is set at zero.

High and low flow allocations to the Boulder WWTP are based on respective high- and low-flow facility discharges of 0.2 cfs and 0.07 cfs. These flow values are multiplied by the most restrictive target for each metal parameter; with hardness-dependent targets determined using the respective high and low flow average hardness values of 28 mg/L and 47 mg/L. Based on the **Table 5-39** results, the WWTP would consistently exceed the lead and copper WLAs and occasionally exceed the WLAs for iron and zinc.

The sum of calculated allocations to natural background sources, permitted stormwater sources, and the Boulder WWTP is subtracted from the TMDL for each metal to arrive at the composite allocations to unpermitted mining sources. The sediment-bound arsenic source between the mouth of the Little Boulder River and site BE-34 downstream of Elkhorn Creek is included as part of the composite WLA to unpermitted metal mining sources in the arsenic TMDL in **Table 5-40**.

Table 5-40 presents the percent reductions needed to meet the TMDL during typical low and high flows. Existing low-flow iron loading is within the TMDL, thus no low-flow load reductions are required for iron. Minimal low-flow load reductions are needed for lead and zinc. Low-flow load reductions for arsenic, cadmium, and copper are approximately half of those required at high flows. Approximate order of magnitude reductions are required of all metal pollutants during high flows.

The load reductions needed in this segment of the Boulder River are not evenly distributed among the sources. This is clearly illustrated in the large difference between the load allocations to upstream mining sources, compared to those allocated to the Boulder WWTP in **Table 5-40**. Much of this difference is due to the large flow difference between the river and the WWTP outfall. In addition, the large allocation differences reflect the magnitude of historic metal mining sources in Basin, Cataract, and High Ore creeks.

Table 5-41 contains a comparison of metals loading from upstream mining sources to metals loading from the city of Boulder WWTP under high-flow conditions. The figures in **Table 5-41** for the Boulder River are median metal concentrations measured at USGS station 06032400 located 4 miles upstream of the WWTP outfall. The figures in **Table 5-41** for the Boulder WWTP outfall are from **Table 5-39** using the median values of all data for copper, iron, and zinc, the median values excluding the non-detects for lead, and the single sample results for arsenic and cadmium.

Table 5-41. Metals loading in the Boulder River from upstream mining sources compared to the contribution from the city of Boulder WWTP outfall

<table>
<tr><th>Metal</th><th>Boulder River Flow (cfs)</th><th>Boulder WWTP Flow (cfs)</th><th>Metal Concentration, Boulder River (µg/L)</th><th>Metal Concentration, Boulder WWTP (µg/L)</th><th>Existing Metal Load, Boulder River (lbs/day)</th><th>Existing Metal Load, Boulder WWTP (lbs/day)</th><th>WWTP Percentage of River Loading</th></tr>
<tr><td>Arsenic</td><td rowspan="6">397</td><td rowspan="6">0.2</td><td>7</td><td>3</td><td>15.0</td><td>0.0032</td><td>0.02</td></tr>
<tr><td>Cadmium</td><td>0.39</td><td>0.17</td><td>0.8</td><td>0.0002</td><td>0.02</td></tr>
<tr><td>Copper</td><td>9.55</td><td>40</td><td>20.5</td><td>0.0432</td><td>0.21</td></tr>
<tr><td>Lead</td><td>0.915</td><td>3</td><td>2.0</td><td>0.0032</td><td>0.17</td></tr>
<tr><td>Iron</td><td>2762</td><td>580</td><td>5915.2</td><td>0.0432</td><td>< 0.01</td></tr>
<tr><td>Zinc</td><td>57.5</td><td>40</td><td>123.1</td><td>0.0432</td><td>0.04</td></tr>
</table>

To compensate for the large disparity in total loading from the city of Boulder WWTP versus that from historic upstream mining sources, a phased allocation implementation approach is proposed for achieving the copper and lead WLAs for the Boulder WWTP outfall. The following numbered items describe marked difference in the magnitude of metals loading from upstream mining sources compared to metals loading from the Boulder WWTP outfall, and justify a phased wasteload allocation to the Boulder WWTP outfall.

The existing copper load from the WWTP represents approximately 0.2% (two tenths of one percent) of the existing copper load in the river at the USGS station four miles upstream of the WWTP outfall. This minimal percentage is the largest contribution from the WWTP for the metal parameters that are causing impairment in the river segment adjacent to the WWTP outfall.

1. Lead and copper are the two parameters that most often exceed targets in the treatment plant outfall. For these two metals, the largest allocation to the treatment plant outfall is 0.002 lbs of copper per day for meeting a low-flow copper TMDL of 2.22 lbs/day (**Table 5-40**). This copper allocation is just under 0.1% of the TMDL.
2. The allowable lead load of 0.0007 lbs/day from the WWTP outfall is just over 0.1% of the high-flow lead TMDL of 4.86 lbs/day (**Table 5-40)**. These differences between the WWTP allocation and the corresponding metals TMDLs demonstrate that the WWTP is not a significant source of copper and lead loading compared to upstream mining sources.
3. The elevated copper and lead loads in the Boulder WWTP outfall result from local groundwater concentrations entering water supply intake, contributions from piping in the residential distribution system, and infiltration of groundwater into the WWTP collection system.

4. The extent of achievable source control is currently unknown within the Basin Creek, Cataract Creek, and High Ore Creek tributaries of the Boulder River. Adaptive management, as it relates to future copper and lead target concentrations, could conceivably result in site-specific standards or other modifications of the copper and lead targets in this part of the watershed. Such modifications may change the current basis for setting the WLA to these sources. Therefore, the final treatment level for WWTP copper and lead should be based on a watershed –scale remediation plan that evaluates all contributing sources, natural background conditions, and achievable instream concentrations after implementing all reasonable remediation and restoration activities.

For the phased metals WLA implementation, the city of Boulder has 20 years to achieve the WLA at levels consistent with discharge flow times the TMDL target concentration. This 20 year period is consistent with Montana State Law (75-5-313 MCA), which allow water treatment facilities up to 20 years to meet numeric nutrient standards. During that time period, the WWTP operators should continue to semi-annually monitor arsenic, cadmium, copper, iron, lead, and zinc concentrations and flow in the outfall with a focus that ensures monitoring also occurs during annual high flow conditions. Also, detection limits need to be low enough to adequately compare results to the TMDL targets within this document. The WLA may be modified prior to the end of the 20 year period should a comprehensive historic mine remediation plan be developed and implemented to provide upstream assimilative capacity (dilution) within the Boulder River, or should site-specific standards be adopted for the Boulder River.

The wasteload allocation examples to the Boulder WWTP in **Table 5-40** only represent example WLAs under assumed discharge flow conditions. Under all flow conditions the treatment system will not cause or contribute to impairment of the Boulder River if the metal concentration in the discharge is less than or equal to the metal target concentration for the Boulder River. Therefore, the allocations can also be interpreted and expressed as concentrations in units of mass per volume (µg/L), as opposed to loads in units of mass per time period (lbs/day). Thus, a concentration-based approach can be used for MPDES permit development, with the concentrations equaling the TMDL metals concentration target values applicable to the Boulder River. This approach may be desirable because there are no implicit or explicit loading caps over time and compliance can be based solely on the measured discharge concentration independent of discharge flow. A concentration-based approach is also consistent with reasonable assurance as defined within **Section 4.4**.

5.7.16 Boulder River, Cottonwood Creek to Mouth (MT41E001_030)

Loading Summary

There are few discrete sources of metals loading to the Boulder River below Cottonwood Creek (**Appendix F, Figure F-15**). The 10 abandoned mine properties in this portion of the planning area are small and widely scattered on upland locations. Five of the inactive mine properties are clay and stone quarries with minimal or no surface disturbance discernible on 2011 aerial imagery. There are no priority sites or permitted point sources in this part of the watershed. Most metals loading to the lowest segment of the Boulder River likely comes from upstream sources.

TMDLs and Allocations

Example TMDLs and allocations for the lower Boulder River are contained in **Table 5-42**. The allocations include a load allocation to natural background concentrations (**$LA_{BLDR\ RV\ NB}$,**) and a wasteload allocation to unpermitted Boulder River mining sources (**$WLA_{BLDR\ RV\ MS}$**). The TMDL is expressed in the following equation:

$$TMDL_{BLDR\ RV} = LA_{BLDR\ RV\ NB} + WLA_{BLDR\ RV\ MS}$$

Table 5-42. Example metal TMDLs and load- and wasteload allocation examples for the lower Boulder River (MT41E001_030) at site BE-27

Metal	Flow Condition*	TMDL (lbs/day)	Existing Metal Concentration (µg/L)	Existing Load (lbs/day)	LA_{NB} (lbs/day)	WLA_{MS} (lbs/day)	Needed Reduction (%)
Arsenic	High flow	12.85	17	21.85	1.93	10.92	45
	Low flow	4.21	13	5.48	0.63	3.58	26
Cadmium	High flow	0.24	0.47	0.60	0.05	0.19	65
	Low flow	0.14	0.14	0.06	0.02	0.12	0
Copper	High flow	8.08	33	42.41	2.57	5.51	86
	Low flow	5.11	9	3.80	0.42	4.69	0
Lead	High flow	2.27	10.3	13.24	0.32	1.95	85
	Low flow	1.98	1.6	0.67	0.105	1.88	0
Iron	High flow	1,285.2	1,540	1,979.2	437	848.2	45
	Low flow	421.2	220	92.7	54.76	366.44	0
Zinc	High flow	101.23	100	128.5	6.43	94.8	22
	Low flow	65.49	20	8.42	2.11	63.38	0

* Specific flow values provided in **Table 5-24**

Natural background loading is represented by median concentrations from the same sites used in the segment above Cottonwood Creek (M07MSKRC01, M07MSKRC02, M07LBNFR02, and BE-46). Sampling sites representing background conditions are in headwater reaches of listed upstream segments. Data is lacking from such sites in the lower Boulder River. Metals impairments in the lower Boulder River are strongly tied to flow condition. Arsenic is the only metal pollutant requiring low-flow source controls. Modest reductions in arsenic, iron, and zinc loading could eliminate these two metals as pollutants.

Results of sediment metals analysis are available for sites BE-33 and BE-27, both located near the southern end of the Boulder River valley. **Figure 5-20** shows the ratio of sample concentration to PEL values for six metal parameters. For comparison, the graph includes the plots for the two sample sites in the adjacent upstream segment of the Boulder River. Copper, lead, and mercury in stream sediment sampled at the mouth are within PEL values. The graph suggests an arsenic source between the mouth of the Little Boulder River and the mainstem Boulder River below Elkhorn Creek.

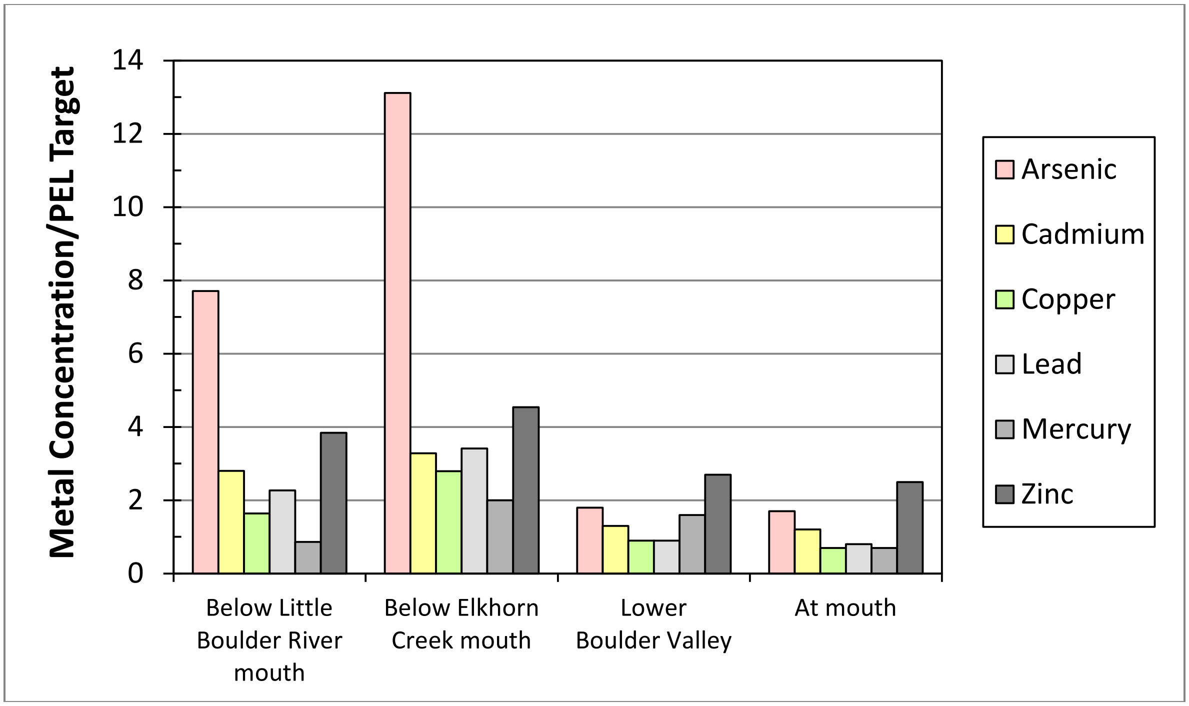

Figure 5-20. Bar graph of sediment metals concentrations divided by PEL targets for sites BE-26, BE-34, BE-33, and BE-27

5.8 Seasonality and Margin of Safety

TMDLs must consider the effects of seasonality on water quality and must incorporate a margin of safety (MOS) to compensate for the uncertainty in loading estimates. These mandatory aspects of TMDL development ensure (to the degree practicable) that estimated maximum loads are within established standards and that they protect beneficial uses. This section describes the considerations given to seasonality and the components of the implicit MOS.

Seasonality

Seasonality addresses the need to ensure year round beneficial-use support. Seasonality is important for metals TMDLs because target values for hardness-dependent metal parameters are smaller (more restrictive) during high flow conditions when snowmelt or precipitation are a larger component of flow compared with low-flow periods when groundwater contributions predominate. Therefore, targets, TMDLs, and load reduction percentages are developed for both high- and low-flow hardness conditions. High- and low-flow TMDLs also account for the seasonal difference in loading attributable to entrained sediment, which is higher during the rising limb of the hydrograph than during base flow periods. Loading from groundwater discharge or mine adit discharges tend to be the major cause of elevated metals concentrations during low-flow conditions.

In summary, seasonality is addressed in this document in the following ways:

- Water column metals concentrations and loading conditions are evaluated for both high- and low-flow periods
- TMDLs are calculated using flow values that change seasonally
- Metals targets vary seasonally with corresponding changes in water hardness.
- TMDLs and required load reduction are developed for high- and low-flow conditions.

Margin of Safety (MOS)
In light of the inherent uncertainty in estimating loads and assigning allocations, TMDLs are required to incorporate a margin of safety to ensure that the prescribed loads support beneficial uses. All metals TMDLs in this document incorporate an implicit MOS provided by the following conservative assumptions:

- Monitoring sites selected to represent natural background conditions occur in headwater reaches, which may underestimate background loading to segments at lower elevations
- Where monitoring results from background sites were less than the method detection limit, the assumed background water column concentration was one half of the detection limit.
- The most restrictive water quality standard was used to calculate TMDLs, thus improving the prospects of meeting all designated beneficial uses
- The monitoring results used to estimate existing water quality conditions are instantaneous measurements used to estimate a daily load, whereas chronic aquatic life standards are based average conditions over 96-hour period
- Existing water quality conditions and needed load reductions are based on the highest measured value for a given flow condition, which may overestimate human-caused loading based on average conditions during a 96-hour period
- TMDLs, allocations, and implementation efforts are based on adaptive management, which provides for informed feedback and adjustment of loads, allocations, and remediation efforts in response to field monitoring.

5.9 Uncertainty and Adaptive Management

Uncertainty is inherent in source assessment methods, extrapolations of field data, loading calculations, and other assessment processes used to develop and implement TMDLs. While some level of uncertainty is unavoidable, an adaptive management approach that revisits, confirms, or updates loading assumptions is vital to maintaining stakeholder confidence and participation in water quality improvement. Adaptive management uses updated monitoring results to refine loading analysis, to further customize monitoring strategies and to develop a better understanding of impairment conditions and the processes that affect impairment. Adaptive management recognizes the dynamic nature of pollutant loading and water quality response to remediation.

Adaptive management also allows for continual feedback on the progress of restoration and the status of beneficial uses. Under adaptive management, targets can be re-defined as necessary to protect the resource or re-evaluated regarding target achievability.

The water quality restoration targets and associated metals TMDLs developed for the Boulder-Elkhorn TPA are based on support of the beneficial uses designated for A-1 and B-1 waters. However, complete restoration may not be possible in all cases because of long-term human-caused sources or elevated natural background loading sources.

An adaptive management approach is recommended for all TMDLs presented in this document. Possible outcomes to adaptive management for water quality problems in the Boulder-Elkhorn TPA are as follows:

- Restoration achieves the metal pollutant targets and all beneficial uses are supported.
- Targets are not attained because of insufficient controls; therefore, impairment remains, and additional remedies are needed.

- Targets are not attained after all reasonable BMPs and applicable abandoned mine remediation activities are applied. Under these circumstances, site-specific standards may be necessary.

The Abandoned Mines Section of DEQ's Remediation Division will lead abandoned mine restoration projects funded by provisions of the Surface Mine Reclamation and Control Act of 1977. DEQ's Federal Superfund Bureau (also in the Remediation Division) will supervise or implement remedial actions at mining Superfund sites on the federal National Priorities List (NPL) that have been delegated to Montana for state-lead status under cooperative agreements with EPA. The Superfund Bureau will also provide technical and management assistance to EPA for remedial investigations and cleanup actions at NPL mine sites in federal-lead status. Under DEQ's Permitting and Compliance Division, the Environmental Management Bureau will help to achieve load reductions required of permitted metal mining point sources.

Monitoring and restoration conducted by other parties, (Forest Service (USFS), Bureau of Land Management, the Montana Department of Natural Resources and Conservation's, Trust Lands Management Division, and Jefferson County Conservation District) should be incorporated into the target attainment and review process as well. Cooperation among agency land managers in the adaptive management process for metals TMDLs will help identify further cleanup and load reduction needs, evaluate monitoring results, and identify water quality trends.

6.0 Other Impairment Causes and Metals TMDLs

6.1 Other impairment Causes and Linkage to Metals TMDLs

Water quality problems are often associated with degraded stream habitat that may be independent of impairment caused by the specific pollutants for which TMDLs are developed. These habitat-related causes are referred to as "non-pollutant" causes, as opposed to "pollutant" causes such as copper, total nitrogen, suspended sediment, or temperature. Thirteen streams in the Boulder-Elkhorn TMDL Planning Area (TPA) appear on the 2012 303(d) List because of non-pollutant impairment causes. **Table 6-1** contains the habitat-related impairment causes from the 2012 Integrated Report (IR) for streams in the Boulder-Elkhorn TPA.

Table 6-1. Waterbody segments with metal pollutant and habitat impairment causes from the 2012 Integrated Report

Waterbody ID	Stream Segment	2012 Probable Causes of Impairment
MT41E002_030	BASIN CREEK, headwaters to mouth (Boulder River)	Alteration in streamside or littoral vegetative covers
MT41E002_070	BISON CREEK, headwaters to mouth (Boulder River)	Alteration in streamside or littoral vegetation covers
MT41E001_021	BOULDER RIVER, Basin Creek to Town of Boulder	Alteration in streamside or littoral vegetation covers
MT41E001_022	BOULDER RIVER, Town of Boulder to Cottonwood Creek	Alteration in streamside or littoral vegetation covers; Low flow alterations
MT41E001_030	BOULDER RIVER, Cottonwood Creek to the mouth (Jefferson Slough), T1N R3W S2	Alteration in streamside or littoral vegetation covers; Low flow alterations
MT41E002_061	ELKHORN CREEK, headwaters to Wood Gulch	Alteration in streamside or littoral vegetation covers; Low flow alterations
MT41E002_062	ELKHORN CREEK, Wood Gulch to the mouth (Unnamed Canal/Ditch), T5N R3W S21	Low flow alterations
MT41E002_040	HIGH ORE CREEK, headwaters to mouth (Boulder River)	Alteration in streamside or littoral vegetation covers
MT41E002_080	LITTLE BOULDER RIVER, headwaters to mouth (Boulder River)	Alteration in streamside or littoral vegetation covers; Physical substrate habitat alterations; Cause Unknown
MT41E002_050	LOWLAND CREEK, headwaters to mouth (Boulder River)	Alteration in streamside or littoral vegetation covers; Physical substrate habitat alterations
MT41E002_100	MUSKRAT CREEK, headwaters to mouth (Boulder River)	Alteration in streamside or littoral vegetation covers
MT41E002_090	NORTH FORK LITTLE BOULDER RIVER, headwaters to mouth (Little Boulder)	Alteration in streamside or littoral vegetation covers
MT41E002_010	UNCLE SAM GULCH, headwaters to mouth (Cataract Creek)	Alteration in streamside or littoral vegetation covers; Other flow regime alterations

Sources of metals loading in the Boulder-Elkhorn TPA commonly contribute to stream habitat-related impairments. Historic milling operations often impounded tailings in and adjacent to stream courses. The breaching of pond dikes deposited fine-textured tailings downstream in channels and on floodplains. Breached tailings impoundments have delivered tens of thousands of cubic yards of tailings to downstream reaches of Jack Creek, Basin, Cataract, High Ore Creek, and Elkhorn creeks, and the lowest three segments of the Boulder River. These mining sources contribute to physical siltation and sediment impairments, as well as those caused by metal toxicity. An example is the Bullion Mine in the headwaters of Jack Creek. The site includes two tailings ponds with original capacity for about 11,000 cubic yards. After breaching, 4,200 cubic yards remain (Montana Department of State Lands, 1995). Approximately 20,000 cubic yards of tailings remain in a larger breached pond 1.5 miles downstream on Jack Creek. **Figure 5-5** illustrates the effects of Jack Creek tailings on chemistry of a Basin Creek sediment sample collected eight miles downstream of Jack Creek.

Excess sediment, including that from mining sources, is an impairment cause for the entire length of metals-impaired Basin Creek, Uncle Sam Gulch, Cataract Creek, High Ore Creek, North Fork Little Boulder River, Elkhorn Creek, and the Boulder River from the town of Boulder to the mouth. Physical habitat damage caused by tailings deposition is compounded in many cases by metal toxicity from oxidation of sulfide minerals in the wastes. To some degree, restoration in the planning area that addresses sediment causes is likely to also reduce metals loading. Remediation that removed and encapsulated streamside sulfide tailings in Jack Creek, for example, would address both pollutant- and non-pollutant caused use impairments downstream. The inherent linkage between sediment and metals impairment causes is reason to adopt a restoration strategy that attends to both cause types.

6.2 Non-Pollutant Impairment Cause Descriptions

Non-pollutant listings are common when available assessment data does not provide a quantifiable linkage to a specific pollutant, but habitat or other negative water quality impacts are present to a degree that suggests impairment. Many metal pollutant causes are clearly linked to non-pollutant cause of impairment and appear together among the cause listings. The following discussions provide rationale for assigning non-pollutant causes to a waterbody, and may also provide insight into the need of additional monitoring or field investigations to clarify linkages to existing pollutant impairment causes.

Alteration in Streamside or Littoral Vegetation Covers
Alteration in streamside or littoral vegetation covers refers to circumstances where land uses along stream channels alters or removes riparian vegetation and subsequently affected bank stability, channel geomorphology, and, in some cases, stream temperature. Such land use activities may include vegetation removal for roadways or utility corridors, timber harvest, and sustained streamside grazing. Stream channels within historic metal mine developments were often used as mill tailings repositories. Sulfide oxidation and the resulting metal toxicity have damaged riparian vegetation. Streamside vegetation damage destabilizes banks, causes accelerated channel widening, and increases sediment loading. Elevated sediment loading often causes higher metals loading. Removal of stream canopy cover can lead to increased water temperatures.

Physical Substrate Habitat Alterations
Physical substrate habitat alterations are generally instances of physical channel disturbance or manipulation such as channel diverting, straightening, and artificial armoring. Placer mining by definition constitutes a major alteration of channel substrates. Such practices often increase flow velocity and accelerate channel scour, entrenchment, and bank erosion. Channel morphology is homogenized through the loss of riffle and pools sequences that enhance habitat for fish and aquatic life.

Low Flow Alterations and Other Flow Regime Changes

Streams are typically listed for low flow alterations when irrigation withdrawal management leads to base flows that are too low to support the beneficial uses. This could result in dry channels or extreme low flow conditions that harm fish and aquatic life. It could also result in lower flow conditions which absorb thermal radiation more readily and increase stream temperatures, which in turn creates dissolved oxygen conditions too low to support some species of fish.

It should be noted that while Montana law states that TMDLs cannot impact Montana water rights and thereby affect the allowable flows at various times of the year, the identification of low flow alterations as a probable source of impairment does not violate any state or federal regulations or guidance related to stream assessment and beneficial use determination. Subsequent to the identification of low flow alteration as a probable cause of impairment, it is up to local users, agencies, and entities to voluntarily evaluate and pursue opportunities to improve flows through water and land management.

Fish Passage Barrier

Impairment caused by fish passage barriers is most often related to channel obstacles such as impoundments or perched culverts at road crossings. The impairments are addressed by modification or removal of the barriers or operational changes to allow migration of fish and other aquatic life. Any fish barrier removal must be done in coordination with state and federal fishery representatives since fish passage barriers can beneficially isolate native fish populations, protecting them from non-native invasive species. For example, the Montana FWP has worked with the USFS and the BLM on two projects to improve native cutthroat trout isolation by constructing physical barriers in Muskrat Creek and High Ore Creek.

In the Boulder watershed toxic barriers due to mine discharge create another form of fish barrier. Toxic fish barriers have been identified within at least three tributaries where the toxic barrier isolates native cutthroat from non-native trout (Jack Creek, High Ore Creek, Little Boulder River). Although maintenance of toxic stream conditions does not represent a desirable method for isolating native fish species, future projects to address toxic stream conditions should incorporate necessary barrier construction or other methods to maintain appropriate native fish isolation. For example, mine reclamation work associated with Jack Creek was conducted in a manner to improve distribution of native cutthroat while maintaining the isolated fishery upstream of the toxic reach of stream.

6.3 Monitoring and BMPs for Non-Pollutant Affected Streams

Streams listed for only for a non-pollutant cause of impairment should not be overlooked when developing watershed management plans. Attempts should be made to collect additional data where existing data is minimal and the linkage to the beneficial uses are not well defined. The monitoring and restoration strategies that follow in **Sections 7.0** and **8.0** are presented to address both pollutant and non-pollutant issues for streams in the Boulder-Elkhorn TPA.

7.0 Restoration Objectives and Implementation Plan

Human land uses and resource development activities are among the identified sources of water quality impairment during TMDL development. Water quality restoration is advanced by better future management of these activities. TMDL development and implementation advocate for changing current and future land management and development practices that will help improve and maintain water quality. This section describes an overall strategy and specific on-the-ground measures designed to restore beneficial water uses and attain water quality standards in the Boulder-Elkhorn TMDL Planning Area (TPA). The strategy includes general measures for reducing loading from significant pollutant sources.

7.1 Water Quality Restoration Objectives

The general water quality goal of this TMDL document is to provide technical guidance for recovery of aquatic life and drinking water uses to all metal impaired streams within the Boulder-Elkhorn TPA. The components of this guidance are:

- Specified water quality targets for metals,
- An assessment of major metal pollutant sources, and
- A general restoration strategy for metal-impaired waters.

Once TMDLs are established, restoration begins with development of a watershed restoration plan (WRP). A WRP is an analytical framework for restoring water quality in impaired waters by reducing loading from pollutant sources (U.S. Environmental Protection Agency, 2008). A WRP focuses on achieving the TMDLs presented in this document, addresses related water quality problems with local interest, and helps develop a detailed and locally organized process for prioritizing, funding, and completing restoration projects.

The WRP is an adaptive document that can be revised when new information on water quality conditions, restoration effectiveness, and stakeholder priorities becomes available. The following are suggested essential elements of a WRP:

- Expressed support for restoration projects that achieve and maintain the TMDLs established in this document and protect good water quality water conditions for all streams in the watershed
- A detailed analysis of the costs, benefits, and spatial effects of water quality improvement projects
- An efficient means of installing future BMPs and tracking results
- An educational component that helps stakeholders understand the benefits of water quality restoration and provides knowledge of available funding assistance
- Expressed support for meeting other natural resource goals linked to water quality such as riparian grazing controls, timber harvest management, and road erosion abatement.
- Development of detailed restoration objectives focused on protection of native aquatic life species, including consideration of native fish isolation goals (see **Section 6.2**).

7.2 Implementation Plan

The restoration implementation plan discussed below would apply adaptive management (**Section 5.9**) for adjusting restoration plans in response to monitoring results and advances in reclamation technology. Successful restoration requires a conscious collaboration among private landowners, government land managing agencies, and other interested stakeholders. The agency and stakeholder roles relevant to the Boulder-Elkhorn TPA are described in the following sections.

7.2.1 Agency and Other Stakeholder Roles and Coordination

The DEQ provides technical and financial assistance for stakeholders interested in improving water quality and administers programs that fund water quality improvement and pollution prevention projects. The DEQ collaborates with interested participants to develop locally-driven WRPs that are guided by established TMDLs. Although the DEQ does not conduct pollutant reduction projects directly, DEQ is a valuable contact for locating potential funding sources for nonpoint source pollution control.

Because most measures to reduce nonpoint source pollutants rely on broadly-applied voluntary action, collaboration is essential for reducing loads along multi-owner stream segments. Specific stakeholders and agencies that have been, and will likely continue to be, vital to restoration efforts in the Boulder-Elkhorn TPA include:

- Montana Region 8 EPA
- DEQ Federal Superfund Bureau
- DEQ Abandoned Mines Bureau
- Planning area landowners
- Deerlodge National Forest
- Bureau of Land Management
- Jefferson County Commission
- Jefferson County Conservation District
- The Montana Department of Fish, Wildlife, and Parks
- The Natural Resource Conservation Service

Other organizations and non-profits that may provide technical assistance, funding, and outreach services include Montana Water Center, University of Montana Watershed Health Clinic, Montana State University Extension Water Quality Program, and Montana Trout Unlimited.

7.2.2 Metals Restoration Strategy for Mining Sources

Metal mining is the principal human-caused source of excess metals loading in the planning area. To date, federal and state government agencies have funded and completed most of the reclamation associated with past mining. Statutory mechanisms and corresponding government agency programs will continue to have the leading role for future restoration. Restoration of metals sources is typically conducted under state and federal cleanup programs. Rather than a detailed discussion of specific BMPs, this section describes general restoration programs and funding sources applicable to mining sources of metals loading. Past efforts have produced abandoned mine site inventories with enough descriptive detail to prioritize the properties contributing the largest metals loads. Additional monitoring needed to further describe impairment conditions and loading sources is addressed in the **Section 8.0** framework monitoring plan.

A number of state and federal regulatory programs continue to address water quality problems from past metal mining, milling, and refining impacts. The statutes that have authorized and funded water quality restoration projects targeting mining sources in the Boulder River watershed include:

- The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA),
- The Surface Mining Control and Reclamation Act of 1977 (SMCRA)
- The Montana Comprehensive Environmental Cleanup and Responsibility Act (CECRA)

7.2.2.1 Superfund Authority in the Boulder-Elkhorn TPA

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly referred to as Superfund, is a Federal statute that addresses cleanup on sites, such as historic mining areas, where there has been a release, or threat of a release of hazardous substances. Sites are prioritized on the National Priority List (NPL) using a hazard ranking system focused on human health effects. CERCLA authorizes two kinds of response actions:

1. Short-term removals that require a prompt response, and
2. Long-term remediation actions that reduce environmental and health threats from hazardous substance releases.

Long-term remediation actions apply to serious, but not immediately life threatening releases at NPL sites. Under CERCLA, those responsible for the release must pay for remediation. Where property owners or others responsible for releases cannot be identified, funding and responsibility for cleanup is delegated by EPA. Remediation funding is only available with EPA authorization. Cleanup actions under CERCLA must be based on professionally developed project plans. Superfund authority is most commonly delegated to government agencies with project planning capacity.

The Basin Mining Area is the only NPL site in the Boulder-Elkhorn TPA. The area was added to the NPL in 1999 in response to information from site inspections and interpretations of soil, sediment, and water sampling completed during the late 1980s and 1990s. The principal contaminants are arsenic, lead, and manganese The Basin Mining Area NPL site is divided into the following operable units (OUs) for planning and administrative purposes.

OU1 - The Town of Basin
OU2 - The drainages of Basin Creek, Cataract Creek, and part of the upper Boulder River Watershed
OU3 - The Luttrell Repository
OU4 - Buckeye-Enterprise Mine (Basin Creek)
OU5 - The Crystal Mine (Uncle Sam Gulch)
OU6 - The Bullion Mine (Jack Creek)

The Town of Basin (OU1) was the initial focus of remediation that occurred between 2002 and 2004. The first five-year site review for OU1 was completed in 2008 (CH2MHill, 2008). According to the review, all identified mine waste areas in OU1 have been remediated. These included the mill tailings generated by the Old Basin Mill and the Jib Mill that operated west of the town of Basin. All but one of the residential properties that contained mine and milling wastes within the town of Basin were remediated. The review concluded that the mine waste removal from OU1 was sufficient to prevent contamination of Basin Creek or the Boulder River from local runoff. Mine waste removal from OU1 also mitigated shallow groundwater contamination from precipitation infiltration through metal-laden mine wastes. The remaining long-term protective actions needed for OU1 include:

- Apply property transfer restrictions where cleanup access is denied or wastes remain beneath existing structures
- Informational program targeting residents and recreationists against ingesting or irrigating with Basin Creek water or coming into direct contact with stream sediments until remediation of the Basin Area Watershed (OU2) is complete and metal contamination from upstream sources is no longer a threat

- Creation of a monitoring program, implemented by EPA or the State of Montana, to assess wind and runoff erosion impacts to remediated and unremediated properties.

The Basin Watershed (OU2) includes the drainages of Basin, Cataract, and creeks and an adjacent portion of the Boulder River. The extent of OU2 is shown in **Figure 7-1**.

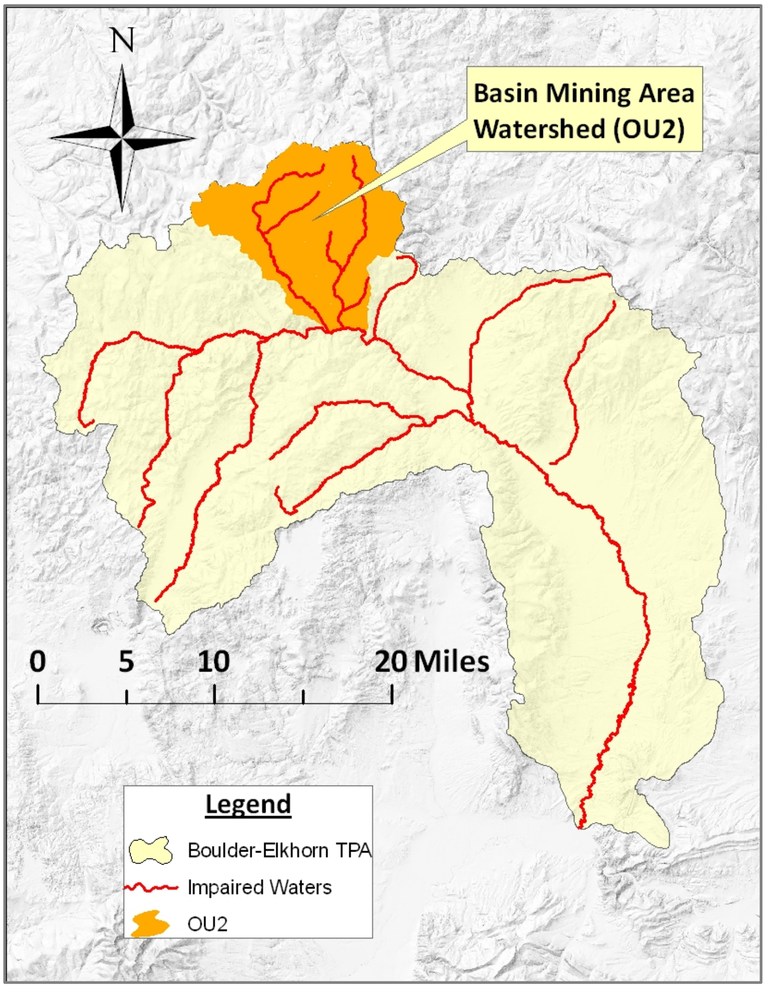

Figure 7-1. Extent of OU2 within the Boulder-Elkhorn TPA

Within OU2 is a portion of the former Basin Creek Mine that was converted into the Luttrell Repository (OU3) when mining ceased. Also within OU2 are the Buckeye-Enterprise mine and mill complex in upper Basin Creek (OU4), the Crystal Mine in Uncle Sam Gulch (OU5), and the Bullion Mine and milling sites in Jack Creek (OU6). The Buckeye-Enterprise Mine, Bullion Mine, and Crystal Mine are major contributors to metals loading to Basin and Cataract creeks and downstream segments to the Boulder River. The Bullion Mine and related milling sites in Jack Creek have the greatest individual and collective impact of any other inactive mine properties in the Basin Mining Area NPL site (CH2MHill, 2008).

Working in partnership with the U.S. Forest Service, the EPA conducted some cleanup of the mining wastes at the Buckeye/Enterprise, Crystal, and Bullion mines that was completed in 2002. Cleanup funding was provided by each agency according to ownership. Wastes were transported to the Luttrell Repository. Draft Remedial investigations and feasibility studies were completed in 2011 for the Crystal and Bullion mines. These documents present an analysis of alternatives for remediation of these two mines. The current alternatives range from no further action to active collection and treatment of acidic discharges from both sites. The next administrative steps for reclamation at the Bullion and Crystal mines are:

- Finalize draft feasibility studies
- Develop a Record-of-Decision that identifies the preferred remediation alternatives and identifies the funding sources.

Once the nature and extent of contamination in known and remediation alternatives identified in the feasibility study, a Record-of-Decision establishes the chosen remediation approach. When removal is complete an NPL site can undergo additional remediation or be scored low enough to no longer qualify for listing. A site could conceivably remain a water quality concern after CERCLA removal activities are completed.

The need for additional cleanup remains at the Buckeye-Enterprise site, the Crystal Mine site, and at sites related to past Bullion Mine operations in Jack Creek. A time-critical removal action is being considered for the lowest collapsed adit at the Bullion Mine. Hydrostatic pressure accumulating behind the collapsed portion of the opening threatens a large discharge of ARD-affected water. Removal of the adit plug, active treatment, and land application of the treated water are being considered as short-term means to protect water quality in Jill Creek and farther downstream.

7.2.2.2 The Surface Mining Control and Reclamation Act (SMCRA)

DEQ's Abandoned Mines Bureau (AMB), is responsible for reclamation of abandoned mines in Montana. The AMB reclamation program is funded through the Surface Mining Control and Reclamation Act of 1977 (SMCRA). SMCRA funding is distributed to states by the federal Office of Surface Mining Reclamation and Enforcement (OSM). Funding eligibility is based on land ownership and date of mining disturbance. Funding is restricted to areas within federal Superfund sites or other selected remediation programs and for properties without a known responsible party. **Table 7-1** lists the priority abandoned mines in the Boulder Elkhorn TPA that are potentially eligible for SMCRA reclamation funding. The listing is in order of priority ranking with the site ranked highest at the top of **Table 7-1**.

Table 7-1. Priority Abandoned Mine Sites in the Boulder-Elkhorn TPA

Site Name	Receiving Stream	Disturbance Area (acres)	Ranking Score
COMET	HIGH ORE CREEK	43	510.14
ENTERPRISE	UPPER BASIN CREEK	6	245.75
CRYSTAL	UNCLE SAM GULCH	40	238.88
BULLION	JACK CREEK	26	99.48
BUCKEYE	UPPER BASIN CREEK	18	55.45
ELKHORN CREEK TAILINGS	ELKHORN CREEK	139	48.93
JOSEPHINE	CLEAR CREEK	29	25.52
CARMODY	SLAUGHTERHOUSE GULCH	210	14.21
EVA MAY	CATARACT CREEK	15	10.14
OLD BASIN MILLSITE	BOULDER RIVER	34	9.03
QUEEN/TOURMALINE QUEEN	ELKHORN CREEK	11	7.73
ELKHORN QUEEN	QUEEN GULCH	20	7.51
BOULDER CHIEF	CATARACT CREEK	51	5.69
GREY EAGLE	BISHOP CREEK	12	4.75
CRESENT/ALSACE	CATARACT CREEK	9	4.63

Table 7-1. Priority Abandoned Mine Sites in the Boulder-Elkhorn TPA

Site Name	Receiving Stream	Disturbance Area (acres)	Ranking Score
BASIN MILLSITE	BOULDER RIVER	10	3.98
ROCKER/ADA	ROCKER CREEK	40	3.78
SOURDOUGH	TURNLEY MEADOWS CREEK	18	2.35
MORNING GLORY	CATARACT CREEK	11	2.13
LADY LEITH (NE NW S6)	UPPER BASIN CREEK	47	2.04
JACK CREEK TAILINGS	JACK CREEK	7	1.22
TACOMA	TACOMA GULCH	20	1.11
DORIS	BASIN CREEK	3	0.79
TRUMLEY HEAP LEACH	TURNLEY MEADOWS CREEK	126	0.50
MANTLE EAST	CATARACT CREEK	20	0.28
IRON	MUSKRAT CREEK	19	0.12
BULLION SMELTER	JACK CREEK	4	0.10
PERRY PARK	GRUB GULCH	10	0.00
MARGUERITE	LILY-OF-THE-WEST GULCH	10	0.00

Table 7-1 is a guide to where the largest metals loads are occurring and where the largest loading reductions can be achieved. The ranking in **Table 7-1** confirms the metals loading analysis results identifying the Crystal, Comet, Bullion, Enterprise, and Buckeye mines as the most damaging sources of metals impairment.

7.2.2.3 Montana Comprehensive Environmental Cleanup and Responsibility Act (CECRA)

Reclamation of past mining-related disturbances administered by the State of Montana and not addressed under SMCRA, are typically addressed through the DEQ State Superfund program. The Comprehensive Environmental Cleanup and Responsibility Act (CECRA) passed the Montana Legislature in 1989 as a means to require cleanup of hazardous substance releases threatening human health and the environment. The CECRA program maintains a prioritized list of facilities potentially requiring response actions based on the confirmed or threatened release of a hazardous or deleterious substance.

CECRA encourages voluntary cleanup activities under the Voluntary Cleanup and Redevelopment Act (VCRA) that recommended a method of apportioning site liability and created a fund for cleanup of sites where a responsible party has not been identified. Mining-related metals loading sources identified in the future could be added to the CECRA list and addressed through CECRA, with or without the VCRA processes. A site can be added to the CECRA list at DEQ's initiative, or in response to a complete written request made to the department by any person. Currently, there are two active sites on the CECRA priority list in the Boulder-Elkhorn TPA: the Basin Mining site that corresponds to the Basin Mining Area Superfund site; and the Boulder River Railroad site, located about 1 mile upstream of the town of Boulder, where railroad grade fill material consists of metal-contaminated mine tailings

The goal of the metals restoration strategy is to limit the input of metals to streams from priority abandoned mine sites and other significant sources. Additional analysis will likely be required to describe site-specific metals delivery pathways and to develop mitigation plans. The following goals and objectives apply to future restoration of most mining-related sources:

- Prevent soluble metal contaminants or metals contaminated solid materials in waste rock and tailings from migrating into surface waters and groundwater.

- Reduce or eliminate concentrated runoff that entrains and delivers metal-laden sediment to adjacent surface waters.
- Identify, prioritize, and select reclamation and restoration options for mining sources based on a thorough source assessment and streamlined risk analysis.

Several significant ARD-affected adit discharges continue to contribute metals loads that can be detected miles downstream. These include the Enterprise, Bullion, Crystal, and Comet mines. The mountainous terrain, seasonal access, and lack of reliable electrical power at these sites drive up the costs of water treatment by the conventional, active treatment method of pH adjustment by lime infusion and precipitation of metal oxides. The costs of access construction, power extensions, perpetual water treatment, and sludge disposal are prompting an evaluation of alternative source control approaches to reducing loads. This strategy seeks to minimize precipitation runoff from and infiltration into sulfide wastes and ore zones that are the sources of acid mine drainage. Acidic discharges are reduced by intercepting and diverting clean water prior to its contact with mine disturbances containing sulfide minerals.

7.3 Potential Funding Sources

Funding of water quality restoration or improvement project is essential for completing restoration activities and evaluating the resulting load reductions. Several government agencies fund watershed or water quality improvement projects. Below is a brief summary of potential funding sources for such projects.

7.3.1 Section 319 Nonpoint Source Grant Program

Section 319 of the federal Clean Water Act makes grant funds available to help identify, prioritize, and implement water quality improvement protection projects addressing nonpoint pollutant sources. The funding program focuses on WRP development to identify projects that obtain the highest and most efficient return in load reductions toward meeting TMDLs. Individual contracts under the annual grant cycle range from $20,000 to $150,000, with a 25% or greater matching funds requirement. Section 319 projects are typically administered through a non-profit or local government entity, such as a watershed planning group, conservation district board, or other county government office.

7.3.2 Future Fisheries Improvement Program

The Future Fisheries grant program is administered by FWP and offers funding for on-the-ground projects focusing on habitat restoration to benefit wild and native fish. Eligible grantees range from private landowners and local community-based groups to state or local government agencies. Applications are reviewed annually in December and June. Projects that may be applicable to the Boulder River watershed include streambank restoration, removal of fish passage barriers, and restoring or protecting fish spawning habitats.

7.3.3 Watershed Planning and Assistance Grants

The MT DNRC administers Watershed Planning and Assistance Grants to watershed groups that are sponsored by a Conservation District. Funding is capped at $10,000 per project and the application cycle is quarterly. The grant focuses on locally developed watershed planning activities; eligible activities include developing a WRP, planning, group coordination costs, environmental data collection, and educational activities.

Numerous other funding opportunities exist for addressing nonpoint source pollution. Additional information regarding funding opportunities from state agencies is contained in Montana's Nonpoint Source Management Plan (Montana Department of Environmental Quality, 2007) and information regarding additional funding opportunities can be found at http://www.epa.gov/nps/funding.html.

7.3.4 Environmental Quality Incentives Program

The Environmental Quality Incentives Program (EQIP) is administered by NRCS and offers financial (i.e., incentive payments and cost-share grants) and technical assistance to farmers and ranchers to help plan and implement conservation practices that improve soil, water, air and other natural resources on their land. The program is based on the concept of balancing agricultural production and forest management with environmental quality, and is also used to help producers meet environmental regulations. EQIP offers contracts with a minimum length of one year after project implementation to a maximum of 10 years. Each county receives an annual EQIP allocation and applications are accepted continually during the year; payments may not exceed $300,000 within a six-year period.

7.3.5 Resource Indemnity Trust/Reclamation and Development Grants Program

The Resource Indemnity Trust/Reclamation and Development Grants Program (RIT/RDG) is an annual program administered by MT DNRC that can provide up to $300,000 to address environmental related issues. This money can be applied to sites included on the Abandoned Mine Lands (AML) priority list, but of low enough priority where cleanup under AML is uncertain. RIT/RDG program funds can also be used for conducting site assessment/ characterization activities such as identifying specific sources of water quality impairment. RIT/RDG projects typically need to be administered through a non-profit or local government such as a conservation district, a watershed planning group, or a county government office.

8.0 Monitoring for Effectiveness

The monitoring framework discussed in this section is an important component of watershed restoration, a requirement of TMDL development under Montana's TMDL law, and the foundation of the adaptive management approach to water quality improvement. An implicit margin-of-safety has been incorporated into the TMDLs developed in this document. Although loading and load allocations are calculated from the most recent data, the calculations are only estimate of a more complex seasonal loading system. The margin of safety is intended offset the effect of this uncertainty, but complications related to the strength and volume of pollutant sources often become apparent only after restoration activities have begun. Monitoring in place during restoration can determine whether TMDL targets are being met, whether all significant sources have been identified, and whether attainment of TMDL targets is feasible in light of new information about pollutant strength and sources. Data from long-term monitoring provides technical justification for modifying restoration strategies, targets, or allocations schemes.

Rather than a fixed monitoring program with assigned responsibilities, the initial monitoring framework presented here allows for future adjustment to refine monitoring needs to field conditions. The recommendations are intended to assist local land managers, stakeholder groups, and federal and state agencies in developing appropriate monitoring plans that measure the effects of water quality restoration practices. Funding for future monitoring is uncertain and can vary with economic and political changes. Monitoring priorities depend on restoration progress, stakeholder priorities, and funding availability.

The objectives for future monitoring in the Boulder-Elkhorn TPA include:

- tracking restoration activities and evaluating the effectiveness of individual and cumulative restoration activities
- baseline and impairment status monitoring to assess attainment of water quality targets and identify long-term trends in water quality, and
- refining the source assessments. Each of these objectives is discussed below.

8.1 Restoration Effectiveness Monitoring

Monitoring should occur before and after restoration projects are implemented to tracks the degree and rate of recovery of the aquatic system. Effectiveness monitoring should address a targeted set of pollutants for each project. Each monitoring project should begin with compiled information on source locations, spatial extent, surface ownership, remediation design, and the location and nature of BMP applications elsewhere in the watershed. Restoration effectiveness monitoring should not be limited to surface water quality monitoring and should include evaluation of all aspects and assumptions of each remediation activity. For example, the continued use of the Luttrell Pit as a repository should include site stability along with surface and ground water quality monitoring. A monitoring strategy that clearly identifies the roles and responsibilities of various cooperating agencies needs to be developed and/or maintained for all significant remediation sites.

BMP effectiveness in reducing metals loading and can best be evaluated by comparisons of water sample analysis results with metals targets. In addition, photo documentation of BMP-affected source reductions is appropriate in cases where significant lag time may occur between BMP application and water quality improvement.

DEQ will conduct a TMDL Implementation Evaluation (TIE) within a watershed to determine whether monitoring results document sufficient in water quality improvement. The TIE process consists of compiling recent data, conducting additional monitoring when needed, completing target comparisons, summarizing the applied BMPs, determining the degree of TMDL achievement, and identifying the water quality trend direction since TMDL development.

If the TIE results indicate the TMDL is being achieved, the waterbody is recommended for a formal reassessment of its use-support status. If TMDLs are not being met, DEQ evaluates the recent progress toward restoring water quality and the effectiveness of land, soil, and water conservation practices in place in the watershed. The evaluation determines whether the solution requires improved BMP application, more time for currently effective BMPs to work, or reevaluating the feasibility of meeting standards with complete BMP application.

Fishery, invertebrate and other aquatic life studies and associated trend analyses also represent an important monitoring strategy component to evaluate watershed health in relation to mine remediation activities. Fishery studies by F. Nelson (1976) and Farag et al (1999) and invertebrate studies by Gardner (1977) and Gless (1990) can provide some long term perspective on trends of aquatic health related to mine waste in the Boulder watershed. Future fishery and aquatic health assessments could benefit from using these data. FWP personnel represent an important resource for coordinating, planning and performing monitoring activities at historical and other sampling locations within the watershed.

8.2 Baseline and Impairment Status Monitoring

In addition to tracking BMP effectiveness, monitoring locations should, in many cases, be distributed to provide adequate knowledge of water quality conditions and loading sources throughout the drainage. These additions to the dataset can be used during the TIE. Since DEQ is the lead agency for evaluating use impairment, the data types and collection methodologies should be compatible with DEQ assessment methods. Other agencies or entities collecting water quality and aquatic life data are encouraged to provide compatible information wherever possible. Guidance for monitoring water quality for metal pollutants is helpful for ensuring that the data quality is adequate as a basis for standards comparisons, impairment evaluations, and trend detection.

8.2.1 Monitoring for Metal Pollutants

Extensive metals sampling occurred during 2009 and 2010 to assist with TMDL development. However, the aluminum and mercury data sets for several streams are insufficient to adequately confirm that aluminum and mercury are not current impairment causes. **Table 8-1** lists the streams needing supplemental aluminum and mercury data. Also included is additional sampling of iron for Spencer Creek (tributary to Muskrat Creek) based on an elevated iron sample result discussed in **Section 5.7.10**.

Table 8-1. Waterbodies needing additional data to evaluate iron, aluminum and mercury impairment

Stream Segment	Waterbody ID	Pollutant/s
BIG LIMBER GULCH,	MT41E002_140	Aluminum
BISON CREEK	MT41E002_070	Aluminum, Mercury
BOULDER RIVER	MT41E001_010	Aluminum, Mercury
BOULDER RIVER	MT41E001_021	Aluminum, Mercury
BOULDER RIVER	MT41E001_022	Aluminum, Mercury
BOULDER RIVER	MT41E001_030	Aluminum, Mercury

Table 8-1. Waterbodies needing additional data to evaluate iron, aluminum and mercury impairment

Stream Segment	Waterbody ID	Pollutant/s
ELKHORN CREEK	MT41E002_061	Mercury
ELKHORN CREEK	MT41E002_062	Mercury
HIGH ORE CREEK	MT41E002_040	Aluminum
JACK CREEK	MT41E003_010	Mercury
LITTLE BOULDER RIVER	MT41E002_080	Mercury
LOWLAND CREEK	MT41E002_050	Mercury
SPENCER CREEK	Not Assigned	Iron
MUSKRAT CREEK	MT41E002_100	Aluminum, Mercury
NORTH FORK LITTLE BOULDER RIVER	MT41E002_090	Mercury
UNCLE SAM GULCH	MT41E002_010	Mercury

8.3 Source Assessment Refinement

The level of detail of the source assessment allows allocations to broad source categories and geographic areas. Additional monitoring may be helpful to better partition pollutant loading at mine sites with multiple sources, such as those having discrete adit discharges versus more diffuse runoff from sulfide waste accumulations. The needed refinements may require more seasonally stratified sampling or a more detailed field reconnaissance and follow-up sampling to better locate stream segments representing background loading.

The inability to distinguish background loading from human-caused loading led to use of broad composite allocations to the combined loading from these sources. **Table 8-2** lists the waterbodies, pollutants, and flow conditions where composite allocations to background and human-caused are used in TMDL development.

Table 8-2. Waterbodies, metal pollutants, and flow conditions for which additional data is needed to better distinguish background from human-caused loading

Stream Segment	Pollutant/s	Flow Condition
BISON CREEK	Copper	High and Low
	Iron	Low
CATARACT CREEK	Aluminum	High
	Cadmium	High
JACK CREEK	Copper	High
	Aluminum	High
LITTLE BOULDER RIVER	Aluminum	High
	Copper	High
	Lead	High
LOWLAND CREEK	Aluminum	High
	Copper	High
NORTH FORK LITTLE BOULDER RIVER	Aluminum	High
	Copper	High and Low
UNCLE SAM GULCH	Lead	High

For the pollutant-waterbody combinations in **Table 8-2**, follow up monitoring should focus on defining the contribution from discrete mining sources within abandoned mine sites. As this information becomes available, TMDL allocation schemes may be modified to include load allocations to background sources, as opposed to the current composite WLAs.

The descriptions of several of the priority abandoned mines are based on information collected during early 1990s site inventories. Additional site reconnaissance and monitoring of discrete sources is needed to develop remediation strategies tailored to difference types of sources.

The following bulleted items describe source assessment information that could improve our understanding of loading at a number of priority mine sites:

- Expand the mapping of Josephine Mine features eastward, to include the drainages of the unnamed Grub Gulch tributaries immediately south of the Luttrell Pit repository. A clearer picture of source locations relative to recent monitoring sites in this area would improve our understanding of metals loading from Grub Gulch.
- A more detailed mapping of source locations and past surface water monitoring sites at the Lady Leith Mine, along with more recent water quality analyses, would help clarify the loading situation and identify workable remediation practices for this site in upper Basin Creek.
- Information on the extent of downstream water quality damage from the discharging adits at the Boulder Chief Mine would help determine the effect of this site on metals loading to Basin Creek .

Additional water quality sampling in streams with minimal data such as Rocker Creek, Nellie Grant Creek, Bishop Creek, Turnley Creek, Sourdough Creek, Slaughterhouse Gulch, and the upper Little Boulder River would yield a better understanding of the specific metals loading sources affecting these streams.

9.0 Stakeholder Outreach, Public Participation, & Public Comments

Stakeholder and public involvement is a component of TMDL planning supported by EPA guidelines and required by Montana state law (MCA 75-5-703, 75-5-704) which directs DEQ to consult with watershed advisory groups and local conservation districts during the TMDL development process. Technical advisors, stakeholders and interested parties, state and federal agencies, interest groups, and the public were solicited to participate in differing capacities throughout the TMDL development process in the Boulder-Elkhorn TMDL Planning Area (TPA).

9.1 Participants and Roles

Throughout completion of the Boulder-Elkhorn TMDLs, DEQ maintained contacts with stakeholders to keep them apprised of project status and solicited input from a TMDL advisory group. A description of the participants in the development of the TMDLs in the Boulder-Elkhorn TPA and their roles is contained below.

Montana Department of Environmental Quality
Montana state law (MCA 75-5-703) directs DEQ to develop all necessary TMDLs. DEQ has provided resources toward completion of TMDLs in terms of staff, funding, internal planning, data collection, technical assessments, document development, and stakeholder communication and coordination. DEQ has worked with other state and federal agencies to gather data and conduct technical assessments.

United States Environmental Protection Agency
EPA is the federal agency responsible for administering and coordinating requirements of the Clean Water Act (CWA). Section 303(d) of the CWA directs states to develop TMDLs (see **Section 1.1**), and EPA has developed guidance and programs to assist states in that regard. EPA has provided funding and technical assistance to Montana's overall TMDL program and is responsible for final TMDL approval.

County Conservation Districts
The entire Boulder-Elkhorn TPA falls within Jefferson County. Therefore, DEQ provided the Jefferson County Conservation District with consultation opportunities during development of TMDLs. This included opportunities to provide comment during the various stages of TMDL development, and an opportunity for participation in the advisory group discussed below.

TMDL Advisory Group
The Boulder-Elkhorn TMDL Advisory Group consisted of selected resource professionals who possess a familiarity with water quality issues and processes in the Boulder River watershed, and also representatives of applicable interest groups. All members were solicited to participate in an advisory capacity per Montana state law (75-5-703 and 704). DEQ requested participation from the interest groups defined in MCA 75-5-704 and included local city and county representatives, livestock-oriented and farming-oriented agriculture representatives, conservation groups, watershed groups, state and federal land management agencies, and representatives of recreation and tourism interests. The advisory group also included additional stakeholders and landowners with an interest in maintaining and improving water quality and riparian resources.

Advisory group involvement was voluntary and the level of involvement was at the discretion of the individual members. Members had the opportunity to provide comment and review of technical TMDL assessments and reports and to attend meetings organized by DEQ for the purpose of soliciting feedback on project planning. Typically, draft documents were released to the advisory group for review and their comments were then compiled and evaluated. Final technical decisions regarding document modifications resided with DEQ.

Communications with the group members included several meetings, as well as e-mail and phone correspondences. Draft documents, general TMDL information, and project updates were made available through DEQ's wiki for TMDL projects (http://montanatmdlflathead.pbworks.com). Opportunities for review and comment were provided for participants at varying stages of TMDL development, including opportunity for review of the draft TMDL document prior to the public comment period.

Area Landowners

Since 37 percent of the planning area is in private ownership, local landowner cooperation in the TMDL process has been important. Their contribution has included access for stream sampling and field assessments and personal descriptions of seasonal water quality and streamflow characteristics. The DEQ sincerely thanks the planning area landowners for their logistical support and informative participation in impromptu water resource and land management discussions with our field staff and consultants.

9.2 Response to Public Comments

The public comment period for this document was initiated on November 8 and concluded on December 6, 2012. A public meeting was held in Boulder on November 26, 2012. During the meeting, DEQ presented information regarding the TMDLs within this document and answered questions posed by attendees. Formal written comments were received by a Montana Fish, Wildlife and Parks representative and two private individuals. **Appendix G** is a summary of these formal public comments along with the DEQ responses to each comment.

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APPENDIX A – WATERSHED DESCRIPTION MAPS

Figure A-1. Boulder-Elkhorn TMDL Planning Area

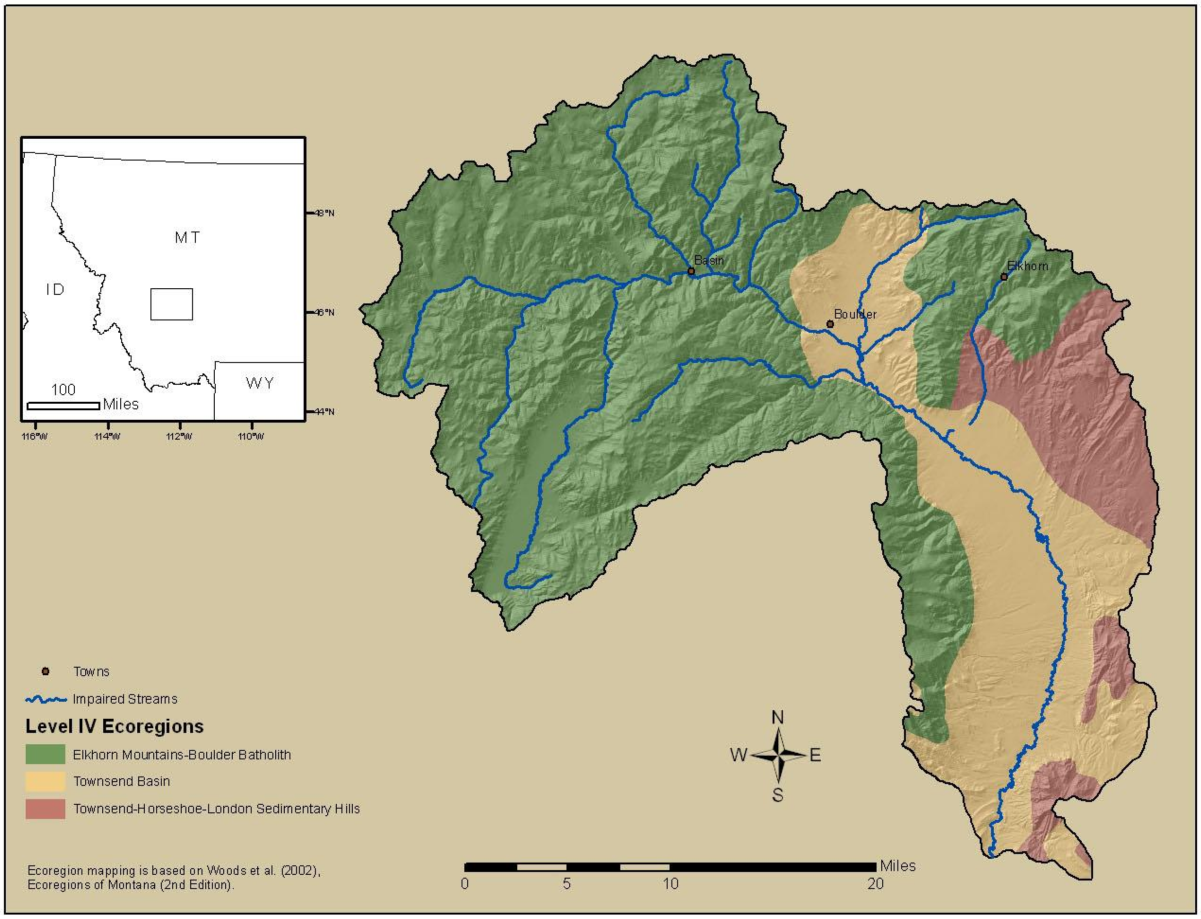

Figure A-2. Ecoregions

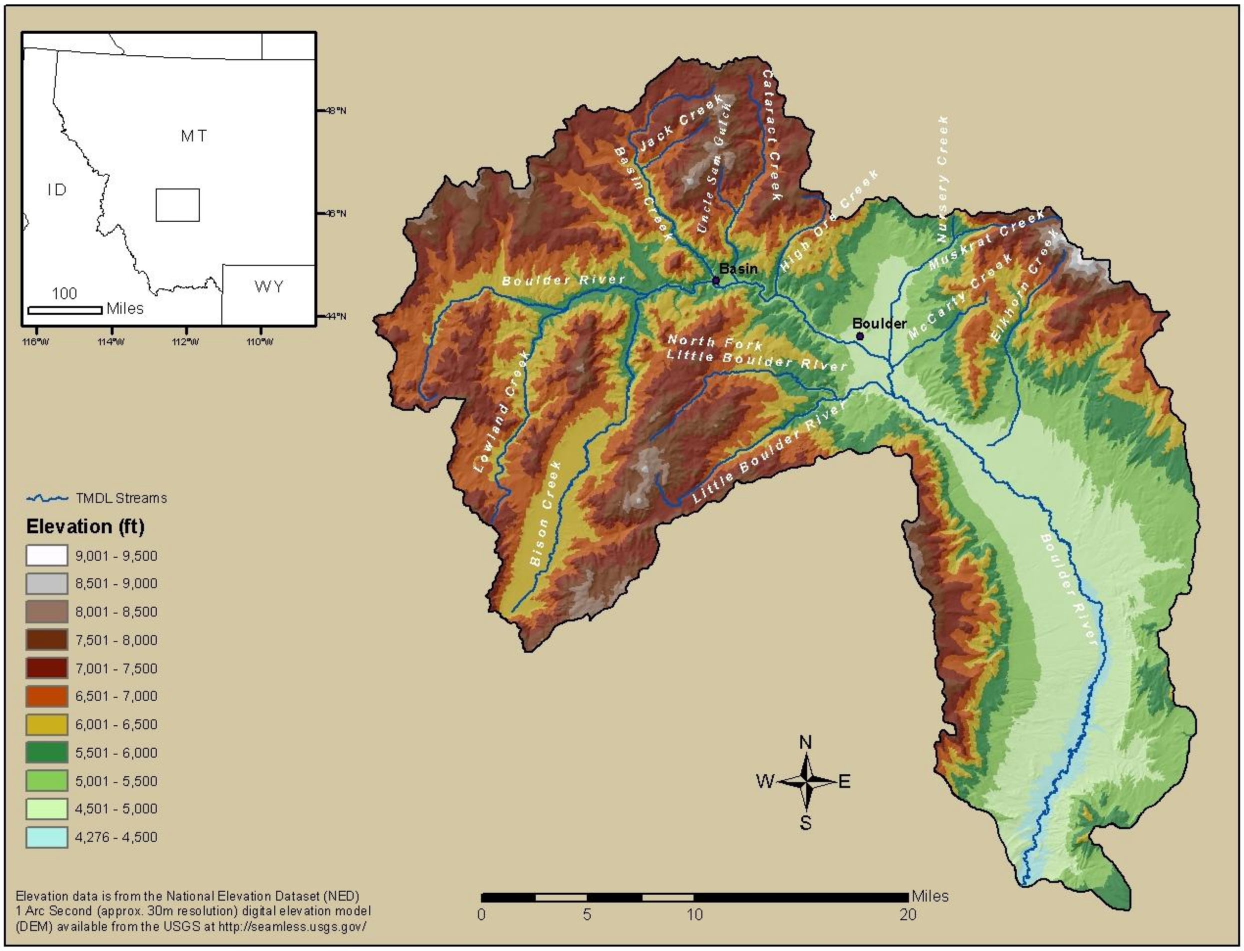

Figure A-3. Topography

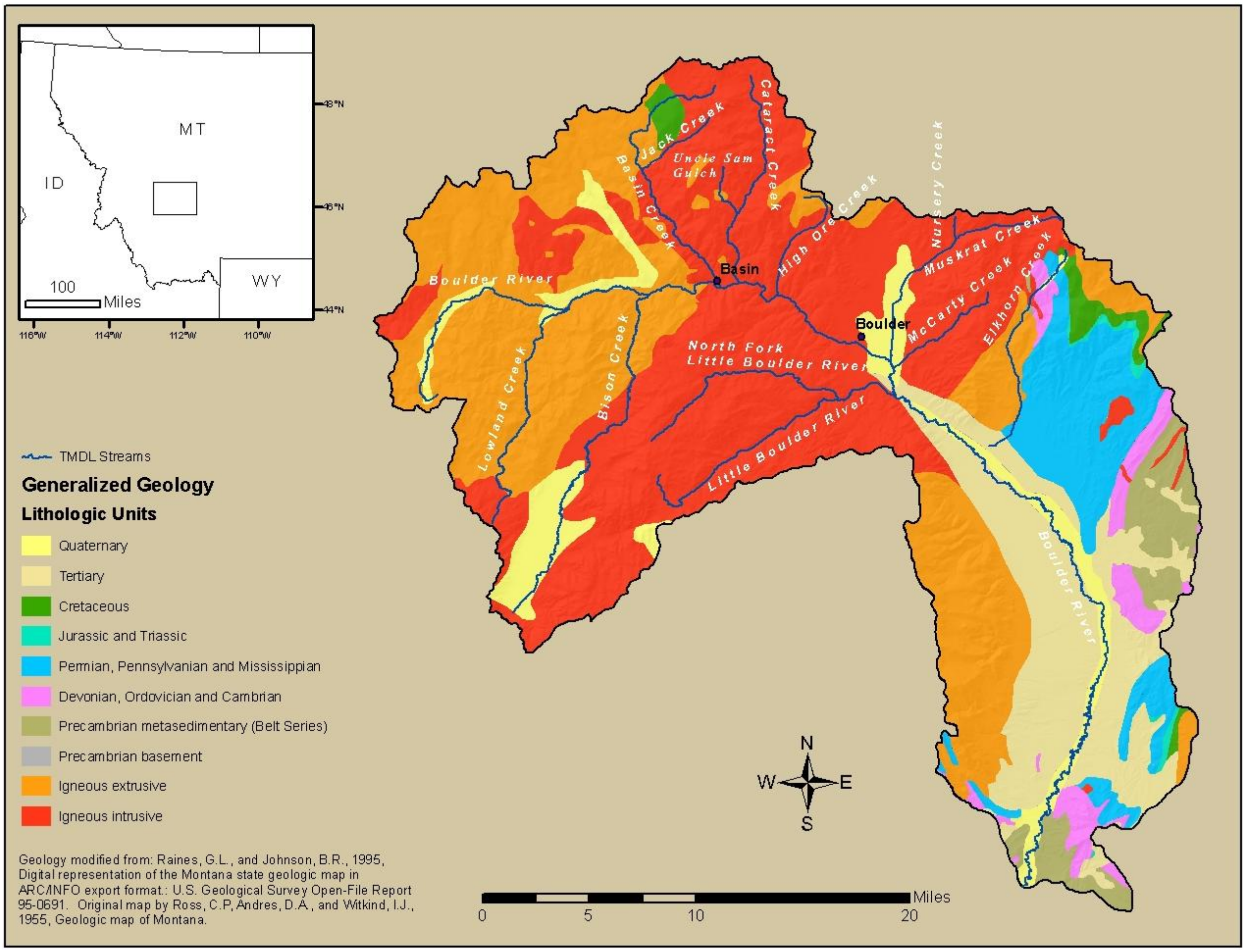

Figure A-4. Geology

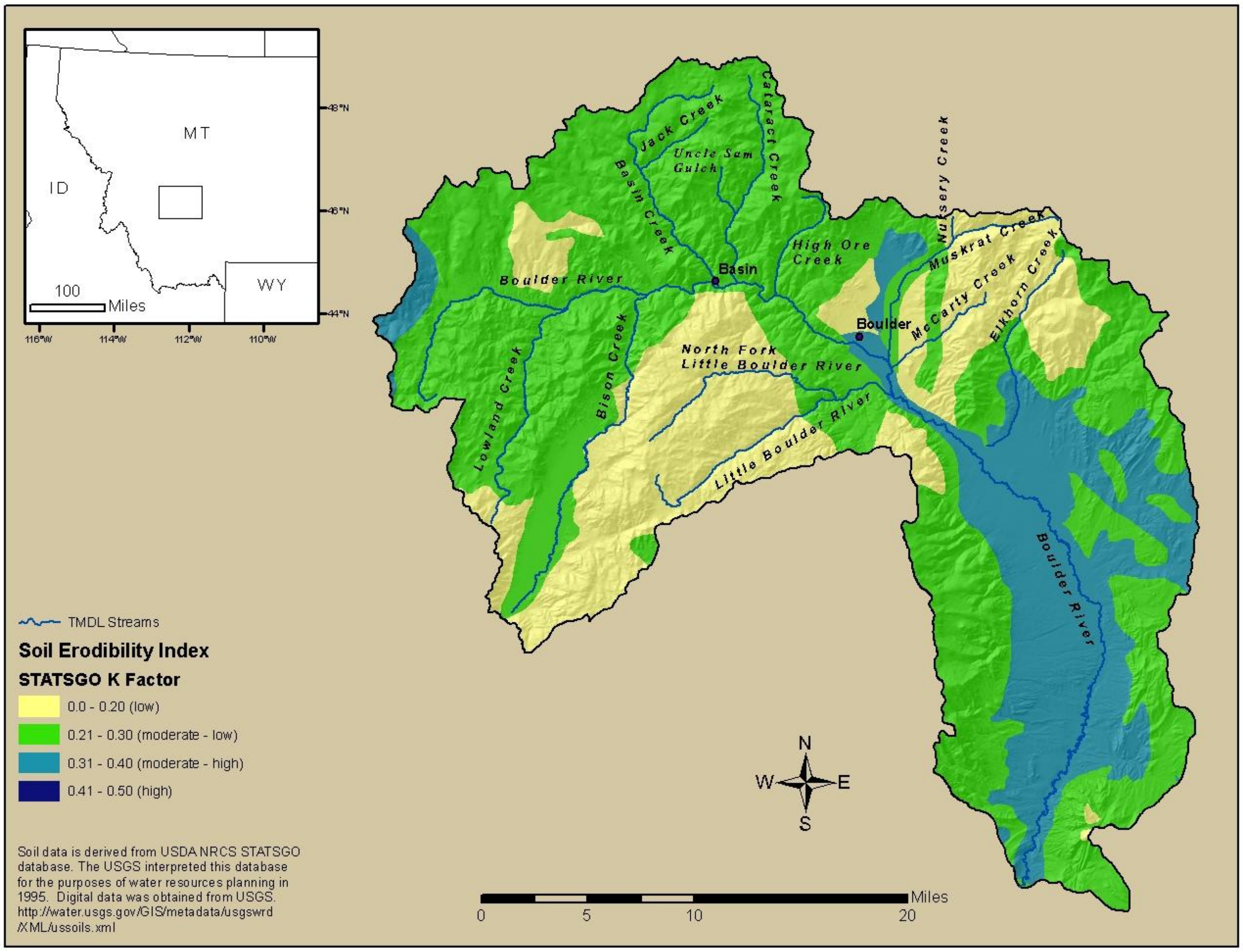

Figure A-5. Erodibility

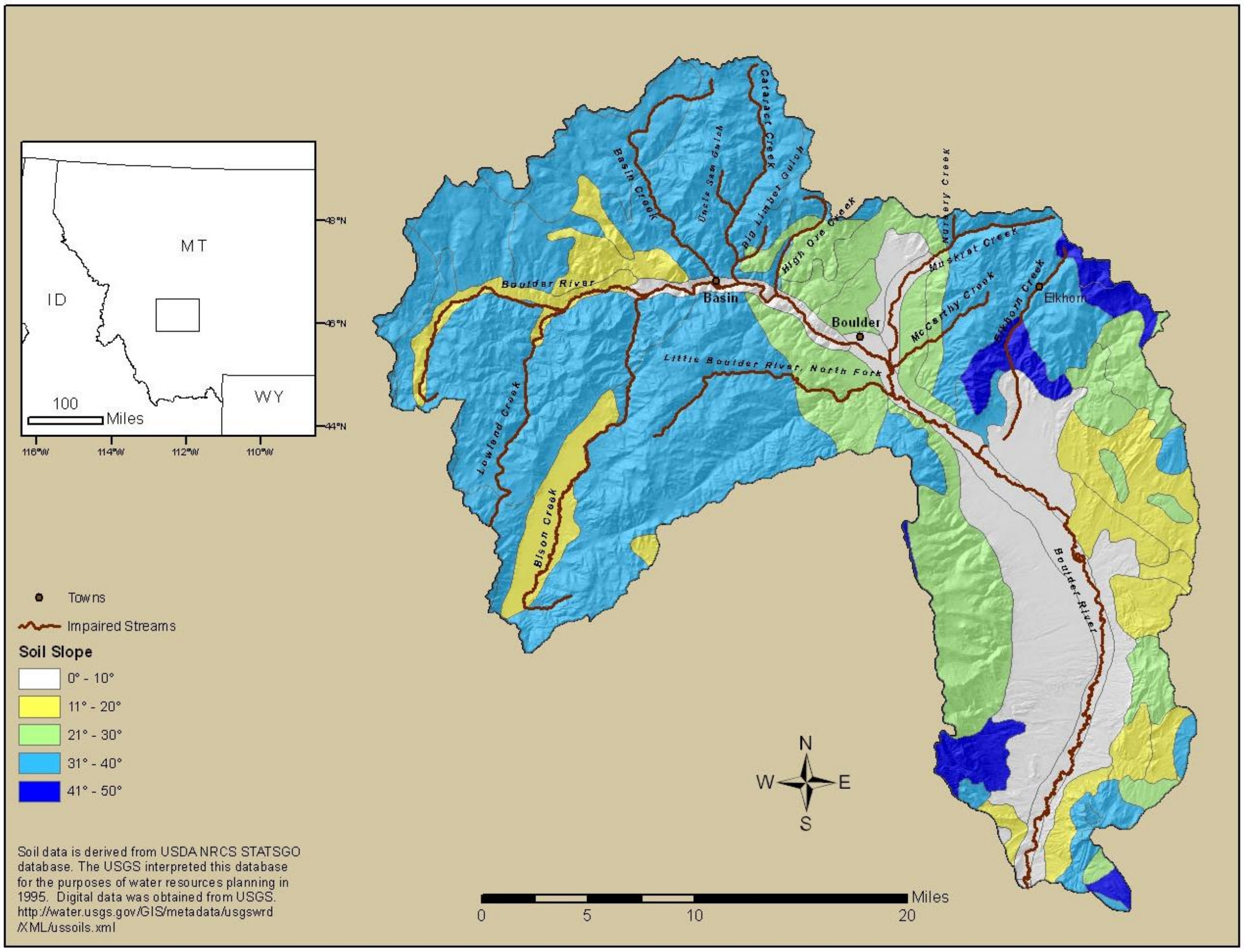

Figure A-6a. Soil Slope Phase

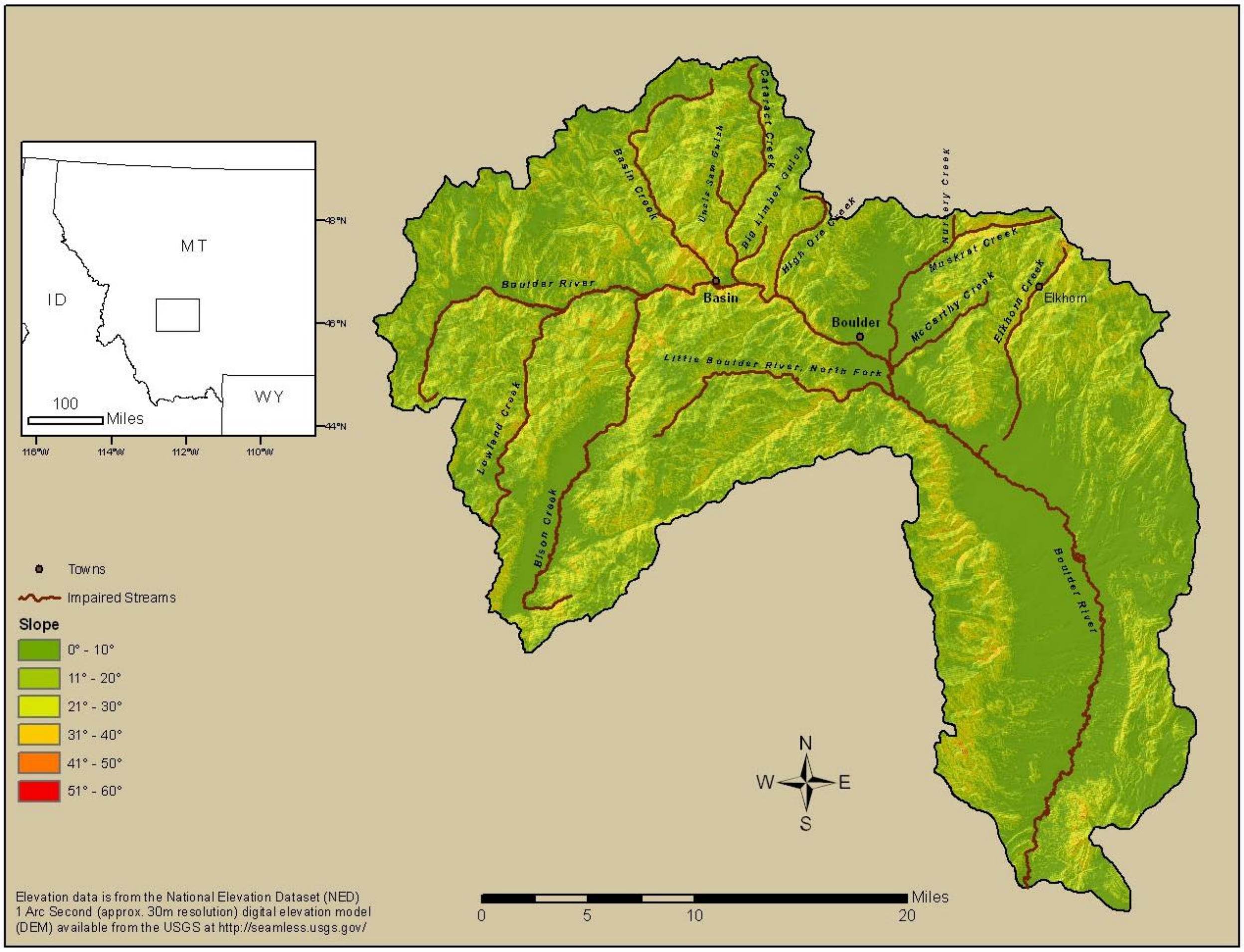

Figure A-6b. Land Surface Slope

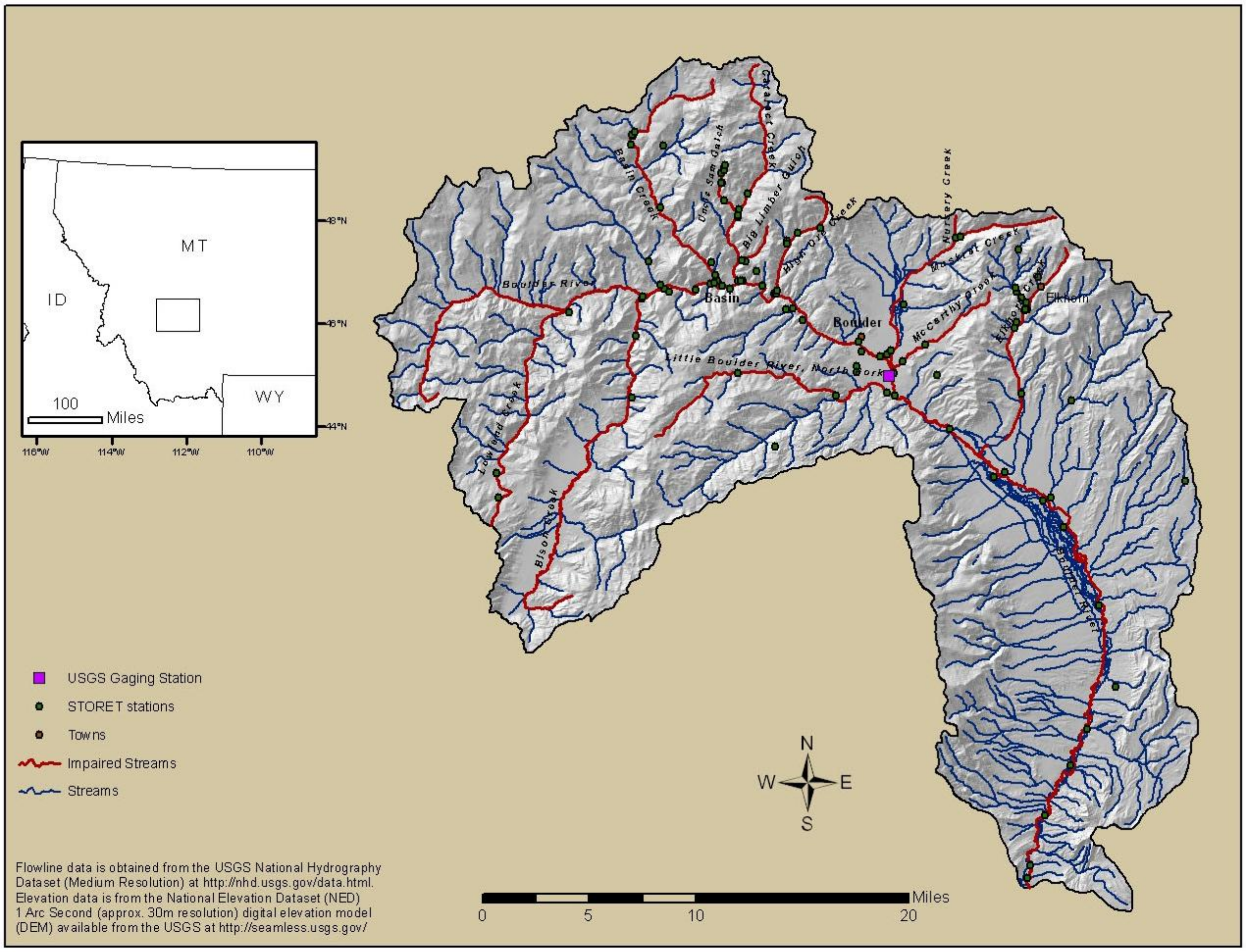

Figure A-7. Hydrography

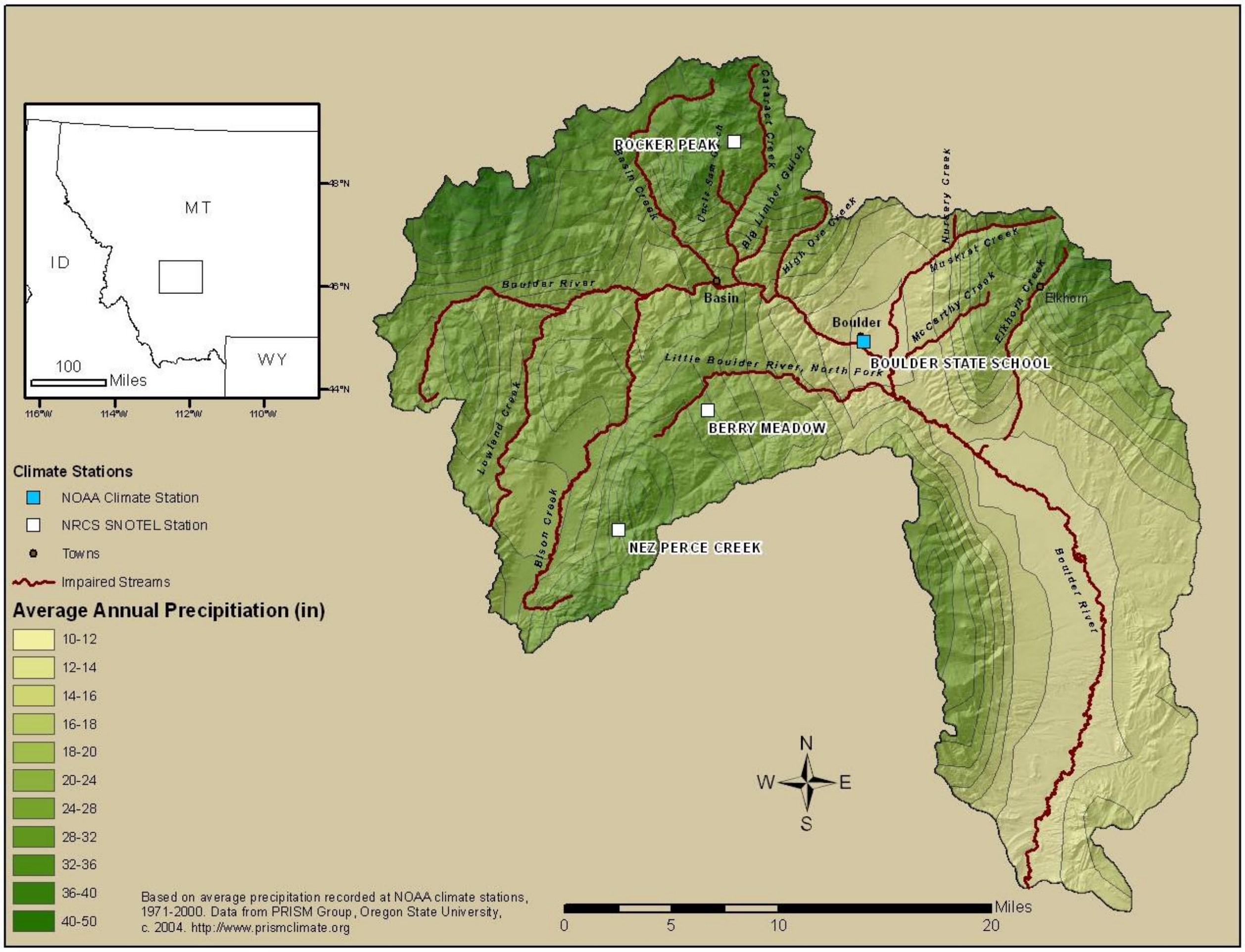

Figure A-8. Annual Precipitation

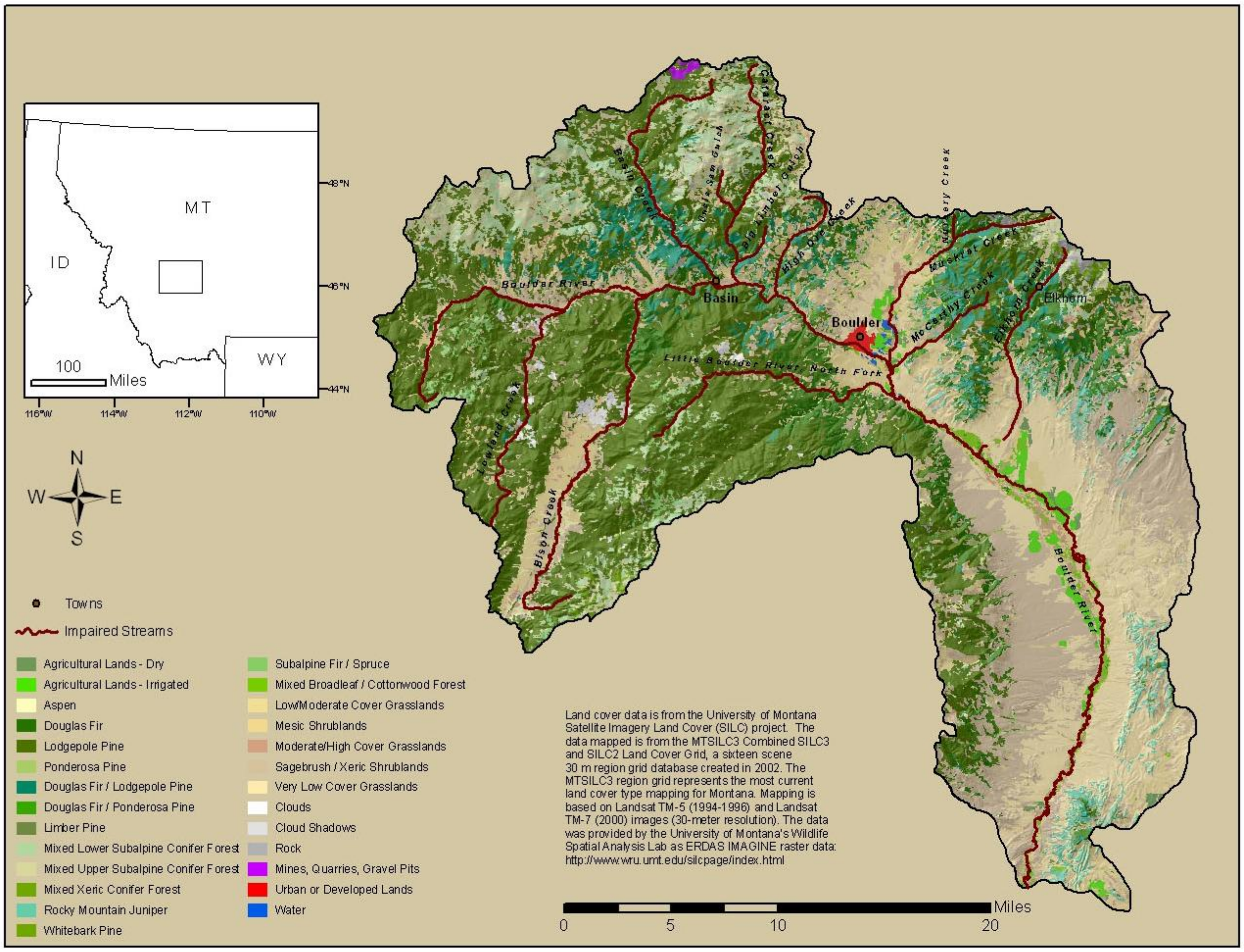

Figure A-9. Land Cover (SILC)

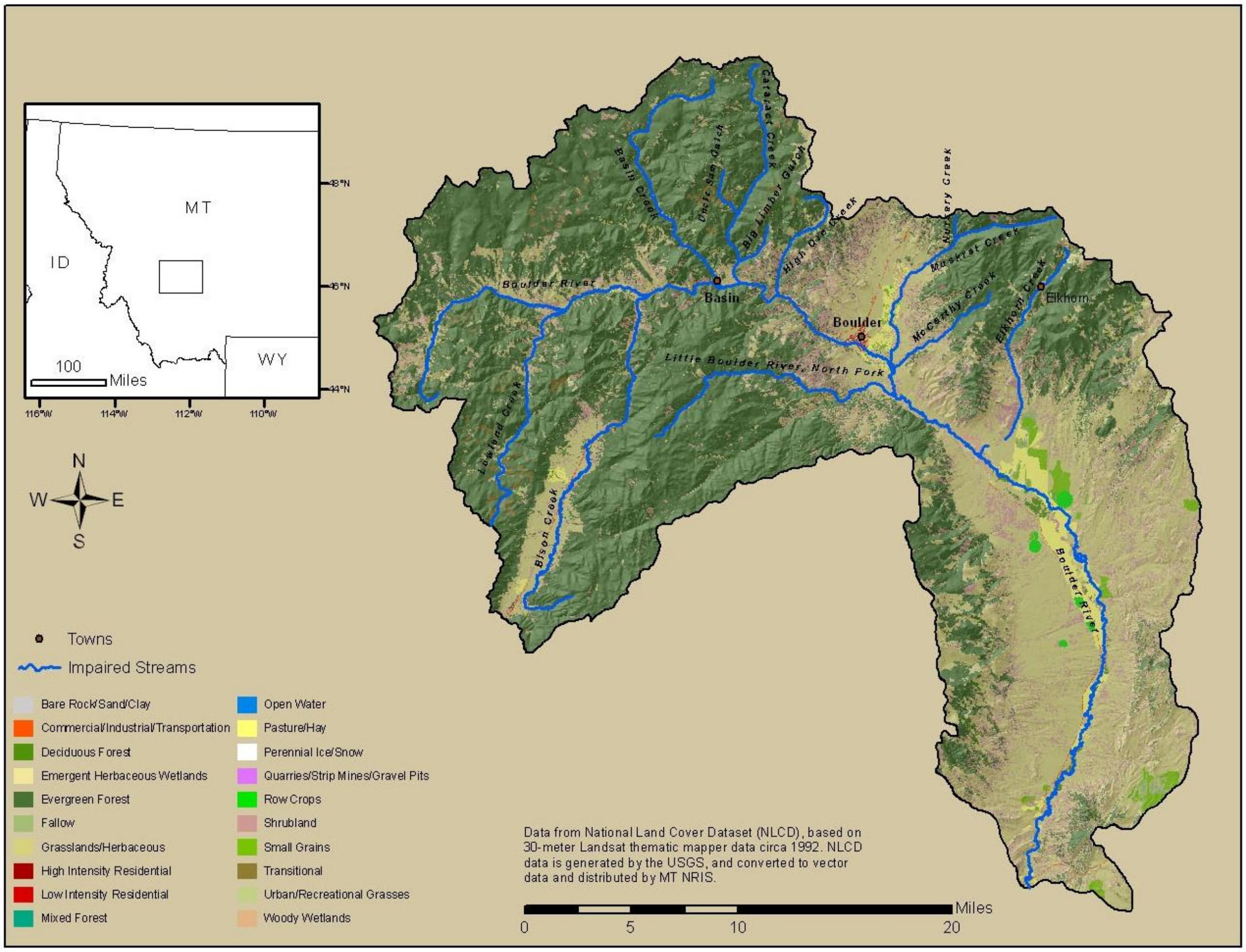

Figure A-10. Land Cover (NLCDS)

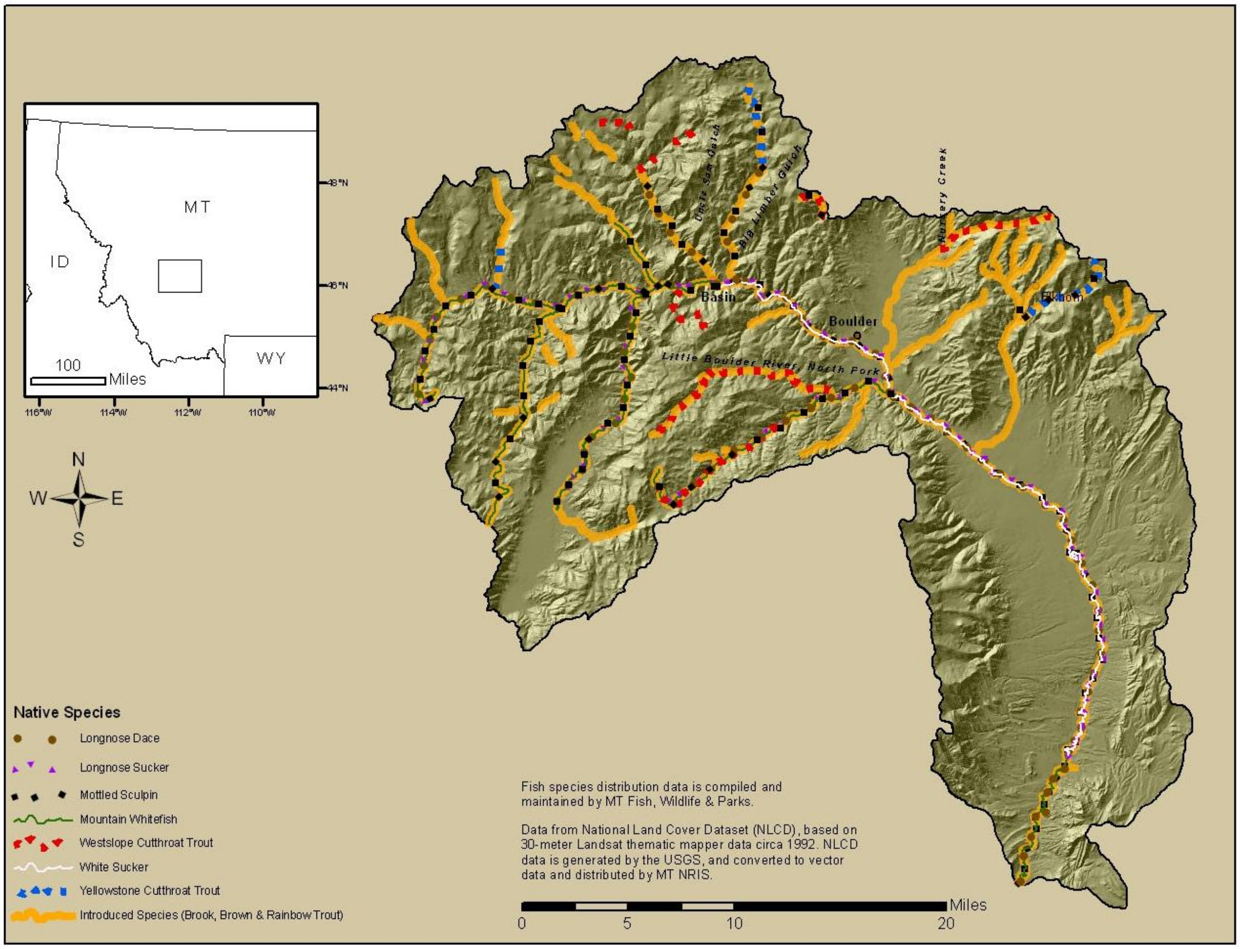

Figure A-11. Fish Distribution

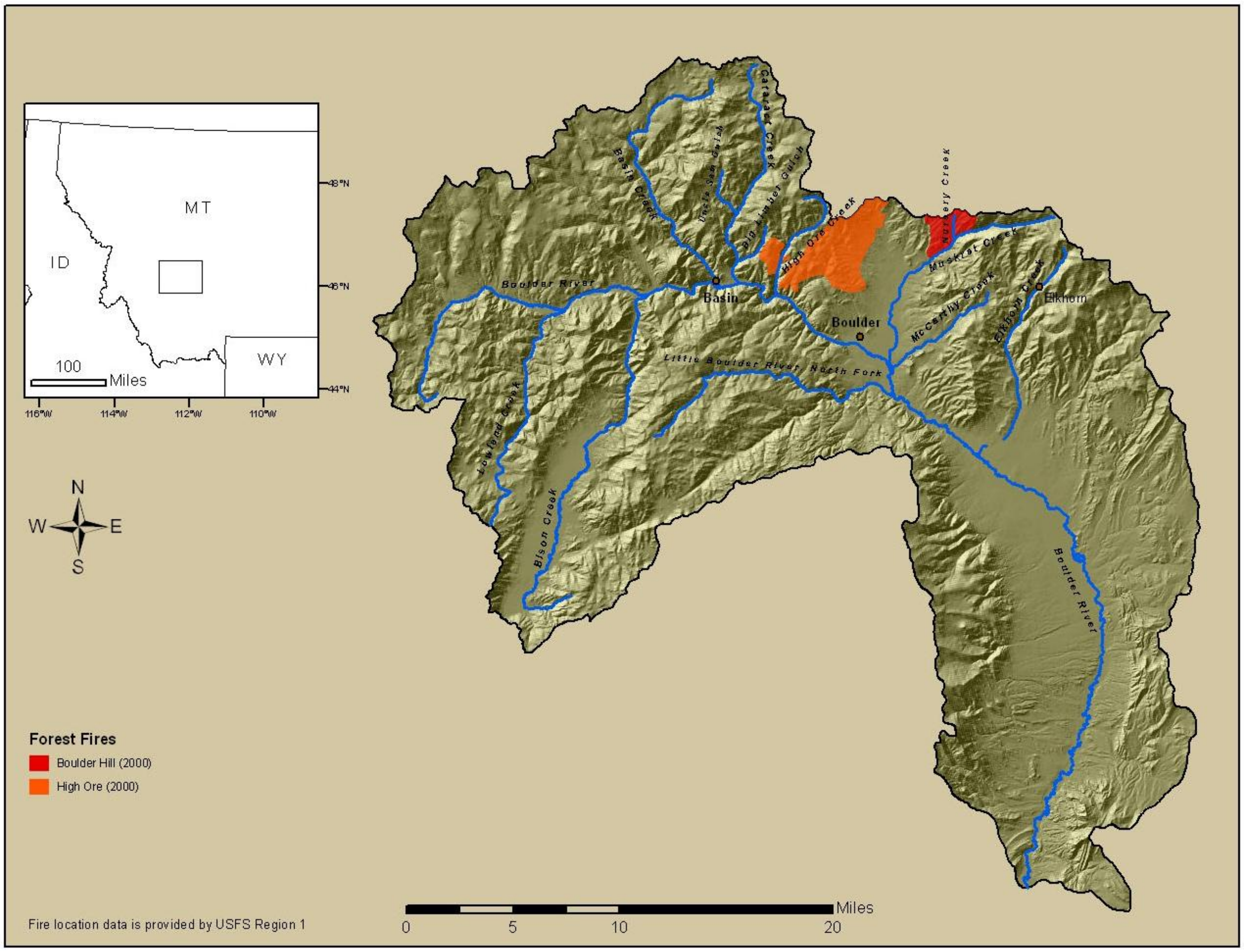

Figure A-12. Forest Fires

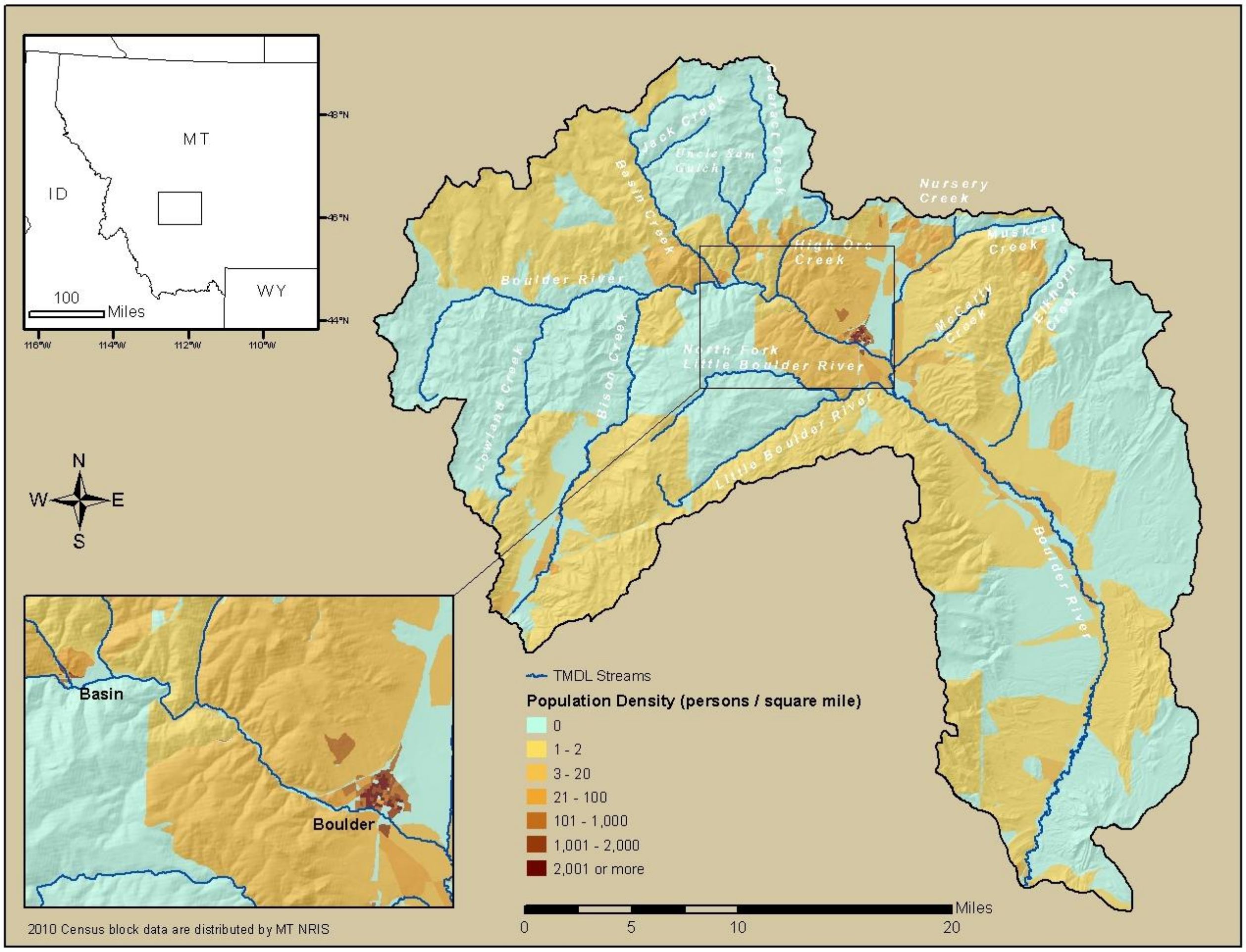

Figure A-13. Population Density

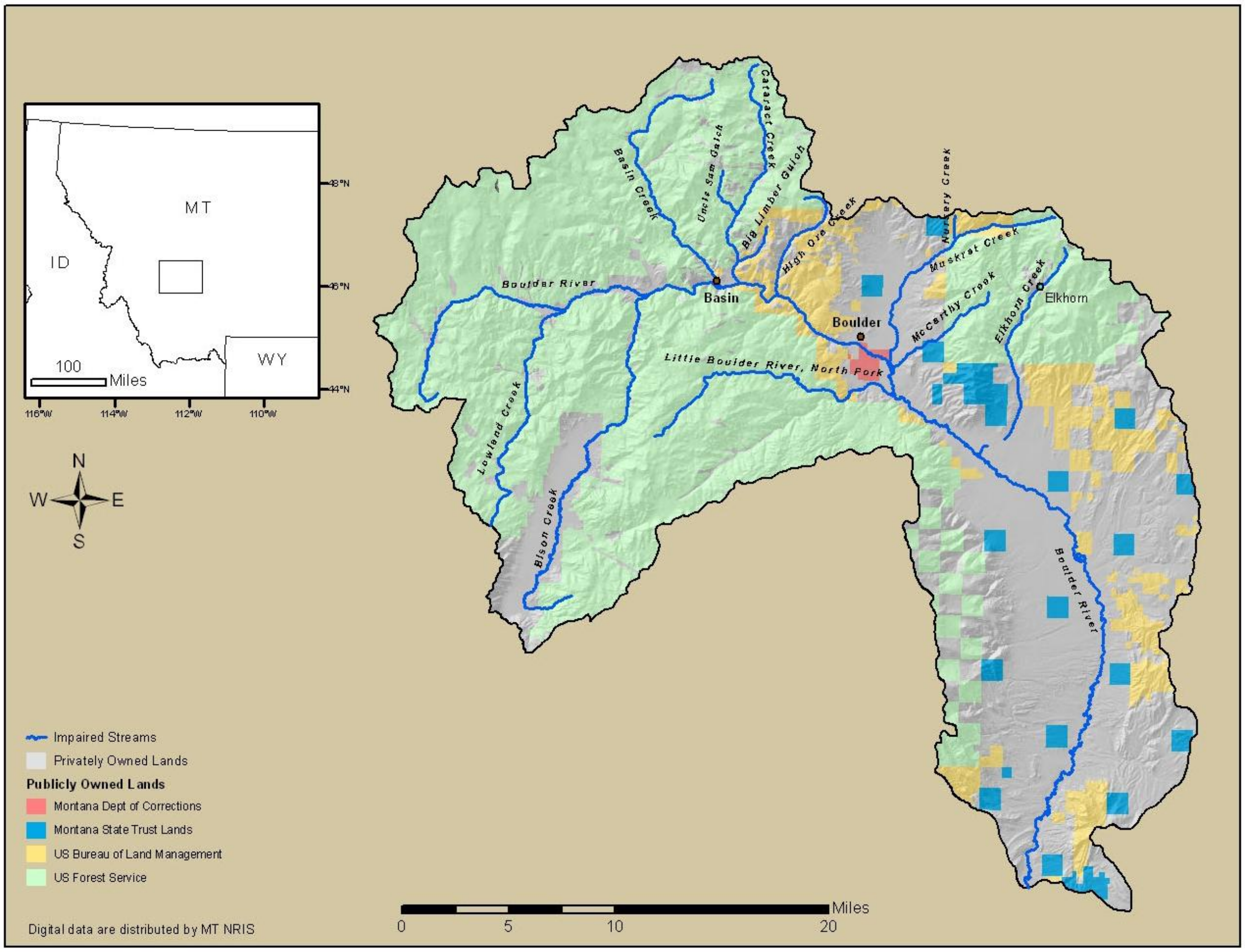

Figure A-14. Land Ownership

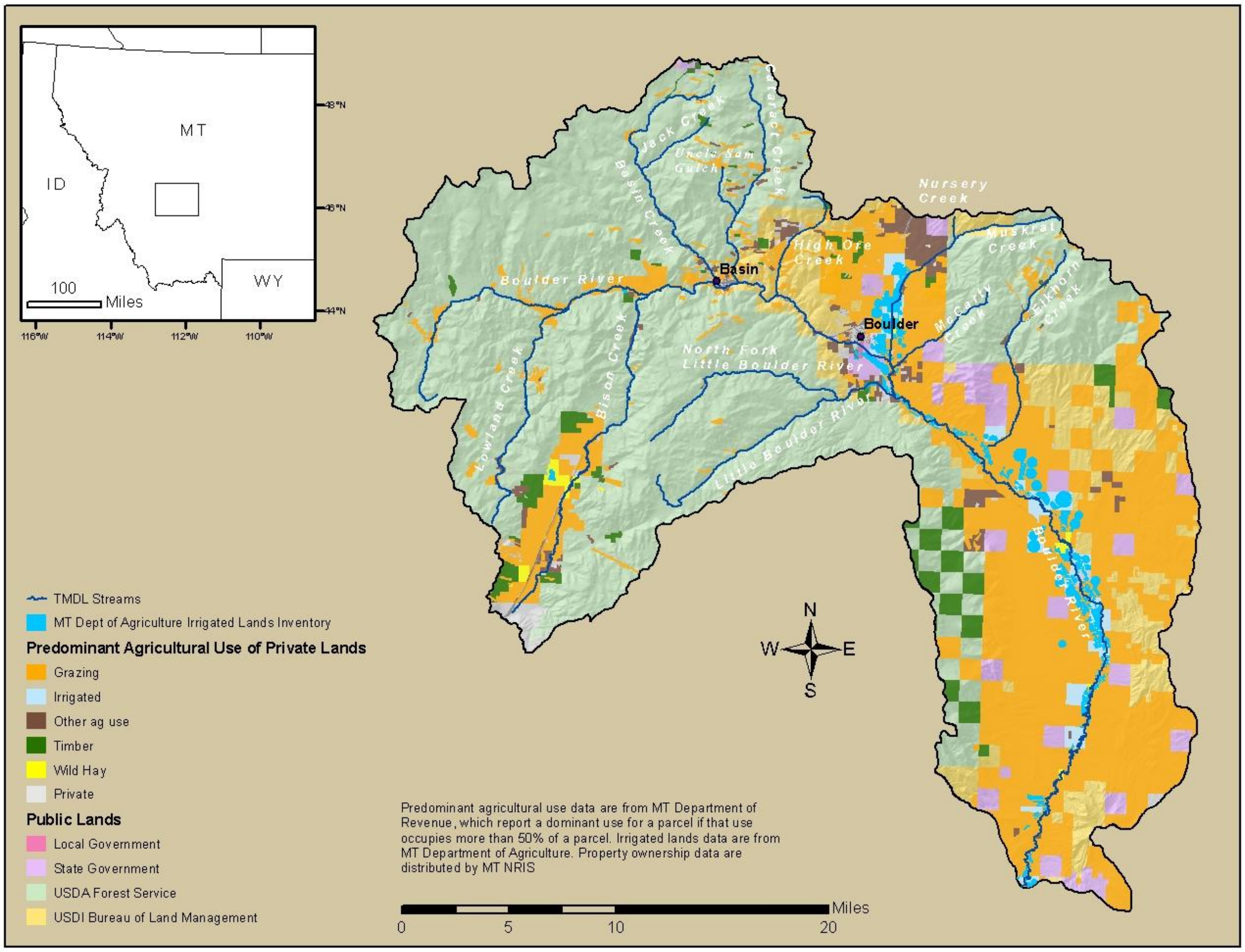

Figure A-15. Agricultural Land Use.

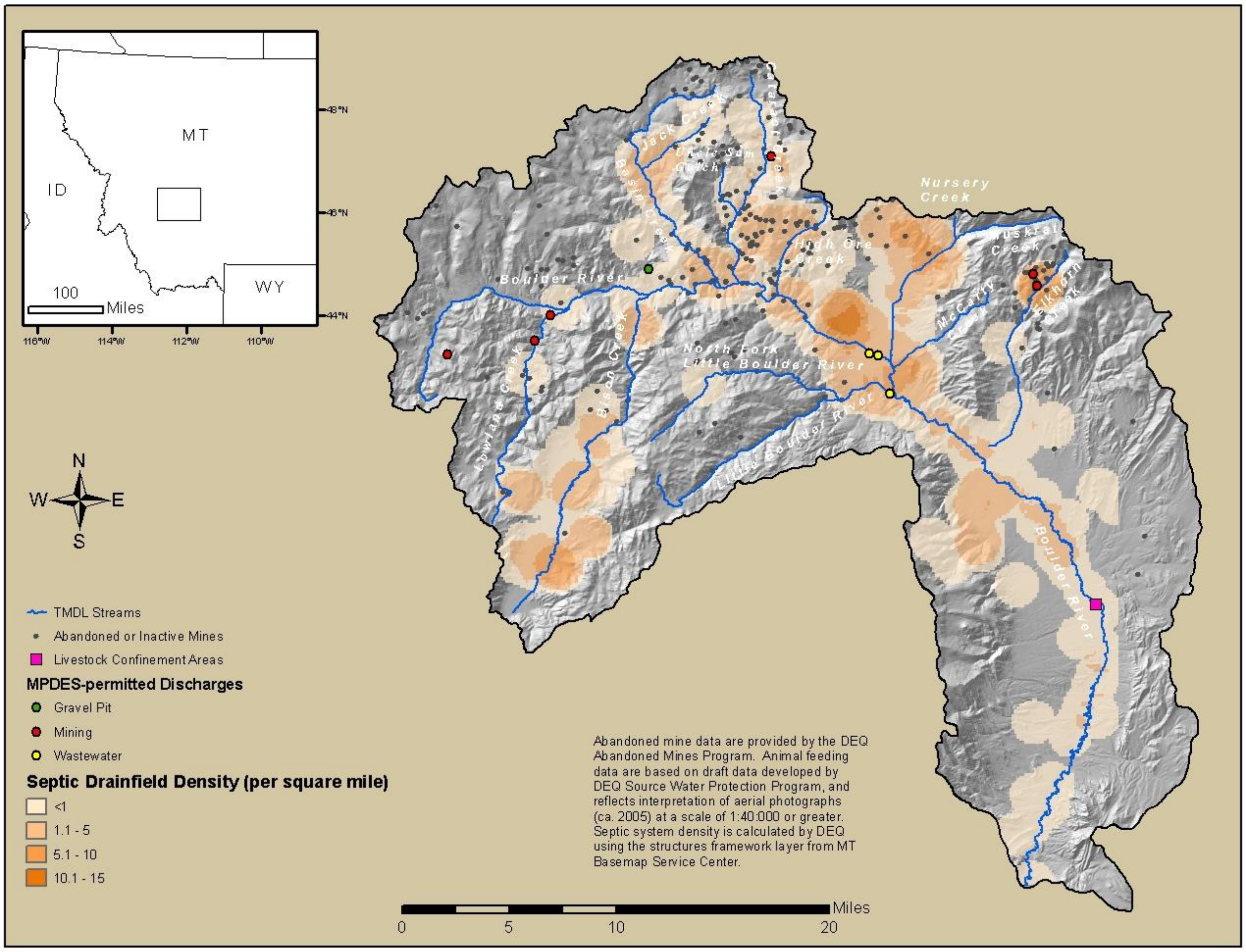

Figure A-16. Potential Discharges

APPENDIX B – TABLE OF 2012 IMPAIRED WATERBODIES, IMPAIRED USES, AND IMPAIRMENT STATUS

This appendix consists of **Table B-1** that contains water use impairment information from the 2012 Montana Water Quality Integrated Report (DEQ 2012) on waterbodies in the Boulder-Elkhorn TMDL Planning Area.

Table B-1. Status of Waterbody Impairments in the Boulder-Elkhorn TMDL Planning Area based on the 2012 Integrated Report

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)	Impairment Cause Status
BASIN CREEK, headwaters to mouth (Boulder River)	MT41E002_030	Alteration in stream-side or littoral vegetative covers	Not a Pollutant	Aquatic Life	Addressed by a sediment TMDL in a separate document
		Arsenic	Metal	Agriculture, Aquatic Life, Drinking Water	Arsenic TMDL contained in this document
		Copper	Metal	Agriculture, Aquatic Life	Copper TMDL contained in this document
		Lead	Metal	Agriculture, Aquatic Life	Lead TMDL contained in this document
		Mercury	Metal	Agriculture, Aquatic Life, Drinking Water	Not impaired based on updated assessment
		Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in a separate document
		Zinc	Metal	Agriculture, Aquatic Life	Zinc TMDL contained in this document
BIG LIMBER GULCH, headwaters to mouth (Cataract Creek-Boulder River)	MT41E002_140	Lead	Metal	Drinking Water	Not impaired based on updated assessment
		Mercury	Metal	Drinking Water	Not impaired based on updated assessment
BISON CREEK, headwaters to mouth (Boulder River)	MT41E002_070	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Aquatic Life	Addressed by a sediment TMDL in a separate document
		Copper	Metal	Aquatic Life	Copper TMDL contained in this document
		Iron	Metal	Aquatic Life	Iron TMDL contained in this document
		Nitrates	Nutrient	Aquatic Life	Addressed by TN TMDL in a separate document

Table B-1. Status of Waterbody Impairments in the Boulder-Elkhorn TMDL Planning Area based on the 2012 Integrated Report

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)	Impairment Cause Status
BOULDER RIVER, headwaters to Basin Creek	MT41E001_010	Cadmium	Metal	Aquatic Life	Not impaired based on updated assessment
		Copper	Metal	Aquatic Life	Copper TMDL contained in this document
		Iron	Metal	Aquatic Life, Drinking Water	Not impaired based on updated assessment
		Lead	Metal	Aquatic Life	Lead TMDL contained in this document
		Zinc	Metal	Aquatic Life	Not impaired based on updated assessment
BOULDER RIVER, Basin Creek to Town of Boulder	MT41E001_021	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Aquatic Life	Discussed in a separate document; not linked to a TMDL
		Cadmium	Metal	Aquatic Life	Cadmium TMDL contained in this document
		Copper	Metal	Aquatic Life	Copper TMDL contained in this document
		Iron	Metal	Aquatic Life, Drinking Water	Not impaired based on updated assessment
		Lead	Metal	Aquatic Life, Drinking Water	Lead TMDL contained in this document
		Silver	Metal	Aquatic Life, Drinking Water	Not impaired based on updated assessment
		Zinc	Metal	Aquatic Life	Zinc TMDL contained in this document

Table B-1. Status of Waterbody Impairments in the Boulder-Elkhorn TMDL Planning Area based on the 2012 Integrated Report

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)	Impairment Cause Status
BOULDER RIVER, Town of Boulder to Cottonwood Creek	MT41E001_022	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Aquatic Life	Addressed by a sediment TMDL in a separate document
		Copper	Metal	Agriculture, Aquatic Life	Copper TMDL contained in this document
		Iron	Metal	Agriculture, Aquatic Life	Iron TMDL contained in this document
		Lead	Metal	Agriculture, Aquatic Life, Drinking Water	Lead TMDL contained in this document
		Low Flow Alterations	Not a Pollutant	Aquatic Life, Primary Contact Recreation	Discussed in a separate document; not linked to a TMDL
		Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in a separate document
		Silver	Metal	Agriculture, Aquatic Life, Drinking Water	Not impaired based on updated assessment
		Temperature, water	Temperature	Aquatic Life	Temperature TMDL contained in a separate document
		Zinc	Metal	Agriculture, Aquatic Life	Zinc TMDL contained in this document

Table B-1. Status of Waterbody Impairments in the Boulder-Elkhorn TMDL Planning Area based on the 2012 Integrated Report

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)	Impairment Cause Status
BOULDER RIVER, Cottonwood Creek to the mouth (Jefferson Slough), T1N R3W S2	MT41E001_030	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Aquatic Life	Addressed by a sediment TMDL in a separate document
		Arsenic	Metal	Agriculture, Aquatic Life, Drinking Water	Arsenic TMDL contained in this document
		Cadmium	Metal	Agriculture, Aquatic Life, Drinking Water	Cadmium TMDL contained in this document
		Copper	Metal	Agriculture, Aquatic Life	Copper TMDL contained in this document
		Lead	Metal	Agriculture, Aquatic Life, Drinking Water	Lead TMDL contained in this document
		Low Flow Alterations	Not a Pollutant	Aquatic Life, Primary Contact Recreation	Discussed in a separate document; not linked to a TMDL
		Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in a separate document
		Temperature, water	Temperature	Aquatic Life	Temperature TMDL contained in a separate document
		Zinc	Metal	Agriculture, Aquatic Life	Zinc TMDL contained in this document

Table B-1. Status of Waterbody Impairments in the Boulder-Elkhorn TMDL Planning Area based on the 2012 Integrated Report

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)	Impairment Cause Status
CATARACT CREEK, headwaters to mouth (Boulder River)	MT41E002_020	Arsenic	Metal	Agriculture, Aquatic Life, Drinking Water	Arsenic TMDL contained in this document
		Cadmium	Metal	Agriculture, Aquatic Life, Drinking Water	Cadmium TMDL contained in this document
		Copper	Metal	Agriculture, Aquatic Life, Drinking Water	Copper TMDL contained in this document
		Lead	Metal	Agriculture, Aquatic Life, Drinking Water	Lead TMDL contained in this document
		Mercury	Metal	Agriculture, Aquatic Life, Drinking Water	Not impaired based on updated assessment
		Nitrogen, Nitrate	Nutrient	Aquatic Life	No TMDL developed; updated 303(d) listing status pending
		Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in a separate document
		Zinc	Metal	Agriculture, Aquatic Life	Zinc TMDL contained in separate document

Table B-1. Status of Waterbody Impairments in the Boulder-Elkhorn TMDL Planning Area based on the 2012 Integrated Report

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)	Impairment Cause Status
ELKHORN CREEK, headwaters to Wood Gulch	MT41E002_061	Alteration in streamside or littoral vegetative covers	Not a pollutant	Aquatic Life	Addressed by a sediment TMDL in a separate document
		Arsenic	Metal	Agriculture, Aquatic Life, Drinking Water	Arsenic TMDL contained in this document
		Cadmium	Metal	Agriculture, Aquatic Life, Drinking Water	Cadmium TMDL contained in this document
		Copper	Metal	Agriculture, Aquatic Life	Copper TMDL contained in this document
		Lead	Metal	Agriculture, Aquatic Life, Drinking Water	Lead TMDL contained in this document
		Low Flow Alterations	Not a Pollutant	Aquatic Life, Primary Contact Recreation	Discussed in a separate document; not linked to a TMDL
		Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in a separate document
		Zinc	Metal	Agriculture, Aquatic Life, Drinking Water	Not impaired based on updated assessment

Table B-1. Status of Waterbody Impairments in the Boulder-Elkhorn TMDL Planning Area based on the 2012 Integrated Report

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)	Impairment Cause Status
ELKHORN CREEK, Wood Gulch to the mouth (Unnamed Canal/Ditch), T5N R3W S21	MT41E002_062	Cadmium	Metal	Agriculture, Aquatic Life, Drinking Water	Cadmium TMDL contained in this document
		Copper	Metal	Agriculture, Aquatic Life	Not impaired based on updated assessment
		Lead	Metal	Agriculture, Aquatic Life, Drinking Water	Lead TMDL contained in this document
		Low Flow Alterations	Not a Pollutant	Aquatic Life, Primary Contact Recreation	Discussed in a separate document; not linked to a TMDL
		Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in a separate document
		Zinc	Metal	Agriculture, Aquatic Life	Not impaired based on updated assessment

Table B-1. Status of Waterbody Impairments in the Boulder-Elkhorn TMDL Planning Area based on the 2012 Integrated Report

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)	Impairment Cause Status
HIGH ORE CREEK, headwaters to mouth (Boulder River)	MT41E002_040	Alteration in streamside or littoral vegetative covers	Not a pollutant	Aquatic Life	Addressed by a sediment TMDL in a separate document
		Arsenic	Metal	Agriculture, Aquatic Life, Drinking Water	Arsenic TMDL contained in this document
		Cadmium	Metal	Agriculture, Aquatic Life, Drinking Water	Cadmium TMDL contained in this document
		Copper	Metal	Agriculture, Aquatic Life, Drinking Water	Copper TMDL contained in this document
		Lead	Metal	Agriculture, Aquatic Life, Drinking Water	Lead TMDL contained in this document
		Mercury	Metal	Agriculture, Aquatic Life, Drinking Water	Not impaired based on updated assessment
		Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in a separate document
		Temperature, water	Temperature	Aquatic Life	Temperature TMDL contained in a separate document
		Total Suspended Solids (TSS)	Sediment	Aquatic Life	Addressed by sediment TMDL in a separate document
		Zinc	Metal	Agriculture, Aquatic Life, Drinking Water	Zinc TMDL contained in this document
LITTLE BOULDER RIVER, headwaters to mouth (Boulder River)	MT41E002_080	Alteration in streamside or littoral vegetative covers	Not a pollutant	Aquatic Life	Discussed in a separate document; not linked to a TMDL
		Cause Unknown	Not a pollutant	Primary Contact Recreation	Not Addressed
		Copper	Metal	Aquatic Life	Copper TMDL contained in this document
		Physical substrate habitat alterations	Not a Pollutant	Aquatic Life	Discussed in a separate document; not linked to a TMDL
		Zinc	Metal	Aquatic Life	Not impaired based on updated assessment

Table B-1. Status of Waterbody Impairments in the Boulder-Elkhorn TMDL Planning Area based on the 2012 Integrated Report

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)	Impairment Cause Status
LOWLAND CREEK, headwaters to mouth (Boulder River)	MT41E002_050	Alteration in streamside or littoral vegetative covers	Not a pollutant	Aquatic Life	Discussed in a separate document; not linked to a TMDL
		Aluminum	Metal	Aquatic Life	Aluminum TMDL contained in this document
		Copper	Metal	Aquatic Life	Copper TMDL contained in this document
		Physical substrate habitat alterations	Not a Pollutant	Aquatic Life	Discussed in a separate document; not linked to a TMDL
		Silver	Metal	Aquatic Life	Not impaired based on updated assessment
McCARTY CREEK, headwaters to mouth (Boulder River	MT41E002_110	Alteration in streamside or littoral vegetative covers	Not a pollutant	Aquatic Life	Addressed by sediment TMDL in a separate document
		Fish-Passage Barrier	Not a pollutant	Aquatic Life	Not Addressed
		Low flow alterations	Not a pollutant	Aquatic Life, Primary Contact Recreation	Not Addressed
		Phosphorus (Total)	Nutrient	Aquatic Life	TP TMDL contained in a separate document
		Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in a separate document
MUSKRAT CREEK, headwaters to mouth (Boulder River)	MT41E002_100	Alteration in streamside or littoral vegetative covers	Not a pollutant	Aquatic Life	Addressed by sediment TMDL in a separate document
		Copper	Metal	Aquatic Life	Not impaired based on updated assessment
		Lead	Metal	Aquatic Life, Drinking Water	Not impaired based on updated assessment
NORTH FORK LITTLE BOULDER RIVER, headwaters to mouth (Little Boulder)	MT41E002_090	Alteration in streamside or littoral vegetative covers	Not a pollutant	Aquatic Life	Addressed by sediment TMDL in a separate document
		Nitrogen (Total)	Nutrients	Aquatic Life	Not impaired based on updated assessment
		Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in a separate document
NURSERY CREEK, headwaters (east branch) to mouth (Muskrat Creek)	MT41E002_130	Nitrate/Nitrite (Nitrite + Nitrate as N)	Nutrient	Aquatic Life	NO^{2}+NO^{3} TMDL contained in a separate document
		Nitrogen (Total)	Nutrient	Aquatic Life	TN TMDL contained in a separate document
		Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in a separate document

Table B-1. Status of Waterbody Impairments in the Boulder-Elkhorn TMDL Planning Area based on the 2012 Integrated Report

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)	Impairment Cause Status
UNCLE SAM GULCH, headwaters to mouth (Cataract Creek)	MT41E002_010	Alteration in streamside or littoral vegetative covers	Not a pollutant	Aquatic Life	Addressed by sediment TMDL in a separate document
		Arsenic	Metal	Agriculture, Aquatic Life, Drinking Water	Arsenic TMDL contained in this document
		Cadmium	Metal	Agriculture, Aquatic Life, Drinking Water	Cadmium TMDL contained in this document
		Copper	Metal	Agriculture, Aquatic Life, Drinking Water	Copper TMDL contained in this document
		Lead	Metal	Agriculture, Aquatic Life, Drinking Water	Addressed by lead TMDL
		Nitrogen, Nitrate	Nutrient	Aquatic Life	NO^2+NO^3 TMDL contained in a separate document
		Other flow regime alterations	Not a pollutant	Aquatic Life	Not Addressed
		Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in a separate document
		Turbidity	Sediment	Aquatic Life	Addressed by a sediment TMDL in a separate document
		Zinc	Metal	Agriculture, Aquatic Life, Drinking Water	Zinc TMDL contained in this document

APPENDIX C - REGULATORY FRAMEWORK AND REFERENCE CONDITION APPROACH

This appendix presents details about applicable Montana Water Quality Standards (WQS) and the general and statistical methods used for development of reference conditions.

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ACRONYMS

Acronym	Definition
ARM	Administrative Rules of Montana
BER	Board of Environmental Review (Montana)
CFR	Code of Federal Regulations
CWA	Clean Water Act
DEQ	Department of Environmental Quality (Montana)
EPA	Environmental Protection Agency (US)
HHC	Human Health Criteria
MCA	Montana Codes Annotated
MCL	Maximum Contaminant Level
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TPA	TMDL Planning Area
TSS	Total Suspended Solids
UAA	Use Attainability Analysis
WQA	Water Quality Act
WQS	Water Quality Standards

C1.0 TMDL DEVELOPMENT REQUIREMENTS

Section 303(d) of the federal Clean Water Act (CWA) and the Montana Water Quality Act (WQA) (Section 75-5-703) requires development of TMDLs for impaired waterbodies that do not meet Montana WQS. Although waterbodies can become impaired from pollution (e.g. low flow alterations and habitat degradation) and pollutants (e.g. nutrients, sediment, metals, pathogens, and temperature), the CWA and Montana state law (75-5-703) require TMDL development only for impaired waters with pollutant causes. Section 303(d) also requires states to submit a list of impaired waterbodies to the U.S. Environmental Protection Agency (EPA) every two years. Prior to 2004, EPA and DEQ referred to this list simply as the 303(d) list.

Since 2004, EPA has requested that states combine the 303(d) list with the 305(b) report containing an assessment of Montana's water quality and its water quality programs. EPA refers to this new combined 303(d)/305(b) report as the Integrated Water Quality Report. The 303(d) list also includes identification of the probable cause(s) of the water quality impairment (e.g. pollutants such as metals, nutrients, sediment, pathogens or temperature), and the suspected source(s) of the pollutants of concern (e.g. various land use activities). State law (MCA 75-5-702) identifies that a sufficient credible data methodology for determining the impairment status of each waterbody is used for consistency. The impairment status determination methodology is described in Section 4.0 of Montana's Water Quality Integrated Report (Montana Department of Environmental Quality, 2006).

Under Montana state law, an "impaired waterbody" is defined as a waterbody or stream segment for which sufficient credible data show that the waterbody or stream segment is failing to achieve compliance with applicable WQS (Montana Water Quality Act; Section 75-5-103(11)). A "threatened waterbody" is defined as a waterbody or stream segment for which sufficient credible data and calculated increases in loads show that the waterbody or stream segment is fully supporting its designated uses, but threatened for a particular designated use because of either (a) proposed sources that are not subject to pollution prevention or control actions required by a discharge permit, the nondegradation provisions, or reasonable land, soil, and water conservation practices or (b) documented adverse pollution trends (Montana WQA; Section 75-5-103(31)). State law and Section 303(d) of the CWA require states to develop all necessary TMDLs for impaired or threatened waterbodies. There are no threatened waterbodies within the Boulder-Elkhorn TMDL Planning Area (TPA).

A TMDL is a pollutant budget for a waterbody identifying the maximum amount of the pollutant that a waterbody can assimilate without causing applicable WQS to be exceeded (violated). TMDLs are often expressed in terms of an amount, or load, of a particular pollutant (expressed in units of mass per time such as pounds per day). TMDLs must account for loads/impacts from point and nonpoint sources in addition to natural background sources and must incorporate a margin of safety and consider influences of seasonality on analysis and compliance with WQS. **Section 4.0** of the main document provides a description of the components of a TMDL.

To satisfy the federal CWA and Montana state law, TMDLs are developed for each waterbody-pollutant combination identified on Montana's 303(d) list of impaired or threatened waters, and are often presented within the context of a water quality restoration or protection plan. State law (Administrative Rules of Montana 75-5-703(8)) also directs Montana DEQ to "…support a voluntary program of reasonable land, soil, and water conservation practices to achieve compliance with water quality standards for nonpoint source activities for waterbodies that are subject to a TMDL…" This is an important directive that is reflected in the overall TMDL development and implementation strategy within this plan. It is important to note that water quality protection measures are not considered voluntary where such measures are already a requirement under existing federal, state, or local regulations.

C2.0 APPLICABLE WATER QUALITY STANDARDS

WQS include the uses designated for a waterbody, the legally enforceable standards that ensure that the uses are supported, and a nondegradation policy that protects the high quality of a waterbody. The ultimate goal of this TMDL document, once implemented, is to ensure that all designated beneficial uses are fully supported and all water quality standards are met. Water quality standards form the basis for the targets described in **Sections C5.4**, **C6.4**, and **C7.4**. Metals pollutants are addressed in this framework water quality improvement plan. This section provides a summary of the applicable water quality standards for metals.

C2.1 CLASSIFICATION AND BENEFICIAL USES

Classification is the assignment (designation) of a single or group of uses to a waterbody based on the potential of the waterbody to support those uses. Designated uses or beneficial uses are simple narrative descriptions of water quality expectations or water quality goals. There are a variety of "uses" of state waters including growth and propagation of fish and associated aquatic life; drinking water; agriculture; industrial supply; and recreation and wildlife. The Montana WQA directs the Board of Environmental Review (BER) (i.e., the state) to establish a classification system for all waters of the state that includes their present (when the Act was originally written) and future most beneficial uses (ARM 17.30.607-616) and to adopt standards to protect those uses (ARM 17.30.620-670).

Montana, unlike many other states, uses a watershed-based classification system, with some specific exceptions. As a result, *all* waters of the state are classified and have designated uses and supporting standards. All classifications have multiple uses and in only one case (A-Closed) is a specific use (drinking water) given preference over the other designated uses. Some waters may not actually be used for a specific designated use, for example as a public drinking water supply; however, the quality of that waterbody must be maintained suitable for that designated use. When natural conditions limit or preclude a designated use, permitted point source discharges or nonpoint source activities or pollutant discharges must not make the natural conditions worse.

Modification of classifications or standards that would lower a water's classification or a standard (i.e., B-1 to a B-3), or removal of a designated use because of natural conditions, can only occur if the water was originally misclassified. All such modifications must be approved by the BER, and are undertaken via a Use Attainability Analysis (UAA) that must meet EPA requirements (40 CFR 131.10(g), (h) and (j)). The UAA and findings presented to the BER during rulemaking must prove that the modification is correct and all existing uses are supported. An existing use cannot be removed or made less stringent.

Streams within the Boulder-Elkhorn TPA are classified as either A-1 or B-1. The Montana Water Quality Standards describe an A-1 classification for Basin Creek that applies to the "Basin Creek drainage to the Basin water supply intake" (ARM 17.30.610(1)(a)(vii)).The extent of the A-1 classification in the Basin Creek drainage is uncertain because the precise location of the Basin water supply intake referenced in the rule is unknown. All other streams in the planning area classified as B-1. Descriptions of Montana's surface water classifications and designated beneficial uses are presented in **Table C2-1**.

Table C2-1. Montana Surface Water Classifications and Designated Beneficial Uses

Classification	Designated Uses
A-CLOSED CLASSIFICATION:	Waters classified A-Closed are to be maintained suitable for drinking, culinary and food processing purposes after simple disinfection
A-1 CLASSIFICATION:	Waters classified A-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment for removal of naturally present impurities. A-1 waters must be maintained suitable for bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B-1 CLASSIFICATION:	Waters classified B-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B-2 CLASSIFICATION:	Waters classified B-2 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B-3 CLASSIFICATION:	Waters classified B-3 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-1 CLASSIFICATION:	Waters classified C-1 are to be maintained suitable for bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-2 CLASSIFICATION:	Waters classified C-2 are to be maintained suitable for bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-3 CLASSIFICATION:	Waters classified C-3 are to be maintained suitable for bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers. The quality of these waters is naturally marginal for drinking, culinary and food processing purposes, agriculture and industrial water supply.
I CLASSIFICATION:	The goal of the State of Montana is to have these waters fully support the following uses: drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

C2.2 STANDARDS

In addition to the use classifications described above, Montana's WQS include numeric and narrative criteria as well as a nondegradation policy.

Numeric Standards

Numeric surface water quality standards have been developed for many parameters to protect human health and aquatic life. These standards are in the Department Circular DEQ-7 (Montana Department of Environmental Quality, 2010). The numeric human health standards have been developed for parameters determined to be toxic, carcinogenic, or harmful and have been established at levels to be protective of long-term (i.e., lifelong) exposures as well as through direct contact such as swimming.

The numeric aquatic life standards include chronic and acute values that are based on extensive laboratory studies including a wide variety of potentially affected species, a variety of life stages and durations of exposure. Chronic aquatic life standards are protective of long-term exposure to a parameter. The protection afforded by the chronic standards includes detrimental effects to reproduction, early life stage survival and growth rates. In most cases the chronic standard is more stringent than the corresponding acute standard. Acute aquatic life standards are protective of short-term exposures to a parameter and are not to be exceeded.

High quality waters are afforded an additional level of protection by the nondegradation policy as stated in statute (75-5-303 MCA) and administrative rules (ARM 17.30.701 et. seq.,). Changes in water quality must be "non-significant", or an authorization to degrade must be granted by the DEQ. However, under no circumstance may standards be exceeded. It is important to note that waters that meet or are of better quality than a standard are high quality for that parameter, and nondegradation policies apply to new or increased discharges to that waterbody.

Narrative Standards

Narrative standards have been developed for substances or conditions for which sufficient information does not exist to develop specific numeric standards. The term "Narrative Standards" commonly refers to the General Prohibitions in ARM 17.30.637 and other descriptive portions of the surface WQS. The General Prohibitions are also called the "free from" standards; that is, the surface waters of the state must be free from substances attributable to discharges, including thermal pollution, that impair the beneficial uses of a waterbody. Uses may be impaired by toxic or harmful conditions (from one or a combination of parameters) or conditions that produce undesirable aquatic life. Undesirable aquatic life includes bacteria, fungi, and algae.

The standards applicable to the list of pollutants addressed in the Boulder-Elkhorn TPA are summarized below. In addition to the standards below, the beneficial use support standard for B-1 streams, as defined above, can apply to other conditions, often linked to pollution, limiting aquatic life. These other conditions can include effects from dewatering/flow alterations and effects from habitat modifications.

C.2.2.1 Metals Standards

Water quality standards that are applicable to metals impairments include both numeric water quality criteria given in DEQ-7 (**Table C2-2**) and general prohibitions (narrative criteria) given in **Table C2-3.** As water quality criteria for many metals is dependent upon water hardness, **Table C2-5** presents acute and chronic metals numeric water quality criteria at water harnesses of 25 mg/L and 100 mg/L for metals of concern in the Boulder-Elkhorn TPA. Also presented in **Table C2-5** is the Human Health Criteria (HHC): note that for mercury and arsenic, the HHC is lower than applicable chronic criteria.

For iron, the human health standard (i.e., 300ug/L) is a secondary maximum contaminant level that is based on aesthetic water properties such as taste, odor, and the tendency of these metals to cause staining. Iron is not classified as a toxin or a carcinogen. Therefore, for the purposes of this TMDL document, the secondary MCL guidance values for iron is not applied or considered in the evaluation of water quality data. The chronic aquatic life standard of 1,000 µg/L for iron is used as the metals target for iron.

It should be noted that recent studies have indicated in some streams metals concentrations may vary through out the day because of diel pH and alkalinity changes. In some cases the variation can cross the standard threshold (both ways) for a metal. Montana water quality standards are not time of day dependent.

Table C2-2. Numeric Water Quality Criteria for metal pollutants at two water hardness conditions

Metal of Concern	Aquatic Life Criteria (µg/L) at 25 mg/L Hardness		Aquatic Life Criteria (µg/L) at 100 mg/L Hardness		Human Health Criteria (µg/L)
	Acute	Chronic	Acute	Chronic	
Aluminum	750	87	750	87	NA
Arsenic, TR	340	150	340	150	10
Cadmium, TR	0.52	0.10	2.13	0.27	5
Copper, TR	3.79	2.85	14.00	9.33	1,300
Iron, TR	---	1,000	---	1,000	*300
Lead, TR	13.98	0.54	81.65	3.18	15
Mercury, total	1.70	0.91	1.70	0.91	0.05
Silver, TR	037	--	4.06	--	100
Zinc, TR	37.02	37.02	119.82	119.82	2,000

*Human Health Criteria for iron is a secondary maximum contaminant level based on aesthetic properties

In addition to numeric criteria given in **Table C2-2**, narrative criteria also address water quality protection. The Administrative Rules of Montana (ARM 17.30.637 (1)(d)) prohibit additions of toxic levels of metals to stream sediment. The narrative criteria related to metals concentrations in stream sediment are given below in **Table C2-3**. The criteria do not allow concentrations or combinations of materials that are toxic or harmful to human, animal, plant, or aquatic life. The numeric and narrative criteria for metal pollutants are the basis for the water quality evaluations contained in **Appendix F** and summarized in **Section 5.5**.

Table C2-3. Applicable Rules for Metals Concentrations in Sediment

Rule(s)	Criteria
17.30.623 (1) 17.30.624 (1)	Waters classified B-1 (B-2) are to be maintained suitable for drinking, culinary, and food processing purposes, after conventional treatment; bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
17.30.623(2) 17.30.624(2)	No person may violate the following specific water quality standards for waters classified B-1 (B-2).
17.30.623 (2) (f) 17.30.624 (2) (f)	(f) No increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except as permitted in 75-5-318, MCA), settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation,
17.30.623 (2) (h) 17.30.624 (2) (h)	(h) Concentrations of carcinogenic, bioconcentrating, toxic, radioactive, nutrient, or harmful parameters may not exceed the applicable standards set forth in department Circular DEQ-7.
17.30.637	General Prohibitions
17.30.637(1)	State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will.
17.30.637(1)(d)	Create concentrations or combinations of materials that are toxic or harmful to human, animal, plant, or aquatic life.

C.2.2.2 pH Standards

Waterbodies impaired by metals are also sometimes impaired by pH as a result of acid mine drainage. For human health, changes in pH are addressed by the general narrative criteria in ARM 17.30.601 et seq. and ARM 17.30.1001 et seq. For aquatic life, which can be sensitive to small pH changes, criteria are specified for each waterbody use classification. For B-1 waters ARM 17.30.623 (2)(c) states "Induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 8.5 must be less than 0.5 pH unit. Natural pH outside this range must be maintained without change. Natural pH above 7.0 must be maintained above 7.0."

C3.0 Reference Conditions

C3.1 Reference Condition Concept as Described in Montana's 2012 Water Quality Integrated Report

A number of Montana's narrative water standards require that water quality be compared to "naturally occurring," conditions. The state of Montana has defined naturally occurring as "conditions or materials present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil and water conservations practices have been applied" (ARM 17.30.602[19]). The Administrative Rules of Montana (ARM) then define reasonable land, soil and water conservation practices as those that, in essence, completely protect all beneficial water uses (ARM 17.30.602[24]). Thus, human activities in a watershed are an integral component of the landscape, as long as those activities do not negatively impact the various beneficial uses of the water (drinking, recreation, fisheries, etc.).DEQ uses the reference condition concept to evaluate the difference between current water quality conditions and naturally occurring conditions.

The reference condition concept asserts that for any group of waterbodies there are relatively undisturbed examples that represent the natural biological, physical, and chemical integrity of a region. These examples, or reference sites, reflect a waterbody's greatest potential for water quality given historic land use activities (Montana Department of Environmental Quality, 2012). All classes of waters are subject to the provision that there can be no increase above naturally occurring concentrations of sediment and settleable solids, oils, or floating solids sufficient to create a nuisance or render the water harmful, detrimental, or injurious. Since naturally occurring concentrations depend on site-specific factors, DEQ applies the reference condition concept and reference sites to assess compliance with such narrative standards.

Waterbodies used to determine reference condition are not necessarily pristine or perfectly suited to giving the best possible support to all possible beneficial uses. Reference condition also does not reflect an effort to turn the clock back to conditions that may have existed before human settlement, but is intended to accommodate natural variations in biological communities, water chemistry, etc. due to climate, bedrock, soils, hydrology, and other natural physiochemical differences. The intention is to differentiate between natural conditions and widespread or significant alterations of biology, chemistry, or hydrogeomorphology due to human activity. Therefore, reference conditions should reflect minimum impacts from human activities. It attempts to identify the potential condition that could be attained (given historical land use) by the application of reasonable land, soil, and water conservation practices. DEQ realizes that pre-settlement water quality conditions usually are not attainable.

Comparison of conditions in a waterbody to reference waterbody conditions must be made during similar season and/or hydrologic conditions for both waters. For example, the Total Suspended Solids (TSS) of a stream at base flow during the summer should not be compared to the TSS of reference condition that would occur during a runoff event in the spring. In addition, a comparison should not be made to the lowest or highest TSS values of a reference site, which represent the outer boundaries of reference conditions.

The following methods may be used to determine reference conditions:

Primary Approach

- Comparing conditions in a waterbody to baseline data from minimally impaired waterbodies that are in a nearby watershed or in the same region having similar geology, hydrology, morphology, and/or riparian habitat.
- Evaluating historical data relating to condition of the waterbody in the past.
- Comparing conditions in a waterbody to conditions in another portion of the same waterbody, such as an unimpaired segment of the same stream.

Secondary Approach

- Reviewing literature (e.g. a review of studies of fish populations, etc., that were conducted on similar waterbodies that are least impaired.
- Seeking expert opinion (e.g. expert opinion from a regional fisheries biologist who has a good understanding of the waterbody's fisheries health or potential).
- Applying quantitative modeling (e.g. applying sediment transport models to determine how much sediment is entering a stream based on land use information, etc.).

DEQ uses the primary approach for determining reference condition if adequate regional reference data are available and uses the secondary approach to estimate reference condition when there is no regional data. DEQ often uses more than one approach to determine reference condition, especially when regional reference condition data are sparse or nonexistent.

C3.2 Use of Statistics for Developing Reference Values or Ranges

Reference value development must consider natural variability as well as variability that can occur as part of field measurement techniques. Statistical approaches are commonly used to help incorporate variability. One statistical approach is to compare stream conditions to the mean (average) value of a reference data set to see if the stream condition compares favorably to this value or falls within the range of one standard deviation around the reference mean. The use of these statistical values assumes a normal distribution; whereas, water resources data tend to have a non-normal distribution (Helsel and Hirsch, 1995). For this reason, another approach is to compare stream conditions to the median value of a reference data set to see if the stream condition compares favorably to this value or falls within the range defined by the 25^{th} and 75^{th} percentiles of the reference data. This is a more realistic approach than using one standard deviation since water quality data often include observations considerably higher or lower than most of the data. Very high and low observations can have a misleading impact on the statistical summaries if a normal distribution is incorrectly assumed, whereas statistics based on non-normal distributions are far less influenced by such observations.

Figure C3-1 is an example boxplot type presentation of the median, 25^{th} and 75^{th} percentiles, and minimum and maximum values of a reference data set. In this example, the reference stream results are stratified by two different stream types. Typical stratifications for reference stream data may include Rosgen stream types, stream size ranges, or geology. If the parameter being measured is one where low values are undesirable and can cause harm to aquatic life, then measured values in the potentially impaired stream that fall below the 25th percentile of reference data are not desirable and can be used to indicate impairment. If the parameter being measured is one where high values are undesirable, then measured values above the 75th percentile can be used to indicate impairment.

The use of a non-parametric statistical distribution for interpreting narrative WQS or developing numeric criteria is consistent with EPA guidance for determining nutrient criteria (Buck et al., 2000). Furthermore, the selection of the applicable 25th or 75th percentile values from a reference data set is consistent with ongoing DEQ guidance development for interpreting narrative WQS where it is determined that there is “good” confidence in the quality of the reference sites and resulting information (Suplee, 2004). If it is determined that there is only a “fair” confidence in the quality of the reference sites, then the 50th percentile or median value should be used, and if it is determined that there is “very high” confidence, then the 90th percentile of the reference data set should be used. Most reference data sets available for water quality restoration planning and related TMDL development, particularly those dealing with sediment and habitat alterations, would tend to be “fair” to “good” quality. This is primarily due to a the limited number of available reference sites/data points available after applying all potentially applicable stratifications on the data, inherent variations in monitoring results among field crews, the potential for variations in field methodologies, and natural yearly variations in stream systems often not accounted for in the data set.

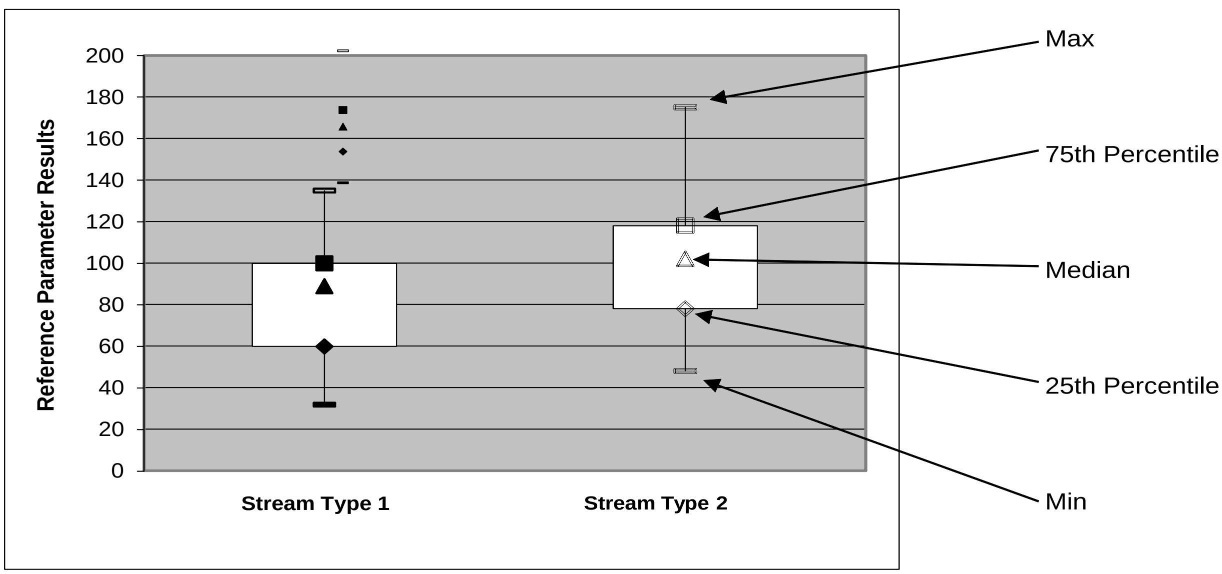

Figure C3-1. Boxplot Example for Reference Data.

The above 25th – 75th percentile statistical approach has several considerations:

1. It is a simple approach that is easy to apply and understand.
2. About 25 percent of all streams would naturally fall into the impairment range. Thus, it should not be applied unless there is some linkage to human activities that could lead to the observed conditions. Where applied, it must be noted that the stream’s potential may prevent it from achieving the reference range as part of an adaptive management plan.

3. About 25 percent of all streams would naturally have a greater water quality potential than the minimum water quality bar represented by the 25th to 75th percentile range. This may represent a condition where the stream's potential has been significantly underestimated. Adaptive management can also account for these considerations.
4. Obtaining reference data that represents a naturally occurring condition can be difficult, particularly for larger waterbodies with multiple land uses within the drainage. This is because all reasonable land, soil, and water conservation practices may not be in place in many larger waterbodies across the region. Even if these practices are in place, the proposed reference stream may not have fully recovered from past activities, such as riparian harvest, where reasonable land, soil, and water conservation practices were not applied.
5. A stream should not be considered impaired unless there is a relationship between the parameter of concern and the beneficial use such that not meeting the reference range is likely to cause harm or other negative impacts to the beneficial use as described by the WQS in **Table B2-2**. In other words, if not meeting the reference range is not expected to negatively impact aquatic life, coldwater fish, or other beneficial uses, then an impairment determination should not be made based on the particular parameter being evaluated. Relationships that show an impact to the beneficial use can be used to justify impairment based on the above statistical approach.

As identified in (2) and (3) above, there are two types of errors that can occur due to this or similar statistical approaches where a reference range or reference value is developed: (1) A stream could be considered impaired even though the naturally occurring condition for that stream parameter does not meet the desired reference range or (2) a stream could be considered not impaired for the parameter(s) of concern because the results for a given parameter fall just within the reference range, whereas the naturally occurring condition for that stream parameter represents much higher water quality and beneficial uses could still be negatively impacted. The implications of making either of these errors can be used to modify the above approach, although the approach used will need to be protective of water quality to be consistent with DEQ guidance and WQS (Suplee, 2004). Either way, adaptive management is applied to this water quality plan and associated TMDL development to help address the above considerations.

Where the data does suggest a normal distribution, or reference data is presented in a way that precludes use of non-normal statistics, the above approach can be modified to include the mean plus or minus one standard deviation to provide a similar reference range with all of the same considerations defined above.

Options When Regional Reference Data is Limited or Does Not Exist

In some cases, there is very limited reference data and applying a statistical approach like above is not possible. Under these conditions, the limited information can be used to develop a reference value or range, with the need to note the greater level of uncertainty and perhaps a greater level of future monitoring as part of the adaptive management approach. These conditions can also lead to more reliance on secondary type approaches for reference development.

Another approach would be to develop statistics for a given parameter from all streams within a watershed or region of interest (Buck et al., 2000). The boxplot distribution of all the data for a given parameter can still be used to help determine potential target values knowing that most or all of the streams being evaluated are either impaired or otherwise have a reasonable probability of having significant water quality impacts. Under these conditions you would still use the median and the 25th or

75th percentiles as potential target values, but you would use the 25th and 75th percentiles in a way that is opposite from how you use the results from a regional reference distribution. This is because you are assuming that, for the parameter being evaluated, as many as 50 percent to 75 percent of the results from the whole data distribution represent questionable water quality. **Figure C3-2** is an example statistical distribution where higher values represent better water quality. In **Figure C3-2**, the median and 25th percentiles represent potential target values versus the median and 75th percentiles discussed above for regional reference distribution. Whether you use the median, the 25th percentile, or both should be based on an assessment of how impacted all the measured streams are in the watershed. Additional consideration of target achievability is important when using this approach. Also, there may be a need to also rely on secondary reference development methods to modify how you apply the target and/or to modify the final target value(s). Your certainty regarding indications of impairment or non-impairment may be lower using this approach, and you may need to rely more on adaptive management as part of TMDL implementation.

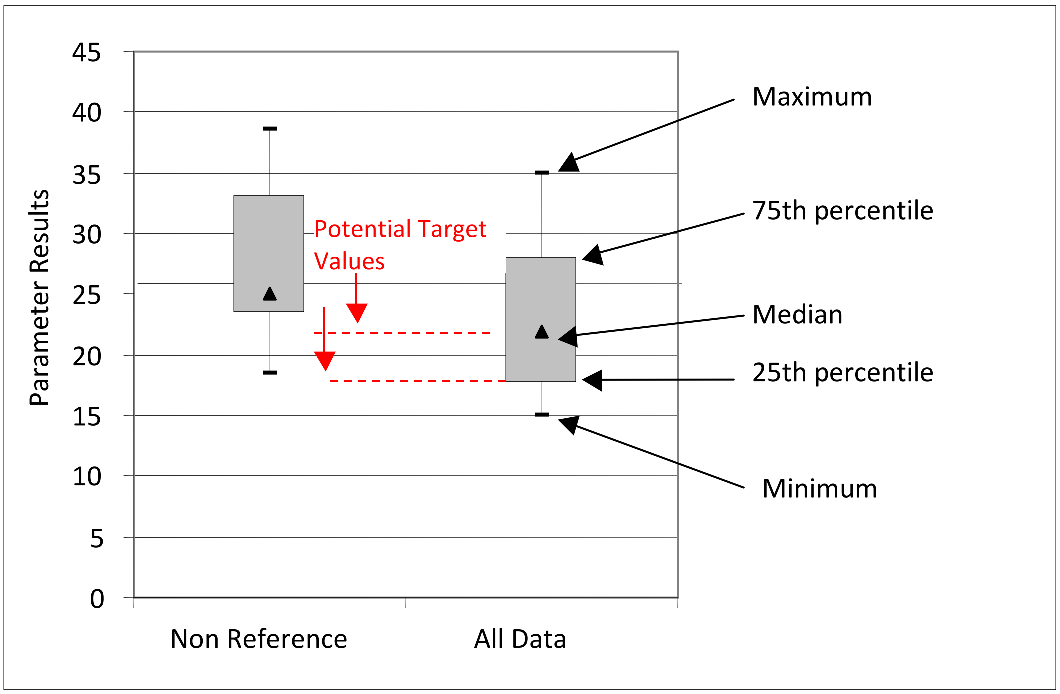

Figure C3-2. Boxplot Example for the Use of All Data to Set Targets.

4.0 REFERENCES

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APPENDIX D – SURFACE WATER AND SEDIMENT CHEMISTRY DATA, BOULDER-ELKHORN TMDL PLANNING AREA

This appendix contains two data tables. **Table D-1** contains surface water flow and chemistry data for streams in the Boulder-Elkhorn. **Table D-2** contains stream channel sediment metals concentration data and the corresponding ratio of each measured concentration to the recommended PEL concentration.

Table D-1. Surface Water Quality Data for the Boulder-Elkhorn TMDL Planning Area

Waterbody Segment	Site ID	Site Description	Sample Date	Hardness (mg/L)	Flow (cfs)	Field pH (su)	AL (Dis) (µg/L)	As (TR) (µg/L)	Cd (TR) (µg/l)	Cu (TR) (µg/l)	Fe (TR) (mg/L)	Hg (TR) (µg/L)	Pb (TR) (µg/l)	Ag (TR) (µg/l)	Zn (TR) (µg/l)
Basin Creek	6031600	Basin Creek at Basin MT	4/26/2001	33	24	7.3	20.3	12	0.7	14.3	675	--	2.6	--	103
Basin Creek	6031600	Basin Creek at Basin MT	5/17/2001	15	126	7.3	--	8	0.46	9.7	--	--	2.92	--	67
Basin Creek	6031600	Basin Creek at Basin MT	8/9/2001	36	5.8	7.8	--	9	0.33	5.2	--	--	< 1	--	45
Basin Creek	6031600	Basin Creek at Basin MT	9/25/2001	42	2.9	7.7	--	6	0.27	3.4	--	--	< 1	--	43
Basin Creek	6031600	Basin Creek at Basin MT	5/22/2002	15	113	7.6	--	12	0.63	12.8	--	--	6.49	--	83
Basin Creek	6031600	Basin Creek at Basin MT	6/11/2002	18	72	7.6	48.1	6	0.38	8.9	200	--	1.49	--	57
Basin Creek	6031600	Basin Creek at Basin MT	2/20/2003	39	4.2	7.8	--	4	0.33	2.9	--	--	0.29	--	74
Basin Creek	6031600	Basin Creek at Basin MT	5/13/2003	21	62	8	--	7	0.37	8	--	--	1.42	--	69
Basin Creek	6031600	Basin Creek at Basin MT	6/4/2003	15	106	7.5	--	10	0.36	10.9	--	--	3.74	--	54
Basin Creek	6031600	Basin Creek at Basin MT	8/20/2003	43	2.7	7.2	--	8	0.24	3.3	--	--	0.24	--	32
Basin Creek	6031600	Basin Creek at Basin MT	3/22/2004	38	7.5	7.5	--	4	0.54	5.2	--	--	0.44	--	89
Basin Creek	6031600	Basin Creek at Basin MT	5/24/2004	17	67	7.2	--	5	0.37	9.3	--	--	1.61	--	57
Basin Creek	6031600	Basin Creek at Basin MT	7/29/2004	34	4.7	7.8	--	7	0.27	4	--	--	0.26	--	41
Basin Creek	6031600	Basin Creek at Basin MT	9/22/2004	35	7	7.7	--	5	0.39	5.1	--	--	0.41	--	68
Basin Creek	6031600	Basin Creek at Basin MT	5/2/2005	28	24	7.7	--	6	0.33	7.2	--	--	1.21	--	62
Basin Creek	6031600	Basin Creek at Basin MT	5/23/2005	15	131	7.4	--	7	0.38	9.2	--	--	3.28	--	48
Basin Creek	6031600	Basin Creek at Basin MT	8/3/2005	31	7.3	7.8	--	7	0.23	4.8	--	--	0.3	--	37
Basin Creek	6031600	Basin Creek at Basin MT	9/21/2005	40	4.8	8	--	5.4	0.22	3	--	--	0.17	--	35
Basin Creek	6031600	Basin Creek at Basin MT	2/8/2006	40	3.5	7.7	--	3.6	0.3	3.2	--	--	< 0.06	--	71
Basin Creek	6031600	Basin Creek at Basin MT	5/17/2006	13	247	7.3	--	38.2	0.73	16.2	--	--	14.6	--	87
Basin Creek	6031600	Basin Creek at Basin MT	7/25/2006	32	4.8	8	--	8.3	0.19	4.9	--	--	0.25	--	19
Basin Creek	6031600	Basin Creek at Basin MT	9/14/2006	44	1.8	7.5	--	5.5	0.23	3.1	--	--	0.16	--	34
Basin Creek	6031600	Basin Creek at Basin MT	3/6/2007	38	3.5	7.5	--	3.1	0.25	2.5	--	--	0.24	--	63
Basin Creek	6031600	Basin Creek at Basin MT	5/8/2007	17	78	7.4	--	5.1	0.33	7.3	--	--	1.62	--	48.2
Basin Creek	6031600	Basin Creek at Basin MT	7/11/2007	29	7.9	7.8	--	6.4	0.2	4.5	--	--	0.39	--	32.2
Basin Creek	6031600	Basin Creek at Basin MT	8/30/2007	42	2.2	7.8	--	5.1	0.22	2.5	--	--	0.12	--	33.5
Basin Creek	6031600	Basin Creek at Basin MT	4/22/2008	35	6.4	7.4	--	4	0.26	3.9	--	--	0.55	--	61.2
Basin Creek	6031600	Basin Creek at Basin MT	6/4/2008	13	203	6.8	--	5.8	0.34	8.4	--	--	2.61	--	45.4
Basin Creek	6031600	Basin Creek at Basin MT	7/17/2008	24	15	7.6	--	6.3	0.37	9.1	--	--	0.61	--	63.1
Basin Creek	6031600	Basin Creek at Basin MT	8/26/2008	35	3.1	8.1	--	6.2	0.24	3.7	--	--	0.24	--	31.9
Basin Creek	6031600	Basin Creek at Basin MT	4/23/2009	25.1	--	7.3	--	--	0.35	19.4	--	--	4.75	0.377	87.2
Basin Creek	6031600	Basin Creek at Basin MT	5/22/2009	14.6	--	7.8	--	--	0.27	11.4	--	--	8.2	0.374	63.2
Basin Creek	6031600	Basin Creek at Basin MT	6/18/2009	16.9	--	7.5	--	--	0.3	10.6	--	--	1.89	0.374	52.5
Basin Creek	6031600	Basin Creek at Basin MT	8/17/2009	28.9	--	7.1	--	--	0.35	8.1	--	--	0.6	0.480	54
Basin Creek	6031600	Basin Creek at Basin MT	3/9/2010	35	--	7.4	--	--	0.25	--	--	--	0.31	0.667	53.4
Basin Creek	6031600	Basin Creek at Basin MT	6/1/2010	14.3	--	6.8	--	--	0.21	9.2	--	--	4.65	0.374	48.5
Basin Creek	6031600	Basin Creek at Basin MT	7/20/2010	27.7	--	--	--	--	0.29	7.8	--	--	0.61	0.446	49.2
Basin Creek	6031600	Basin Creek at Basin MT	8/25/2010	29.2	--	7.5	--	--	0.24	7.1	--	--	0.53	0.488	47.8
Basin Creek	462347112180401	D/S of Buckeye Mine	4/26/2001	28	0.82	7.3	62.7	--	0.65	9.4	807	--	8.84	--	120
Basin Creek	462347112180401	D/S of Buckeye Mine	8/8/2001	34	0.94	7.3	--	--	0.34	4.8	--	--	3.1	--	53
Basin Creek	462347112180401	D/S of Buckeye Mine	9/25/2001	36	0.38	7.8	--	--	0.33	3	--	--	3.51	--	55

Table D-1. Surface Water Quality Data for the Boulder-Elkhorn TMDL Planning Area

Waterbody Segment	Site ID	Site Description	Sample Date	Hardness (mg/L)	Flow (cfs)	Field pH (su)	AL (Dis) (µg/L)	As (TR) (µg/L)	Cd (TR) (µg/l)	Cu (TR) (µg/l)	Fe (TR) (mg/L)	Hg (TR) (µg/L)	Pb (TR) (µg/l)	Ag (TR) (µg/l)	Zn (TR) (µg/l)
Basin Creek	462347112180401	D/S of Buckeye Mine	11/15/2001	34	0.52	7.5	34.5	--	0.47	4.2	360	--	< 1	--	87
Basin Creek	462347112180401	D/S of Buckeye Mine	6/11/2002	20	2.8	7.1	119	--	0.61	7.8	209	--	3.24	--	95
Basin Creek	462347112180401	D/S of Buckeye Mine	6/17/2002	18	9.3	7.4	--	--	0.4	5.6	--	--	2.74	--	62
Basin Creek	462347112180401	D/S of Buckeye Mine	3/24/2003	43	0.48	6.8	--	--	0.24	3	--	--	1.02	--	52
Basin Creek	462347112180401	D/S of Buckeye Mine	5/14/2003	35	1.9	--	--	--	0.97	12	--	--	5.18	--	192
Basin Creek	462347112180401	D/S of Buckeye Mine	6/3/2003	17	11	7.5	--	--	0.32	5.2	--	--	4.32	--	54
Basin Creek	462347112180401	D/S of Buckeye Mine	8/21/2003	41	0.35	7.3	--	--	0.14	2.2	--	--	1.45	--	22
Basin Creek	462347112180401	D/S of Buckeye Mine	3/30/2004	36	0.7	7.4	--	--	0.64	5.9	--	--	1.85	--	114
Basin Creek	462347112180401	D/S of Buckeye Mine	5/24/2004	19	5.2	7.4	--	--	0.63	7.4	--	--	2.3	--	87
Basin Creek	462347112180401	D/S of Buckeye Mine	7/29/2004	31	0.75	7.1	--	--	0.22	2.3	--	--	1.19	--	38
Basin Creek	462347112180401	D/S of Buckeye Mine	9/22/2004	31	0.92	7.3	--	--	0.28	3.2	--	--	0.57	--	53
Basin Creek	462347112180401	D/S of Buckeye Mine	5/4/2005	34	2.4	7.6	--	--	0.75	8.4	--	--	3.42	--	128
Basin Creek	462347112180401	D/S of Buckeye Mine	5/24/2005	18	10	6.8	--	--	0.29	4.6	--	--	3.23	--	45
Basin Creek	462347112180401	D/S of Buckeye Mine	8/3/2005	29	0.76	7.6	--	--	0.1	1.6	--	--	0.58	--	30
Basin Creek	462347112180401	D/S of Buckeye Mine	9/21/2005	35	0.89	7.4	--	--	0.13	1.7	--	--	2.15	--	24
Basin Creek	462347112180401	D/S of Buckeye Mine	2/9/2006	35	E 0.3	7.6	--	--	0.2	2.9	--	--	6.37	--	46
Basin Creek	462347112180401	D/S of Buckeye Mine	5/18/2006	14	18	7.3	--	--	0.36	9.2	--	--	6.74	--	54
Basin Creek	462347112180401	D/S of Buckeye Mine	7/25/2006	33	0.62	7.5	--	--	0.14	2	--	--	0.57	--	25
Basin Creek	462347112180401	D/S of Buckeye Mine	9/8/2006	37	0.31	7.1	--	--	0.14	1.5	--	--	0.73	--	22
Basin Creek	462347112180401	D/S of Buckeye Mine	3/6/2007	35	0.43	6.8	--	--	0.21	2.2	--	--	0.57	--	49
Basin Creek	462347112180401	D/S of Buckeye Mine	5/9/2007	18	7.7	7.8	--	--	0.38	6.3	--	--	3.25	--	63.4
Basin Creek	462347112180401	D/S of Buckeye Mine	7/11/2007	29	0.68	7.4	--	--	0.14	1.9	--	--	0.35	--	33.3
Basin Creek	462347112180401	D/S of Buckeye Mine	8/29/2007	38	0.33	7.5	--	--	0.11	0.7	--	--	0.52	--	22.8
Basin Creek	BE-01	U/S Buckeye Mine	6/10/2009	18.0	7.72	6.07	--	< 3.0	< 0.08	2.0	130	< 0.05	< 0.5	< 0.5	10
Basin Creek	BE-01	U/S Buckeye Mine	6/12/2009	--	6.83	7.25	--	--	--	--	--	--	--	--	--
Basin Creek	BE-01	U/S Buckeye Mine	8/20/2009	28.0	1.32	6.4	--	< 3.0	< 0.08	1.0	50	< 0.05	< 0.5	< 0.5	< 10
Basin Creek	BE-02	1000 ft U/S Grub Gulch	6/10/2009	17.0	10.96	6.50	--	9.0	0.28	5.0	170	< 0.05	1.4	< 0.5	50
Basin Creek	BE-02	1000 ft U/S Grub Gulch	8/20/2009	29.0	1.6	6.71	--	8.0	0.14	2.0	160	< 0.05	< 0.5	< 0.5	30
Basin Creek	BE-03	D/S Grub Gulch	6/10/2009	15.0	18.56	6.15	--	8.0	0.2	6.0	250	< 0.05	1.9	< 0.5	40
Basin Creek	BE-03	D/S Grub Gulch	8/20/2009	29.0	3.31	7.33	--	13.0	0.12	4.0	490	< 0.05	2.1	< 0.5	40
Basin Creek	BE-04	D/S Clear Cr	6/10/2009	15.0	26.14	6.14	--	7.0	0.19	6.0	240	< 0.05	1.8	< 0.5	40
Basin Creek	BE-04	D/S Clear Cr	6/12/2009	--	25.14	7.52	--	--	--	--	--	--	--	--	--
Basin Creek	BE-04	D/S Clear Cr	8/20/2009	27.0	3.62	7.31	--	12.0	0.12	4.0	450	< 0.05	2.1	< 0.5	30
Basin Creek	BE-05	U/S Joe Bowers Cr	6/10/2009	12.0	31.44	5.59	--	5.0	0.14	5.0	190	< 0.05	1.2	< 0.5	30
Basin Creek	BE-05	U/S Joe Bowers Cr	8/20/2009	23.0	4.21	7.51	--	9.0	< 0.08	3.0	240	< 0.05	1.0	< 0.5	20
Basin Creek	BE-06	D/S Joe Bowers Cr	6/10/2009	11.0	36.55	5.81	--	5.0	0.13	5.0	190	< 0.05	1	< 0.5	20
Basin Creek	BE-06	D/S Joe Bowers Cr	8/20/2009	21.0	5.09	7.37	--	8.0	< 0.08	3.0	230	< 0.05	0.9	< 0.5	20
Basin Creek	BE-07	Jack Creek confluence	6/10/2009	13.0	60.50	5.92	--	5.0	0.2	6.0	220	< 0.05	1.4	< 0.5	30
Basin Creek	BE-07	Jack Creek confluence	6/12/2009	--	65.43	7.22	--	--	--	--	--	--	--	--	--
Basin Creek	BE-07	Jack Creek confluence	8/20/2009	27.0	8.29	7.36	--	7.0	0.82	14.0	250	< 0.05	0.7	< 0.5	100
Basin Creek	BE-08	U/S town of Basin	6/10/2009	15.0	492.7	6.54	--	6.0	0.3	9.0	330	< 0.05	1.9	< 0.5	40
Basin Creek	BE-08	U/S town of Basin	6/12/2009	--	217.4	7.21	--	--	--	--	--	--	--	--	--
Basin Creek	BE-08	U/S town of Basin	8/20/2009	31.0	13.57	7.45	--	6.0	0.29	7.0	130	< 0.05	< 0.5	< 0.5	50
Basin Creek	BE-09	At Canyon Campground	6/10/2009	14.0	105.13	6.32	--	5.0	0.28	8.0	320	< 0.05	1.7	< 0.5	40
Basin Creek	BE-09	At Canyon Campground	8/20/2009	28.0	8.3	7.49	--	7.0	0.40	8.0	220	< 0.05	0.5	< 0.5	50
Basin Creek	M07BASNC02 (BE-01)	U/S Buckeye Mine	6/6/2010	16	12.2	--	80	< 3.0	< 0.08	3	270	--	< 0.5	< 0.5	< 10
Basin Creek	M07BASNC02 (BE-01)	U/S Buckeye Mine	7/15/2010	22	1.84	--	< 30	< 3.0	< 0.08	2	60	--	< 0.5	< 0.5	< 10

Table D-1. Surface Water Quality Data for the Boulder-Elkhorn TMDL Planning Area

Waterbody Segment	Site ID	Site Description	Sample Date	Hardness (mg/L)	Flow (cfs)	Field pH (su)	AL (Dis) (µg/L)	As (TR) (µg/L)	Cd (TR) (µg/l)	Cu (TR) (µg/l)	Fe (TR) (mg/L)	Hg (TR) (µg/L)	Pb (TR) (µg/l)	Ag (TR) (µg/l)	Zn (TR) (µg/l)
Basin Creek	M07BASNC03 (BE-02)	1000 ft U/S Grub Gulch	6/6/2010	16	17.24	--	100	10	0.25	5	270	--	2	< 0.5	40
Basin Creek	M07BASNC03 (BE-02)	1000 ft U/S Grub Gulch	7/14/2010	25	2.41	--	30	7	0.15	3	120	--	0.7	< 0.5	30
Basin Creek	M07BASNC04 (BE-03)	D/S Grub Gulch	6/6/2010	14	41.05	--	120	10	0.19	6	290	--	3.3	< 0.5	40
Basin Creek	M07BASNC04 (BE-03)	D/S Grub Gulch	7/14/2010	24	3.2	--	30	17	0.1	3	270	--	1.1	< 0.5	30
Basin Creek	M07BASNC05 (BE-04)	D/S Clear Cr	6/6/2010	15	75.64	--	170	9	0.2	7	280	--	3.1	< 0.5	40
Basin Creek	M07BASNC05 (BE-04)	D/S Clear Cr	7/14/2010	20	4.39	--	60	13	0.11	3	230	--	1	< 0.5	30
Basin Creek	M07BASNC06 (BE-06)	D/S Joe Bowers Cr	6/6/2010	10	C 331.4	--	150	6	0.12	5	220	--	1.8	< 0.5	20
Basin Creek	M07BASNC06 (BE-06)	D/S Joe Bowers Cr	7/14/2010	16	7.81	--	60	7	< 0.08	3	170	--	0.6	< 0.5	20
Basin Creek	M07BASNC07 (BE-07)	Jack Creek confluence	6/8/2010	11	C 167.3	--	130	6	0.09	5	210	--	1.8	< 0.5	20
Basin Creek	M07BASNC07 (BE-07)	Jack Creek confluence	7/14/2010	19	16.86	--	40	6	0.09	3	110	--	0.6	< 0.5	20
Big Limber Gulch	BE-11	Abv Waldy/Redwing Complex	06/11/09	24.0	0.218	7.25	--	< 3	< 0.08	1	160	--	< 0.5	< 0.5	< 10
Big Limber Gulch	BE-11	Abv Waldy/Redwing Complex	08/24/09	61.0	0.03	7.99	--	4	< 0.08	1	90	< 0.005	< 0.5	< 0.5	< 10
Big Limber Gulch	BE-12	Abv Minneapolis Placer	06/11/09	56.0	0.405	7.39	--	< 3	< 0.08	1	220	< 0.005	< 0.5	< 0.5	< 10
Big Limber Gulch	BE-12	Abv Minneapolis Placer	08/21/09	116.0	0.057	6.5	--	3	0.18	4	570	--	1.0	< 0.5	20
Big Limber Gulch	BE-13	At mouth	06/11/09	81.0	0.491	7.78	--	< 3	< 0.08	1	180	--	< 0.5	< 0.5	< 10
Big Limber Gulch	BE-13	At mouth	08/24/09	137.0	0.063	8.02	--	3	< 0.08	1	300	< 0.005	0.7	< 0.5	< 10
Big Limber Gulch	M07BLMBG01	Abv Waldy/Redwing Complex	6/4/2010	40	0.45	--	110	8	0.22	11	2740	< 0.005	8.4	< 0.5	40
Big Limber Gulch	M07BLMBG01	Abv Waldy/Redwing Complex	6/14/2010	--	--	--	--	--	--	--	--	--	--	--	--
Big Limber Gulch	M07BLMBG01	Abv Waldy/Redwing Complex	7/9/2010	45	0.12	--	< 30	< 3	< 0.08	1	140	< 0.005	ND	< 0.5	< 10
Big Limber Gulch	M07BLMBG02	Abv Minneapolis Placer	6/4/2010	66	0.54	--	< 30	< 3	< 0.08	2	390	--	0.7	< 0.5	< 10
Big Limber Gulch	M07BLMBG02	Abv Minneapolis Placer	6/14/2010	--	--	--	--	--	--		--	--	--	--	--
Big Limber Gulch	M07BLMBG02	Abv Minneapolis Placer	7/9/2010	87	0.31	--	< 30	< 3	< 0.08	2	460	< 0.005	0.9	< 0.5	< 10
Big Limber Gulch	M07BLMBG03	At mouth	6/4/2010	95	0.53	--	< 30	4	< 0.08	3	690	--	1.9	< 0.5	< 10
Big Limber Gulch	M07BLMBG03	At mouth	6/14/2010	--	--	--	--	--	--	--	--	--	--	--	--
Big Limber Gulch	M07BLMBG03	At mouth	7/8/2010	103	0.37	--	< 30	3	< 0.08	2	290	< 0.005	0.9	< 0.5	ND
Big Limber Gulch	M07BLMBG03	At mouth	7/8/2010	--	--	--	--	--	--	--	--	< 0.005	--	--	--
Bison Creek	M07BISNC09	upper Elk Park ditch	7/19/2010	265	0	--	< 30	87	< 0.08	6	4080	--	1.2	< 0.5	< 10
Bison Creek	M07BISNC09	upper Elk Park ditch	8/19/2010	228	0	--	< 30	73	< 0.08	8	2990	--	1.3	< 0.5	< 10
Bison Creek	M07BISNC09	upper Elk Park ditch	9/30/2010	183	0	--	< 30	31	< 0.08	7	3880	--	1.1	< 0.5	10
Bison Creek	BE-18	D/S Res. Subdivision	6/9/2009	39.0	18.55	6.49	--	6.0	< 0.08	8.0	490	< 0.05	< 0.5	< 0.5	20
Bison Creek	BE-18	D/S Res. Subdivision	8/18/2009	39.0	3.67	7.06	--	9.0	< 0.08	5.0	1040	< 0.05	< 0.5	< 0.5	10
Bison Creek	BE-17	North end of Elk Park	6/9/2009	32.0	133.1	6.46	--	5.0	< 0.08	7.0	550	< 0.05	< 0.5	< 0.5	10
Bison Creek	BE-17	North end of Elk Park	8/18/2009	35.0	12.91	6.76	--	5.0	< 0.08	3.0	840	< 0.05	< 0.5	< 0.5	10
Bison Creek	BE-15	Bison Creek mouth	6/9/2009	37.0	330.5	6.66	--	6.0	< 0.08	8.0	1370	< 0.05	0.9	< 0.5	10
Bison Creek	BE-15	Bison Creek mouth	8/18/2009	48.0	28.62	7.12	--	4.0	< 0.08	3.0	710	< 0.05	< 0.5	< 0.5	10
Bison Creek	M07BISNC02 (BE-15)	Bison Creek mouth	6/9/2010	41	352.9	--	50	7	< 0.08	9	1450	--	1.1	< 0.5	20
Bison Creek	M07BISNC02 (BE-15)	Bison Creek mouth	7/18/2010	49	28.67	--	< 30	5	< 0.08	4	540	--	< 0.5	< 0.5	< 10
Upper Boulder River	BE-28	U/S of Powderhorn Mine	6/9/2009	34	14.1	6.79	--	4	< 0.08	3.0	320	< 0.05	< 0.5	0.1	< 10
Upper Boulder River	BE-28	U/S of Powderhorn Mine	8/18/2009	52	1.98	8.15	--	4	< 0.08	3.0	250	< 0.05	< 0.5	< 0.5	< 10
Upper Boulder River	M07TMDL_BE-30	D/S Lowland Cr mouth	6/9/2009	34	14.1	6.79	--	4	< 0.08	3.0	320	< 0.05	< 0.5	0.1	< 10
Upper Boulder River	M07TMDL_BE-30	D/S Lowland Cr mouth	8/18/2009	52	1.98	8.15	--	4	< 0.08	1.0	250	< 0.05	< 0.5	< 0.5	< 10
Upper Boulder River	M07TMDL_BE-29	D/S of Little Cottonwood Cr	6/9/2009	23	436.3	6.74	--	4	< 0.08	3.0	490	< 0.05	0.6	< 0.1	< 10
Upper Boulder River	M07TMDL_BE-29	D/S of Little Cottonwood Cr	8/20/2009	44	21.3	7.66	--	4	< 0.08	1.0	280	< 0.05	< 0.5	< 0.5	< 10
Upper Boulder River	M07TMDL_BE-31	U/S bison Cr mouth	6/9/2009	20	92.94	6.83	--	< 3	< 0.08	2.0	260	< 0.05	< 0.5	0.3	< 10
Upper Boulder River	M07TMDL_BE-31	U/S bison Cr mouth	8/20/2009	39	7.87	7.74	--	< 3	< 0.08	< 1	190	< 0.05	< 0.5	< 0.5	< 10
Upper Boulder River	BE-20	D/S of Red Rock Cr	6/9/2009	24	433.7	6.9	--	4	< 0.08	3.0	530	< 0.05	0.8	0.2	< 10
Upper Boulder River	BE-20	D/S of Red Rock Cr	8/20/2009	45	22	7.55	--	4	< 0.08	1.0	250	< 0.05	< 0.5	< 0.5	< 10

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Waterbody Segment	Site ID	Site Description	Sample Date	Hardness (mg/L)	Flow (cfs)	Field pH (su)	AL (Dis) (µg/L)	As (TR) (µg/L)	Cd (TR) (µg/l)	Cu (TR) (µg/l)	Fe (TR) (mg/L)	Hg (TR) (µg/L)	Pb (TR) (µg/l)	Ag (TR) (µg/l)	Zn (TR) (µg/l)
Upper Boulder River	BE-20	D/S of Red Rock Cr	6/8/2010	28	952.81		110	5	< 0.08	6.0	850	--	1	< 0.5	< 10
Upper Boulder River	BE-20	D/S of Red Rock Cr	8/18/2010	51	50.66	8.5	< 30	5	< 0.08	2.0	360	--	< 0.5	< 0.5	< 10
Upper Boulder River	BE-21	1 mile U/S of Basin Cr	6/9/2009	28	799	6.91	--	4	< 0.08	5.0	830	< 0.05	0.9	< 0.1	< 10
Upper Boulder River	BE-21	1 mile U/S of Basin Cr	8/18/2009	46	60.81	7.42	--	4	< 0.08	3.0	460	< 0.05	< 0.5	< 0.5	< 10
Upper Boulder River	6031450	1 mile U/S of Basin Cr	6/9/2009	27	871.9	7.03	--	4	< 0.08	5.0	810	< 0.05	0.8	< 0.1	< 10
Upper Boulder River	6031450	1 mile U/S of Basin Cr	8/18/2009	46	67.98	7.42	--	4	< 0.08	2.0	410	< 0.05	< 0.5	< 0.5	< 10
Upper Boulder River	6031450	1 mile U/S of Basin Cr	8/9/2001	49.5	--	--	--	--	< 0.04	2.2	--	--	< 1	--	4
Upper Boulder River	6031450	1 mile U/S of Basin Cr	9/25/2001	55.9	--	--	--	--	< 0.04	2.6	--	--	< 1	--	6
Upper Boulder River	6031450	1 mile U/S of Basin Cr	5/23/2002	25.2	--	--	--	--	< 0.04	4.1	--	--	< 1	--	7
Upper Boulder River	6031450	1 mile U/S of Basin Cr	6/13/2002	29.1	--	--	17	--	< 0.04	3.8	462	--	< 1	< 0.05	9
Upper Boulder River	6031450	1 mile U/S of Basin Cr	2/20/2003	54.5	--	--	--	--	< 0.04	3.4	--	--	0.19	--	7
Upper Boulder River	6031450	1 mile U/S of Basin Cr	5/12/2003	44.4	--	--	--	--	< 0.04	5.8	--	--	1.19	--	12
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	4/27/01	30	607	7.4	11.7	17	0.95	32	5140	0.028	10	0.27	117
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	5/16/01	21	781	6.9	--	7	0.48	15.2	--	--	3.64	--	57
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	8/9/01	53	28	8.3	--	8	0.55	10.6	--	--	< 1	--	58
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	9/26/01	64	14	8.2	--	7	0.97	9.5	--	--	< 1	--	133
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	5/22/02	21	397	7.7	--	8	0.59	16.7	--	--	4.38	--	81
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	6/13/02	25	404	7.5	45.7	7	0.48	13.7	384	E 0.01	2.19	0.04	67
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	2/21/03	59	18	8.1	--	4	0.76	10.6	--	--	0.55	--	135
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	5/13/03	39	332	7.7	--	5	0.32	9.7	--	--	1.14	--	50
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	6/5/03	22	497	7.8	--	7	0.43	17.9	--	--	4.23	--	52
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	8/20/03	63	12	7.7	--	9	0.38	10.1	--	--	0.34	--	37
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	3/22/04	55	61	7.8	--	7	0.55	11.7	--	--	1.8	--	96
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	5/24/04	28	329	7.5	--	5	0.35	9.6	--	--	1.66	--	55
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	7/29/04	59	23	8.6	--	7	0.42	8.2	--	--	0.22	--	47
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	9/22/04	48	105	8.1	--	4	0.53	7.4	--	--	0.72	--	71
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	5/2/05	43	82	7.7	--	4	0.32	8	--	--	0.76	--	62
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	5/23/05	22	703	7.5	--	8	0.38	15.7	--	--	4.41	--	53
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	8/4/05	55	32	7.9	--	5	0.45	7.5	--	--	0.32	--	77
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	9/22/05	61	27	7.6	--	5	0.55	6.1	--	--	0.39	--	99
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	2/8/06	62	29	7.4	--	3.7	0.48	6.1	--	--	0.35	--	97
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	5/18/06	18	970	7.6	--	12.9	0.53	17.6	--	--	7.13	--	63
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	7/25/06	56	26	8.1	--	6.4	0.4	8.8	--	--	0.19	--	52
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	9/14/06	75	11	8.1	--	6.8	0.37	6.4	--	--	0.25	--	49
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	3/6/07	55	24	7.5	--	4.2	0.4	8.3	--	--	0.66	--	85
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	5/8/07	26	205	7.8	--	4.9	0.29	8.9	--	--	1.99	--	54
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	7/11/07	48	33	8.4	--	7.1	0.28	8.1	--	--	0.43	--	35.9
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	8/30/07	66	10	8.7	--	7.8	0.29	7.4	--	--	0.34	--	35.4
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	4/22/08	52	56	7.8	--	4.6	0.31	9.6	--	--	1.07	--	58.6
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	6/4/08	20	851	7.7	--	7.5	0.43	12.8	--	--	4.54	--	63.8
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	7/17/08	40	89	8	--	5.8	0.29	8.7	--	--	0.5	--	41.2
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	8/26/08	53	24	8.8	--	7.7	0.27	8.5	--	--	0.3	--	37.1
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	4/24/09	32.1	--	--	--	--	0.140	11.9	--	--	3.40	--	46.4
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	5/21/09	22.6	--	--	--	--	0.230	17.7	--	--	9.88	--	73.8
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	6/18/09	25.7	--	--	--	--	0.160	9	--	--	2.31	--	36.4
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	8/17/09	47.1	--	--	--	--	0.230	6	--	--	0.64	--	37.9
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	3/11/10	60	--	--	--	--	0.320	6	--	--	0.32	--	70.8

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Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	6/1/10	23.2	--	--	--	--	0.200	13.3	--	--	6.41	--	56.8
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	7/20/10	44.9	--	--	--	--	0.190	7	--	--	0.44	--	34.8
Boulder River, (Basin Cr. To Boulder)	6032400	D/S of Little Galena Gulch	8/25/10	51.2	--	--	--	--	0.190	6.9	--	--	0.50	--	34.1
Boulder River, (Basin Cr. To Boulder)	BE-22	U/S of Cataract Cr.	6/9/09	24.0	1338.7	7.2	--	4.0	< 0.08	6.0	680	< 0.05	1.2	< 0.1	20
Boulder River, (Basin Cr. To Boulder)	BE-22	U/S of Cataract Cr.	8/18/09	44.0	75.27	7.86	--	5.0	0.11	7.0	350	< 0.05	< 0.5	< 0.1	20
Boulder River, (Basin Cr. To Boulder)	BE-23	D/S of Cataract Cr.	6/9/09	23.0	1165.1	6.98	--	5.0	0.23	9.0	570	< 0.05	2.5	< 0.1	30
Boulder River, (Basin Cr. To Boulder)	BE-23	D/S of Cataract Cr.	8/18/09	44.0	83.78	7.82	--	5.0	0.25	8.0	310	< 0.05	< 0.5	< 0.1	30
Boulder River, (Basin Cr. To Boulder)	BE-24	D/S of High Ore Cr.	6/9/09	24.0	1341.6	7.12	--	5.0	0.2	8.0	560	< 0.05	1.5	< 0.1	30
Boulder River, (Basin Cr. To Boulder)	BE-24	D/S of High Ore Cr.	8/18/09	46.0	84.03	8.13	--	6.0	0.23	8.0	270	< 0.05	< 0.5	< 0.1	30
Boulder River, (Basin Cr. To Boulder)	BE-32	D/S of Little Galena Gulch	6/11/09	26.0	721.5	7.28	--	6.0	0.25	9.0	610	< 0.05	1.8	< 0.1	40
Boulder River, (Basin Cr. To Boulder)	BE-32	D/S of Little Galena Gulch	8/19/09	47.0	74.98	6.73	--	5.0	0.26	8.0	250	< 0.05	0.5	< 0.1	50
Boulder River, (Boulder to Cottonwood Cr.)	BE-25	D/S of Boulder WWTP	8/19/2009	25.0	1183.8	7.02	--	6.0	0.26	13.0	630	< 0.05	3	< 0.1	50
Boulder River, (Boulder to Cottonwood Cr.)	BE-25	D/S of Boulder WWTP	6/9/2009	49.0	70.63	7.62	--	6.0	0.32	8.0	200	< 0.05	< 0.5	< 0.5	60
Boulder River, (Boulder to Cottonwood Cr.)	BE-26	D/S Little Boulder River	8/19/2009	30.0	1257.7	7.34	--	8.0	0.25	13.0	810	< 0.05	3.2	< 0.1	50
Boulder River, (Boulder to Cottonwood Cr.)	BE-26	D/S Little Boulder River	6/9/2009	< 1.0	96.47	7.69	--	6.0	0.25	8.0	320	< 0.05	< 0.5	< 0.1	60
Boulder River, (Boulder to Cottonwood Cr.)	BE-34	D/S Eklhorn Cr.	6/10/2009	32.0	2085.9	6.65	--	11.0	0.36	18.0	910	< 0.05	6.3	0.2	80
Boulder River, (Boulder to Cottonwood Cr.)	BE-34	D/S Eklhorn Cr.	8/21/2009	57.0	78.42	7.59	--	10.0	0.30	9.0	300	< 0.05	0.7	< 0.5	70
Boulder River, (Boulder to Cottonwood Cr.)	M07BOLDR03	D/S of Elkhorn Drive Bridge	6/1/2010	51	1241.1	--	90	30	1.05	69	3010	--	31.2	< 0.5	220
Boulder River, (Boulder to Cottonwood Cr.)	M07BOLDR03	D/S of Elkhorn Drive Bridge	8/1/2010	119	74.46	8.6	< 30	16	0.17	10	200	--	1.5	< 0.5	20
Boulder River, (Cottonwood to mouth)	BE-33	U/S of Golden Sunlight	6/10/2009	57.0	1011.9	7.16	--	15.0	0.37	27.0	1200	< 0.05	7	< 0.5	90
Boulder River, (Cottonwood to mouth)	BE-33	U/S of Golden Sunlight	8/21/2009	117.0	90.23	7.85	--	10.0	0.12	7.0	200	< 0.05	1.2	< 0.5	20
Boulder River, (Cottonwood to mouth)	BE-27	At mouth	6/1/2010	66	1931.3	--	70	14	0.47	33	1540	--	10.3	< 0.5	100
Boulder River, (Cottonwood to mouth)	BE-27	At mouth	8/1/2010	136	112.2	8.6	< 30	13	0.14	9	210	--	1.6	< 0.5	20
Boulder River, (Cottonwood to mouth)	BE-27	At mouth	9/2/2010	141	82.6	8.6	< 30	9	< 0.08	6	115	--	0.9	< 0.5	10
Boulder River, (Cottonwood to mouth)	BE-27	At mouth	6/10/2009	60.0	1355.9	6.92	--	17.0	0.36	28.0	1450	< 0.05	7.3	< 0.5	90
Boulder River, (Cottonwood to mouth)	BE-27	At mouth	8/21/2009	119.0	89.88	7.75	--	10.0	0.12	7.0	220	< 0.05	1.3	< 0.5	20
Cataract Creek	6031960	At mouth	4/27/2001	40	22	7.7	29.4	12	4.02	103	572	--	6.71	0.15	376
Cataract Creek	6031960	At mouth	5/17/2001	23	60	7.2	--	9	1.47	32.6	--	--	3.3	--	145
Cataract Creek	6031960	At mouth	8/9/2001	56	3.9	7.9	--	5	4.03	17.1	--	--	< 1	--	286
Cataract Creek	6031960	At mouth	9/26/2001	65	2.2	8.2	--	4	4.73	13.5	--	--	< 1	--	381
Cataract Creek	6031960	At mouth	5/23/2002	25	52	7	--	8	1.76	37.5	--	--	4.28	--	186
Cataract Creek	6031960	At mouth	6/12/2002	19	87	7.8	57.9	7	1.31	30.7	327	--	2.76	0.04	139
Cataract Creek	6031960	At mouth	2/20/2003	58	2.3	7.5	--	3	3.07	10.2	--	--	0.39	--	307
Cataract Creek	6031960	At mouth	5/13/2003	33	46	7.7	--	4	1.34	22	--	--	1.65	--	148
Cataract Creek	6031960	At mouth	6/4/2003	20	68	7.3	--	11	1.05	26.9	--	--	6.21	--	118
Cataract Creek	6031960	At mouth	8/20/2003	68	2	8.2	--	5	1.89	8.6	--	--	0.14	--	129
Cataract Creek	6031960	At mouth	3/22/2004	57	4.6	7.6	--	4	2.29	11.2	--	--	0.39	--	228
Cataract Creek	6031960	At mouth	5/24/2004	22	45	7.4	--	4	1.11	18.7	--	--	2	--	128
Cataract Creek	6031960	At mouth	7/29/2004	56	3.8	8	--	5	2.51	10.8	--	--	0.41	--	212
Cataract Creek	6031960	At mouth	9/22/2004	47	8.3	7.8	--	3	3.13	21.6	--	--	1.05	--	286
Cataract Creek	6031960	At mouth	5/2/2005	44	7.4	7.8	--	4	1.49	15.9	--	--	2.23	--	167
Cataract Creek	6031960	At mouth	5/23/2005	19	118	7.6	--	11	0.98	25.9	--	--	7.57	--	102
Cataract Creek	6031960	At mouth	8/3/2005	53	5.1	7.8	--	5	1.9	12.1	--	--	0.76	--	177
Cataract Creek	6031960	At mouth	9/22/2005	66	3.3	7.8	--	3.9	2.66	8.6	--	--	0.29	--	245
Cataract Creek	6031960	At mouth	2/8/2006	59	3.9	7.8	--	3	2.07	10	--	--	0.22	--	220
Cataract Creek	6031960	At mouth	5/17/2006	18	119	7.5	--	30.6	1.62	49.6	--	--	19.7	--	157
Cataract Creek	6031960	At mouth	7/25/2006	58	3.4	8	--	5.5	1.64	9.2	--	--	0.32	--	134

Table D-1. Surface Water Quality Data for the Boulder-Elkhorn TMDL Planning Area

Waterbody Segment	Site ID	Site Description	Sample Date	Hardness (mg/L)	Flow (cfs)	Field pH (su)	AL (Dis) (µg/L)	As (TR) (µg/L)	Cd (TR) (µg/l)	Cu (TR) (µg/l)	Fe (TR) (mg/L)	Hg (TR) (µg/L)	Pb (TR) (µg/l)	Ag (TR) (µg/l)	Zn (TR) (µg/l)
Cataract Creek	6031960	At mouth	9/15/2006	72	2	7.9	--	4.3	1.73	5.7	--	--	0.27	--	155
Cataract Creek	6031960	At mouth	3/6/2007	58	3	7.6	--	3.7	1.45	6.4	--	--	0.68	--	165
Cataract Creek	6031960	At mouth	5/8/2007	23	51	7.6	--	5.7	0.89	18.6	--	--	3.97	--	104
Cataract Creek	6031960	At mouth	7/12/2007	49	5	7.4	--	4.9	1.65	10.5	--	--	0.58	--	148
Cataract Creek	6031960	At mouth	8/30/2007	66	1.2	8.1	--	4.6	1.33	4.7	--	--	0.14	--	105
Cataract Creek	6031960	At mouth	4/22/2008	56	7.7	7.7	--	4.2	1.61	16.4	--	--	1.84	--	179
Cataract Creek	6031960	At mouth	6/4/2008	18	155	7.1	--	10.4	0.96	24.6	--	--	7.99	--	120
Cataract Creek	6031960	At mouth	7/17/2008	37	13	7.8	--	5.2	1.46	14.9	--	--	0.88	--	155
Cataract Creek	6031960	At mouth	8/27/2008	58	3.2	8	--	5.5	1.81	7.9	--	--	0.44	--	183
Cataract Creek	6031960	At mouth	4/23/2009	31.2	--	--	--	11.2	1.37	35.7	--	--	10.30	--	192
Cataract Creek	6031960	At mouth	5/22/2009	20.6	--	--	--	12.7	0.79	30.3	--	--	9.76	--	129
Cataract Creek	6031960	At mouth	6/18/2009	22	--	--	--	6.7	0.62	17.3	--	--	3.61	--	82.9
Cataract Creek	6031960	At mouth	8/17/2009	45.4	--	--	--	5.5	1.26	11.5	--	--	1.45	--	131
Cataract Creek	6031960	At mouth	3/9/2010	55.6	--	--	--	4.3	1.35	6	--	--	0.85	--	154
Cataract Creek	6031960	At mouth	6/1/2010	19.2	--	--	--	11.6	0.64	24.2	--	--	8.96	--	102
Cataract Creek	6031960	At mouth	7/20/2010	45.6	--	--	--	4.5	1	10.3	--	--	0.55	--	104
Cataract Creek	6031960	At mouth	8/25/2010	48.3	--	--	--	4.8	1.01	9.7	--	--	1.05	--	109
Cataract Creek	461905112144201	U/S Uncle Sam Gulch	5/17/01	21	62	7.2	--	3	0.2	8.1	--	--	1.57	--	44
Cataract Creek	461905112144201	U/S Uncle Sam Gulch	8/9/01	46	3	8	--	3	0.15	4.3	--	--	< 1	--	25
Cataract Creek	461905112144201	U/S Uncle Sam Gulch	9/26/01	53	1.4		--	3	0.22	3.6	--	--	< 1	--	45
Cataract Creek	461905112144201	U/S Uncle Sam Gulch	11/15/01	47	2.6	7.4	2.4	2	0.23	3.5	74	--	< 1	< 0.05	59
Cataract Creek	461905112144201	U/S Uncle Sam Gulch	5/23/02	21	47	7.4	--	4	0.27	9.2	--	--	3.51	--	56
Cataract Creek	461905112144201	U/S Uncle Sam Gulch	6/12/02	18	74	7.6	58.6	3	0.19	7	234	--	1.3	E 0.04	43
Cataract Creek	461905112144201	U/S Uncle Sam Gulch	3/25/03	52	3.2	7.8	--	E 2	0.32	7.4	--	--	0.5	--	64
Cataract Creek	461905112144201	U/S Uncle Sam Gulch	5/4/05	36	16	7.8	--	2	0.2	6.8	--	--	1.05	--	44
Cataract Creek	461905112144201	U/S Uncle Sam Gulch	5/24/05	19	85	7.6	--	4	0.25	9.1	--	--	2.58	--	49
Cataract Creek	461905112144201	U/S Uncle Sam Gulch	8/4/05	48	3.5	7.9	--	3	0.2	4.3	--	--	0.33	--	42
Cataract Creek	461905112144201	U/S Uncle Sam Gulch	9/22/05	53	2.8	7.6	--	2.6	0.24	3.7	--	--	0.2	--	53
Cataract Creek	461905112144201	U/S Uncle Sam Gulch	2/10/06	52	3.6	7.9	--	2.8	0.44	7.8	--	--	0.8	--	78
Cataract Creek	461905112144201	U/S Uncle Sam Gulch	5/17/06	17	110	7.5	--	5.6	0.32	12	--	--	4.27	--	56
Cataract Creek	461905112144201	U/S Uncle Sam Gulch	7/26/06	50	2.3	7.7	--	3.5	0.21	4.7	--	--	0.4	--	41
Cataract Creek	461905112144201	U/S Uncle Sam Gulch	9/15/06	61	1.6	7.7	--	3	0.28	3.7	--	--	0.19	--	58
Cataract Creek	461905112144201	U/S Uncle Sam Gulch	4/3/07	45	3.8	7.5	--	2	0.24	7.1	--	--	0.39	--	59
Cataract Creek	461905112144201	U/S Uncle Sam Gulch	5/10/07	19	52	6.2	--	3	0.2	8.5	--	--	1.53	--	48.4
Cataract Creek	461905112144201	U/S Uncle Sam Gulch	7/12/07	43	3.6	7.8	--	3	0.22	5.1	--	--	0.25	--	44.1
Cataract Creek	461905112144201	U/S Uncle Sam Gulch	8/31/07	59	1.1	8.1	--	2.9	0.22	2.6	--	--	0.08	--	40
Cataract Creek	BE-35	U/S Nellie Grant Cr.	6/11/2009	12.0	2.99	6.39	--	< 3.0	0.72	15.0	100	< 0.05	0.9	< 0.5	170
Cataract Creek	BE-35	U/S Nellie Grant Cr.	8/19/2009	26.0	0.194	6.95	--	< 3.0	0.79	10.0	110	< 0.05	< 0.5	< 0.5	190
Cataract Creek	BE-35	U/S Nellie Grant Cr.	7/13/10	--	0.26	--	--	--	--	--	--	--	--	--	--
Cataract Creek	BE-35	U/S Nellie Grant Cr.	9/27/10	--	0.3	8	--	--	--	--	--	--	--	--	--
Cataract Creek	BE-36	D/S Nellie Grant Cr.	6/11/09	14.0	14.38	6.46	--	< 3.0	0.19	5.0	180		< 0.5	< 0.5	40
Cataract Creek	BE-36	D/S Nellie Grant Cr.	8/19/2009	27.0	1.49	6.84	--	< 3.0	0.15	3.0	210	< 0.05	< 0.5	< 0.5	30
Cataract Creek	BE-36	D/S Nellie Grant Cr.	7/13/10	--	2.43	--	--	--	--	--	--	--	--	--	--
Cataract Creek	BE-36	D/S Nellie Grant Cr.	9/27/10	--	1.46	8	--	--	--	--	--	--	--	--	--
Cataract Creek	BE-37	D/S Rocker Creek	6/11/09	15.0	40.61	6.72	--	< 3.0	< 0.08	8.0	210	< 0.05	< 0.5	< 0.5	20
Cataract Creek	BE-37	D/S Rocker Creek	8/19/2009	28.0	3.61	6.86	--	< 3.0	< 0.08	3.0	180	< 0.05	< 0.5	< 0.5	< 10
Cataract Creek	BE-37	D/S Rocker Creek	6/4/10	13.0	303.3	--	130	< 3	< 0.08	7.0	320		0.6	< 0.5	30

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Cataract Creek	BE-37	D/S Rocker Creek	7/13/10	23.0	7.3	--	30	<3	< 0.08	5.0	180		< 0.5	< 0.5	10
Cataract Creek	BE-37	D/S Rocker Creek	9/27/10	--	4.76	8.2	--	--	--	--	--	--	--	--	--
Cataract Creek	BE-38	U/S of Hoodoo Cr.	6/11/09	16.0	26.13	6.44	--	< 3.0	< 0.08	7.0	270	< 0.05	0.5	< 0.5	20
Cataract Creek	BE-38	U/S of Hoodoo Cr.	8/19/2009	30.0	3.81	7.53	--	< 3.0	< 0.08	3.0	350	< 0.05	0.5	< 0.5	10
Cataract Creek	BE-38	U/S of Hoodoo Cr.	7/13/10	--	10.14	--	--	--	--	--	--	--	--	--	--
Cataract Creek	BE-38	U/S of Hoodoo Cr.	9/26/10	--	6.56	8.3	--	--	--	--	--	--	--	--	--
Cataract Creek	BE-39	D/S of Hoodoo Cr.	6/11/09	18.0	62.71	6.58	--	< 3.0	0.13	7.0	230	< 0.05	0.7	< 0.5	20
Cataract Creek	BE-39	D/S of Hoodoo Cr.	8/19/2009	33.0	5.83	7.35	--	< 3.0	0.27	6.0	150	< 0.05	< 0.5	< 0.5	40
Cataract Creek	BE-39	D/S of Hoodoo Cr.	7/8/10	--	18.95	7.9	--	--	--	--	--	--	--	--	--
Cataract Creek	BE-39	D/S of Hoodoo Cr.	9/13/10	--	8.31	7.9	--	--	--	--	--	--	--	--	--
Cataract Creek	BE-40	D/S Cataract Tailings	6/11/09	19.0	154.6	6.35	--	3.0	< 0.08	8.0	260	< 0.05	1.5	< 0.5	40
Cataract Creek	BE-40	D/S Cataract Tailings	8/20/2009	38.0	6.5	7.41	--	< 3.0	0.20	6.0	150	< 0.05	< 0.5	< 0.5	40
Cataract Creek	BE-40	D/S Cataract Tailings	7/8/10	--	23.43	--	--	--	--	--	--	--	--	--	--
Cataract Creek	BE-40	D/S Cataract Tailings	9/13/10	--	10.17	8.1	--	--	--	--	--	--	--	--	--
Cataract Creek	BE-41	D/S Morning Glory Tailings	6/11/09	20.0	264.5	6.77	--	7.0	0.61	18.0	280	< 0.05	3.9	< 0.5	90
Cataract Creek	BE-41	D/S Morning Glory Tailings	8/20/2009	40.0	9	7.14	--	4.0	1.58	13.0	130	< 0.05	0.9	< 0.5	180
Cataract Creek	BE-41	D/S Morning Glory Tailings	7/8/10	--	28.67	--	--	--	--	--	--	--	--	--	--
Cataract Creek	BE-41	D/S Morning Glory Tailings	9/12/10	--	12.52	8.1	--	--	--	--	--	--	--	--	--
Cataract Creek	BE-41	D/S Morning Glory Tailings	8/12/11	43.9	9.48	--	20	4	1.75	13	110		0.5		177.6
Cataract Creek	BE-42	U/S of Big Limber Gulch	6/11/09	21.0	101.1	6.88	--	7.0	0.67	21.0	300	< 0.05	4.1	< 0.5	100
Cataract Creek	BE-42	U/S of Big Limber Gulch	8/19/2009	46.0	5.73	7.84	--	4.0	1.30	12.0	100	< 0.05	0.7	< 0.5	140
Cataract Creek	BE-42	U/S of Big Limber Gulch	7/8/10	--	32.2		--	--	--	--	--	--	--	--	--
Cataract Creek	BE-42	U/S of Big Limber Gulch	9/12/10	--	14.63	8.2	--	--	--	--	--	--	--	--	--
Cataract Creek	BE-42	U/S of Big Limber Gulch	8/12/11	55.8	9.19	--	10	4	1.33	10	80	< 0.05	0.5		134.7
Upper Elkhorn Creek	BE-48	D/S of Queens Gulch	6/10/2009	37.0	16.68	6.97	--	< 3.0	0.4	2.0	140	< 0.05	3.7	< 0.5	20
Upper Elkhorn Creek	BE-48	D/S of Queens Gulch	8/21/2009	62.0	3.65	8.04	--	3.0	0.72	3.0	230		6.2	< 0.5	40
Upper Elkhorn Creek	BE-48	D/S of Queens Gulch	6/2/2010	38	22.96	--	< 30	3	0.56	5	250		9.5	< 0.5	50
Upper Elkhorn Creek	BE-48	D/S of Queens Gulch	7/2/2010	39	26.25	--	< 30	< 3	0.56	4	210		6	< 0.5	30
Upper Elkhorn Creek	BE-48	D/S of Queens Gulch	9/2/2010	61	7.5	8.2	< 30	< 3	0.72	2	210		4.8	< 0.5	30
Upper Elkhorn Creek	BE-47	D/S of Slaughterhouse gulch	6/2/2010	133	0.74	--	< 30	14	0.26	35	1710	--	10.7	< 0.5	50
Upper Elkhorn Creek	BE-47	D/S of Slaughterhouse gulch	7/3/2010	102	1.16	--	< 30	14	0.17	21	1010	--	6.2	< 0.5	20
Upper Elkhorn Creek	BE-47	D/S of Slaughterhouse gulch	9/3/2010	105	0.55	8.5	< 30	8	0.1	14	760	< 0.05	3.4	< 0.5	20
Upper Elkhorn Creek	BE-47	D/S of Slaughterhouse gulch	6/10/2009	109.0	0.62	7.42	--	9.0	0.11	14.0	1170	< 0.05	3.5	< 0.5	10
Upper Elkhorn Creek	BE-47	D/S of Slaughterhouse gulch	8/21/2009	108.0	0.253	8.39	--	8.0	< 0.08	11.0	670	--	4.7	< 0.5	10
Upper Elkhorn Creek	BE-46	Headwaters	7/3/2010	35	0.1		< 30	4	< 0.08	< 1	< 50		< 0.5	< 0.5	< 10
Upper Elkhorn Creek	BE-46	Headwaters	9/3/2010	< 1	0		< 30	< 3	< 0.08	< 1	< 50	< 0.05	< 0.5	< 0.5	< 10
Lower Elkhorn Creek	BE-50	End of flowing segment	6/10/2009	95.0	1.01	6.90		6.0	0.24	2.00	70	< 0.05	76.5	< 0.5	10
Lower Elkhorn Creek	M07ELKHC06	2.3 mi D/S Wood Gulch	6/2/2010	89	7.89	--	< 30	8	0.21	3.00	510	--	70.4	< 0.5	20
Lower Elkhorn Creek	M07ELKHC06	2.3 mi D/S Wood Gulch	7/1/2010	62	10.9	--	< 30	5	0.31	2.00	80	--	44.4	< 0.5	< 10
Lower Elkhorn Creek	M07ELKHC06	2.3 mi D/S Wood Gulch	8/3/2010	152	0.08	--	< 30	10	0.10	2.00	200	--	139.1	< 0.5	< 10
Lower Elkhorn Creek	M07ELKHC05	1.3 mi D/S Wood Gulch	6/2/2010	65	6.58	--	< 30	5	0.19	4.00	170	--	47.2	< 0.5	20
Lower Elkhorn Creek	M07ELKHC05	1.3 mi D/S Wood Gulch	7/1/2010	57	10.52	--	< 30	4	0.25	3.00	110	--	39.9	< 0.5	20
Lower Elkhorn Creek	BE-49	0.14 mi D/S Wood Gulch	6/10/2009	43.0	3.80	7.05		< 3.0	0.55	3.00	140	< 0.05	27.9	< 0.5	40
Lower Elkhorn Creek	BE-49	0.14 mi D/S Wood Gulch	8/21/2009	68.0	3.37	8.11		6.0	0.63	3.00	270	< 0.05	50.0	< 0.5	40
Lower Elkhorn Creek	BE-49	0.14 mi D/S Wood Gulch	6/2/2010	46	6.93		< 30	4	0.90	6.00	320	--	30.4	< 0.5	70
Lower Elkhorn Creek	BE-49	0.14 mi D/S Wood Gulch	7/2/2010	49	10.91		< 30	4	0.74	5.00	210	--	32.9	< 0.5	60
Lower Elkhorn Creek	BE-49	0.14 mi D/S Wood Gulch	8/3/2010	138	0.01	8.1	< 30	11	1.39	3.00	540	--	123.0	< 0.5	50

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High Ore Creek	BE-53	High Ore Cr U/S of Comet Mine	6/11/09	31.0	2.09	7.26		< 3.0	< 0.08	< 1.0	210	< 0.05	< 0.5	< 0.5	< 10
High Ore Creek	BE-53	High Ore Cr U/S of Comet Mine	8/19/09	53.0	0.38	7.89		< 3.0	< 0.08	1.0	740	< 0.05	1.9	< 0.5	< 10
High Ore Creek	BE-55	D/S of Comet Mine	6/11/09	60.0	2.36	7.39		10.0	1.91	2.0	200	< 0.05	1.8	< 0.5	710
High Ore Creek	BE-55	D/S of Comet Mine	8/19/09	135.0	0.43	7.72		11.0	3.35	2.0	190	< 0.05	1.8	< 0.5	1270
High Ore Creek	BE-56	U/S of Bishop Cr.	6/11/09	64.0	2.79	7.7		15.0	1.72	4.0	240	< 0.05	5.8	< 0.5	630
High Ore Creek	BE-56	U/S of Bishop Cr.	8/19/09	124.0	0.535	7.9		16.0	2.17	3.0	180	< 0.05	2.8	< 0.5	730
High Ore Creek	BE-57	At mouth	6/11/09	69.0	5.36	7.74		25.0	1.53	6.0	330	< 0.05	10.3	--	480
High Ore Creek	BE-57	At mouth	8/24/09	130.0	0.84	7.87		23.0	2.30	4.0	190	< 0.05	3.7	--	660
High Ore Creek	BE-57	At mouth	6/14/10	--	--	--	--	--	--	--	--	--	--	< 0.5	--
High Ore Creek	BE-57	At mouth	7/8/10	--	2.97	--	--	--	--	--	--	--	--	< 0.5	--
High Ore Creek	6032300	At mouth	4/6/01	160	1.5	8.1	1000	88	6.3	18.9	1660	--	64.9	--	1800
High Ore Creek	6032300	At mouth	9/25/01	190	0.41	8.3	--	33	3.58	4.5	--	--	3.46	--	607
High Ore Creek	6032300	At mouth	11/15/01	170	0.44	7.9	21	24	4.17	3.2	65	--	3.71	--	1180
High Ore Creek	6032300	At mouth	5/22/02	110	7.1	8.2	--	52	3.84	15.6	--	--	48.1	--	944
High Ore Creek	6032300	At mouth	6/12/02	98	4	8.2	278	49	4.12	11.9	736	--	36.8	--	973
High Ore Creek	6032300	At mouth	8/9/02	170	1.3	8.3	--	33	3.31	8	--	--	17.6	--	844
Jack Creek	462047112201901	At mouth	4/26/2001	33	6.7	7.3	39.2	32	4.61	170	2500	--	12.1	--	514
Jack Creek	462047112201901	At mouth	5/16/2001	22	18	7.2	--	13	1.8	32.3	--	--	4.14	--	215
Jack Creek	462047112201901	At mouth	8/8/2001	36	1.7	7.7	--	13	2.53	23.7	--	--	1.47	--	256
Jack Creek	462047112201901	At mouth	9/25/2001	42	0.98	7.5	--	7	4.43	32.6	--	--	< 1	--	537
Jack Creek	462047112201901	At mouth	5/22/2002	21	17	8.1	--	21	2.09	43.4	--	--	8.78	--	217
Jack Creek	462047112201901	At mouth	6/11/2002	21	13	7.1	73.6	11	1.61	28.7	363	--	2.74	--	190
Jack Creek	462047112201901	At mouth	4/23/2003	34	14	7.5	--	65	3.61	133	--	--	26.4	--	409
Jack Creek	462047112201901	At mouth	5/13/2003	26	11	7.7	--	8	1.36	22.1	--	--	1.77	--	173
Jack Creek	462047112201901	At mouth	6/4/2003	18	22	7.7	--	21	1.01	26.7	--	--	7.17	--	123
Jack Creek	462047112201901	At mouth	8/20/2003	44	1.3	7.9	--	8	3.3	22.9	--	--	0.62	--	391
Jack Creek	462047112201901	At mouth	3/22/2004	39	1.4	7.9	--	5	2.85	36.9	--	--	1.18	--	379
Jack Creek	462047112201901	At mouth	5/24/2004	24	12	7.4	--	7	1.41	24.3	--	--	1.87	--	174
Jack Creek	462047112201901	At mouth	7/29/2004	37	1.4	7.5	--	8	2.68	23.2	--	--	0.64	--	339
Jack Creek	462047112201901	At mouth	9/22/2004	40	2.1	7.5	--	5	3.81	34.8	--	--	0.81	--	473
Jack Creek	462047112201901	At mouth	5/2/2005	35	4.9	7.6	--	11	2.04	33.2	--	--	4.34	--	261
Jack Creek	462047112201901	At mouth	5/24/2005	20	22	7.4	--	13	0.96	21	--	--	4.26	--	109
Jack Creek	462047112201901	At mouth	8/3/2005	36	2.3	7.4	--	7	3.56	40.5	--	--	1.09	--	434
Jack Creek	462047112201901	At mouth	9/21/2005	40	1.8	7.6	--	4.7	3.54	27	--	--	0.32	--	423
Jack Creek	462047112201901	At mouth	2/8/2006	39	1.4	7.7	--	3.9	2.79	26.2	--	--	0.55	--	363
Jack Creek	462047112201901	At mouth	5/17/2006	19	36	7.7	--	20.3	1.15	32.9	--	--	7.69	--	125
Jack Creek	462047112201901	At mouth	7/26/2006	38	1.5	7.3	--	6.9	2.42	22.7	--	--	0.55	--	270
Jack Creek	462047112201901	At mouth	9/14/2006	40	0.97	6.6	--	5.3	2.33	18.4	--	--	0.31	--	302
Jack Creek	462047112201901	At mouth	3/6/2007	41	1	7	--	3.3	2.06	13.2	--	--	0.43	--	293
Jack Creek	462047112201901	At mouth	5/9/2007	25	12	7.6	--	5.8	0.94	19.2	--	--	1.75	--	131
Jack Creek	462047112201901	At mouth	7/11/2007	31	2.9	7.6	--	6.7	2.06	27	--	--	0.76	--	261
Jack Creek	462047112201901	At mouth	8/30/2007	40	0.91	7.9	--	4.7	2.27	14.9	--	--	0.27	--	295
Jack Creek	462047112201901	At mouth	4/22/2008	40	1.2	7.4	--	3.8	1.7	15	--	--	0.51	--	260
Jack Creek	462047112201901	At mouth	6/4/2008	17	36	7.3	--	12.3	0.92	27.4	--	--	4.16	--	109
Jack Creek	462047112201901	At mouth	7/17/2008	26	5.5	7.3	--	12.9	3.12	49.2	--	--	1.17	--	406
Jack Creek	462047112201901	At mouth	8/26/2008	35	1.8	7.5	--	5.6	3.13	27.9	--	--	0.53	--	390
Jack Creek	462047112201901	At mouth	4/22/2009	24.2	--	--	--	--	1.16	137	--	--	20.1	--	359

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Waterbody Segment	Site ID	Site Description	Sample Date	Hardness (mg/L)	Flow (cfs)	Field pH (su)	AL (Dis) (µg/L)	As (TR) (µg/L)	Cd (TR) (µg/l)	Cu (TR) (µg/l)	Fe (TR) (mg/L)	Hg (TR) (µg/L)	Pb (TR) (µg/l)	Ag (TR) (µg/l)	Zn (TR) (µg/l)
Jack Creek	462047112201901	At mouth	5/22/2009	18.3	--	--	--	--	0.57	18.7	--	--	5.21	--	92.1
Jack Creek	462047112201901	At mouth	6/18/2009	18.3	--	--	--	--	1.11	25.6	--	--	2.3	--	144
Jack Creek	462047112201901	At mouth	8/17/2009	31.1	--	--	--	--	2.08	34.5	--	--	1.04	--	271
Jack Creek	462047112201901	At mouth	3/9/2010	34.5	--	--	--	--	1.48	9.4	--	--	0.39	--	221
Jack Creek	462047112201901	At mouth	6/2/2010	19.4	--	--	--	--	0.55	25.1	--	--	8.47	--	95.2
Jack Creek	462047112201901	At mouth	7/20/2010	27.5	--	--	--	--	2.09	31.8	--	--	1.02	--	271
Jack Creek	462047112201901	At mouth	8/25/2010	31.6	--	--	--	--	1.96	28.2	--	--	0.98	--	283
Jack Creek	462155112181501	U/S of Jill Creek	3/24/2003	44	0.39	7.8	--	4	0.24	3.2	--	--	E 0.04	--	40
Jack Creek	462155112181501	U/S of Jill Creek	5/13/2003	45	2	7.6	--	4	0.1	3.5	--	--	0.28	--	19
Jack Creek	462155112181501	U/S of Jill Creek	6/3/2003	20	11	7.4	--	8	0.1	6.4	--	--	2.05	--	21
Jack Creek	462155112181501	U/S of Jill Creek	8/21/2003	48	0.25	7.2	--	6	0.08	1.8	--	--	0.07	--	9
Jack Creek	462155112181501	U/S of Jill Creek	3/30/2004	48	0.57	7.4	--	5	0.34	3.9	--	--	E 0.03	--	48
Jack Creek	462155112181501	U/S of Jill Creek	5/24/2004	26	3.9	7.5	--	5	0.11	4.7	--	--	0.31	--	19
Jack Creek	462155112181501	U/S of Jill Creek	7/30/2004	39	0.48	7.3	--	7	0.21	3.5	--	--	0.17	--	30
Jack Creek	462155112181501	U/S of Jill Creek	9/23/2004	36	1.8	7.6	--	6	0.09	3.1	--	--	0.2	--	12
Jack Creek	462155112181501	U/S of Jill Creek	5/2/2005	52	0.78	7.7	--	4	0.16	3.3	--	--	0.12	--	26
Jack Creek	462155112181501	U/S of Jill Creek	5/24/2005	25	7.7	7.4	--	5	0.07	25.6	--	--	0.93	--	12
Jack Creek	462155112181501	U/S of Jill Creek	8/3/2005	36	0.94	7.4	--	6	0.08	2.4	--	--	0.11	--	14
Jack Creek	462155112181501	U/S of Jill Creek	9/21/2005	43	0.73	7.2	--	5.3	0.21	3.3	--	--	0.07	--	31
Jack Creek	462155112181501	U/S of Jill Creek	2/9/2006	43	0.4	7.5	--	5	0.11	1.9	--	--	E 0.04	--	19
Jack Creek	462155112181501	U/S of Jill Creek	5/18/2006	23	12	7.5	--	7.2	0.1	8.2	--	--	1.71	--	17
Jack Creek	462155112181501	U/S of Jill Creek	7/25/2006	41	0.48	7.3	--	6.7	0.16	8.7	--	--	0.22	--	20
Jack Creek	462155112181501	U/S of Jill Creek	9/14/2006	46	0.22	7	--	5.4	0.14	1.7	--	--	E 0.04	--	19
Jack Creek	462155112181501	U/S of Jill Creek	3/6/2007	45	0.4	7.8	--	4.5	0.31	3.3	--	--	0.07	--	47
Jack Creek	462155112181501	U/S of Jill Creek	5/9/2007	30	4.6	7.5	--	4.7	0.12	4.7	--	--	0.4	--	16.9
Jack Creek	462155112181501	U/S of Jill Creek	7/11/2007	37	1.2	7.7	--	6.3	0.09	2.5	--	--	0.12	--	13.1
Jack Creek	462155112181501	U/S of Jill Creek	8/29/2007	47	0.28	7.6	--	5.5	0.03	< 1.2	--	--	E 0.03	--	4.6
Jack Creek	BE-58	D/S of Bullion Mine	06/10/09	18.0	20.60	6.13	--	10.0	1.13	23.0	520	< 0.05	1.8	< 0.5	140
Jack Creek	BE-58	D/S of Bullion Mine	08/20/09	35.0	2.31	7.26	--	9.0	4.25	76.0	940	< 0.05	1.2	< 0.5	520
Jack Creek	M07JACKC01	U/S of Jill Creek	6/8/2010	20	--	--	70	5	ND	5	250	--	1.1	ND	10
Jack Creek	M07JACKC01	U/S of Jill Creek	7/16/2010	27	--	--	< 30	6	ND	3	50	--	ND	ND	10
Jack Creek	M07JACKC01	U/S of Jill Creek	8/16/2010	32	--	--	< 30	6	ND	3	70	--	ND	ND	ND
Jack Creek	M07JACKC03 (BE-58)	D/S of Bullion Mine	6/8/2010	18	--	--	110	9	0.55	15	460	--	2.4	ND	70
Jack Creek	M07JACKC03 (BE-58)	D/S of Bullion Mine	7/15/2010	29	--	--	50	11	3.82	70	970	--	1.3	ND	480
Jack Creek	M07JACKC03 (BE-58)	D/S of Bullion Mine	8/16/2010	32	--	--	40	8	3.08	52	750	--	1.2	ND	370
Little Boulder River	M07LBLDR01	D/S of Wilson Creek	6/5/2010	17	167.1	--	110	6	< 0.08	8	630	--	1	< 0.5	< 10
Little Boulder River	M07LBLDR01	D/S of Wilson Creek	8/2/2010	34	11.72	8.2	< 30	4	< 0.08	3	520	--	1.1	< 0.5	< 10
Little Boulder River	BE-59	U/S of NF Little Boulder	6/10/2009	25.0	68.79	7.18	--	4.0	< 0.08	6.0	620	< 0.05	7	< 0.5	< 10
Little Boulder River	BE-59	U/S of NF Little Boulder	8/20/2009	43.0	11.88	7.64	--	< 3.0	< 0.08	2.0	240	< 0.05	< 0.5	< 0.5	10
Little Boulder River	BE-59	U/S of NF Little Boulder	6/5/2010	21	150.6	--	110	6	< 0.08	8	680	--	1	< 0.5	< 10
Little Boulder River	BE-59	U/S of NF Little Boulder	8/2/2010	42	16.53	8.2	< 30	3	< 0.08	3	400	--	< 0.5	< 0.5	< 10
Little Boulder River	BE-60	At mouth	6/12/2009	31.0	84.90	7.30	--	4.0	< 0.08	5.0	280	< 0.05	< 0.5	< 0.5	< 10
Little Boulder River	BE-60	At mouth	8/20/2009	46.0	19.25	7.89	--	< 3.0	< 0.08	2.0	650	< 0.05	< 0.5	< 0.5	< 10
Little Boulder River	BE-60	At mouth	6/5/2010	32	640.13	--	80	5	< 0.08	7	1050	--	1	< 0.5	< 10
Little Boulder River	BE-60	At mouth	8/2/2010	45	24.47	8.2	< 30	4	< 0.08	3	660	--	< 0.5	< 0.5	< 10
Little Boulder River	BE-61	U/S Bolder Hot Springs	6/15/2009	29.0	161.60	6.71	--	4.0	< 0.08	7.0	1270	< 0.05	0.9	< 0.5	< 10
Little Boulder River	BE-61	U/S Bolder Hot Springs	8/24/2009	47.0	16.42	7.07	--	< 3.0	< 0.08	2.0	770	< 0.05	< 0.5	< 0.5	< 10

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Waterbody Segment	Site ID	Site Description	Sample Date	Hardness (mg/L)	Flow (cfs)	Field pH (su)	AL (Dis) (µg/L)	As (TR) (µg/L)	Cd (TR) (µg/l)	Cu (TR) (µg/l)	Fe (TR) (mg/L)	Hg (TR) (µg/L)	Pb (TR) (µg/l)	Ag (TR) (µg/l)	Zn (TR) (µg/l)
Lowland Cr	BE-63	At first road crossing	8/18/2009	51	0.18	8.12	30	7.0	< 0.08	5.0	280	< 0.05	< 0.5	< 0.5	< 10
Lowland Cr	BE-63	At first road crossing	6/9/2009	26	1.64	6.52	110	5.0	< 0.08	8.0	250	< 0.05	< 0.5	< 0.5	< 10
Lowland Cr	BE-63	At first road crossing	7/18/2010	42	0.28	--	50	7.0	< 0.08	5.0	310	--	< 0.5	< 0.5	< 10
Lowland Cr	BE-63	At first road crossing	9/28/2010	57	0.1	--	< 30	5.0	< 0.08	2.0	180	--	< 0.5	< 0.5	< 10
Lowland Cr	BE-64	U/S Ruby Mine	8/18/2009	34.0	7.06	7.5	--	5.0	< 0.08	2.0	400	< 0.05	< 0.5	< 0.1	< 10
Lowland Cr	BE-64	U/S Ruby Mine	6/9/2009	27.0	56.31	6.67	--	5.0	< 0.08	4.0	850	< 0.05	0.8	< 0.1	< 10
Lowland Cr	BE-64	U/S Ruby Mine	6/9/2010	28.0	56.46	--	320	5.0	< 0.08	5	710	--	0.8	< 0.1	< 10
Lowland Cr	BE-64	U/S Ruby Mine	7/17/2010	36.0	14.77	--	130	5.0	< 0.08	2	410	--	< 0.5	< 0.1	< 10
Lowland Cr	BE-65	At mouth	8/18/2009	46.0	10.89	8.41	120	6.0	< 0.08	2.0	260	< 0.05	< 0.5	< 0.1	< 10
Lowland Cr	BE-65	At mouth	6/9/2009	32.0	88.24	6.97	210	6.0	< 0.08	4.0	760	< 0.05	0.7	< 0.1	< 10
Lowland Cr	BE-65	At mouth	6/9/2010	31	66.67		320	6.0	< 0.08	4	650	--	0.7	< 0.1	< 10
Lowland Cr	BE-65	At mouth	7/17/2010	46	24.84		100	6.0	< 0.08	2	330	--	< 0.5	< 0.1	< 10
Lowland Cr	BE-65	At mouth	9/28/2010	56	6.2	8.3	40	6.0	< 0.08	1	150	--	< 0.5	< 0.1	< 10
Muskrat Creek	M07MSKRC01	At 2nd pack trail crossing	6/3/2010	15	20.98	--	70	< 3.0	< 0.08	2	--	--	< 0.5	< 0.5	< 10
Muskrat Creek	M07MSKRC01	At 2nd pack trail crossing	7/5/2010	19	13.16	--	30	< 3.0	< 0.08	1	90	--	< 0.5	< 0.5	< 10
Muskrat Creek	M07MSKRC01	At 2nd pack trail crossing	8/6/2010	--	2.96	8.1	--	--	--	--	--	--	--	--	--
Muskrat Creek	M07MSKRC01	At 2nd pack trail crossing	9/9/2010	--	2.7	8	--	--	--	--	--	--	--	--	--
Muskrat Creek	BE-69	U/S of Nursery Creek	6/9/2009	23.0	12.18	6.90	--	3.0	< 0.08	1.0	100	< 0.05	< 0.5	< 0.1	< 10
Muskrat Creek	BE-69	U/S of Nursery Creek	8/19/2009	36.0	3.09	7.62	--	< 3.0	< 0.08	1.0	< 30	< 0.05	< 0.5	< 0.5	< 10
Muskrat Creek	M07MSKRC02 (BE-69)	U/S of Nursery Creek	6/3/2010	23	18.59	--	50	< 3.0	< 0.08	2	340	--	< 0.5	< 0.5	< 10
Muskrat Creek	M07MSKRC02 (BE-69)	U/S of Nursery Creek	7/5/2010	26	16.76	--	< 30	< 3.0	< 0.08	1	170	--	< 0.5	< 0.5	< 10
Muskrat Creek	M07MSKRC02 (BE-69)	U/S of Nursery Creek	8/6/2010	--	8.13	8.5	--	--	--	--	--	--	--	--	--
Muskrat Creek	M07MSKRC02 (BE-69)	U/S of Nursery Creek	9/9/2010	--	6.04	8	--	--	--	--	--	--	--	--	--
Muskrat Creek	BE-68	0.5 mi U/S from mouth	6/9/2009	149.0	18.86	7.32	--	4.0	< 0.08	2.0	960	< 0.05	< 0.5	0.1	< 10
Muskrat Creek	BE-68	0.5 mi U/S from mouth	8/19/2009	101.0	6.65	7.83	--	< 3	< 0.08	2.0	850	< 0.05	< 0.5	< 0.5	< 10
Muskrat Creek	BE-68	0.5 mi U/S from mouth	6/3/2010	160	13.46	--	< 30	7	< 0.08	5	2000	--	1.2	< 0.5	10
Muskrat Creek	BE-68	0.5 mi U/S from mouth	7/5/2010	103	25.33	--	< 30	4	< 0.08	2	1260	--	0.8	< 0.5	< 10
Muskrat Creek	BE-68	0.5 mi U/S from mouth	8/5/2010	--	8.43	8	--	--	--	--	--	--	--	--	--
Muskrat Creek	BE-68	0.5 mi U/S from mouth	9/9/2010	--	10.25	7.7	--	--	--	--	--	--	--	--	--
Little Boulder River North Fork	BE-62	0.25 mi U/S of mouth	6/10/2009	29.0	31.90	7.21	--	< 3.0	< 0.08	4.0	880	< 0.05	< 0.5	< 0.1	< 10
Little Boulder River North Fork	BE-62	0.25 mi U/S of mouth	8/20/2009	46.0	6.13	7.97	--	< 3.0	< 0.08	2.0	760	< 0.05	< 0.5	< 0.5	< 10
Little Boulder River North Fork	BE-62	0.25 mi U/S of mouth	6/5/2010	29	34.01	--	60	4	< 0.08	7	1040	--	< 0.5	< 0.5	< 10
Little Boulder River North Fork	BE-62	0.25 mi U/S of mouth	7/4/2010	33	24.38	--	50	4	< 0.08	5	1000	--	< 0.5	< 0.5	< 10
Little Boulder River North Fork	BE-62	0.25 mi U/S of mouth	8/4/2010	46	8.24	8.4	< 30	< 3	< 0.08	2	790	--	< 0.5	< 0.5	< 10
Little Boulder River North Fork	M07LBNFR01	Near mouth	6/16/2004	48	3.19	7.22	< 100	< 3	< 0.1	2.0	370	--	< 0.5	< 3	< 10
Little Boulder River North Fork	M07LBNFR02	1/2 mile D/S of Porcupine Gulch	6/16/2004	33	--	--	< 100	< 3	< 0.1	3.0	320	--	< 0.5	< 3	< 10
Little Boulder River North Fork	M07LBNFR02	1/2 mile D/S of Porcupine Gulch	6/5/2010	24	31.93	--	90	6	< 0.08	6	900	--	0.6	< 0.5	< 10
Little Boulder River North Fork	M07LBNFR02	1/2 mile D/S of Porcupine Gulch	7/4/2010	27	20.68	--	80	4	< 0.08	5	700	--	< 0.5	< 0.5	< 10
Little Boulder River North Fork	M07LBNFR02	1/2 mile D/S of Porcupine Gulch	8/4/2010	36	6.07	--	< 30	< 3	< 0.08	2	420	--	< 0.5	< 0.5	< 10
Little Boulder River North Fork	M07LBNFR03	D/S of Hidden Meadows	6/5/2010	21	28.5	--	90	5	< 0.08	6	590	--	< 0.5	< 0.5	< 10
Little Boulder River North Fork	M07LBNFR03	D/S of Hidden Meadows	7/4/2010	22	15.58	--	60	4	< 0.08	5	520	--	< 0.5	< 0.5	< 10
Little Boulder River North Fork	M07LBNFR03	D/S of Hidden Meadows	8/4/2010	32	5.31	8.2	< 30	< 3	< 0.08	2	510	--	< 0.5	< 0.5	< 10
Uncle Sam Gulch	BE-75	D/S of Crystal Mine	6/11/2009	18.0	1.52	5.91	--	19.0	22.51	250.0	980	< 0.05	11.4	< 0.5	1870
Uncle Sam Gulch	BE-75	D/S of Crystal Mine	8/21/2009	90.0	0.1	4.26	--	34.0	147.00	1900.0	5320	< 0.05	37.3	< 0.5	12100
Uncle Sam Gulch	BE-74	U/S of Crystal Mine	6/11/2009	6.0	1.03	7.28	--	< 3.0	< 0.08	2.0	110	< 0.05	0.6	< 0.5	< 10
Uncle Sam Gulch	BE-74	U/S of Crystal Mine	8/21/2009	15.0	0.065	7.28	--	6.0	< 0.08	2.0	160	< 0.05	0.7	< 0.5	10
Uncle Sam Gulch	M07UCLSG01	U/S of Crystal Mine	6/4/2010	13	0.28	--	50	< 3	< 0.08	2	80	--	1.3	< 0.5	< 10

Table D-1. Surface Water Quality Data for the Boulder-Elkhorn TMDL Planning Area

Waterbody Segment	Site ID	Site Description	Sample Date	Hardness (mg/L)	Flow (cfs)	Field pH (su)	AL (Dis) (µg/L)	As (TR) (µg/L)	Cd (TR) (µg/l)	Cu (TR) (µg/l)	Fe (TR) (mg/L)	Hg (TR) (µg/L)	Pb (TR) (µg/l)	Ag (TR) (µg/l)	Zn (TR) (µg/l)
Uncle Sam Gulch	M07UCLSG01	U/S of Crystal Mine	7/12/2010	19	0.03	--	< 30	< 3	< 0.08	< 1	< 50	--	< 0.5	< 0.5	< 10
Uncle Sam Gulch	M07UCLSG02	D/S of Crystal Mine	6/4/2010	12	0.68	--	80	< 3	< 0.08	2	90	--	1.1	< 0.5	< 10
Uncle Sam Gulch	M07UCLSG02	D/S of Crystal Mine	7/12/2010	17	0.04	--	40	< 3	< 0.08	< 1	< 50	--	< 0.5	< 0.5	< 10
Uncle Sam Gulch	M07UCLSG03	At mouth	7/12/2010	--	2.93	--	--	--	--	--	--	--	--	--	--
Uncle Sam Gulch	M07UCLSG03	At mouth	8/9/2010	--	1.72	8.4	--	--	--	--	--	--	--	--	--
Uncle Sam Gulch	M07UCLSG03	At mouth	9/26/2010	--	1.28	8.2	--	--	--	--	--	--	--	--	--
Uncle Sam Gulch	M07UCLSG03	At mouth	8/12/2011	48.9	1.38	--	30	9	10.17	68	100		1.5		920.2
Uncle Sam Gulch	M07UCLSG03	At mouth	9/12/2011	--	--	--	30	--	--	--	--	--	--	--	--
Uncle Sam Gulch	461904112144401	At mouth	5/17/2001	27	5.4	7	--	59	13.9	260	--	--	11.6	--	1170
Uncle Sam Gulch	461904112144401	At mouth	8/9/2001	59	0.56	7.3	--	8	48.6	243	--	--	4.41	--	3910
Uncle Sam Gulch	461904112144401	At mouth	9/26/2001	71	0.28		--	4	54.6	321	--	--	3.8	--	4700
Uncle Sam Gulch	461904112144401	At mouth	11/15/2001	56	0.71	7.2	17.8	5	39.2	237	101	--	3	--	3520
Uncle Sam Gulch	461904112144401	At mouth	5/23/2002	28	4.8	7.2	--	75	15.5	345	--	--	34.2	--	1410
Uncle Sam Gulch	461904112144401	At mouth	6/12/2002	23	6	7.7	125	47	13.1	282	991	--	9.04	--	1100
Uncle Sam Gulch	461904112144401	At mouth	3/25/2003	50	0.54	7.5	--	3	23	87.9	--	--	0.82	--	2170
Uncle Sam Gulch	461904112144401	At mouth	5/13/2003	35	3.4	8	--	15	11.2	125	--	--	8.19	--	1020
Uncle Sam Gulch	461904112144401	At mouth	6/4/2003	18	8.4	7.4	--	59	6.28	173	--	--	40	--	560
Uncle Sam Gulch	461904112144401	At mouth	8/21/2003	73	0.37	8	--	5	19.6	38.3	--	--	0.59	--	1650
Uncle Sam Gulch	461904112144401	At mouth	3/30/2004	43	1.1	7.1	--	6	20.3	165	--	--	3.57	--	2400
Uncle Sam Gulch	461904112144401	At mouth	5/24/2004	26	3.6	7.2	--	14	8.48	101	--	--	8.68	--	803
Uncle Sam Gulch	461904112144401	At mouth	7/6/2004	37	1.5	7.5	--	12	15.5	109	--	--	5.91	--	1470
Uncle Sam Gulch	461904112144401	At mouth	7/30/2004	61	0.56	7.4	--	7	28.1	106	--	--	2.57	--	2440
Uncle Sam Gulch	461904112144401	At mouth	8/27/2004	50	0.79	7.5	--	14	21.7	116	--	--	9.31	--	2040
Uncle Sam Gulch	461904112144401	At mouth	9/23/2004	43	1.5	7.8	--	21	21.6	168	--	--	16.9	--	1940
Uncle Sam Gulch	461904112144401	At mouth	11/9/2004	55	0.55	6.3	--	4	18.3	60	--	--	0.99	--	1850
Uncle Sam Gulch	461904112144401	At mouth	5/4/2005	44	1	7.5	--	9	12.5	71.2	--	--	3.9	--	1200
Uncle Sam Gulch	461904112144401	At mouth	5/24/2005	20	7	7.1	--	66	7.17	176	--	--	38.2	--	578
Uncle Sam Gulch	461904112144401	At mouth	7/12/2005	37	1.6	7.8	--	18	13.4	107	--	--	6.47	--	1310
Uncle Sam Gulch	461904112144401	At mouth	8/4/2005	58	0.74	7.7	--	8	21	95.2	--	--	2.48	--	1990
Uncle Sam Gulch	461904112144401	At mouth	9/22/2005	64	0.81	7.3	--	5.5	23.4	80.2	--	--	1.41	--	1950
Uncle Sam Gulch	461904112144401	At mouth	2/10/2006	58	0.51	7.6	--	73.8	25	323	--	--	43.4	--	2090
Uncle Sam Gulch	461904112144401	At mouth	5/17/2006	19	14	7.3	--	239	12.4	378	--	--	145	--	894
Uncle Sam Gulch	461904112144401	At mouth	6/23/2006	29	2.6	7.3	--	13.5	7.64	78.2	--	--	5.37	--	706
Uncle Sam Gulch	461904112144401	At mouth	7/26/2006	58	0.6	7.6	--	11.8	12.5	53.7	--	--	3.06	--	989
Uncle Sam Gulch	461904112144401	At mouth	8/15/2006	60	0.44	7.8	--	8.4	11.5	28.2	--	--	1.79	--	903
Uncle Sam Gulch	461904112144401	At mouth	9/15/2006	72	0.32	7.5	--	7	15.7	33	--	--	1.12	--	1440
Uncle Sam Gulch	461904112144401	At mouth	4/3/2007	52	0.7	7.7	--	8.8	10.6	45.8	--	--	2.49	--	1080
Uncle Sam Gulch	461904112144401	At mouth	5/10/2007	25	4.5	6	--	51.6	7.37	149	--	--	48.1	--	633
Uncle Sam Gulch	461904112144401	At mouth	6/12/2007	23	4.1	7	--	7.6	6.15	75.9	--	--	2.47	--	615
Uncle Sam Gulch	461904112144401	At mouth	7/12/2007	47	0.47	7.4	--	8.6	13.2	52.2	--	--	2.28	--	1190
Uncle Sam Gulch	461904112144401	At mouth	8/31/2007	73	0.23	8	--	6.1	12.4	23.4	--	--	0.53	--	1100

Table D-2. Metal concentrations in sediment and corresponding ratios of measured concentration to metal PEL concentrations recommended for fresh water sediment.

SEGMENT NAME	SITE ID	Sample Date	SiteDescription	As Conc. (ug/kg)	As Conc/ PEL Ratio	Cd Conc. (ug/kg)	Cd Conc/ PEL Ratio	Cu Conc. (ug/kg)	Cu Conc/ PEL Ratio	Pb Conc. (ug/kg)	Pb Conc/ PEL Ratio	Hg Conc. (ug/kg)	Hg Conc/ PEL Ratio	Zn Conc. (ug/kg)	Zn Conc/ PEL Ratio
Basin Cr	BE-07	8/20/09	Basin Cr. D/S of Jack Cr. confluence	1,180,000	69.4	29,100	8.2	874,000	4.4	739,000	8.1	320	0.7	2,960,000	9.4
Basin Cr	BE-08	8/20/09	Basin Cr. U/S of Basin	227,000	13.4	15,700	4.4	279,000	1.4	357,000	3.9	810	1.7	1,770,000	5.6
Basin Cr	BE-06	8/20/09	Basin Cr. D/S of Joe Bowers Cr. confluence	332,000	19.5	4,800	1.4	61,000	0.3	268,000	2.9	280	0.6	580,000	1.8
Basin Cr	BE-04	8/20/09	Basin Cr. D/S of Clear Cr. confluence	384,000	22.6	6,200	1.8	52,000	0.3	316,000	3.5	240	0.5	404,000	1.3
Clear Cr	BE-44	8/20/09	Clear Cr. Near mouth	16,000	0.9	600	0.2	16,000	0.1	37,000	0.4	600	1.2	72,000	0.2
Jack Cr.	M07JACKC03	7/15/10	Jack Creek D/S of Bullion Mine	1,420,000	83.5	22,000	6.2	853,000	4.3	674,000	7.4	140	0.3	1,940,000	6.2
Big Limber Gulch	BE-11	8/24/09	Big Limber Gulch U/S of Waldy /Redwing mine	63,000	3.7	1,400	0.4	43,000	0.2	50,000	0.5	230	0.5	159,000	0.5
Bison Cr	BE-16	8/18/09	headwater tributary of Bison Cr.	54,000	3.2	1,700	0.5	106,000	0.5	36,000	0.4	1,400	0.3	111,000	0.4
Bison Cr	M07BISNC01	8/19/10	Bison Cr headwaters	41,000	2.4	900	0.3	68,000	0.3	--	--	--	--	--	--
Bison Cr	BE-15	8/18/09	Bison Creek mouth	11,000	0.6	500	0.1	33,000	0.2	14,000	0.2	380	0.2	89,000	0.3
Boulder River	BE-28	8/18/09	Upper Boulder River headwaters	14,000	0.8	1,000	0.3	28,000	0.2	22,000	0.2	510	1.0	72,000	0.2
Boulder River	BE-30	8/20/09	Boulder River D/S of Lowland Cr.	16,000	0.9	1,100	0.3	37,000	0.2	30,000	0.3	600	1.2	94,000	0.3
Boulder River	BE-21	8/18/09	Boulder River 1 mile U/S of Basin Cr.	21,000	1.2	1,100	0.3	59,000	0.4	33,000	0.4	1,200	2.5	186,000	0.6
Rocker Cr	BE-72	8/19/09	Rocker Cr. At mouth	200,000	11.8	9,000	2.5	408,000	2.7	179,000	2.0	310	0.6	745,000	2.4
Boulder River	BE-22	8/18/09	Boulder River U/S of Cataract Cr.	70,000	4.1	6,000	1.7	211,000	1.1	136,000	1.5	380	0.8	10,000	0.0
Boulder River	BE-23	8/18/09	Boulder River D/S of Cataract Cr.	104,000	6.1	10,000	2.8	200,000	1.0	167,000	1.8	810	1.7	891,000	2.8
Boulder River	BE-24	8/18/09	Boulder River D/S of High Ore Cr.	147,000	8.6	13,300	3.8	213,000	1.1	206,000	2.3	240	0.5	1,160,000	3.7
Boulder River	BE-26	8/19/09	Boulder River D/S of Little Boulder River	131,000	7.7	9,900	2.8	324,000	1.6	207,000	2.3	420	0.9	1,210,000	3.8
Boulder River	BE-34	8/21/09	Bouler River D/S of Elkhorn Cr.	223,000	13.1	11,600	3.3	550,000	2.8	312,000	3.4	820	1.7	1,430,000	4.5
Boulder River	BE-27	8/21/09	Boulder River at mouth	29,000	1.7	4,300	1.2	147,000	0.7	72,000	0.8	350	0.7	775,000	2.5
Boulder River	BE-33	8/21/09	Boulder River U/S of Golden Sunlight Mine	31,000	1.8	4,500	1.3	168,000	0.9	79,000	0.9	760	1.6	858,000	2.7
Cataract Cr	BE-35	8/19/09	Cataract Cr. U/S of Nellie Grant Cr.	30,000	1.8	32600	9.2	311,000	1.6	167,000	1.8	660	1.4	3,650,000	11.6
Cataract Cr	BE-37	8/19/09	Cataract Cr D/S of Rocker Cr.	104,000	6.1	11,800	3.3	158,000	0.8	97,000	1.1	1,000	2.1	859,000	2.7
Cataract Cr	BE-39	8/19/09	Cataract Cr. D/S Hoodoo Cr.	525,000	30.9	6,900	2.0	229,000	1.2	782,000	8.6	1,700	3.5	866,000	2.7
Cataract Cr	BE-41	8/20/09	Cataract Cr D/S of Morning Glory tailings	1,220,000	71.8	22,200	6.3	712,000	3.6	1,330,000	14.6	950	2.0	2,180,000	6.9
Elkhorn Cr	BE-49	8/21/09	Elkhorn Cr. End of upper segment	69,000	4.1	37,900	10.7	174,000	0.9	1,070,000	11.7	11,000	22.6	3,100,000	9.8
High Ore Cr	BE-53	8/19/09	High Ore Cr. U/S of Comet Mine	19,000	1.1	1,200	0.3	26,000	0.1	48,000	0.5	290	0.6	101,000	0.3
Bishop Cr	BE-14	8/19/09	Bishop Cr. At mouth	47,000	2.8	2,100	0.6	60,000	0.3	119,000	1.3	540	1.1	330,000	1.0
High Ore Cr	BE-57	8/24/09	High Ore Cr. At mouth	1,390,000	81.8	35,800	10.1	286,000	1.5	1,210,000	13.3	490	1.0	8,070,000	25.6
Little Boulder River	BE-60	8/20/09	Little Boulder River at mouth	26,000	1.5	1,000	0.3	42,000	0.2	20,000	0.2	920	1.9	80,000	0.3
Little Boulder River	M07LBLDR01	8/2/10	Little Boulder River D/S of Wilson Cr.	56,000	3.3	1,700	0.5	75,000	0.4	< 170	0.5	--	--	150,000	0.5
Little Boulder River, NF	M07LBNFR04	8/3/10	North Fork Little Boulder River at mouth	15,000	0.9	300	0.1	24,000	0.1	9,000	0.1	< 110	--	48,000	0.2
Lowland Cr	BE-63	8/18/09	Lowland Cr headwaters	58,000	3.4	1,200	0.3	72,000	0.4	38,000	0.4	350	0.4	97,000	0.3
Lowland Cr	BE-63	9/2/10	Lowland Creek at road crossing	71,000	4.2	900	0.3	82,000	0.4	41,000	0.5	81	--	114,000	0.4
Lowland Cr	BE-65	8/18/09	Lowland Cr. At mouth	13,000	0.8	700	0.2	25,000	0.1	20,000	0.2	1,100	1.4	59,000	0.2
Lowland Cr	BE-65	9/28/10	Lowland Creek U/S of mouth	12,000	0.7	400	0.1	29,000	0.2	23,000	0.3	95	0.1	66,000	0.2
Uncle Sam Gulch	97-BMS-108S1	1997	0.5 mile U/S of Crystal Mine	3,9000	2.3	2,000	0.6	36,000	0.2	34,000	0.4	--	--	160,000	0.5
Uncle Sam Gulch	97-BMS-116	1997	0.5 mile D/S of Crystal Mine	3600,000	212	7,000	2	560,000	2.8	1,900,000	21	--	--	920,000	3
Uncle Sam Gulch	97-BMS-134	1997	0.9 mile D/S of Crystal Mine	3,900,000	229	9,000	2.5	220,000	1.1	1,600,000	18	--	--	2,700,000	30
Uncle Sam Gulch	97-BMS-118	1997	0.4 mile U/S of mouth	1,300,000	76	39,000	11	2,300,000	12	920,000	10	--	--	3,800,000	12

APPENDIX E – WATER CHEMISTRY FOR NATURAL BACKGROUND SITES, BOULDER-ELKHORN TPA

This appendix consists of **Table E-1** that contains site information and water chemistry results for monitoring locations representing natural background conditions in the Boulder-Elkhorn TMDL planning area.

Table E-1. Surface Water Quality Data for natural background sites, Boulder-Elkhorn TMDL Planning Area

Waterbody Segment	Site ID	Site Description	Sample Date	Hardness (mg/L)	Flow (cfs)	Field pH (su)	AL (Dis) (µg/L)	As (TR) (µg/L)	Cd (TR) (µg/l)	Cu (TR) (µg/l)	Fe (TR) (mg/L)	Hg (TR) (µg/L)	Pb (TR) (µg/l)	Ag (TR) (µg/l)	Zn (TR) (µg/l)
Basin Creek	BE-01	Headwaters	6/10/2009	18.0	7.72	6.07	--	<3.0	<0.08	2.0	130	< 0.05	< 0.5	< 0.5	10
Basin Creek	BE-01	Headwaters	6/12/2009	--	6.83	7.25	--	--	--	--	--	--	--	--	--
Basin Creek	BE-01	Headwaters	8/20/2009	28.0	1.32	6.4	--	<3.0	<0.08	1.0	50	< 0.05	< 0.5	< 0.5	< 10
Basin Creek	M07BASNC01	Headwaters	7/15/2010	22	0.11	--	50	<3.0	<0.08	2	170	--	< 0.5	< 0.5	< 10
Basin Creek	M07BASNC01	Headwaters	6/6/2010	12	2.1	--	130	<3.0	<0.08	4	220	--	< 0.5	< 0.5	< 10
Basin Creek	BE-01	Headwaters	7/15/2010	22	1.84	--	<30	<3.0	<0.08	2	60	--	< 0.5	< 0.5	< 10
Basin Creek	BE-01	Headwaters	6/6/2010	16	12.2	--	80	<3.0	<0.08	3	270	--	< 0.5	< 0.5	< 10
Big Limber Gulch	BE-11	Headwaters	8/24/2009	61.0	0.03	8	--	4.0	<0.08	1.0	90	< 0.05	< 0.5	< 0.5	10
Big Limber Gulch	BE-11	Headwaters	6/11/2009	24.0	0.218	7	--	<3.0	<0.08	1.0	160	< 0.05	< 0.5	< 0.5	< 10
Big Limber Gulch	BE-11	Headwaters	6/4/2010	40	0.45	--	110	8	0.22	11	2740	--	8.4	< 0.5	40
Big Limber Gulch	BE-11	Headwaters	7/9/2010	45	0.12	--	< 30	<3.0	<0.08	1	140	--	< 0.5	< 0.5	< 10
Bison Cr	BE-16	Headwaters Trib.	6/9/2009	22	7.95	6.3	--	5	<0.08	7	490	< 0.05	< 0.5	< 0.5	< 10
Bison Cr	BE-16	Headwaters Trib.	6/9/2010	23	10.51	--	70	6	<0.08	10	790	--	0.8	< 0.5	< 10
Bison Cr	BE-16	Headwaters Trib.	8/18/2009	28.0	1.87	7.61	--	5.0	<0.08	4.0	320	< 0.05	< 0.5	< 0.5	10
Bison Cr	BE-16	Headwaters Trib.	7/19/2010	30	1.86	--	50	9	0.13	13	2120	--	3.2	< 0.5	10
Bison Cr	BE-16	Headwaters Trib.	8/19/2010	33	1.22	--	< 30	5	<0.08	4	370	--	< 0.5	< 0.5	< 10
Bison Cr	BE-16	Headwaters Trib.	9/30/2010	36	1.03	--	< 30	4	<0.08	3	300	--	< 0.5	< 0.5	< 10

Table E-1. Surface Water Quality Data for natural background sites, Boulder-Elkhorn TMDL Planning Area

Waterbody Segment	Site ID	Site Description	Sample Date	Hardness (mg/L)	Flow (cfs)	Field pH (su)	AL (Dis) (µg/L)	As (TR) (µg/L)	Cd (TR) (µg/l)	Cu (TR) (µg/l)	Fe (TR) (mg/L)	Hg (TR) (µg/L)	Pb (TR) (µg/l)	Ag (TR) (µg/l)	Zn (TR) (µg/l)
Upper Boulder River	Be-28	Headwaters	6/9/2009	34	14.1	6.79	--	4	<0.08	3.0	320	< 0.05	< 0.5	< 0.5	< 10
Upper Boulder River	BE-28	Headwaters	8/18/2009	52	1.98	8.15	--	4	<0.08	1.0	250	< 0.05	< 0.5	< 0.5	< 10
Cataract Cr.	BE-36	D/S Nellie Grant Cr	8/19/2009	27.0	1.49	6.84	--	<3.0	0.15	3.0	210	< 0.05	< 0.5	< 0.5	30
Cataract Cr.	BE-36	D/S Nellie Grant Cr	6/11/09	14.0	14.38	6.46	--	<3.0	0.19	5.0	180	--	< 0.5	--	--
Elkhorn Cr.	M07ELKHC01	U/S of town site	7/3/2010	35	0.1	--	< 30	4	<0.08	< 1	< 50	--	< 0.5	< 0.5	< 10
Elkhorn Cr.	M07ELKHC01	U/S of town site	9/3/2010	25	0	--	< 30	<3.0	<0.08	< 1	< 50	--	< 0.5	< 0.5	< 10
High Ore Cr.	BE-53	U/S of Comet MIne	6/11/09	31.0	--	--	--	--	--	--	--	--	--	--	--
High Ore Cr.	BE-53	U/S of Comet MIne	8/19/09	53.0	--	--	--	--	--	--	--	--	--	--	--
Jack Cr.	M07JACKC02	tributary U/S of Bullion Mine	6/8/2010	12	--	--	140	<3.0	<0.08	3	< 50	--	0.33	< 0.5	< 10
Jack Cr.	M07JACKC02	tributary U/S of Bullion Mine	7/16/2010	20	--	--	60	<3.0	<0.08	2	250	--	< 0.5	< 0.5	< 10
Little Boulder River	M07LBLDR01	D/S of Wilson Cr	6/5/2010	17	167.1	--	110	6	<0.08	8	630		1	< 0.5	< 10
Little Boulder River	M07LBLDR01	D/S of Wilson Cr	8/2/2010	34.0	11.72	8.2	< 30	4	<0.08	3	520	--	1.1	< 0.5	< 10
Little Boulder River	M07LBLDR02	U/S of NF confluence	6/5/2010	21	150.6	--	110	6	0.08	8	680		1	< 0.5	< 10

Table E-1. Surface Water Quality Data for natural background sites, Boulder-Elkhorn TMDL Planning Area

Waterbody Segment	Site ID	Site Description	Sample Date	Hardness (mg/L)	Flow (cfs)	Field pH (su)	AL (Dis) (µg/L)	As (TR) (µg/L)	Cd (TR) (µg/l)	Cu (TR) (µg/l)	Fe (TR) (mg/L)	Hg (TR) (µg/L)	Pb (TR) (µg/l)	Ag (TR) (µg/l)	Zn (TR) (µg/l)
Little Boulder River	M07LBLDR02	U/S of NF confluence	6/10/2009	25.0	68.79	7.2	--	4	<0.08	6	620	< 0.05	7	< 0.5	< 10
Little Boulder River	M07LBLDR02	U/S of NF confluence	8/20/2009	43.0	11.88	7.6	--	<3.0	<0.08	2	240	< 0.05	< 0.5	< 0.5	10
Little Boulder River	M07LBLDR02	U/S of NF confluence	8/2/2010	42	16.53	8.2	<30	3	<0.08	3	400	--	< 0.5	< 0.5	< 10
Lowland Cr.	M07LOWLC03	Headwater Trib.	6/9/2010	23	2.81	--	130	4	<0.08	4	380	--	< 0.5	< 0.5	< 10
Lowland Cr.	BE-63	Headwaters	6/9/2009	26	1.64	6.5	110	5.0	<0.08	8	250	< 0.05	< 0.5	< 0.1	< 10
Lowland Cr.	BE-63	Headwaters	8/18/2009	51	0.18	8.1	30	7.0	<0.08	5	280	< 0.05	< 0.5	< 0.1	< 10
Lowland Cr.	BE-63	Headwaters	7/18/2010	42	0.28	--	50	7	<0.08	5	310	--	< 0.5	< 0.5	< 10
Lowland Cr.	BE-63	Headwaters	9/28/2010	57	0.1	--	<30	5	<0.08	2	180	--	< 0.5	< 0.5	< 10
Muskrat Cr.	M07MSKRC01	Headwaters	6/3/2010	15	20.98	--	70	<3.0	<0.08	2		--	< 0.5	< 0.5	< 10
Muskrat Cr.	M07MSKRC01	Headwaters	7/5/2010	19	13.16	--	30	<3.0	<0.08	1	90	--	< 0.5	< 0.5	< 10
Muskrat Cr.	M07MSKRC01	Headwaters	8/6/2010		2.96	8.1	--	--	--	--	--	--	--	--	--
Muskrat Cr.	M07MSKRC01	Headwaters	9/9/2010		2.7	8	--	--	--	--	--	--	--	--	--
Muskrat Cr.	M07MSKRC02	U/S of Nursery Cr.	6/3/2010	23	18.59	--	50	<3.0	<0.08	2	340	--	< 0.5	< 0.5	< 10
Muskrat Cr.	M07MSKRC02	U/S of Nursery Cr.	7/5/2010	26	16.76	--	<30	<3.0	<0.08	1	170	--	< 0.5	< 0.5	< 10
Muskrat Cr.	M07MSKRC02	U/S of Nursery Cr.	8/6/2010	--	8.13	8.5	--	--	--	--	--	--	--	--	--
Muskrat Cr.	M07MSKRC02	U/S of Nursery Cr.	9/9/2010	--	6.04	8	--	--	--	--	--	--	--	--	--
North Fork Little Boulder River	M07LBNFR02	1/2 mi D/S of Porcupine Gulch	6/16/2004	33	--	--	<100	<3.0	< 0.1	4.9	320	--	< 0.5	<3.0	< 10

Table E-1. Surface Water Quality Data for natural background sites, Boulder-Elkhorn TMDL Planning Area

Waterbody Segment	Site ID	Site Description	Sample Date	Hardness (mg/L)	Flow (cfs)	Field pH (su)	AL (Dis) (µg/L)	As (TR) (µg/L)	Cd (TR) (µg/l)	Cu (TR) (µg/l)	Fe (TR) (mg/L)	Hg (TR) (µg/L)	Pb (TR) (µg/l)	Ag (TR) (µg/l)	Zn (TR) (µg/l)
North Fork Little Boulder River	M07LBNFR02	1/2 mi D/S of Porcupine Gulch	6/16/2004	--	2.87	6.9	--	--	--	--	--	--	--	--	--
North Fork Little Boulder River	M07LBNFR02	1/2 mi D/S of Porcupine Gulch	6/5/2010	24	31.93	--	90	6	<0.08	3.8	900	--	0.6	< 0.5	< 10
North Fork Little Boulder River	M07LBNFR02	1/2 mi D/S of Porcupine Gulch	7/4/2010	27	20.68	--	80	4	<0.08	4.1	700	--	< 0.5	< 0.5	< 10
North Fork Little Boulder River	M07LBNFR02	1/2 mi D/S of Porcupine Gulch	8/4/2010	36	6.07	--	< 30	<3.0	<0.08	5.3	420	--	< 0.5	< 0.5	< 10
North Fork Little Boulder River	M07LBNFR02	1/2 mi D/S of Porcupine Gulch	9/8/2010	--	4.34	8	--	--	--	--	--	--	--	--	--
Uncle Sam Gulch	BE-74	U/S of Crystal Mine	8/21/2009	15.0	0.065	7.28	--	6.0	<0.08	2.0	160	< 0.05	< 0.5	< 0.5	10
Uncle Sam Gulch	BE-74	U/S of Crystal Mine	6/11/2009	6.0	1.03	4.28	--	<3.0	<0.08	2.0	110	< 0.05	< 0.5	< 0.5	< 10
Uncle Sam Gulch	M07UCLSG01	U/S of Crystal Mine	6/4/2010	13	0.28	--	50	<3.0	<0.08	2	80	--	< 0.5	< 0.5	< 10
Uncle Sam Gulch	M07UCLSG01	U/S of Crystal Mine	7/12/2010	19.0	0.03	--	< 30	<3.0	<0.08	< 1	< 50	--	< 0.5	< 0.5	< 10

APPENDIX F – SOURCE ASSESSMENT AND TARGET DEPARTURE ANALYSIS

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ACRONYMS

Acronym	**Definition**
AAL	acute aquatic life
CAL	chronic aquatic life
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DEQ	Department of Environmental Quality (Montana)
EE/CA	Engineering Evaluation/Cost Analysis
EPA	Environmental Protection Agency (US)
HH	human health
LAD	land application disposal
MBMG	Montana Bureau of Mines and Geology
MGWPCS	Montana Ground Water Pollution Control System
MPDES	Montana Pollutant Discharge Elimination System
PELS	probable effects levels
TMDL	Total Maximum Daily Load
TPA	Trading Partner Agreement
USGS	United States Geological Survey
WWTP	Wastewater Treatment Plant

F1.0 INTRODUCTION

This appendix summarizes the difference between water quality and stream sediment data from impaired streams and water quality and steam sediment targets for metals (**Section 5.4**). The water quality targets are the numeric criteria for chronic aquatic life (CAL), acute aquatic life (AAL) and human health (HH), contained in DEQ-7 (Montana Department of Environmental Quality, 2010) for metal parameters. The numeric probable effects levels (PELs) for metals in fresh water stream sediment are supplemental indicators of metals impairment (**Table 5-4**). Loading sources are described for each stream segment and watershed maps are included to show the stream extent, the locations of monitoring sites, and locations of potential metals sources.

The differences between numeric targets and metal concentrations measured in stream samples are interpreted to determine whether water uses are impaired. The target departures and impairment determinations are summarized in a table for each stream segment. Regardless of the current 303(d) listing status, the departure analysis is based on data for a core list of nine metals parameters: aluminum, arsenic, cadmium, copper, iron, lead, mercury, silver, and zinc. The departure analysis for hardness-dependent metals includes only results with corresponding hardness values. The number and timing of available water quality analyses vary by stream. The raw data used in the departure analysis is contained in **Appendix D**.

Metal mining has probably affected nearly all streams in the planning area to some degree. However, a number of sites on selected stream segments are remote enough from mining and other human sources to represent the natural background metals loading condition. Water quality from these sites is assumed to have minimal influence from mining and other human-caused sources. The analytical results from these “background” sites are used to quantify background loading and estimate the magnitude of human-caused sources.

F2.0 SOURCE ASSESSMENT AND TARGET DEPARTURES BY STREAM

Departures from target values are summarized below for 17 stream segments in the Boulder-Elkhorn TPA. Each of the following sections describes the metals loading sources, the current condition data set, and the metals target departures for a single stream segment. The need for TMDLs is based on the outcomes for several data-related and source-related decision factors. These factors, explained in **Section 5.4.3**, are column headings in each of the target departure tables presented below. TMDL conclusions for each metal parameter are drawn from the entries in the tables for each factor. An entry of “NA” indicates a factor for a specific metal does not apply. Since there is no human health criterion for aluminum, an “NA” is entered in the corresponding cell in each table.

The streams are discussed in order of importance to metals loading in the planning area and location in the Boulder River watershed. The target departures for stream segments in Basin, Cataract, and High Ore creeks are described first since these drainages contribute the most significant metals loads. The remaining segments are discussed in upstream to downstream order. The relationship between sources and target departures is clearer when the sections of this appendix are reviewed with the corresponding, segment-specific discussions in **Section 5.7** of the main document.

F2.1 BASIN CREEK (MT41E002_030)

Basin Creek is listed as impaired in the 2012 Integrated Report (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2010) for arsenic, copper, lead, mercury, and zinc. The stream extends for 16.7 miles from its headwaters at the Continental Divide to its confluence with the Boulder River near the town of Basin. **Figure F-1** shows the Basin Creek watershed, recent sample sites, and locations of mine-related sources.

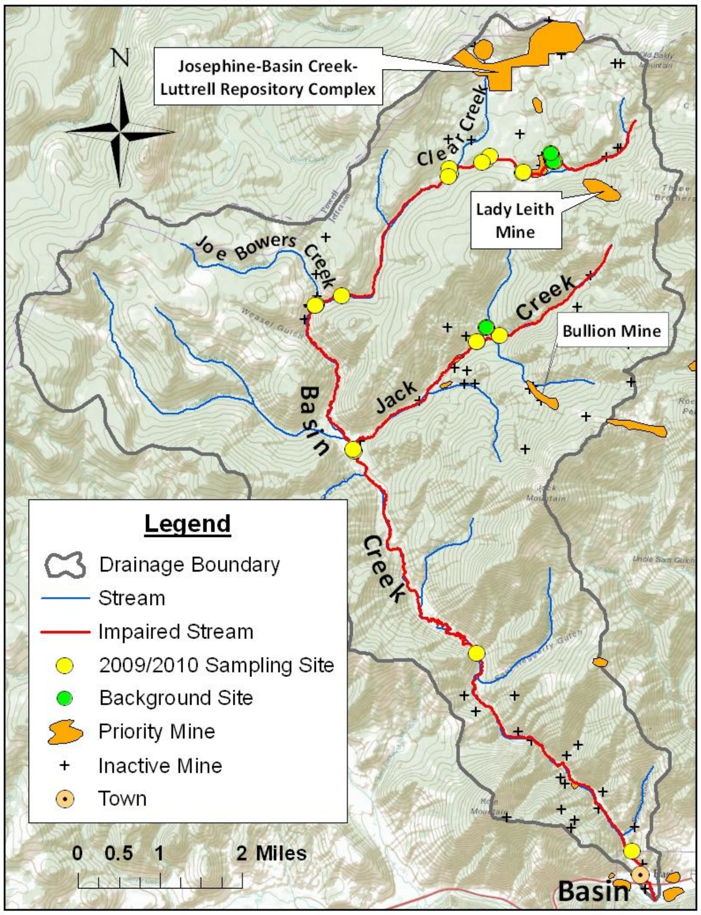

Figure F-1. The Basin Creek watershed, monitoring sites, and mining sources

Water quality data and loading from Jack Creek is assessed separately. Jack Creek is the largest sub-basin in the watershed and contains the Bullion Mine, a significant metals loading source to Basin Creek.

F2.1.1 Basin Creek Sources

The MBMG database lists 59 inactive and abandoned mines in the Basin Creek watershed. Placer mining that began in the 1860s was followed by lode mining of mostly vein deposits. Historic placer mining sources include the abandoned seven-acre Perry Park dredge operation along the headwater tributary of Grub Gulch. Historic placer operations occurred on nearly the entire length of Basin Creek.

The Josephine was a lode deposit developed for gold, silver, and lead production. The Josephine site includes an acidic adit discharge to Clear Creek and 21,000 cubic yards (yd^3) of wasterock in several dumps, with some located on the Clear Creek floodplain. Adit discharge data from a 1993 site inventory reported a pH of 4.2 and elevated concentrations of cadmium, copper, lead, and zinc. The Josephine-Basin Creek complex straddles the Continental Divide. In the Basin Creek watershed, the site disturbs approximately 250 acres.

The Clear Creek and Grub Gulch headwater tributaries of Basin Creek contain all or portions of 7 abandoned mine properties inventoried by the Montana Bureau of Mines and Geology (Montana Bureau of Mines and Geology, 1997). The largest mine disturbance in the drainage is that associated with the Josephine-Basin Creek complex located along the Continental Divide. The Basin Creek Mine was most recently a cyanide heap leach mine operated by the Pegasus Gold Corporation from 1989 to 1996. What remains of the open pit after the bankruptcy of Pegasus Gold is now the Luttrell Repository owned by Montana Department of Environmental Quality. The State of Montana, in partnership with the US Forest Service and the Environmental Protection Agency, are cooperating in the remediation of the site as part of the Upper Tenmile Creek Mining Area Site. Remediation is ongoing under authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The CERCLA process has produced a Record of Decision for remediation of the Tenmile Creek Mining Area (Geotechnical Services Technical Service Center, Bureau of Reclamation, 2002). The portion of the Tenmile Creek Mining Site that occurs in the Basin Creek drainage includes a portion of the mine waste repository, two reclaimed leach pads, a borrow area disturbance, and associated access roads and runoff retention ponds. Precipitation leachate from the repository is collected in two dedicated containment ponds and pumped to an 18-acre land application disposal (LAD) area located near the repository. The application rate is approximately 10 gallons per minute. Environmental monitoring includes soil sampling within the LAD area and seasonal surface water monitoring in Grub Gulch and Clear Creek tributaries. The monitoring has recorded elevated cadmium, copper, lead, and zinc. Revisions to the monitoring plan are being considered to isolated potential contributions from the LAD from those of other mining sources in the area.

Upstream of the Clear Creek and Grub Gulch tributaries, the combined Buckeye and Enterprise mines disturb about 20 acres on the north bank of Basin Creek. The sites contain about 28,000 yd^3s of wasterock and 21,000 yd^3s of mill tailings. An acidic (pH = 2.9) adit discharge from the Enterprise Mine enters Basin Creek near the downstream edge of the site. Two miles farther upstream, an unnamed Basin Creek tributary contains the former Lady Leith lead and zinc mine. The Lady Leith has two adit discharges that contain elevated concentrations of arsenic, cadmium, copper, lead, and zinc.

Several inactive mines occur near the mouth of Joe Bowers Creek, located about three miles downstream of the Clear Creek confluence. These include small, hillside prospects, a quarry, and former placer operations in lower Joe Bowers Creek. Water quality data are not available from these properties.

Except for sources in Jack Creek, Basin Creek is relatively undisturbed for about six miles below the mouth of Joe Bowers Creek. From the mouth of Basin Creek to about three miles upstream, there are 19 named inactive mines in the Basin Creek drainage. These are mostly small hillside disturbances associated with lode ore deposits and one placer deposit. The Doris Mine is the only priority ranked mine because of a 5000 yd^3 waste rock dump adjacent to and eroding into the Basin Creek channel.

The Basin Creek assessment dataset for water quality includes 98 records from 11 monitoring locations (**Figure F-1**). Water samples were collected during high and low flow conditions from 2001 through 2010. Nine of the sites were established by DEQ monitoring and assessment efforts; two Basin Creek sites, one below the mouth of Jack Creek and one within the town of Basin were established by the

USGS. Four sediment chemistry samples were collected by DEQ from Basin Creek assessment sites during low flows in 2009.

F2.1.2 Basin Creek Target Departures

Surface water column chemistry results are compared with Circular DEQ 7 numeric criteria for human health (HH), acute aquatic life (AAL), and chronic aquatic life (CAL). The water quality and sediment chemistry data are assessed against TMDL decision factors for metals. **Table F-1** summarizes the results of the target departure analysis in terms of critical TMDL decision factors. The far right column in **Table F-1** specifies a TMDL development conclusion for each metal parameter.

Table F-1. Basin Creek TMDL Decision Factors and TMDL Conclusion

Pollutant Parameter	Sample Size	CAL Exceedance Rate >10%*	Results Twice the AAL Criterion	Human Health Criterion exceeded	Sediment PEL Exceeded	Human-Caused Sources Present	2012 Listing Status	TMDL Decision
Aluminum	17	Y	N	NA	NA	Y	Not Listed	Al TMDL
Arsenic	60	N	N	Y	Y	Y	Listed	As TMDL
Cadmium	94	Y	N	N	Y	Y	Not Listed	Cd TMDL
Copper	93	Y	Y	N	Y	Y	Listed	Cu TMDL
Iron	35	N	NA	NA	NA	Y	Not Listed	No TMDL
Lead	94	Y	N	N	Y	Y	Listed	Pb TMDL
Mercury	18	N	N	N	Y	Y	Listed	No TMDL
Silver	38	N	N	N	NA	Y	Not Listed	No TMDL
Zinc	94	Y	Y	N	Y	Y	Listed	Zn TMDL

* AAL is used for Silver since Silver does not have a CAL

The 10 percent CAL exceedance threshold was exceeded for aluminum, cadmium, copper, lead, and zinc. Although less than 10 percent of the arsenic results exceeded the CAL criterion, seven samples exceeded the 10 µg/L HH criterion. Although there are documented or conceivable human caused sources present, there were no water column target exceedances for iron, mercury, or silver.

Table F-2 summarizes the sediment chemistry data as the ratios of the metal concentrations measured in sediment samples, to the PEL concentration recommended of metals parameters in stream sediment. For example, the value of 22.6 for arsenic at site BE-04 is obtained by dividing the measured arsenic value of 384,000 micrograms per kilogram (µg/kg) by the arsenic PEL of 17,000 µg/kg (384000 µg/kg/ 17,000 µg/kg = 22.6). Sediment chemistry data are given by stream segment in **Appendix D**.

For values less than one, the measured metal concentration in the sediment sample is less than the supplemental indicator PEL. The monitoring site identification numbers, site locations, and sediment metals ratios are arranged in upstream to downstream order in **Table F-2**.

Table F-2. Ratios of measured sediment metals concentrations to PELs for sediment samples from Basin Creek.

SITE ID	Site Location	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc
BE-44	Clear Creek at Mouth	0.9	0.2	0.1	0.4	1.2	0.2
BE-04	Basin Creek Below Clear Creek	22.6	1.8	0.3	3.5	0.5	1.3
BE-06	Basin Creek Below Joe Bowers Creek	19.5	1.4	0.3	2.9	0.6	1.8
BE-07	Basin Creek Below Jack Creek	69.4	8.2	4.4	8.1	0.7	9.4
BE-08	Basin Creek at Basin	13.4	4.4	1.4	3.9	1.7	5.6

Site BE-44 is located at the mouth of Clear Creek, a headwater tributary of Basin Creek that drains the western extent of the Josephine-Basin Creek abandoned mine site. Except for mercury, all ratios for site BE-44 are less than 1.0. Thus, Clear Creek does not appear to be a significant sediment metals loading source to Basin Creek. By contrast, site BE-04, located on Basin Creek about 100 feet below the Clear Creek mouth, has high sediment concentrations of arsenic, cadmium, and lead. The ratios at this site indicate large upstream sources of sediment-bound metals. **Table F-2** also indicates that Jack Creek is a major source of sediment laden arsenic, cadmium, copper, lead, and zinc.

F2.1.3 Basin Creek TMDL Summary

The listing status and TMDL conclusions for metals in Basin Creek are summarized in **Table F-3.**

Table F-3. Metals listing status and TMDL conclusions for Basin Creek

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	New Listing	Y
Arsenic	Current Listing	Y
Cadmium	New Listing	Y
Copper	Current Listing	Y
Iron	Not a Cause	N
Lead	Current Listing	Y
Silver	Not a Cause	N
Zinc	Current Listing	Y
Mercury	Current Listing	N
Number of TMDLs Required		6

F2.2 Jack Creek (MT41E003_010)

Jack Creek is a second order tributary of Basin Creek. The Jack Creek drainage area is approximately 8.6 square miles and comprises 21 percent of the Basin Creek watershed. Jack Creek does not appear on the 2012 Integrated Report (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2010) since impairment determinations were not completed prior to publication of the document. The stream extends for 4.3 miles from its headwaters mouth on Basin Creek. **Figure F-2** shows the Jack Creek watershed, recent sample sites, and locations of mine-related sources.

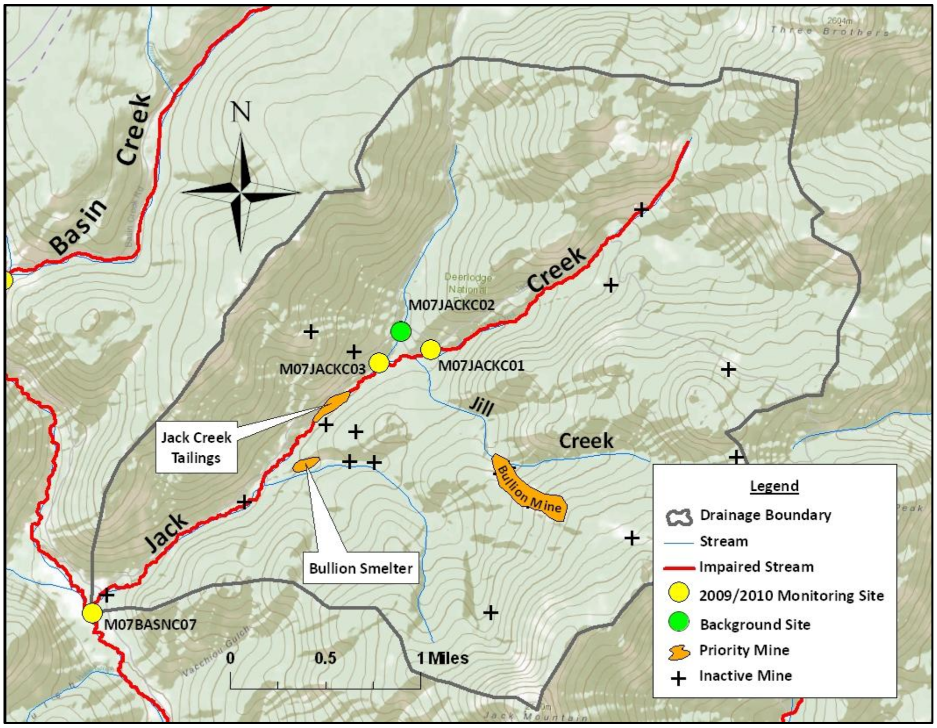

Figure F-2. Jack Creek watershed, monitoring sites, and mining sources

F2.2.1 Jack Creek Sources

The MBMG database lists 17 inactive mines in the Jack Creek watershed. The largest mine disturbances in the drainage are those associated with the priority ranked Bullion Mine located on a steep, northwest facing slope adjacent to the Jill Creek tributary of Jack Creek about five miles north of Basin. The gold and silver mine was first active during the 1890s, but production continued from 1905 to 1955 with construction a floatation concentrator and smelter. Approximately 40 acres are disturbed within Bullion Mine that includes three adits (two discharging), about 42,000 yd^3s of waste rock, two open pits, mine structures, roadways, and a mill with two breached tailings impoundments adjacent to Jill Creek. The smelter was constructed in an adjacent unnamed tributary about a mile west of the mine.

The Bullion Mine has been the focus of several studies that began with a site inventory and water quality sampling by MBMG and USGS in 1992. The adit discharges from the mine contain elevated concentrations of cadmium, copper, iron, lead, manganese, mercury, and zinc that could be traced downstream to Jill Creek, Jack Creek, and Basin Creek. Maxim Technologies, Inc. conducted a focused assessment of mill site tailings adjacent to Jill Creek in 1999. The tailings contained elevated metals concentrations and ranged in depth from one to nine feet. The study led to a joint Deerlodge National Forest-EPA remediation in 2001 that removed 27,000 yd^3s of tailings from the Jill Creek area and 700 yd^3s of tailings from the Bullion smelter site. Removed wastes were placed in the Luttrell Repository. After the tailings removal, the surface was re-contoured, soils amended with lime and compost, and the area reseeded and planted with trees. Staff and students of Montana State University conducted follow-up monitoring in 2003 and 2004. The study documented improvements in water quality in Jill Creek, as well as upward migration of acidic conditions into reclamation cover soils. In 2009, a draft Engineering Evaluation/Cost Analysis (EE/CA) was prepared for the Bullion Mine to evaluate non-time-critical removal action alternatives. EPA is pursuing a focused investigation and feasibility study of the site before scoring selecting among the alternatives.

In addition to the Bullion Mine and Bullion Smelter sites, the Jack Creek Tailings site is a third priority abandoned mine site in the watershed. The site is an accumulation of 27,000 yd^3s of tailings that straddle the Jack Creek channel about one half mile downstream of the Jill Creek confluence. The tailings contain elevated metal concentrations. Sampling of Jack Creek surface water above and below the deposit in 1993 documented an increased lead concentration.

F2.2.2 Jack Creek Target Departures

Table F-4 summarizes the results of the target departure analysis in terms of TMDL decision factors. Since Jack Creek is a newly established assessment unit, the listing status in 2012 does not apply. Jack Creek will first appear in the 2014 Integrated Report for Montana. The far right column in **Table F-4** specifies a TMDL development conclusion based on the decision factors for each of nine metal parameters.

Table F-4. Jack Creek TMDL Decision Factors and TMDL Conclusion

Pollutant Parameter	Sample Size	CAL Exceedance Rate > 10%*	Results Twice the AAL Criterion	Human Health Criterion exceeded	Sediment PEL Exceeded	Human-Caused Sources Present	2012 303(d) Listing Status	TMDL Decision
Aluminum	8	Y	N	NA	NA	Y	NA	Al TMDL
Arsenic	58	N	N	Y	NA	Y	NA	As TMDL
Cadmium	66	Y	Y	N	NA	Y	NA	Cd TMDL
Copper	66	Y	Y	N	NA	Y	NA	Cu TMDL
Iron	10	N	NA	NA	NA	Y	NA	Fe TMDL
Lead	66	Y	N	Y	NA	Y	NA	Pb TMDL
Mercury	2	N	N	N	NA	Y	NA	No TMDL
Silver	8	N	N	N	NA	Y	NA	No TMDL
Zinc	66	Y	Y	N	NA	Y	NA	Zn TMDL

* AAL is used for Silver since Silver does not have a CAL

The 10 percent CAL exceedance threshold was exceeded for aluminum, cadmium, copper, lead, and zinc. Thirteen samples exceeded the 10 µg/L HH criterion for arsenic. Among 10 results for iron, a sample from near the mouth of Jack Creek contained 2,500 µg/L. Low flow samples collected downstream of Jill Creek in 2009 and 2010 contained 940 and 970 µg/L respectively. Although within the CAL exceedance threshold, the two recent values near the 1,000 µg/L CAL target, the magnitude of the one exceedance which was more than double the CAL, and the magnitude of mining sources support an iron listing for Jack Creek. Although there are human caused sources present, there were no water column target exceedances for mercury or silver.

There are no recent stream sediment chemistry data available for Jack Creek. However, sediment samples collected in a 1993 site inventory (Montana Department of State Lands, 1995) of the Jack Creek Tailing site exceeded the PEL criteria for arsenic, cadmium, copper, lead, and zinc.

F2.2.3 Jack Creek TMDL Summary

The listing status and TMDL conclusions for metals in Jack Creek are summarized in **Table F-5.** TMDLs are required in Jack Creek for aluminum, arsenic, cadmium, copper, iron, lead, and zinc.

Table F-5. Metals listing status and TMDL conclusions for Jack Creek

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	New Listing	Y
Arsenic	New Listing	Y
Cadmium	New Listing	Y
Copper	New Listing	Y
Iron	New Listing	Y
Lead	New Listing	Y
Silver	Not a Cause	N
Mercury	Not a Cause	N
Zinc	New Listing	Y
Number of TMDLs Required		7

F2.3 Cataract Creek (MT41E002_020)

Cataract Creek is listed as impaired in the 2012 Integrated Report (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2010) for arsenic, cadmium, copper, lead, mercury, and zinc. The stream extends for 11.7 miles from its headwaters at the Continental Divide to its confluence with the Boulder River one mile east of the town of Basin. **Figure F-3** shows the Cataract Creek watershed, recent sample sites, and locations of mine-related sources. Big Limber Gulch and Uncle Sam Gulch are separate assessment units with discussions of target departures in subsequent sections.

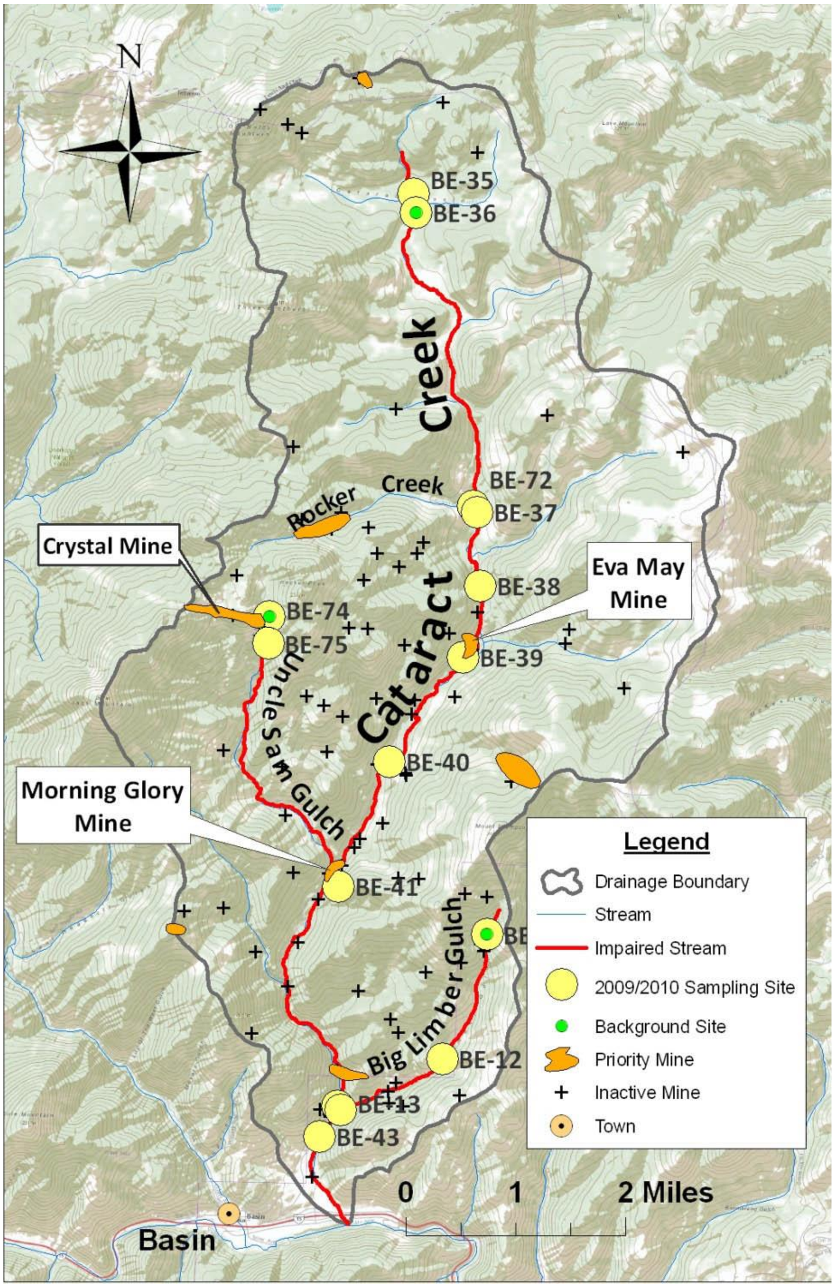

Figure F-3. Cataract Creek watershed, monitoring sites, and mining sources

F2.3.1 Cataract Creek Sources

The mining history of Cataract Creek is similar to that of Basin Creek. Placer mining during the 1860s gave way to lode mining that occurred from the 1880s to early 1960s. The MBMG inventory of abandoned mines lists 90 properties in the Cataract Creek watershed. Significant lode mines include the Eva May, Morning Glory, and Uncle Sam mines. The Eva May Mine, located at the confluence of Cataract Creek and Hoodoo Creek, operated a gravity concentrator which also received ore from the Bullion Mine in Jack Creek. The mine area contains approximately 92,000 yd^3s of waste rock and 11,000 yd^3s of mill tailings adjacent to the Cataract Creek channel. The Morning Glory Mine, located on the east side of Cataract Creek opposite the mouth of Uncle Sam Gulch, was a consistent small producer from 1900 to the late 1950s, producing 19,000 tons of gold and silver ore. The site contains 29,000 yd^3s of waste rock and 7,200 yd^3s of floatation mill tailings adjacent to the Cataract Creek channel (Montana Department of State Lands, 1995).

The Eva May and Morning Glory mines are among eight priority ranked mines in the Cataract Creek watershed. Others include the Crescent-Alsace property at the Continental Divide, the Rocker-Ada complex in Rocker Creek, the Crystal Mine in Uncle Sam Gulch, the Boulder Chief on the divide between Cataract and High Ore creeks, the Marguerite Mine on the divide between Cataract and Basin creeks, and the Mantle East Mine on Cataract Creek above the mouth of Big Limber Gulch. All except the Mantle East have exposed waste rock, mill tailings, and adits discharging to surface water.

A general discharge permit for operation of a portable suction dredge (permit number MTG370320) has been issued to a private entity on Snowdrift Creek. Snowdrift Creek enters Cataract Creek from the east about one half mile downstream of monitoring site BE-37. The permit grants a general mixing zone that extends for a distance of 10 stream widths downstream of the dredge location. The effluent limit that applies to seasonal dredge operations is no visible increase in stream turbidity at the downstream edge of the mixing zone.

F2.3.2 Cataract Creek Target Departures

The recent water quality dataset for Cataract Creek contains 84 records from 12 monitoring sites. DEQ established 10 sites on Cataract Creek for monitoring during 2009 and 2010. Two Cataract Creek sites are established by the USGS above the mouth of Uncle Sam Gulch and at the mouth of Cataract Creek. **Table F-6** summarizes the target departure analysis for Cataract Creek.

Table F-6. Cataract Creek TMDL Decision Factors and TMDL Conclusion

Pollutant Parameter	Sample Size	CAL Exceedance Rate > 10%	Results Twice the AAL Criterion	Human Health Criterion exceeded	Sediment PEL Exceeded	Human-Caused Sources Present	2012 303(d) Listing Status	TMDL Decision
Aluminum	8	Y	N	NA	NA	Y	Not Listed	Al TMDL
Arsenic	77	N	N	Y	Y	Y	Listed	As TMDL
Cadmium	77	Y	Y	N	Y	Y	Listed	Cd TMDL
Copper	77	Y	Y	N	Y	Y	Listed	Cu TMDL
Iron	24	N	NA	NA	NA	Y	Not Listed	No TMDL
Lead	77	Y	N	Y	Y	Y	Listed	Pb TMDL
Mercury	15	N	N	N	Y	Y	Listed	No TMDL
Silver	22	N	N	N	NA	Y	Not Listed	No TMDL
Zinc	77	Y	Y	N	Y	Y	Listed	Zn TMDL

* AAL is used for Silver since Silver does not have a CAL

The 10 percent CAL exceedance threshold was exceeded for aluminum, cadmium, copper, lead, and zinc. Eight samples exceeded the 10 µg/L HH criterion for arsenic. There were no target exceedances among 24 results for iron. Water quality data for mercury and silver do not indicate the need for TMDLs

The sediment chemistry data are from four samples collected from Cataract Creek in 2009. **Table F-7** summarizes the sediment chemistry data as the ratio of the measured metal concentration over the PEL concentration (**Table 5-4**). The sampling sites (**Figure F-3**) are distributed along seven stream miles from the headwaters to below the Morning Glory Mine site. The sediment metals concentration data are in **Appendix D**.

Table F-7. Ratios of measured sediment metals concentrations to PELs for sediment samples from Cataract Creek.

SITE ID	Site Location	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc
BE-35	Headwaters	2	9	2	2	1	12
BE-37	Below Rocker Creek	6	3	1	1	2	3
BE-39	Below Eva May mine.	31	2	1	9	3	3
BE-41	Below Morning Glory mine	72	6	4	15	2	7

Site BE-35 is downstream of the priority ranked Crescent and Ida May mines that produced lead and zinc ores. Site BE-37 is downstream of Rocker Creek sources that include the priority ranked Rocker-Ada mine with wasterock high in arsenic, lead, and mercury. Site BE-37 is also downstream of the Cataract Placer mine, a potential mercury source. The sample from site BE-39 probably contains tailings from the Eva May mine immediately upstream. Site BE-41 is below the Morning Glory tailings deposit that contains high concentrations of arsenic, lead and zinc.

F2.3.3 Cataract Creek TMDL Summary

The listing status and TMDL conclusions for metals in Cataract Creek are summarized in **Table F-8.** TMDLs are required aluminum, arsenic, cadmium, copper, lead, and zinc.

Table F-8. Metals listing status and TMDL conclusions for Cataract Creek

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	Not Listed	Y
Arsenic	Current Listing	Y
Cadmium	Current Listing	Y
Copper	Current Listing	Y
Iron	Not Listed	N
Lead	Current Listing	Y
Silver	Not Listed	N
Zinc	Current Listing	Y
Mercury	Not a Cause	N
Number of TMDLs Required		6

F2.4 Uncle Sam Gulch (MT41E002_010)

Uncle Sam Gulch Creek is listed as impaired in the 2012 Integrated Report (Montana Department of Environmental Quality, 2012) for arsenic, cadmium, copper, lead, and zinc. The stream extends for three miles from its headwaters to its mouth on Cataract Creek. The watershed area is 3.2 square miles. **Figure F-4** shows the Uncle Sam Gulch watershed, recent sample sites, and locations of mine-related sources.

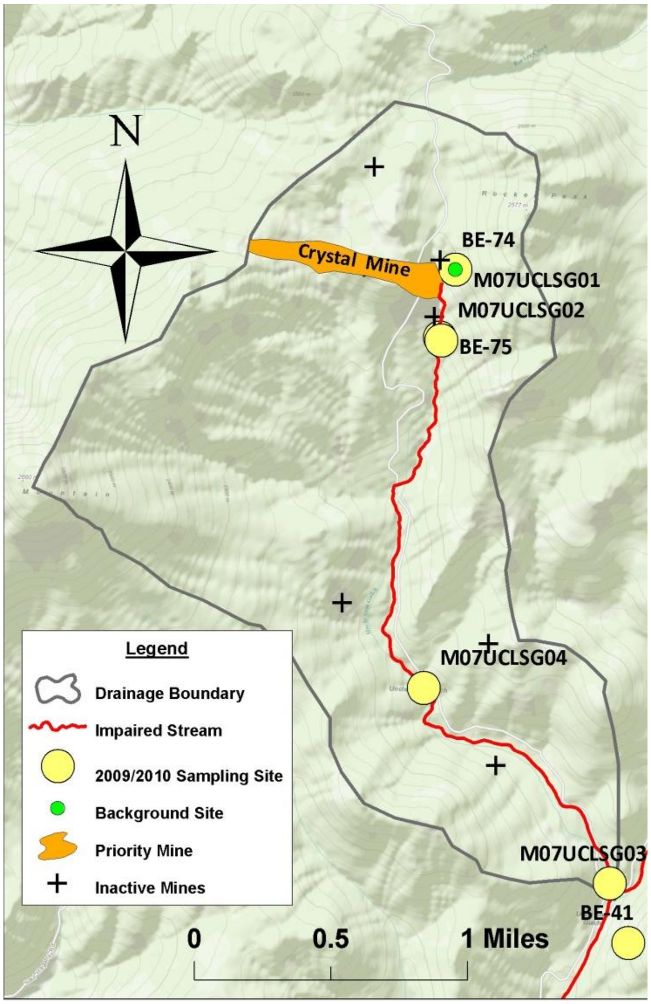

Figure F-4. The Uncle Sam Gulch watershed, monitoring sites and mining sources.

F2.4.1 Uncle Sam Gulch Sources

The MBMG database lists eight inactive mines in the Uncle Sam Gulch drainage. The most significant source is the Crystal Mine near the northern edge of the basin. The mine development is centered on a 50-foot wide mineralized band of quartz and sulfide minerals. The mine site covers approximately 22 disturbed acres that include an east-west trending trench oriented parallel to the mineralized zone.

The east end of the trench descends steeply to the Uncle Sam Gulch drainage channel over an extensive waste rock dump. A collapsed adit is near the top of the dump and a second, discharging adit is near it's the base. The site also contains several other waste rock piles, ore bins, ore chutes, mine buildings, and two lined settling ponds built near the lower adit. The U. S. Forest Service, USGS, and MBMG concluded from sampling in 1991 and 1992 that the Crystal Mine is the major source of water quality degradation in Uncle Sam Gulch. The mine was included in an inventory of abandoned mines in 1993. The ponds are part of a 1994 adit discharge treatment study by MSE Inc. (MSE Technology Applications, Inc., 1998). Effluent draining from the lower adit was piped to a quicklime injection system and primary settling ponds before being discharged into Uncle Sam Gulch. The effluent consistently exceeded human health and aquatic life criteria, often by several orders of magnitude. In 2001 the EPA conducted surface contouring and liner placement at the Crystal Mine to reduce snow melt and rainfall infiltration into a trenched area created by surface mining. Precipitation runoff into the trench recharged the underground mine workings and increased the discharge from the lower adit. The reclamation helped reduce the adit discharge rate (Geotechnical Services Technical Service Center, Bureau of Reclamation, 2002).

Information reported on other mines in Uncle Sam Gulch includes accounts of un-vegetated disturbances of various sizes. The Uncle Sam Mine is located on the west side of the drainage about one half mile upstream from Cataract Creek. The Mine was mistakenly reported to have a discharging adit is actually a spring unrelated to the mine.

F2.4.2 Uncle Sam Gulch Target Departures

The recent water quality dataset for Uncle Sam Gulch contains 46 records from six monitoring sites. DEQ established 5 sites on Uncle Sam Gulch for monitoring during 2009 and 2010. One site is established by the USGS at the mouth of Uncle Sam Gulch. **Table F-9** summarizes the target departure analysis for Uncle Sam Gulch.

Table F-9. Uncle Sam Gulch TMDL Decision Factors and TMDL Conclusion

Pollutant Parameter	Sample Size	CAL Exceedance Rate > 10%	Results Twice the AAL Criterion	Human Health Criterion exceeded	Sediment PEL Exceeded	Human-Caused Sources Present	2012 303(d) Listing Status	TMDL Decision
Aluminum	8	Y	N	NA	NA	Y	Not Listed	Al TMDL
Arsenic	42	N	N	Y	Y	Y	Listed	As TMDL
Cadmium	42	Y	Y	Y	Y	Y	Listed	Cd TMDL
Copper	42	Y	Y	Y	Y	Y	Listed	Cu TMDL
Iron	11	N	NA	NA	N	Y	Not Listed	No TMDL
Lead	42	Y	Y	Y	Y	Y	Listed	Pb TMDL
Mercury	4	N	N	N	N	Y	Not Listed	No TMDL
Silver	8	N	N	N	NA	Y	Not Listed	No TMDL
Zinc	42	Y	Y	Y	Y	Y	Listed	Zn TMDL

* AAL is used for Silver since Silver does not have a CAL

The 10 percent CAL exceedance threshold was exceeded for aluminum, cadmium, copper, lead, and zinc. Eighteen samples (42%) exceeded the 10 µg/L HH criterion for arsenic. One in 11 results for total recoverable iron exceeded the 1,000 µg/L CAL criterion. The human health criteria exceedance rates were notably high for arsenic (43%), cadmium (86%), lead (19%), and zinc (21%). Water quality data for silver do not indicate the need for TMDLs. None among the four mercury analysis results was greater than the method detection limit.

No recent bed sediment samples are available from Uncle Sam Gulch. However, samples collected at four sites in 1997 by the USGS (Fey et al., 2000) bracketed Crystal Mine contributions. **Table F-10** summarizes these sediment chemistry data as the ratio of the measured metal concentration over the PEL concentrations in **Table 5-4**. The sampling sites are distributed along three stream miles from the headwaters to about 2.5 miles below the Crystal Mine. The sediment metals concentration data are in **Appendix D**.

Table F-10. Ratios of measured sediment metals concentrations to PELs for sediment samples from Uncle Sam Gulch.

SITE ID	Site Location	Arsenic	Cadmium	Copper	Lead	Zinc
97-BMS-108S1	0.5 mile upstream of Crystal Mine Sources	2.3	0.6	0.2	0.4	0.5
97-BMS-116	0.5 mile downstream of Crystal Mine Sources	212	2	2.8	21	3
97-BMS-134	0.9 mile downstream of Crystal Mine Sources	229	2.5	1.1	18	30
97-BMS-118	0.4 mile upstream of mouth (Cataract Creek)	76	11	12	10	12

The sediment chemistry data indicate that metal concentrations are generally less than PELs upstream of the Crystal Mine. The area may have naturally elevated arsenic concentrations in sediments. However, the Crystal Mine is the source of extreme arsenic loading. Sediment concentrations of lead and zinc are generally two orders of magnitude higher than those occurring upstream of the mine.

F2.4.3 Uncle Sam Gulch TMDL Summary

The listing status and TMDL conclusions for metals in Uncle Sam Gulch are summarized in **Table F-11.** TMDLs are required in Uncle Sam Gulch for aluminum, arsenic, cadmium, copper, lead, and zinc.

Table F-11. Metals listing status and TMDL conclusions for Uncle Sam Gulch

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	New Listing	Y
Arsenic	Current Listing	Y
Cadmium	Current Listing	Y
Copper	Current Listing	Y
Iron	Not Listed	N
Lead	Current Listing	Y
Mercury	Not Listed	N
Silver	Not Listed	N
Zinc	Current Listing	Y
Number of TMDLs Required		6

F2.5 Big Limber Gulch (MT41E002_140)

Big Limber Gulch Creek is listed as impaired in the 2012 Integrated Report (Montana Department of Environmental Quality, 2012) for lead and mercury. The stream extends for 2.6 miles from its headwaters to its mouth on Cataract Creek. The watershed area is 2.5 square miles. **Figure F-5** shows the Big Limber Gulch watershed, recent sample sites, and locations of mine-related sources.

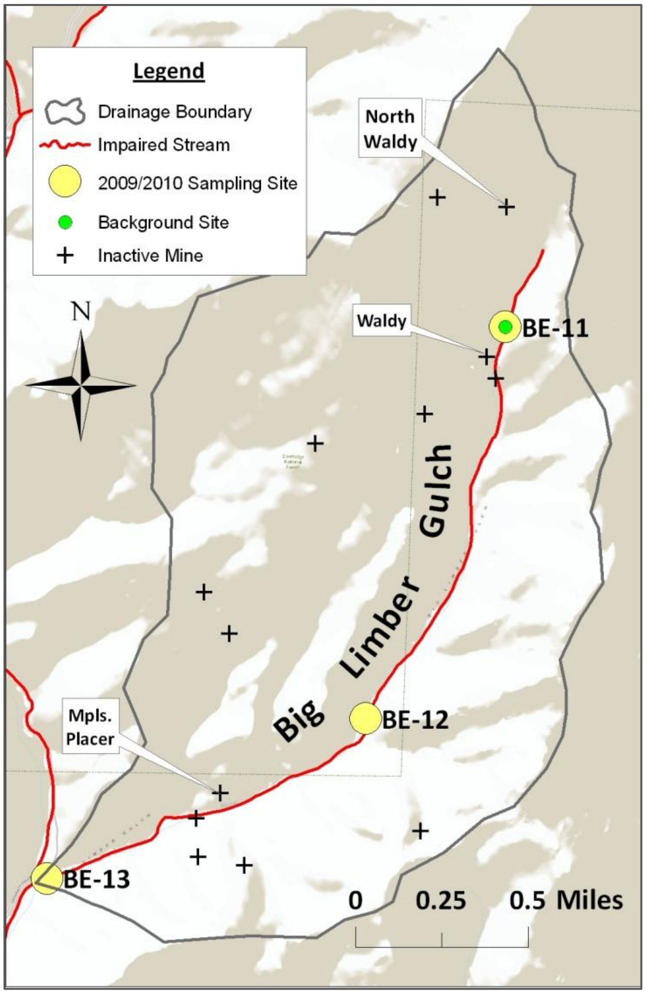

Figure F-5. The Big Limber Gulch watershed, monitoring sites, and mining sources

F2.5.1 Big Limber Gulch Sources

The MBMG abandoned mine database lists 14 inactive mines in the Big Limber Gulch drainage. The properties are predominantly small scale prospects developed for lead and zinc production. The North Waldy Mine, near the top of the gulch, consists of a collapsed adit and small waste rock dump. A small seep (1 gpm) drains from adit area and infiltrates into the ground about 300 feet from the Big Limber Gulch channel. A sample of the discharge collected in 1993 had no water quality exceedances. About a half mile downstream is the Waldy Mine that consists of a collapsed adit and small waste rock dump on opposite sides of the stream. The adit has a small seep that exceeded CAL criteria for mercury and silver in a 1993 sample (Montana Bureau of Mines and Geology, 1997). Just downstream of the Waldy is the Redwing Mine that consists of two collapsed adits (one discharging) and a small waste rock dump adjacent to the stream. An adit discharge sample exceeded a secondary maximum contaminant level for manganese. The Minneapolis Mine and associated placer workings occur in an intermittent drainage entering Big Limber Gulch from the north about one half mile above the mouth. A surface water exceeded aquatic life criteria for mercury in a 1993 sample from the tributary (Montana Bureau of Mines and Geology, 1997).

F2.5.2 Big Limber Gulch Target Departures

The recent water quality dataset for Big Limber Gulch contains 16 records from three monitoring sites established by DEQ in 2009 and revisited in 2010. **Table F-12** summarizes the target departure analysis for Big Limber Gulch.

Table F-12. Big Limber Gulch TMDL Decision Factors and TMDL Conclusion

Pollutant Parameter	Sample Size	CAL Exceedance Rate > 10%	Results Twice the AAL Criterion	Human Health Criterion exceeded	Sediment PEL Exceeded	Human-Caused Sources Present	2012 303(d) Listing Status	TMDL Decision
Aluminum	6	Y	N	NA	NA	Y	Not Listed	No TMDL
Arsenic	12	N	N	N	Y	Y	Not Listed	No TMDL
Cadmium	12	N	N	N	N	Y	Not Listed	No TMDL
Copper	12	N	N	N	N	Y	Not Listed	No TMDL
Iron	12	N	NA	NA	NA	Y	Not Listed	No TMDL
Lead	12	N	N	N	N	Y	Listed	No TMDL
Mercury	8	N	N	N	N	Y	Listed	No TMDL
Silver	12	N	N	N	NA	Y	Not Listed	No TMDL
Zinc	12	N	N	N	N	Y	Not Listed	No TMDL

* AAL is used for Silver since Silver does not have a CAL

Despite the presence of human-caused metals sources, only an aluminum result from a small sample set exceeded the chronic aquatic life target of 75 µg/L. Since the stream is not currently listed as impaired by aluminum, water quality monitoring is recommended in place of an aluminum TMDL. No water quality metals targets were exceeded for other metals in recent samples from Big Limber Gulch. A single recent sediment sample collected in 2009 from siteBE-11 contained arsenic at 3.7 times the PEL value. Water quality monitoring for arsenic in Big Limber Gulch is recommended in lieu of TMDL development. **Table F-13** summarizes the BIG Limber Gulch TMDL requirements.

Table F-13. Metals listing status and TMDL conclusions for Big Limber Gulch

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	New Listing	N
Arsenic	Current Listing	N
Cadmium	Current Listing	N
Copper	Current Listing	N
Iron	Not Listed	N
Lead	Current Listing	N
Mercury	Not Listed	N
Silver	Not Listed	N
Zinc	Current Listing	N
Number of TMDLs Required		0

No metals TMDLs are required for Big Limber Gulch.

F2.6 High Ore Creek (MT41E002_040)

High Ore Creek is listed as impaired in the 2012 Integrated Report (Montana Department of Environmental Quality, 2012) for arsenic, cadmium, copper, lead, mercury, and zinc. The stream extends for 6.7 miles from its headwaters to its mouth on the Boulder River. The watershed area is 10 square miles. **Figure F-6** shows the High Ore Creek watershed, recent sample sites, and locations of mine-related sources.

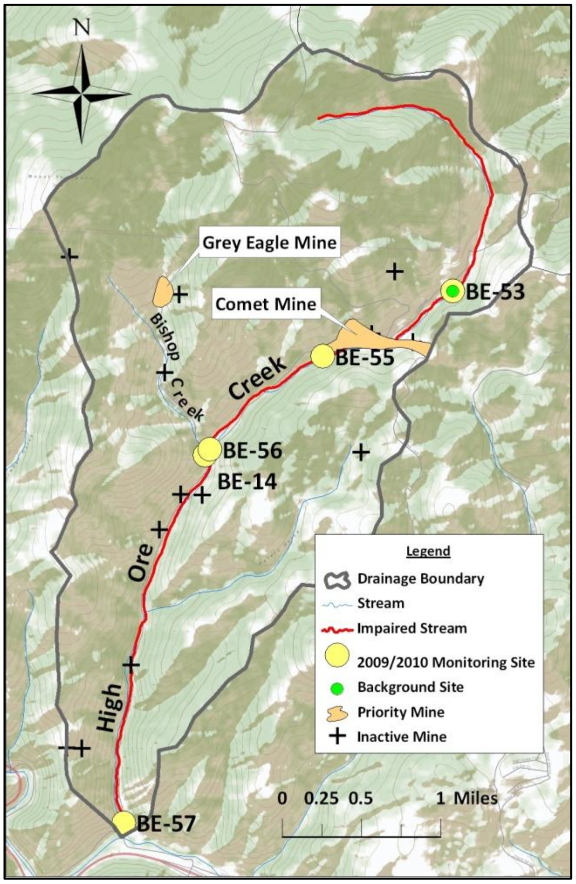

Figure F-6. The High Ore Creek watershed, monitoring sites, and mining sources.

F2.6.1 High Ore Creek Sources

The MBMG database of abandoned and inactive mines lists 14 such properties in High Ore Creek. Two of these sites, the Comet Mine and the Grey Eagle Mine, are listed as priority abandoned mines. Although mining may have begun on High Ore Creek as early as 1869, large scale development did not occur until 1883. Both the Comet and Grey Eagle mines produced from a large mineralized zone containing vein deposits of metal sulfides (Montana Bureau of Mines and Geology, 1997).

The Helena mining and Reduction Company constructed an ore concentrator and ore delivery tram between High Ore Creek mines and the smelter at Wickes, Montana. With failure of the Wickes smelter, ore was shipped to a new facility at East Helena. The mine operated profitably despite the silver panic and economic depression of the1890s. A large floatation mill was built at the Comet Mine in 1926, and the Comet and Grey Eagle mines operated together until closure in 1941 (Montana Department of Environmental Quality, Remediation Division, Mine Waste Cleanup Bureau, Abandoned Mine Section, 2011).

The Comet Mine was the largest ore producer in the Basin Mining District (Montana Department of Environmental Quality, Remediation Division, Mine Waste Cleanup Bureau, Abandoned Mine Section, 2011). There are an estimated 20,000 feet of underground workings and a large open pit at the site

(Montana Bureau of Mines and Geology, 1997). The tailings volume in two ponds is estimated at a half million yd^3s; the site contains approximately 214,000 yd3s of waste rock (Montana Department of State Lands, 1995). The breached tailing impoundments have been the source metal contaminated sediment for the entire length of the stream. Reclamation of the site began in 1990 with diversion of the stream channel around the tailings impoundments and construction of a sedimentation pond. A second sedimentation pond was added during 1995-1996. An onsite tailings repository was constructed in 1997; a second repository on the High Ore Creek –Boomerang Gulch divide was constructed in 1999 {Tupling, 2001 17841 /id}. Water quality below the Comet Mine greatly exceeds standards for cadmium and zinc (Montana Bureau of Mines and Geology, 1997).

The Grey Eagle Mine is located one mile west of the Comet Mine in the headwaters of the High Ore Creek tributary of Bishop Creek. The site contains 73,000 yd^3s of waste rock containing elevated concentrations of copper, lead, and zinc. An adit at the site discharges intermittently (Montana Department of State Lands, 1995).

F2.5.2 High Ore Creek Target Departures

The recent water quality dataset for High Ore Creek contains 16 records from four monitoring sites. DEQ established three sites in 2009; the fourth site is USGS station 06032300 at the mouth of the stream. Site BE-57 was revisited by DEQ in 2010. **Table F-14** summarizes the water quality target departures for High Ore Creek.

Table F-14. High Ore Creek TMDL Decision Factors and TMDL Conclusion

Pollutant Parameter	Sample Size	CAL Exceedance Rate > 10%	Results Twice the AAL Criterion	Human Health Criterion exceeded	Sediment PEL Exceeded	Human-Caused Sources Present	2012 303(d) Listing Status	TMDL Decision
Aluminum	3	N	N	NA	NA	Y	Not Listed	No TMDL
Arsenic	14	N	N	Y	Y	Y	Listed	As TMDL
Cadmium	14	Y	N	Y	Y	Y	Listed	Cd TMDL
Copper	14	Y	N	N	Y	Y	Listed	Cu TMDL
Iron	11	N	NA	NA	NA	Y	Not Listed	No TMDL
Lead	14	Y	N	Y	Y	Y	Listed	Pb TMDL
Mercury	8	N	N	N	Y	Y	Listed	No TMDL
Silver	8	N	N	N	NA	Y	Not Listed	No TMDL
Zinc	14	Y	Y	N	Y	Y	Listed	Zn TMDL

* AAL is used for Silver since Silver does not have a CAL

The 10 percent CAL exceedance threshold was exceeded for cadmium, copper, lead, and zinc. Eleven samples (79%) exceeded the 10 µg/L HH criterion for arsenic. One in 11 results for total recoverable iron exceeded the 1,000 µg/L CAL criterion. The human health criteria exceedance rates were notably high for arsenic (79%) and lead (29%), and zinc (21%). Water quality data for mercury and silver do not indicate the need for TMDLs. None among the eight mercury analysis results was greater than the method detection limit.

Sediment chemistry data are from two samples collected from High Ore Creek at sites BE-53 and BE-57 in 2009. **Table F-15** summarizes the sediment chemistry data as the ratio of the measured metal concentration over the PEL concentration (**Table 5-4**). The sampling sites (**Figure F-6**) are in the headwaters above the Comet Mine and at the mouth. The sediment metals concentration data are in **Appendix D**.

Table F-15. Ratios of measured sediment metals concentrations to PELs for sediment samples from High Ore Creek.

SITE ID	Site Location	Arsenic	Cadmium	Copper	Lead	Zinc
BE-53	0.5 mile upstream of Comet Mine	1.1	0.34	0.13	0.53	0.32
BE-57	Near mouth	81	10	1.5	13.3	25.6

Sediment samples from near the mouth of High Ore Creek contain extremely high concentrations of arsenic, cadmium, lead, and zinc. The sample from site BE-53 probably resembles naturally occurring sediment metals concentrations outside of the mineralized bedrock zone.

F2.6.3 High Ore Creek TMDL Summary

The listing status and TMDL conclusions for metals in High Ore Creek are summarized in **Table F-16.** TMDLs are required in High Ore Creek arsenic, cadmium, copper, lead, and zinc.

Table F-16. Metals listing status and TMDL conclusions for High Ore Creek

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	Not Listed	N
Arsenic	Current Listing	Y
Cadmium	Current Listing	Y
Copper	Current Listing	Y
Iron	Not Listed	N
Lead	Current Listing	Y
Mercury	Current Listing	N
Silver	Not Listed	N
Zinc	Current Listing	Y
Number of TMDLs Required		5

F2.7 Boulder River, Headwaters to Basin Creek (MT41E001_010)

The Boulder River is divided into four segments for water quality assessment. The upper most segment extends for 24.4 miles from its headwaters to its confluence with Basin Creek at the town of Basin. The watershed area is 98.5 square miles. This segment of the river is listed as impaired by elevated cadmium, copper, iron, lead, and zinc. **Figure F-7** shows the upper Boulder River watershed, recent sample sites, and locations of mine-related sources.

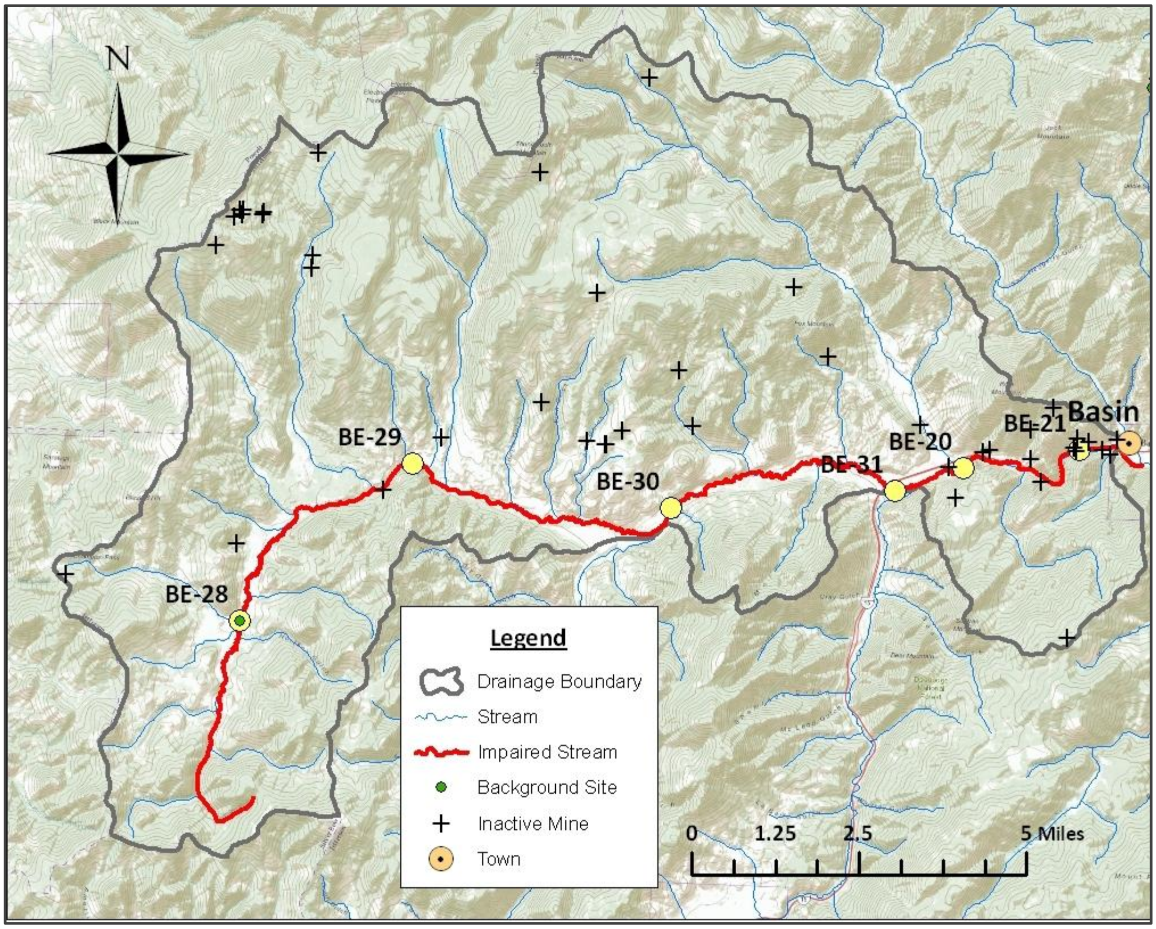

Figure F-7. The upper Boulder River watershed, monitoring sites, and mining sources.

F2.7.1 Upper Boulder River Sources

The MBMG abandoned mine database lists 43 inactive mines in the upper Boulder River drainage. Approximately half of these properties are exploration prospects that lack environmental data. The remaining sites are small mine operations having un-vegetated slopes or highwalls. Several mining and milling sources are located in and around the town of Basin. These sources became part of the Basin Area superfund site in 1999. The site is divided into two operable units (OUs): the Town of Basin (OU1), and the surrounding watersheds of Basin Creek, Cataract Creek, and part of the upper Boulder River (OU2). Primary sources of metal contamination and the health risks associated with OU1 are contaminated soils, mill tailings, and numerous scattered mine waste rock piles resulting from mining and ore processing in the town of Basin from the late 1800s through the early 1900s.

A remedial investigation identified 28 residential areas with contaminated soils, milling wastes around the pits of the Hope-Katie Mine complex, and two tailings impoundments related to operation of the Jib Mill on the western edge of Basin and on the south side of the Boulder River immediately southwest of the town. The Basin Mill site on the east side of town is a separate source omitted as part of the superfund OU1 because its owners obtained a groundwater discharge permit from DEQ and planned to operate the facility as a custom mill {CH2MHill, 2008 17846 /id}.

Jim Gilman Excavating holds a general stormwater discharge permit for construction activities at the Carlson Pit, an aggregate quarry located in the Rock Creek drainage one mile upstream of its confluence with the Boulder River.

F2.7.2 Upper Boulder River Target Departures

The recent water quality dataset for the upper Boulder River contains 22 records from seven monitoring sites. DEQ established six sites in 2009; the seventh site is USGS station 06031450 located about 400 feet downstream of site BE-20 (**Figure F-7**). Site BE-20 was revisited by DEQ in 2010. **Table F-17** summarizes the water quality target departures for upper Boulder River.

Table F-17. Upper Boulder River TMDL Decision Factors and TMDL Conclusion

Pollutant Parameter	Sample Size	CAL Exceedance Rate > 10%	Results Twice the AAL Criterion	Human Health Criterion exceeded	Sediment PEL Exceeded	Human-Caused Sources Present	2012 303(d) Listing Status	TMDL Decision
Aluminum	3	Y	N	NA	NA	Y	Not Listed	No TMDL
Arsenic	16	N	N	N	Y	Y	Not Listed	No TMDL
Cadmium	22	N	N	N	N	Y	Listed	No TMDL
Copper	22	Y	N	N	N	Y	Listed	Cu TMDL
Iron	17	N	NA	NA	NA	Y	Listed	No TMDL
Lead	22	Y	N	N	N	Y	Listed	Pb TMDL
Mercury	14	N	N	N	Y	Y	Not Listed	No TMDL
Silver	17	N	N	N	N	Y	Not Listed	No TMDL
Zinc	22	N	N	N	N	Y	Listed	No TMDL

* AAL is used for Silver since Silver does not have a CAL

The 10 percent CAL exceedance threshold was exceeded for aluminum, copper, and lead. Due to the small sample size for aluminum analyses, additional monitoring for aluminum is recommended in lieu of TMDL development. Although the sediment PELs were exceeded for arsenic and mercury, water column concentrations were either below method detection limits or less than the human health targets. The water chemistry data do not support the previous listings for cadmium, iron, and zinc.

Sediment chemistry data are from three samples collected in 2009 from the upper Boulder River at sites BE-21, BE-28, and BE-30. **Table F-18** summarizes the sediment chemistry data from these sites as the ratio of the measured metal concentration over the PEL concentrations **Table 5-4** of the main document. The sampling sites, arranged in **Table F-18** from upstream to downstream order (**Figure F-7**), are located the upper Boulder River headwaters (BE-28), downstream of the Boulder River confluence with Lowland Creek (BE-30), and one mile upstream of the Boulder River confluence with Basin Creek (BE-21). The sediment metals concentration data are in **Appendix D**.

Table F-18. Ratios of measured sediment metals concentrations to PELs for sediment samples from the upper Boulder River.

SITE ID	Site Location	Arsenic	Cadmium	Copper	Lead	Zinc
BE-28	Upper Boulder River headwaters	0.82	0.28	0.19	0.24	0.23
BE-30	0.5 mile below Lowland Creek	0.94	0.31	0.25	0.33	0.30
BE-21	One mile upstream of Basin Creek	1.24	0.31	0.40	0.36	0.59

The ratios in **Table F-18** indicate that sediment metals concentrations are within the supplemental indicator PEL values, except for arsenic at site BE-21. The arsenic concentration in the site BE-21 sample is 24 percent higher than the PEL value. Despite the elevated arsenic in sediment near the lower end of the stream segment, water column arsenic concentrations measured at the same site were 4.0 µg/L during both high and low flow sampling events in 2009. The most restrictive water quality arsenic target is the human health criterion of 10 µg/L.

F2.7.3 Upper Boulder River TMDL Summary

The listing status and TMDL conclusions for metals in the upper Boulder River are summarized in **Table F-19.** TMDLs are required in the upper Boulder River for copper, and lead.

Table F-19. Metals listing status and TMDL conclusions for the upper Boulder River

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	Not Listed	N
Arsenic	Not Listed	N
Cadmium	Current Listing	N
Copper	Current Listing	Y
Iron	Current Listing	N
Lead	Current Listing	Y
Mercury	Not Listed	N
Silver	Not Listed	N
Zinc	Current Listing	N
Number of TMDLs Required		2

F2.8 Lowland Creek (MT41E002_050)

Lowland Creek is listed as impaired in the 2012 Integrated Report (Montana Department of Environmental Quality, 2012) for aluminum, copper, and silver. The stream extends for 14.25 miles from its headwaters in the Deerlodge Mountains north of Butte, Montana, to its mouth on the upper Boulder River about 14.5 miles upstream of the town of Basin. The watershed area is 43 square miles. **Figure F-8** shows the Lowland Creek watershed, recent sample sites, and locations of mine-related sources.

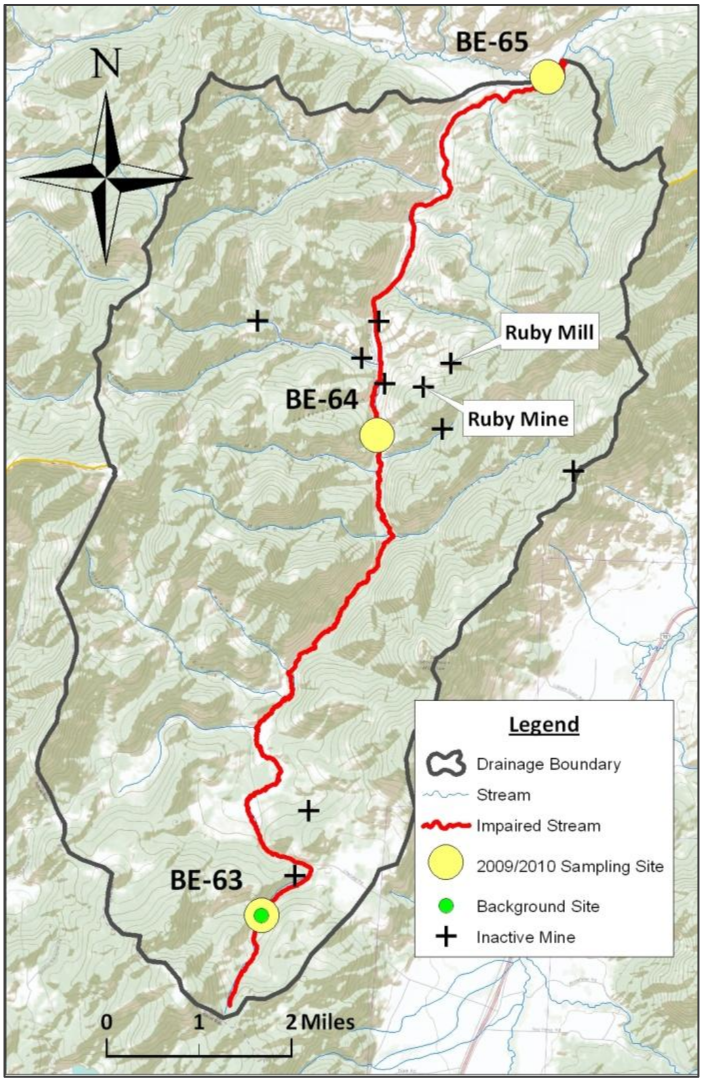

Figure F-8. The Lowland Creek watershed, monitoring sites, and mining sources.

F2.8.1 Lowland Creek Sources

Placer miners established the Lowland Mining District during the 1870s and likely discovered the lode deposits that were the source of the placer gold (Montana Department of Environmental Quality, Remediation Division, Mine Waste Cleanup Bureau, Abandoned Mine Section, 2011). The MBMG abandoned mine database lists 10 inactive mines in the Lowland Creek drainage. Mining activity focused on gold and silver recovery at the Ruby Mine and nearby mill located in upper Ruby Creek, and the Columbia Mine located one half mile farther south that also produced copper ore. A second episode of placer mining occurred during the 1930s with a dry land dredge operating from 1938 to 1941 (Montana Department of Environmental Quality, Remediation Division, Mine Waste Cleanup Bureau, Abandoned Mine Section, 2011). Dredge mining occurred along the lower four miles of the stream. Two suction dredge operations operate along Lowland Creek under general discharge permits (MTG370313 and MTG370269). What remains of the other mine sites are small, sparsely vegetated surface disturbances.

F2.8.2 Lowland Creek Target Departures

The recent water quality dataset for Lowland Creek contains 13 records from three monitoring sites. The sites are located in the relatively undisturbed headwaters (BE-63), on Lowland Creek upstream of Ruby Creek (BE-64), and near the mouth downstream of the dredge mining disturbances (BE-65). DEQ established the three sites in 2009 and re-sampled in 2010. **Table F-20** summarizes the water quality target departures for Lowland Creek.

Table F-20. Lowland Creek TMDL Decision Factors and TMDL Conclusion

Pollutant Parameter	Sample Size	CAL Exceedance Rate > 10%	Results Twice the AAL Criterion	Human Health Criterion exceeded	Sediment PEL Exceeded	Human-Caused Sources Present	2012 303(d) Listing Status	TMDL Decision
Aluminum	13	Y	N	N	NA	Y	Listed	Al TMDL
Arsenic	13	N	N	N	Y	Y	Not Listed	No TMDL
Cadmium	13	N	N	N	N	Y	Not Listed	No TMDL
Copper	13	Y	Y	N	N	Y	Listed	Cu TMDL
Iron	13	N	NA	NA	NA	Y	Not Listed	No TMDL
Lead	13	Y	N	N	N	Y	Not Listed	Pb TMDL
Mercury	6	N	N	N	N	Y	Not Listed	No TMDL
Silver	13	N	N	N	NA	Y	Listed	No TMDL
Zinc	13	N	N	N	N	Y	Not Listed	No TMDL

* AAL is used for Silver since Silver does not have a CAL

The 10 percent CAL exceedance threshold was exceeded for aluminum, copper, and lead. Although the sediment PELs were exceeded for arsenic, water column concentrations were less than the human health targets. The water chemistry data do not support the previous listing for silver.

Sediment chemistry data are from four samples collected in 2009 from the headwaters area (BE-63) and from the sampling site at the mouth (BE-65) during low flow conditions in 2009 and 2010. **Table F-21** summarizes the sediment chemistry data from these sites as the ratio of the measured metal concentration over the PEL concentration. The ratios in **Table F-21** are mean values from sampling in 2009 and 2010. The sediment metals concentration data are in **Appendix D**.

Table F-21. Ratios of measured sediment metals concentrations to PELs for sediment samples from Lowland Creek.

SITE ID	Site Location	Arsenic	Cadmium	Copper	Lead	Zinc
BE-63	Upper Boulder River headwaters	3.8	0.30	0.40	0.44	0.34
BE-65	0.5 mile below Lowland Creek	0.73	0.16	0.14	0.24	0.20

The arsenic concentration in sediment from the headwaters site is nearly four times the PEL. Water column concentrations range between five and seven µg/L, with no values greater than the 10 µg/L human health criterion in any of 13 samples.

F2.8.3 Lowland Creek TMDL Summary

The listing status and TMDL conclusions for metals in Lowland Creek are summarized in **Table F-22.**

Table F-22. Metals listing status and TMDL conclusions for Lowland Creek.

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	Not Listed	Y
Arsenic	Not Listed	N
Cadmium	Current Listing	N
Copper	Current Listing	Y
Iron	Current Listing	N
Lead	Current Listing	Y
Mercury	Not Listed	N
Silver	Not Listed	N
Zinc	Current Listing	N
Number of TMDLs Required		3

TMDLs are required in Lowland Creek for aluminum, copper, and lead.

F2.9 Bison Creek (MT41E002_070)

Bison Creek is listed as impaired in the 2012 Integrated Report (Montana Department of Environmental Quality, 2012) for the metals copper and iron. The stream extends for 25.45 miles from its headwaters at the southern end of Elk Park to its mouth on the upper Boulder River about four miles upstream of the town of Basin. The watershed area is 77 square miles. **Figure F-9** shows the Bison Creek watershed, sample sites for 2009 and 2010, and locations of mine-related sources.

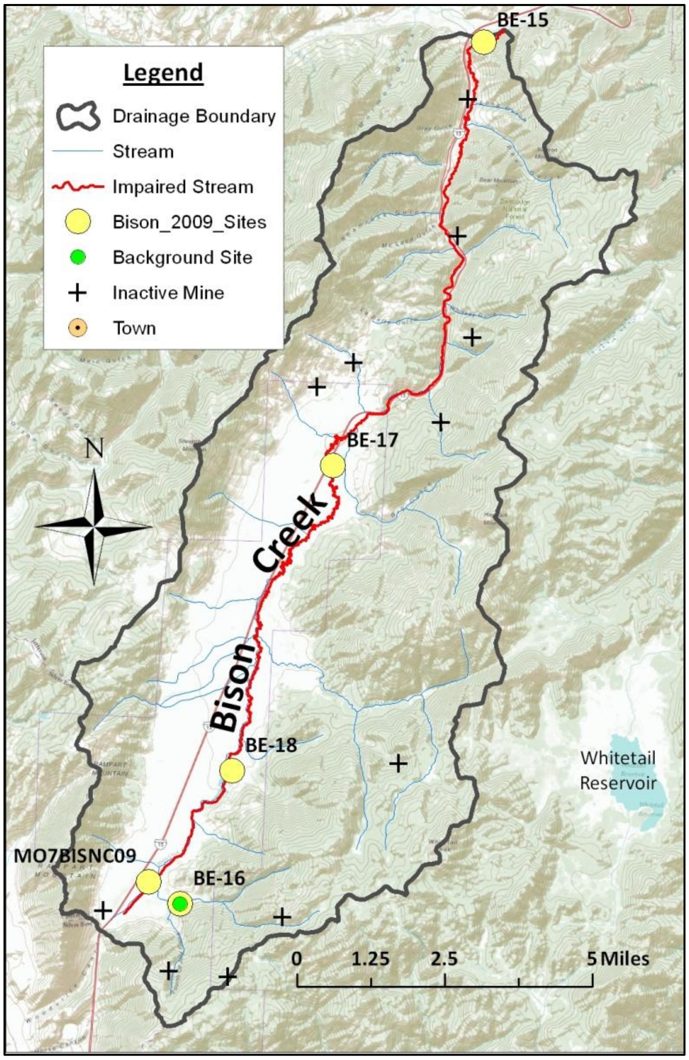

Figure F-9. The Bison Creek watershed, monitoring sites, and mining sources.

F2.9.1 Bison Creek Sources

The Elk Park area had minimal mining development activity compared with that of the Basin Mining District to the north and the Butte district across the Continental Divide to the south. The MBMG abandoned mine database lists 12 inactive mines in the Bison Creek drainage. The Montreal and Sunset mines near the south end of the watershed produced gold, silver, copper, and lead between 1906 and the mid-1940s (Montana Department of Environmental Quality, Remediation Division, Mine Waste Cleanup Bureau, Abandoned Mine Section, 2011). A small abandoned placer mine is located near the mouth of the drainage. Aside from building structures, little surface evidence remains from mining at these properties. An abandoned railroad right-of-way extends along the entire length of the drainage axis. Anecdotal evidence from local residents indicates that the Elk Park portion of the railroad grade was constructed from waste materials hauled from the mines at Butte.

F2.9.2 Bison Creek Target Departures

The recent water quality dataset for Bison Creek contains 11 records from five monitoring sites (**Figure F-9**). Four of the sites are located in Elk Park and the fifth (BE-15) is near the mouth. DEQ established the sites in 2009 and re-sampled in 2010. **Table F-23** summarizes the water quality target departures for Bison Creek.

Table F-23. Bison Creek TMDL Decision Factors and TMDL Conclusion

Pollutant Parameter	Sample Size	CAL Exceedance Rate > 10%	Results Twice the AAL Criterion	Human Health Criterion exceeded	Sediment PEL Exceeded	Human-Caused Sources Present	2012 303(d) Listing Status	TMDL Decision
Aluminum	5	N	N	NA	NA	Y	Not Listed	No TMDL
Arsenic	11	N	N	Y	Y	Y	Not Listed	As TMDL
Cadmium	11	N	N	N	N	Y	Not Listed	No TMDL
Copper	11	Y	N	N	N	Y	Listed	Cu TMDL
Iron	11	Y	NA	NA	NA	Y	Listed	Fe TMDL
Lead	11	N	N	N	N	Y	Not Listed	No TMDL
Mercury	6	N	N	N	Y	Y	Not Listed	No TMDL
Silver	11	N	N	N	N	Y	Not Listed	No TMDL
Zinc	11	N	N	N	N	Y	Not Listed	No TMDL

* AAL is used for Silver since Silver does not have a CAL

The 10 percent CAL exceedance threshold is exceeded for copper, and iron. Both the human health targets and sediment PELs were exceeded for arsenic. Despite exceedance of the mercury PEL, water column concentrations were less than the method detection limits for both mercury and aluminum in the small datasets.

Sediment chemistry data are from two samples collected from the headwaters area (BE-16) and from the sampling site at the mouth (BE-15) during low flow conditions in 2009 and 2010. **Table F-24** summarizes the sediment chemistry data from these sites as the ratio of the measured metal concentration over the PEL concentration. Entries in **Table F-24** for site BE-16 are the means for the two samples from this site. The sediment metals concentration data are in **Appendix D**.

Table F-24. Ratios of measured sediment metals concentrations to PELs for sediment samples from Bison Creek.

SITE ID	Site Location	Arsenic	Cadmium	Copper	Lead	Zinc
BE-16	Bison Creek headwaters	1.9	0.31	0.35	0.27	0.32
BE-15	Bison Creek mouth	2.4	0.25	0.35	--	0.28

The arsenic concentrations in sediment from both the headwaters site and the site at the mouth are twice the PEL. Water column arsenic concentrations range between five and seven µg/L, with no values greater than the 10 µg/L human health criterion in any of the 11 samples.

F2.9.3 Bison Creek TMDL Summary

The listing status and TMDL conclusions for metals in Bison Creek are summarized in **Table F-25.**

Table F-25. Metals listing status and TMDL conclusions for Bison Creek

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	Not Listed	N
Arsenic	Not Listed	Y
Cadmium	Not Listed	N
Copper	Current Listing	Y

Table F-25. Metals listing status and TMDL conclusions for Bison Creek

Metal	Listing Status	TMDL Needed? (Y/N)
Iron	Current Listing	Y
Lead	Not Listed	N
Mercury	Not Listed	N
Silver	Not Listed	N
Zinc	Current Listing	N
Number of TMDLs Required		3

TMDLs are required in Bison Creek for arsenic, copper, and iron.

F2.10 Boulder River, Basin Creek to Town of Boulder (MT41E001_021)

The segment of the Boulder River between the Basin Creek confluence and the town of Boulder is 9.3 miles long and is listed as impaired by elevated cadmium, copper, iron, lead, silver, and zinc. **Figure F-10** shows the extent of the 28 square mile watershed for this segment of the stream, recent sample sites, and locations of mine-related sources.

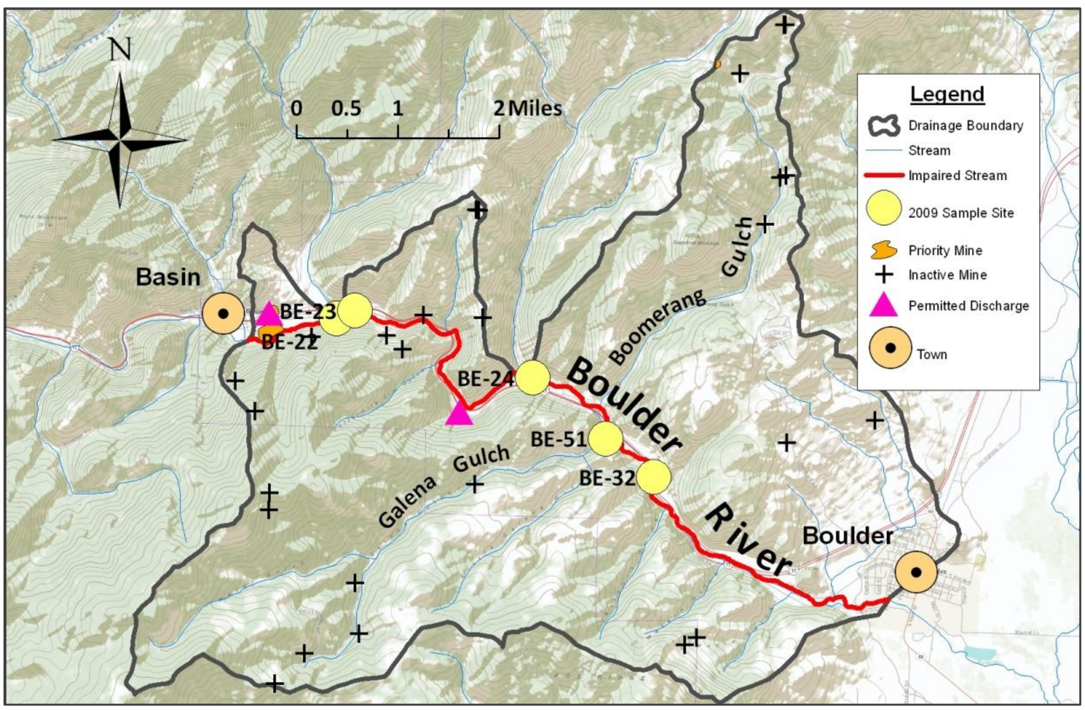

Figure F-10. The watershed for the Boulder River from Basin Creek to the town of Boulder, monitoring sites, and mining sources.

F2.10.1 Boulder River (MT41E001_021) Sources

The MBMG abandoned mines database lists 27 properties in the drainage basin for this segment of the Boulder River. Twenty of these sites are small scale lode mines developed for gold, silver, lead, copper and zinc. Current conditions among these sites are mostly un-vegetated waste rock or overburden deposits on uplands remote from stream channels. Exceptions are the inactive mines in the northern tributary of Boomerang Gulch, five underground lode mines and one placer mine where surface disturbances, waste rock, and tailings deposits are adjacent to the stream channel.

The watershed contains a priority mine site comprised of several streamside tailings deposits associated with the Old Basin Mill. The deposits occur on the north side of the Boulder River immediately downstream of the mouth of Basin Creek. The Basin Mining Area Superfund cleanup project removed some of the tailings to the Luttrell Repository in 2003 and 2004. A primary settling pond and a four-celled infiltration pond for the Basin County Water and Sewer District wastewater treatment facility are constructed within the footprint of the former tailings impoundment. The pond dikes are constructed of tailings material. The unpermitted discharge from the percolation ponds enters and is diluted by the local groundwater prior to recharging the Boulder River channel about 400 feet down-gradient. The portion of the property outside of the wastewater treatment pond system is currently part of the Merry Widow Health Mine and associated campground {CH2MHill, 2008 17846 /id}.

The Basin Mill is located on north of Interstate Highway I-15 on the east side of the town of Basin. The custom mill, owned by the O. T. Mining Corporation, currently holds MGWPCS permit number MTX000014 for mill tailings pond seepage discharges to groundwater. The discharge monitoring reports for the O. T. Mining operations at the Basin Mill site report no discharge from the facility since the most recent permit was issued in October, 2009. The last reported operation of the custom mill occurred in 1989. The discharge monitoring reports contain groundwater chemistry data from a local shallow monitoring well down-gradient of the tailings pond. Results for metal and nitrogen parameters are available for sampling dates in 2003, 2006, and 2008.

Discharge permit limitations are the groundwater standards for metals in DEQ-7 (Montana Department of Environmental Quality, Remediation Division, Mine Waste Cleanup Bureau, Abandoned Mine Section, 2011) applied to water samples from monitoring the wells. The monitoring record for the past 10 years does not include a period of mill operations or tailings pond use. Therefore, the record documents existing groundwater quality in the absence of seepage from a source of dissolved metals at the mill. Among 54 analysis results for metals, the record contains three arsenic exceedances in four samples, three iron exceedances in nine samples, and four lead exceedances in six samples. Since the mill has not operated during the past decade it is not a likely source of metal loading that can be distinguished from significant upstream sources in and around the town of Basin and in Basin Creek {Montana Department of Environmental Quality, 2009 17852 /id}.

A second permitted discharge to the Boulder River is a portable suction dredge operating in the Stardust Placer Claim in Section 22, Township 6 North, Range 5 West. This location includes about 1.3 miles of the Boulder River channel immediately upstream of the mouth of High Ore Creek. The current general permit for portable suction dredges requires daily visual monitoring of stream turbidity below a standard mixing zone that is 10 stream widths down gradient of the dredge location. The effluent limitation is no visible increase in turbidity. The authorization letter for the general permit includes a seasonal limitation on dredge operation to the period between January 1 and August 31 of each year.

Four inactive mines or mine prospects are located in the Galena Gulch tributary. These are small disturbances containing un-vegetated waste rock piles and associated access roads. Sources to the segment of the Boulder River between Basin Creek and the town of Boulder also includes those described above for upstream listed stream segments that include the Boulder River from its headwaters to Basin Creek, Lowland and Bison creeks, and Basin, Cataract, and High Ore Creeks.

A tailing repository in upper Boomerang Gulch is a component of Phase I reclamation of the Comet Mine in High Ore Creek. The reclamation required construction of the repository for disposal of approximately

300,000 cubic yards of waste rock and tailings removed from the High Ore Creek floodplain. The work was completed in 1999 {Browne, 2002 17845 /id}. Upper Boomerang Gulch also contains the inactive Hope and Bullion mines. A seep from a mine shaft discharges to surface water in Boomerang Gulch. Water samples collected from the gulch did not contain elevated metals concentrations (Montana Bureau of Mines and Geology, 1997). Farther downstream, Boomerang Gulch contains the former Molly McGregor Mine and gravity mill and the Baltimore mine. The sites contain un-vegetated waste rock and tailings deposits. As with the Hope-Bullion complex farther upstream, sampling did not detect mine effects on surface water quality (Montana Bureau of Mines and Geology, 1997).

F2.10.2 Boulder River (MT41E001_021) Target Departures

The recent water quality dataset for the Boulder River from Basin Creek to the town of Boulder contains 48 records from five monitoring sites (**Figure F-9**). Four sites are established by DEQ during stream assessments in 2009. The fifth site is USGS station 06322400 that is the same location as site BE-32, on the Boulder River below the mouth of Galena Gulch. **Table F-26** summarizes the water quality target departures for the segment of the Boulder River between Basin Creek and the town of Boulder.

Table F-26. Boulder River (MT41E001_021) TMDL Decision Factors and TMDL Conclusions

Pollutant Parameter	Sample Size	CAL Exceedance Rate > 10%	Results Twice the AAL Criterion	Human Health Criterion exceeded	Sediment PEL Exceeded	Human-Caused Sources Present	2012 303(d) Listing Status	TMDL Decision
Aluminum	2	N	N	NA	NA	Y	Not Listed	No TMDL
Arsenic	38	N	N	Y	Y	Y	Not Listed	As TMDL
Cadmium	46	Y	N	N	Y	Y	Listed	Cd TMDL
Copper	46	Y	Y	N	Y	Y	Listed	Cu TMDL
Iron	10	N	NA	NA	NA	Y	Listed	No TMDL
Lead	46	Y	N	N	Y	Y	Listed	Pb TMDL
Mercury	10	N	N	N	Y	Y	Not Listed	No TMDL
Silver	10	N	N	N	N	Y	Listed	No TMDL
Zinc	46	Y	Y	N	Y	Y	Listed	Zn TMDL

* AAL is used for Silver since Silver does not have a CAL

The 10 percent CAL exceedance threshold was exceeded for cadmium, copper, lead, and zinc. The human health criterion for arsenic was exceeded in two samples from site BE-32. Although the sediment PELs are exceeded for mercury, water column concentrations were either below method detection limits or less than the human health targets. The water chemistry data do not support the previous listings for iron and silver.

Sediment chemistry data are from three samples collected in 2009 from sampling sites above the mouth of Cataract Creek (BE-22), below the mouth of Cataract Creek (BE-23), and below the mouth of High Ore Creek (BE-24). **Table F-27** summarizes the sediment chemistry data from these sites as the ratio of the measured metal concentration over the PEL concentration. The sampling sites are arranged in **Table F-27** from upstream to downstream order. The sediment metals concentration data are in **Appendix D**.

Table F-27. Ratios of measured sediment metals concentrations to PELs for sediment samples from the Boulder River between Basin Creek and the town of Boulder.

SITE ID	Site Location	Arsenic	Cadmium	Copper	Lead	Zinc
BE-22	Above Cataract Creek	4.1	1.7	1.07	1.5	0.03
BE-23	Below Cataract Creek	6.1	2.8	1.02	1.8	2.83
BE-24	Below High Ore Creek	8.6	3.8	1.08	2.3	3.68

The data indicate significant sediment-bound arsenic, cadmium, and lead loads that increase with contributions from both Cataract and High Ore creeks. Copper concentrations are slightly elevated with little change among the three sites. Both Cataract Creek and High Ore Creek contribute significant sediment-bound loads of zinc.

F2.10.3 Boulder River (MT41E001_021) TMDL Summary

The listing status and TMDL conclusions for metals in the Boulder River between Basin Creek and Boulder are summarized in **Table F-28.**

Table F-28. Metals listing status and TMDL conclusions for the Boulder River between Basin Creek and Boulder

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	Not Listed	N
Arsenic	Not Listed	Y
Cadmium	Current Listing	Y
Copper	Current Listing	Y
Iron	Current Listing	N
Lead	Current Listing	Y
Mercury	Not Listed	N
Silver	Current Listing	N
Zinc	Current Listing	Y
Number of TMDLs Required		5

Five TMDLs are required in Bison Creek for arsenic, cadmium, copper, lead, and zinc. The data indicate that current impairment listings for iron and silver be reevaluated.

F2.11 Muskrat Creek (MT41E002_100)

Muskrat Creek extends for 13 miles from its headwaters on the north slope of Elkhorn Peak to its mouth on the Boulder River. Metals impairments for the stream include copper and lead. **Figure F-11** shows the extent of the 40 square mile watershed, recent sample sites for metals, and locations of mine-related sources.

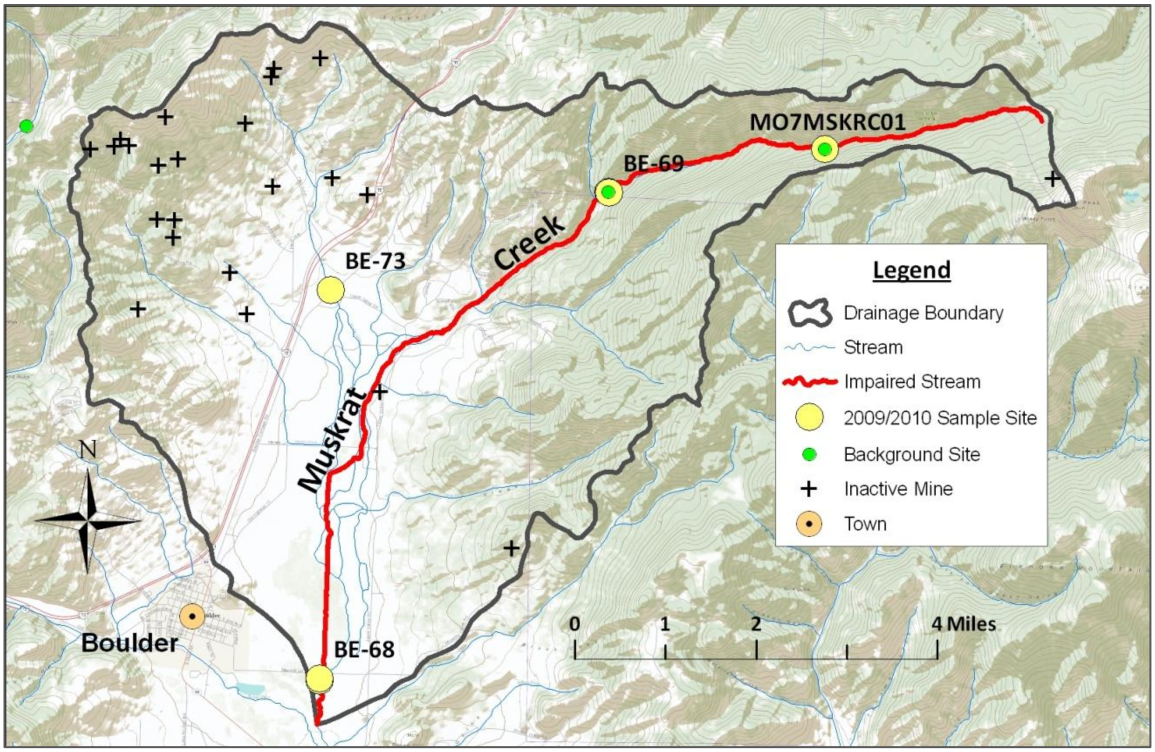

Figure F-11. The Muskrat Creek watershed, metals monitoring sites, and mining sources.

F2.11.1 Muskrat Creek Sources

The MBMG abandoned mine database lists 23 inactive mines in the Muskrat Creek drainage. Most are clustered in the northwest portion of the water shed within the Amazon Mining District. The properties are mainly small underground lode mines that operated intermittently from 1870 to 1950 to produce gold, silver, and lead (Montana Department of Environmental Quality, Remediation Division, Mine Waste Cleanup Bureau, Abandoned Mine Section, 2011). Surface evidence of past mining consists mainly of un-vegetated, hillside waste rock piles, collapsed adits and roadways.

F2.11.2 Muskrat Creek Target Departures

The recent water quality dataset for Muskrat Creek contains 10 records from three monitoring sites (**Figure F-9**). DEQ established two sampling sites on Muskrat Creek mainstem in 2009: one near its valley entrance to the valley (BE-69) and one near the mouth (BE-68). DEQ established site M07MSKRC01 in the mountainous reach of the stream in 2010. Site BE-73 (**Figure F-11**) is on Spencer Creek that drains the Amazon Mining District area. **Table F-29** summarizes the Muskrat Creek water quality target departures.

Table F-29. Muskrat Creek TMDL Decision Factors and TMDL Conclusions

Pollutant Parameter	Sample Size	CAL Exceedance Rate > 10%	Results Twice the AAL Criterion	Human Health Criterion exceeded	Sediment PEL Exceeded	Human-Caused Sources Present	2012 303(d) Listing Status	TMDL Decision
Aluminum	6	N	N	NA	NA	Y	Not Listed	No TMDL
Arsenic	10	N	N	N	NA	Y	Not Listed	No TMDL
Cadmium	10	N	N	N	NA	Y	Not Listed	No TMDL
Copper	10	N	N	N	NA	Y	Listed	No TMDL

Table F-29. Muskrat Creek TMDL Decision Factors and TMDL Conclusions

Pollutant Parameter	Sample Size	CAL Exceedance Rate > 10%	Results Twice the AAL Criterion	Human Health Criterion exceeded	Sediment PEL Exceeded	Human-Caused Sources Present	2012 303(d) Listing Status	TMDL Decision
Iron	9	Y	NA	NA	NA	Y	Not Listed	Fe TMDL
Lead	10	N	N	N	NA	Y	Listed	No TMDL
Mercury	4	N	N	N	NA	Y	Not Listed	No TMDL
Silver	10	N	N	N	NA	Y	Not Listed	No TMDL
Zinc	10	N	N	N	NA	Y	Not Listed	No TMDL

* AAL is used for Silver since Silver does not have a CAL

Two of nine results (22%) for total recoverable iron exceed the 1,000 µg/L chronic aquatic life criterion. No results exceeded the human health criteria or were greater than twice the acute aquatic life criteria. Recent sediment chemistry data are not available for Muskrat Creek. The water chemistry data do not support the previous listings for copper and lead.

F2.11.3 Muskrat Creek TMDL Summary

The listing status and TMDL conclusions for metals in Muskrat Creek are summarized in **Table F-30.**

Table F-30. Metals listing status and TMDL conclusions for Muskrat Creek

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	Not Listed	N
Arsenic	Not Listed	N
Cadmium	Not Listed	N
Copper	Current Listing	N
Iron	Not Listed	Y
Lead	Current Listing	N
Mercury	Not Listed	N
Silver	Not Listed	N
Zinc	Not Listed	N
Number of TMDLs Required		1

A TMDL for iron is required for Muskrat Creek. The data indicate that current impairment listings for copper and lead need reevaluation.

F2.12 Little Boulder River (MT41E002_080)

Figure F-12 shows the watershed boundaries, sample site locations, and inactive mine sources of the Little Boulder River and its largest tributary, the North Fork Little Boulder**.** Water quality of the North Fork is discussed in a following section. The mainstem Little Boulder River extends for 16.3 miles from its headwaters in the Deerlodge Mountains to its mouth on the Boulder River. The respective areas of the mainstem Little Boulder and North Fork watersheds are 40 and 19 square miles. Metal impairments on the mainstem Little Boulder River are for copper and zinc. Although the North Fork is not listed in 2012 as impaired for metals, recent monitoring results indicate elevated concentrations of aluminum and copper.

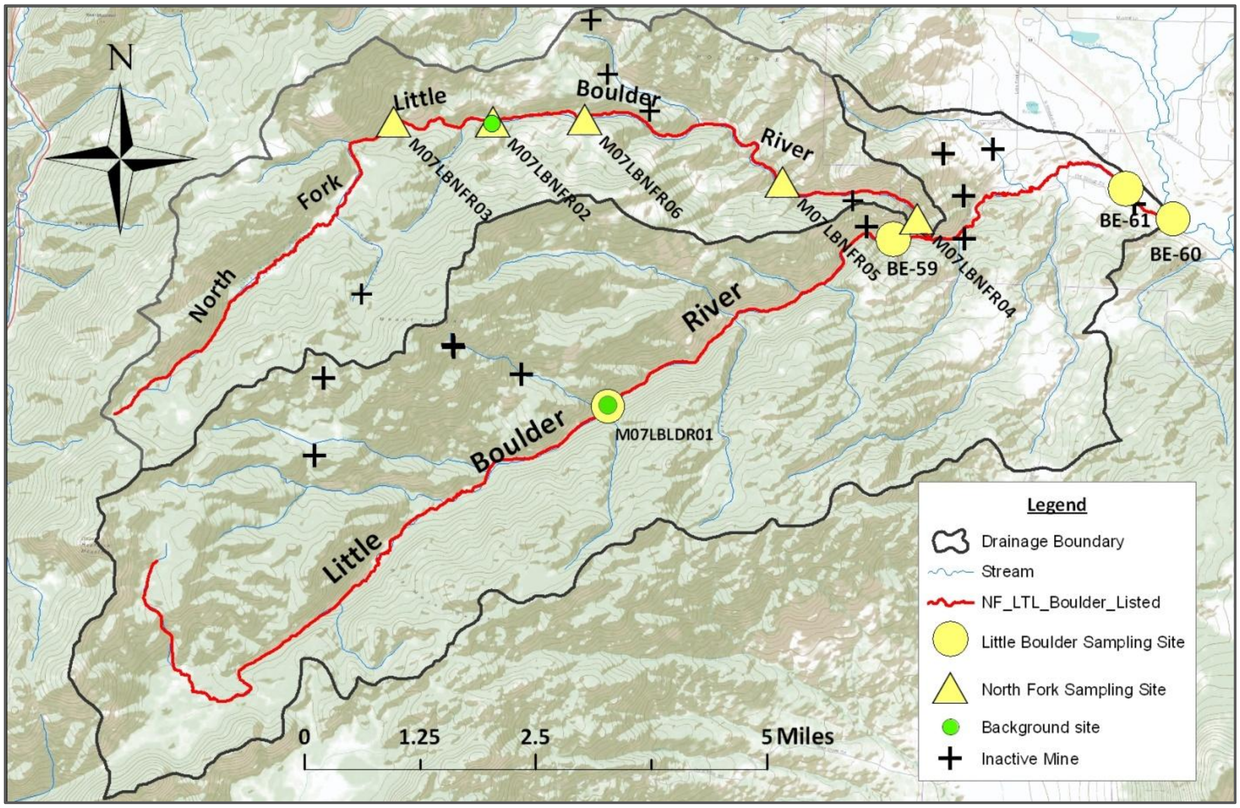

Figure F-12. The Little Boulder River watershed, monitoring sites, and mining sources.

F2.12.1 Little Boulder River Sources

The MBMG abandoned mine database lists 11 inactive mines in Little Boulder River drainage. Three of these properties are historic, upland placer mines in southwest corner of the Boulder Valley that have been partially regraded and reseeded. Farther upstream the inactive mines are small-scale hillside disturbances with un-vegetated waste rock deposits and access roads.

Boulder Hot Springs hold MPDES permit number MT0023639 for a facultative lagoon discharge to the Little Boulder River about 1,700 feet upstream from its mouth. No metals monitoring for either the outfall or the receiving stream is required under the permit. Recent monitoring of the outfall from wastewater pond by DEQ does not indicate that the outfall is a source of elevated metals loading to the Little Boulder River. The outfall contained detectable concentrations of arsenic and copper that are less than the lowest applicable target for these metals.

The Montana Department of Transportation also holds a general stormwater discharge permit (No. MTR103698) for road construction on Montana Highway 69 about three miles south of the town of Boulder. The site is adjacent to the Little Boulder River near its mouth.

F2.12.1 Little Boulder River Target Departures

The recent water quality dataset for the Little Boulder River contains 12 records from four monitoring sites (**Figure F-12**). Three sites are established by DEQ during stream assessments in 2009 with two re-sampled and a fourth established in 2010. **Table F-31** summarizes the water quality target departures for the Little Boulder River.

Table F-31. Little Boulder River TMDL Decision Factors and TMDL Conclusions

Pollutant Parameter	Sample Size	CAL Exceedance Rate > 10%	Results Twice the AAL Criterion	Human Health Criterion exceeded	Sediment PEL Exceeded	Human-Caused Sources Present	2012 303(d) Listing Status	TMDL Decision
Aluminum	6	Y	N	NA	NA	Y	Not Listed	Al TMDL
Arsenic	12	N	N	N	Y	Y	Not Listed	No TMDL
Cadmium	12	N	N	N	N	Y	Not Listed	No TMDL
Copper	12	Y	Y	N	N	Y	Listed	Cu TMDL
Iron	12	Y	NA	NA	NA	Y	Not Listed	Fe TMDL
Lead	6	Y	N	N	N	Y	Not Listed	Pb TMDL
Mercury	6	N	N	N	Y	Y	Not Listed	No TMDL
Silver	12	N	N	N	NA	Y	Not Listed	No TMDL
Zinc	12	N	N	N	N	Y	Listed	No TMDL

* AAL is used for Silver since Silver does not have a CAL

The 10 percent CAL exceedance threshold was exceeded for aluminum, copper, iron, and lead. No sample exceeded a human health criterion. Although the sediment PELs are exceeded for arsenic and mercury (at site M07LBLDR01 only), water column concentrations were either below method detection limits or less than the human health targets. The water chemistry data do not support the previous listing for zinc.

Sediment chemistry data are from one sample collected in 2009 from sampling site BE-60 above the mouth and site M07LBLDR01 in the central area of the drainage. **Table F-32** summarizes the sediment chemistry data from these sites as the ratio of the measured metal concentration over the PEL concentration. The sampling sites are arranged in **Table F-32** from upstream to downstream. The PEL values are exceeded for both arsenic and mercury. The sediment metals concentration data are in **Appendix D**.

Table F-32. Ratios of measured sediment metals concentrations to PELs for sediment samples from the Little Boulder River

SITE ID	Site Location	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc
M07LBLDR01	Central Drainage	1.5	0.3	0.21	0.2	1.9	0.2
BE-60	Near the mouth	3.3	0.5	0.38	0.6	--	0.4

F2.12.3 Little Boulder River TMDL Summary

The listing status and TMDL conclusions for metals in the Little Boulder River mainstem are summarized in **Table F-33.**

Table F-33. Metals listing status and TMDL conclusions for the Little Boulder River

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	Not Listed	Y
Arsenic	Not Listed	N
Cadmium	Not Listed	N
Copper	Current Listing	Y
Iron	Not Listed	Y
Lead	Not Listed	Y
Mercury	Not Listed	N
Silver	Not Listed	N

Table F-33. Metals listing status and TMDL conclusions for the Little Boulder River

Metal	Listing Status	TMDL Needed? (Y/N)
Zinc	Current Listing	N
Number of TMDLs Required		4

TMDLs for aluminum, copper, iron, and lead are required for the Little boulder River. The data indicate that current impairment listing for zinc needs reevaluation.

F2.13 North Fork Little Boulder River (MT41E002_090)

The North Fork Little Boulder River extends for 12 miles from its headwaters in the Deerlodge Mountains to its mouth on the mainstem Little Boulder River (**Figure F-12**). In 2012 the stream is listed as impaired by sediment, total nitrogen, and streamside vegetation alteration. An examination of water column metals concentrations discovered elevated levels of aluminum and copper.

F2.13.1 North Fork Little Boulder River Sources

The MBMG abandoned mine database lists five inactive mines or mining prospects in Little Boulder River drainage. These are small-scale disturbances remote from stream channels and are unlikely to have measurable effects on water quality. Roadways in the North Fork Little Boulder are a potential source of sediment-bound metals loading. A near stream access road extends for six miles from the mouth of the stream to site M07LBNFR02 in the central part of the drainage. In addition, there is a four square mile area in the central drainage where road densities are greater than two miles per square mile.

F2.13.2 North Fork Little Boulder River Target Departures

The recent water quality dataset for the Little Boulder River contains 23 records from six monitoring sites (**Figure F-12**). Water chemistry data are available from four sites. Sites M07LBNFR01 and M07LBNFR02 were established by DEQ for assessment purposes in 2004. Site BE-62 near the mouth of the stream was established by DEQ in 2009. All three sites were sampled again by DEQ in 2010. Sites M07LBNFR05 and M07LBNFR06 were established by DEQ in 2010 for discharge measurements only. **Table F-34** summarizes the water quality target departures for the North Fork Little Boulder River.

Table F-34. North Fork Little Boulder River TMDL Decision Factors and TMDL Conclusions

Pollutant Parameter	Sample Size	CAL Exceedance Rate > 10%	Results Twice the AAL Criterion	Human Health Criterion exceeded	Sediment PEL Exceeded	Human-Caused Sources Present	2012 303(d) Listing Status	TMDL Decision
Aluminum	11	Y	N	NA	NA	Y	Not Listed	Al TMDL
Arsenic	13	N	N	N	N	Y	Not Listed	No TMDL
Cadmium	13	N	N	N	N	Y	Not Listed	No TMDL
Copper	13	Y	N	N	N	Y	Not Listed	Cu TMDL
Iron	13	N	NA	NA	NA	Y	Not Listed	No TMDL
Lead	13	N	N	N	N	Y	Not Listed	No TMDL
Mercury	2	N	N	N	N	Y	Not Listed	No TMDL
Silver	13	N	N	N	NA	Y	Not Listed	No TMDL
Zinc	13	N	N	N	N	Y	Not Listed	No TMDL

* AAL is used for Silver since Silver does not have a CAL

The 10 percent CAL exceedance threshold was exceeded for aluminum and copper. No sample exceeded a human health criterion. No sediment PELs were exceeded for any North Fork sample.

Sediment chemistry data are from one sample collected in 2009 from site BE-62 near the mouth. **Table F-35** summarizes the sediment chemistry data from the site as the ratio of the measured metal concentration over the PEL concentration. The sediment metals concentration data are in **Appendix D**.

Table F-35. Ratios of measured sediment metals concentrations to PELs for sediment samples from the North Fork Little Boulder River

SITE ID	Site Location	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc
BE-62	Near the mouth	0.9	0.1	0.1	0.1	< 0.2	0.2

F2.13.3 North Fork Little Boulder River TMDL Summary

The listing status and TMDL conclusions for metals in the North Fork Little Boulder River are summarized in **Table F-36.**

Table F-36. Metals listing status and TMDL conclusions for the North Fork Little Boulder River

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	Not Listed	Y
Arsenic	Not Listed	N
Cadmium	Not Listed	N
Copper	Not Listed	Y
Iron	Not Listed	N
Lead	Not Listed	N
Mercury	Not Listed	N
Silver	Not Listed	N
Zinc	Current Listing	N
Number of TMDLs Required		2

TMDLs for aluminum and copper are required for the North Fork Little Boulder River.

F2.14 Upper Elkhorn Creek (MT41E002_061)

Figure F-13 shows the watershed boundaries, sample site locations, and potential mine sources of metals loading for both the upper and lower segments of Elkhorn Creek.

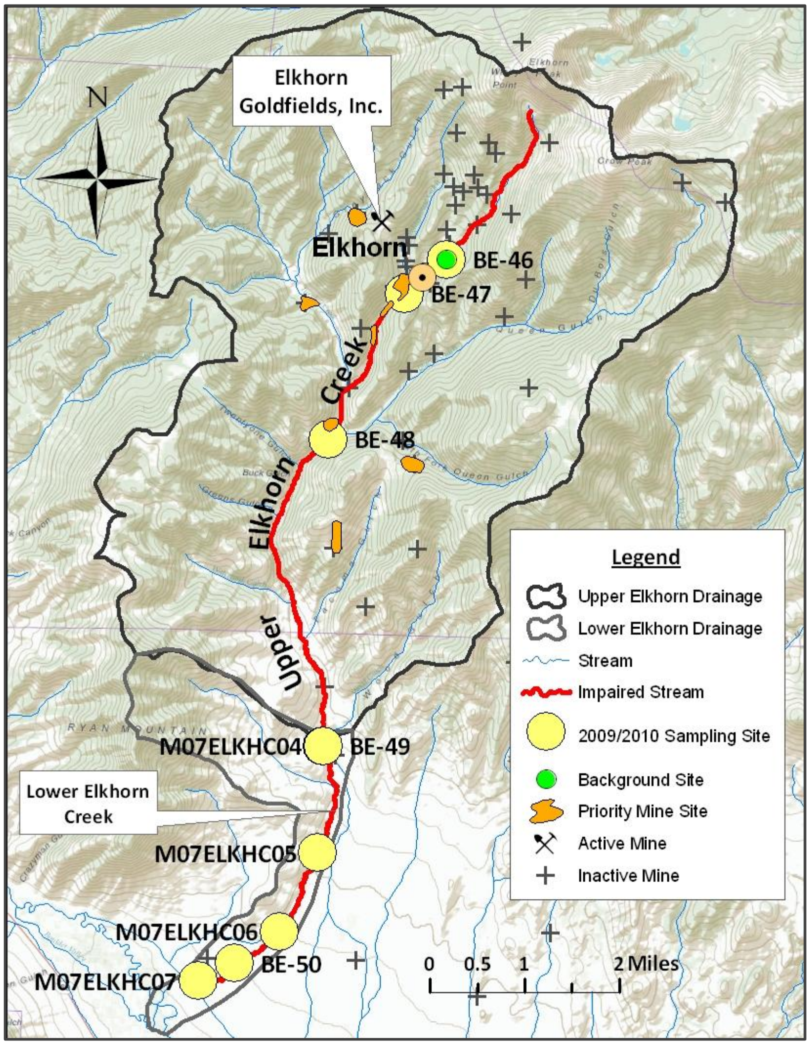

Figure F-13. Upper and lower Elkhorn Creek watersheds, monitoring sites, and mining sources.

Water quality of the lower segment is discussed separately in **Section F2.15**. Upper Elkhorn Creek extends for 8.2 miles from its headwaters in the Elkhorn Mountains to its confluence with Wood Creek, where the lower segment of Elkhorn Creek begins. The respective drainages areas of the upper and lower Elkhorn Creek are 32 and 4 square miles. Metal impairments on the upper segment are because of arsenic, cadmium, copper, lead, and zinc; lower segment impairments are for cadmium, copper, lead, and zinc.

F2.14.1 Upper Elkhorn Creek Sources

The history of the Elkhorn Mining District centers on the development of the Elkhorn Mine. The claims were first worked in the late 1870s. Production increased through a series of mill and process upgrades during the following 20 years and the Elkhorn Mine became one of the largest silver producers in the country. Declining ore values and pumping costs forced closure of the mine in 1951 (Montana Department of Environmental Quality, Remediation Division, Mine Waste Cleanup Bureau, Abandoned Mine Section, 2011). Ore milling and reworking of earlier tailings left approximately 85,000 yd^{3}s of tailings adjacent to the Elkhorn Creek tributary of Slaughterhouse Gulch and Elkhorn Creek within the Elkhorn townsite and downstream for about a mile. Smaller properties include the partially reclaimed

Trumley Heap Leach site located one mile west of the Elkhorn on Turnley Creek. The Sourdough Mine is farther upstream on the Turnley Creek tributary of Greyback Gulch. The site contains about 32,000 yd^3s of uncovered waste rock containing elevated concentrations of arsenic, copper, and mercury (Montana Department of State Lands, 1995). An adit discharge at the Sourdough Mine containing elevated cadmium seeps into the ground before it reaches the Greyback Gulch stream channel.

Farther downstream on Elkhorn Creek are the priority mine properties of the Tourmaline Queen that contains about 80,000 yd^3s of waste rock near the confluence of Elkhorn Creek and Queen's Gulch. The Elkhorn Queen and Tacoma mines are located in Tacoma Gulch that enters Elkhorn Creek about a mile above end of the upper segment. The two sites combined contain about 30,000 yd^3s of waste rock containing elevated concentrations of arsenic and iron (Montana Department of State Lands, 1995).

DEQ issued hardrock mine operating permit number 000173 to Elkhorn Goldfields, Inc. in November, 2011. The underground hardrock gold mine is located northwest of the Elkhorn townsite on the slopes and ridgeline between Greyback Gulch and Slaughterhouse Gulch (**Figure F-13**). The mine is currently developing portal and underground access to the ore body. The mine plans to recover from 500 to 1,000 tons of ore per day for offsite milling and processing for gold recovery. Mining will disturb about 30 acres within 383 acres of private land within the Deerlodge National Forest. The mine site consists of a three-portal bench in the Greyback Gulch drainage; mine offices, parking, shop, water storage pond, and waste rock repository on the ridge area; and an ore load out facility in Slaughterhouse Gulch.

The operation will continuously discharge an estimated 150 to 300 gpm of treated wastewater from mine dewatering and ore recovery operations to groundwater through a subsurface drainfield. Wastewater is treated is for arsenic removal using an iron oxide or hydroxide adsorption medium. A 5,200 gallon bacterial reactor operating at 20 gpm will remove wastewater nitrogen. The drainfield consists of 3,528 feet of buried four-inch perforated PVC pipe divided into three segments. One segment is placed on the flank of the ridge draining to Turnley Creek; the other two segments are on the opposite side of the ridge that drains to Slaughterhouse Gulch. The drainfield segments will be used on a rotating schedule to prevent saturation of the substrate beneath any single line. A groundwater monitoring well will be constructed down-gradient of each line.

Table F-37 gives averages and ranges for selected nutrient and metal parameters detected in water pumped from the mine.

Table F-37. Mean values for selected water quality parameters for receiving groundwater and parameter ranges for water pumped from the active mine.

Parameter	Receiving Groundwater	Process Wastewater pumped from the mine	
	Average	Maximum	Minimum
Hardness (mg/L)	164	--	--
Specific Conductance (µmhos/cm)	334	--	--
NO_3 + NO_2-N (mg/L)	0.24	1.2	0.40
Aluminum (mg/L)	0.09	0.1	0.1
Arsenic (mg/L)	0.020	0.025	0.008
Cadmium (mg/L)	0.0001	0.0001	0.0001
Copper (mg/L)	0.005	0.009	0.001
Lead (mg/L)	0.0036	0.003	0.003
Mercury(mg/L)	0.0001	0.0001	0.0001
Zinc (mg/L)	0.017	0.220	0.05

Compared with human health criteria for metals, the process water is high in total recoverable arsenic and mercury. Maximum values in water pumped from the mine also exceed human health criteria for arsenic and mercury. The permit contains monitoring requirements for process wastewater, groundwater, and surface water in Greyback Gulch, Slaughterhouse Gulch and Elkhorn Creek. Elkhorn Goldfields, Inc. also holds a general stormwater discharge permit from DEQ for mining activity (permit No. MTR300264) that addresses stormwater from surface disturbances related to the mine operations and an office and parking area.

F2.14.2 Upper Elkhorn Creek Target Departures

The recent water quality dataset for upper Elkhorn Creek contains 12 records from three monitoring sites: BE-46, BE-47, and BE-48 (**Figure F-13**). DEQ established all three sites for assessment purposes in 2009 and re-sampled in 2010. **Table F-38** summarizes the water quality target departures for upper Elkhorn Creek.

Table F-38. Upper Elkhorn Creek TMDL Decision Factors and TMDL Conclusions

Pollutant Parameter	Sample Size	CAL Exceedance Rate > 10%	Results Twice the AAL Criterion	Human Health Criterion exceeded	Sediment PEL Exceeded	Human-Caused Sources Present	2012 303(d) Listing Status	TMDL Decision
Aluminum	8	N	N	NA	NA	NA	Not Listed	No TMDL
Arsenic	12	N	N	Y	NA	Y	Listed	As TMDL
Cadmium	12	Y	N	N	NA	Y	Listed	Cd TMDL
Copper	12	Y	N	N	NA	Y	Listed	Cu TMDL
Iron	12	Y	NA	NA	NA	Y	Not Listed	Fe TMDL
Lead	12	Y	N	N	NA	Y	Listed	Pb TMDL
Mercury	4	N	N	N	NA	Y	Not Listed	No TMDL
Silver	12	N	N	N	NA	Y	Not Listed	No TMDL
Zinc	12	N	N	N	NA	Y	Listed	No TMDL

* AAL is used for Silver since Silver does not have a CAL

The 10 percent CAL exceedance threshold was exceeded for cadmium, copper, lead, and iron. The human health criterion for arsenic was exceeded at site BE-47. No sample exceeded water quality criteria for zinc.

No recent stream sediment data are available from upper Elkhorn Creek. Tailings and waste rock samples collected during an inventory of the Elkhorn Mine in 1994, contained metal concentrations that are one to two orders of magnitude higher than the PELs for arsenic, copper, lead, and zinc (Montana Department of State Lands, 1995).

F2.14.3 Upper Elkhorn Creek TMDL Summary

The listing status and TMDL conclusions for metals in upper Elkhorn Creek are summarized in **Table F-39.**

Table F-39. Metals listing status and TMDL conclusions for upper Elkhorn Creek

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	Not Listed	N
Arsenic	Current Listing	Y
Cadmium	Current Listing	Y

Table F-39. Metals listing status and TMDL conclusions for upper Elkhorn Creek

Metal	Listing Status	TMDL Needed? (Y/N)
Copper	Current Listing	Y
Iron	Not Listed	Y
Lead	Current Listing	Y
Mercury	Not Listed	N
Silver	Not Listed	N
Zinc	Current Listing	N
Number of TMDLs Required		5

TMDLs for arsenic, cadmium, copper, iron, and lead are required for upper Elkhorn Creek. The current listing for zinc should be reevaluated.

F2.15 Lower Elkhorn Creek (MT41E002_062)

Figure F-13 shows the watershed boundaries, sample site locations, and potential mine sources of metals loading for lower segments of Elkhorn Creek. During high flow, Lower Elkhorn Creek extends four miles from the confluence with Wood Gulch to the mouth on the Boulder River. Under low flow conditions during the irrigation season, Elkhorn Creek is completely dewatered at site BE-50.
Metal impairments on the lower segment are caused by cadmium, copper, lead, and zinc.

F2.15.1 Lower Elkhorn Creek Sources

Lower Elkhorn Creek sources are those described above for the upper segment. A couple of placer gold prospects occur along the lower segment but the disturbances have been re-graded and converted to irrigated hay production.

F2.15.2 Lower Elkhorn Creek Target Departures

The recent water quality dataset for lower Elkhorn Creek contains 11 records from four monitoring sites: BE-49, M07ELKHC05, M07ELKHC06, and BE-50 (**Figure F-13**). DEQ established sites BE-49 and BE-50 in 2009, re-sampled them in 2010, and established M07ELKHC05 and M07ELKHC06 in 2010. **Table F-40** summarizes the water quality target departures for upper Elkhorn Creek.

Table F-40. Lower Elkhorn Creek TMDL Decision Factors and TMDL Conclusions

Pollutant Parameter	Sample Size	CAL Exceedance Rate > 10%	Results Twice the AAL Criterion	Human Health Criterion exceeded	Sediment PEL Exceeded	Human-Caused Sources Present	2012 303(d) Listing Status	TMDL Decision
Aluminum	8	N	N	NA	NA	Y	Not Listed	No TMDL
Arsenic	11	N	N	Y	Y	Y	Not Listed	As TMDL
Cadmium	11	Y	N	N	Y	Y	Listed	Cd TMDL
Copper	11	N	N	N	N	Y	Listed	No TMDL
Iron	11	N	NA	NA	NA	Y	Not Listed	No TMDL
Lead	11	Y	N	Y	Y	Y	Listed	Pb TMDL
Mercury	3	N	N	N	N	Y	Not Listed	No TMDL
Silver	11	N	NA	N	NA	Y	Not Listed	No TMDL
Zinc	11	N	N	N	Y	Y	Listed	No TMDL

* AAL is used for Silver since Silver does not have a CAL

The 10 percent CAL exceedance threshold was exceeded for cadmium and lead. The human health criteria were exceeded for arsenic and lead at site BE-49. Although sediment concentrations of zinc are nearly 10 times the PEL value, water column concentrations are well below the most restrictive target criterion.

Sediment chemistry data are available for a sample collected in 2009 from site BE-49 at the upper end of the stream segment. **Table F-41** summarizes the sediment chemistry data from the site as the ratio of the measured metal concentration over the PEL concentration. The sediment metals concentration data are in **Appendix D**.

Table F-41. Ratios of measured sediment metals concentrations to PELs for sediment samples from site BE-49 on lower Elkhorn Creek

SITE ID	Site Location	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc
BE-49	Upstream end of segment	4.1	10.7	0.9	11.7	25	0.08

Sediment metals concentrations are extremely high relative to PEL values for arsenic, cadmium, lead and mercury. Sediment chemistry at the upper end of the segment remains strongly affected by upstream mine tailings.

F2.15.3 Lower Elkhorn Creek TMDL Summary

The listing status and TMDL conclusions for metals in lower Elkhorn Creek are summarized in **Table F-42.**

Table F-42. Metals listing status and TMDL conclusions for lower Elkhorn Creek

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	Not Listed	N
Arsenic	Not Listed	Y
Cadmium	Current Listing	Y
Copper	Current Listing	N
Iron	Not Listed	N
Lead	Current Listing	Y
Mercury	Not Listed	N
Silver	Not Listed	N
Zinc	Current Listing	N
Number of TMDLs Required		3

TMDLs for arsenic, cadmium, and lead are required for lower Elkhorn Creek. The current listing for zinc is questionable and should be reevaluated.

F2.16 Boulder River, Town of Boulder to Cottonwood Creek (MT41E001_022)

The segment of the Boulder River between the town of Boulder and Cottonwood Creek is 36 miles long and is listed as impaired by elevated copper, iron, lead, silver, and zinc. **Figure F-14** shows the extent of the 230 square mile watershed for this segment of the river, along with locations of recent sample sites, permitted discharges, and mine-related sources.

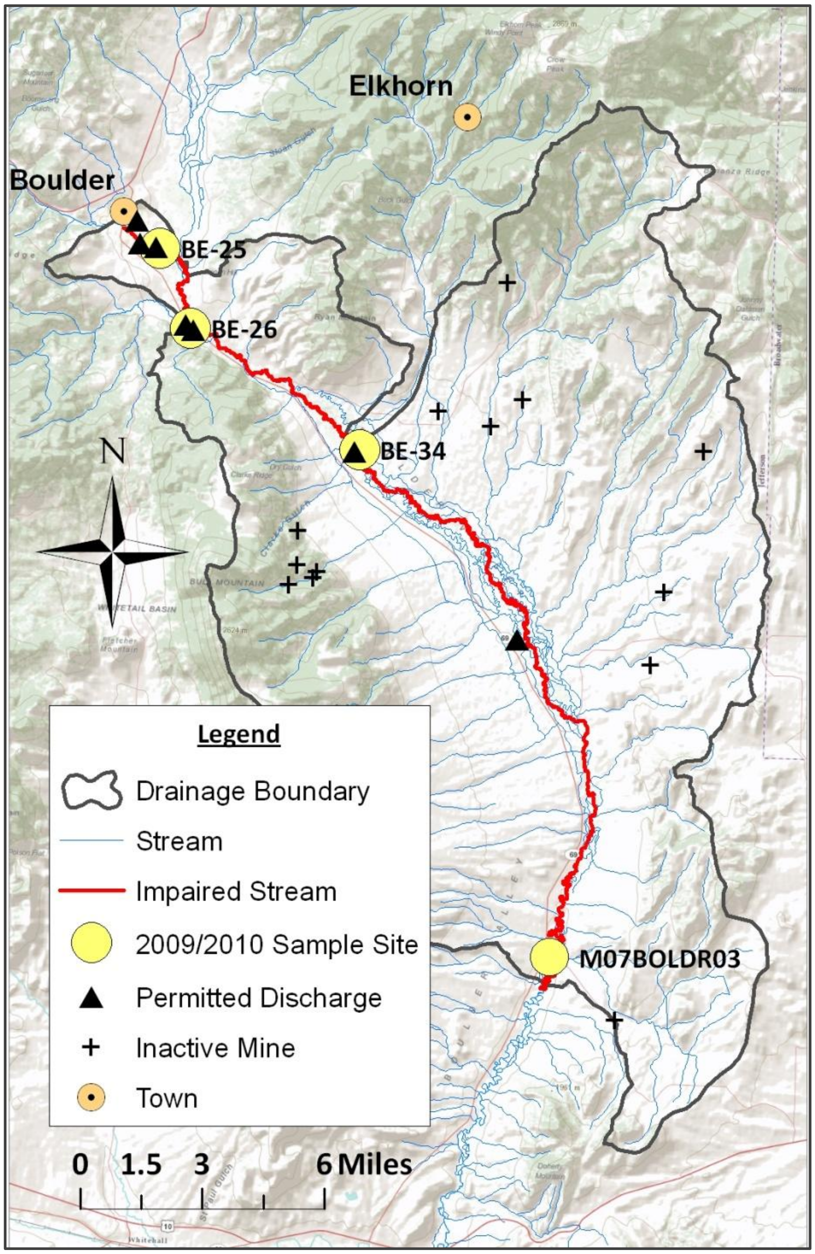

Figure F-14. Boulder River (MT41E001_22) watershed, monitoring sites, permitted discharges, and mining sources.

F2.16.1 Boulder River (MT41E001_022) Sources

The MBMG abandoned mines database lists 14 properties in the drainage basin for this segment of the Boulder River. None of them are among Montana's high priority sites. Five of the properties are clustered on the east slope of Bull Mountain and are small-scale lode mines or prospects for gold and lead. A small scale placer gold prospect is located in the same area in an unnamed Boulder River tributary to the north of Jack Creek. Across the Boulder River valley to the northeast east are four prospects for iron, gold, and lead. Farther south in the sedimentary hills are three lead and silver prospects that are small disturbances with associated access trails. A small phosphate surface mine is located near the southeast corner of the watershed just off of Negro Hollow road on the divide between Boulder River watershed and the lower Jefferson River drainage. These sites consist of un-vegetated waste rock or ore stockpiles and small surface quarries under an acre with access roads. None are described as having adit or portal discharges.

There are eight permitted discharges within this segment of the Boulder River. The wastewater treatment plant for the town of Boulder has permitted outfall 001 that is sampled regularly for conventional pollutants (pH, temperature, total suspended solids, five-day biochemical oxygen demand (BOD_5), oil and grease, and fecal coliform bacteria). Semiannual (June and December) sampling for hardness, total recoverable copper, Iron, lead, silver, and zinc are required by the permit for the outfall and the river upstream of the outfall beginning in 2010. **Table F-43** contains the results of the effluent monitoring required by the discharge permit, plus the effluent analysis results for a sample collected in September, 2012, by DEQ to quantify arsenic and cadmium concentrations in the outfall.

Table F-43. Total hardness and total recoverable metals monitoring results for the Boulder wastewater treatment system outfall 001.*

Sample Period	Total Hardness	Arsenic	Cadmium	Copper	Iron	Lead	Silver	Zinc
Jan.-June, 2010	43	--	--	**0.03**	0.58	< 0.01	< 0.005	0.02
July-Dec., 2010	54	--	--	< 0.02	0.29	< 0.01	< 0.005	< 0.01
Jan.-June, 2011	28	--	--	**0.04**	0.04	< 0.01	< 0.005	**0.05**
July-Dec., 2011	61	--	--	**0.02**	0.09	< 0.01	< 0.005	< 0.01
Jan.-June, 2012	28	--	--	**0.06**	0.72	**0.003**	< 0.001	0.04
July-Dec., 2012	40	--	--	**0.06**	0.72	**0.003**	< 0.001	0.04
Sept., 2012	48	< 0.003	0.00017	**0.063**	**1.66**	0.00042	< 0.0005	0.05

* The shaded cells in the table identify analytical results for which the method detection limits were higher than the hardness-based aquatic life targets. Bolded values in the table identify actual target exceedances.

The values for total hardness in **Table F-43** are those measured in the Boulder River near the treatment system outfall. The only available results for arsenic and cadmium are from the September, 2012, sample collected by DEQ. From these limited results, arsenic and cadmium concentrations in the effluent appear to meet the most restrictive targets for these metals.

The treatment system discharge ranges from 0.03 to 0.42 cfs; with a median flow of 0.12 cfs. The average of flows greater than 0.12 cfs is 0.2 cfs; the average of flows less than the 50^{th} percentile is 0.07 cfs. These average high and low flows, and calculated median metal concentrations in the outfall, can be used to calculate existing high- and low-flow metals loading examples for the treatment system outfall. **Table F-44** contains median metal concentrations and corresponding high- and low-flow loading examples for the Boulder WWTP outfall.

Table F-44. Median concentrations and existing loading rate examples for metal pollutants in the Boulder WWTP outfall.

	Metal Pollutants					
	Arsenic	**Cadmium**	**Copper**	**Iron**	**Lead**	**Zinc**
Median Metal Concentrations (µg/L)	3	0.17	40	580	10	40
Existing High Flow Loading (lbs/day)	0.003237	0.000183	0.043157	0.625780	0.010789	0.043157
Existing Low Flow Loading (lbs/day)	0.001133	0.000064	0.015105	0.219023	0.003776	0.015105

The median concentrations in **Table F-44** are calculated from the measured results and method detection limits contained in **Table F-43**. The median values for arsenic, cadmium, iron, and zinc are within the most restrictive targets for these metals. The median values for copper and lead are an order of magnitude greater than the most restrictive target value.

A general stormwater discharge permit for construction activity (No. MTR103757) is held by McAlvain Construction for the Big Boulder Residences development. The site is in a residential area of Boulder about 1,500 feet from the north bank of the river. The Montana Department of Transportation holds a general stormwater discharge permit (No. MTR103698) for road construction activity about three miles south of the town of Boulder. The site is adjacent to the right bank of the Boulder River near the mouth of the Little Boulder River. Two other general stormwater permits for construction activity are held by aggregate quarries. Both sites are about 15 acres in area and are adjacent to the Highway 69 right-of-way 7.5 miles and 14 miles south of Boulder. Both facilities are about one thousand feet from the Boulder River channel with intervening pasture land and irrigation delivery canals. Because of distance and infrastructure barriers, it is unlikely that facilities holding general stormwater permits would directly discharge to the Boulder River.

F2.16.2 Boulder River (MT41E001_022) Target Departures

The recent water quality dataset for the Boulder River from Boulder to Cottonwood Creek contains eight records from four monitoring sites: BE-25 down-gradient of the Boulder WWTP, BE-26 below the confluence with the Little Boulder River, BE-34 below the mouth of Elkhorn Creek, and M07BOLDR03 near the downstream end of the segment. DEQ established the upper three sites in 2009 and the fourth in 2010. **Table F-45** summarizes the water quality target departures for this segment of the river.

Table F-45. Boulder River (MT41E001_022) TMDL Decision Factors and TMDL Conclusions

Pollutant Parameter	Sample Size	CAL Exceedance Rate > 10%	Results Twice the AAL Criterion	Human Health Criterion exceeded	Sediment PEL Exceeded	Human-Caused Sources Present	2012 303(d) Listing Status	TMDL Decision
Aluminum	2	Y	N	NA	NA	Y	Not Listed	No TMDL
Arsenic	8	N	N	Y	Y	Y	Not Listed	As TMDL
Cadmium	8	Y	N	N	Y	Y	Not Listed	Cd TMDL
Copper	8	Y	Y	N	Y	Y	Listed	Cu TMDL
Iron	8	Y	NA	NA	NA	Y	Listed	Fe TMDL
Lead	8	Y	N	Y	Y	Y	Listed	Pb TMDL
Mercury	6	N	N	N	Y	Y	Not Listed	No TMDL
Silver	8	N	N	N	NA	Y	Listed	No TMDL
Zinc	8	Y	N	N	Y	Y	Listed	Zn TMDL

* AAL is used for Silver since Silver does not have a CAL

The 10 percent CAL exceedance threshold was exceeded for aluminum, cadmium, copper, iron, lead, and zinc. The sample size for aluminum analyses (2) is not sufficient to establish a new aluminum listing. The human health criteria were exceeded for arsenic and lead at sites BE-34 and M07BOLDR03. Applicable PELS were exceeded for arsenic, cadmium, copper, lead, mercury, and zinc. Although the mercury concentration in one sediment sample is 1.7 times the PEL value, all six low-level water column mercury analyses reported less than detectable concentrations.

Sediment chemistry data are available for two samples collected in 2009 from sites BE-26 and BE-34. **Table F-46** summarizes the sediment chemistry data from the site as the ratio of the measured metal concentration over the PEL concentration. The sediment metals concentration data are in **Appendix D**.

Table F-46. Ratios of measured sediment metals concentrations to PELs for sediment samples from sites BE-26 and BE-34 on the Boulder River

SITE ID	Site Location	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc
BE-26	Below Little Boulder River confluence	7.7	2.8	1.6	2.3	0.9	3.8
BE-34	Below Elkhorn Creek confluence	13.1	3.3	2.8	3.4	1.7	4.5

Sediment metals concentrations for all parameters are elevated compared with PEL values except that for mercury at site BE-26. Significant increases for all parameters occur between the Little boulder River and site BE-34 below Elkhorn Creek.

F2.16.3 Boulder River (MT41E001_022) TMDL Summary

The listing status and TMDL conclusions for metals in the Boulder River between the town of Boulder and Cottonwood Creek are summarized in **Table F-47.**

Table F-47. Metals listing status and TMDL conclusions for Boulder River, segment MT41E001_022

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	Not Listed	N
Arsenic	Not Listed	Y
Cadmium	Not Listed	Y
Copper	Current Listing	Y
Iron	Current Listing	Y
Lead	Current Listing	Y
Mercury	Not Listed	N
Silver	Current Listing	N
Zinc	Current Listing	Y
Number of TMDLs Required		6

TMDLs for arsenic, cadmium, copper, iron, lead, and zinc are required for the Boulder River between the town of Boulder and Cottonwood Creek. The current listing for silver is questionable and should be reevaluated.

F2.17 Boulder River, Cottonwood Creek to mouth (MT41E001_030)

Figure F-15 shows the extent of the 54 square mile watershed for this 14-mile segment of the river, along with locations of recent metals sample sites, and mine-related sources.

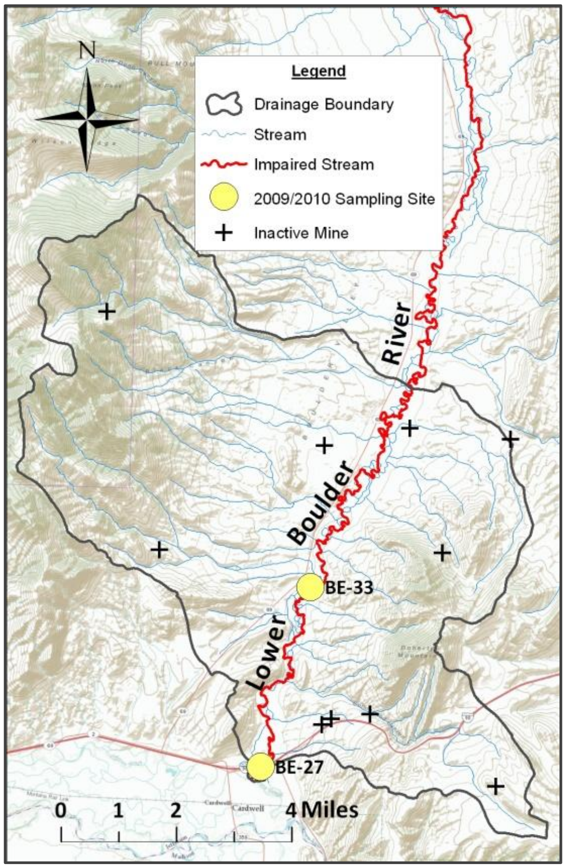

Figure F-15. Lower Boulder River watershed, monitoring sites, and mining sources.

The segment of the Boulder River between Cottonwood Creek and the mouth of the river on the Jefferson Slough is listed as impaired by elevated arsenic, cadmium, copper, lead, and zinc.

F2.17.1 Lower Boulder River (MT41E001_030) Sources

The MBMG abandoned mines database lists 10 properties in the drainage basin for this river segment. None of them are among Montana's high priority sites. Five of the properties are surface clay and stone quarries with minimal or no surface disturbance. The remaining properties are metal prospects on the southeastern slope of the Bull Mountains with minimal surface disturbance. Most metals loading to the lower Boulder River is likely from upstream sources in the planning area.

F2.17.2 Lower Boulder River (MT41E001_030) Target Departures

The recent water quality dataset for the lower Boulder contains seven records from two monitoring sites: BE-27 at the mouth of the lower Boulder and site BE-33 located seven miles upstream.

DEQ established both sites in 2009 and re-sampled site BE-27 in 2010. **Table F-48** summarizes the water quality target departures for the lower Boulder River.

Table F-48. Lower Boulder River (MT41E001_030) TMDL Decision Factors and TMDL Conclusions

Pollutant Parameter	Sample Size	CAL Exceedance Rate > 10%	Results Twice the AAL Criterion	Human Health Criterion exceeded	Sediment PEL Exceeded	Human-Caused Sources Present	2012 303(d) Listing Status	TMDL Decision
Aluminum	3	N	N	NA	NA	Y	Not Listed	No TMDL
Arsenic	7	N	N	Y	Y	Y	Listed	As TMDL
Cadmium	7	Y	N	N	Y	Y	Listed	Cd TMDL
Copper	7	Y	Y	N	N	Y	Listed	Cu TMDL
Iron	7	Y	NA	NA	NA	Y	Not Listed	Fe TMDL
Lead	7	Y	N	N	N	Y	Listed	Pb TMDL
Mercury	4	N	N	N	Y	Y	Not Listed	No TMDL
Silver	7	N	N	N	NA	Y	Not Listed	No TMDL
Zinc	7	Y	N	N	Y	Y	Listed	Zn TMDL

* AAL is used for Silver since Silver does not have a CAL

The 10 percent CAL exceedance threshold was exceeded for cadmium, copper, iron, lead, and zinc. The human health criterion for arsenic was exceeded in samples from both sites. Applicable PELS were exceeded for arsenic, cadmium, mercury, and zinc. Although the mercury concentration in the upstream sediment exceeded the PEL value, all four low-level water column mercury analyses reported less than detectable concentrations.

Sediment chemistry data are available for both sites from 2009 samples. **Table F-49** summarizes the sediment chemistry data from the sites as the ratio of the measured metal concentration over the PEL concentration. The sediment metals concentration data are in **Appendix D**.

Table F-49. Ratios of measured sediment metals concentrations to PELs for sediment samples from sites BE-33 and BE-27 on the lower Boulder River

SITE ID	Site Location	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc
BE-33	Seven miles above the mouth	1.7	1.2	0.7	0.8	0.7	2.5
BE-27	At the mouth	1.8	1.3	0.9	0.9	1.6	2.7

Sediment metals concentrations for arsenic, cadmium, mercury, and zinc are elevated compared with PEL values. Concentrations were similar at both sites, except for the doubling in sediment mercury concentration.

F2.17.3 Lower Boulder River (MT41E001_030) TMDL Summary

The listing status and TMDL conclusions for metals in the lower Boulder River are summarized in **Table F-50.**

Table F-50. Metals listing status and TMDL conclusions for the lower Boulder River, segment MT41E001_030

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	Not Listed	N
Arsenic	Current Listing	Y
Cadmium	Current Listing	Y
Copper	Current Listing	Y
Iron	Not Listed	Y
Lead	Current Listing	Y

Table F-50. Metals listing status and TMDL conclusions for the lower Boulder River, segment MT41E001_030

Metal	Listing Status	TMDL Needed? (Y/N)
Mercury	Not Listed	N
Silver	Not Listed	N
Zinc	Current Listing	Y
Number of TMDLs Required		6

TMDLs for arsenic, cadmium, copper, iron, lead, and zinc are required for the Lower Boulder River.

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APPENDIX G – RESPONSE TO PUBLIC COMMENTS

G1.0 PUBLIC COMMENTS AND DEQ RESPONSES

Montana Fish, Wildlife & Parks (FWP) Comments #1 through #5

Comment #1
Table 5.1: This table does not specifically identify Jack Creek or Elkhorn Creek. Were these streams left off the table for a specific reason?

> **Response to Comment #1**
> **Table 5.1** includes only those streams with a metal impairment cause identified on the 2012 303(d) List. Elkhorn Creek was included in **Table 5.1**, whereas Jack Creek and North Fork Little Boulder River were not included within **Table 5.1** because they did not have metals impairment causes identified on the 2012 303(d) List. The document has been edited to better clarify why Jack Creek and North Fork Little Boulder River are not included within **Table 5-1**.

Comment #2
Section 6.1.1, Fish Passage Barriers: This section states that fish passage barriers most often occur from channel obstacles (culverts, impoundments, etc.). A discussion of toxic barriers due to mine discharge seems warranted, and FWP is aware of at least three tributaries where the toxic barrier resulted in isolating native cutthroat from non-native trout (Jack Creek, High Ore Creek, Little Boulder River). Also, FWP (along with USFS and BLM) has worked on two projects to improve native cutthroat trout isolation by constructing barriers (Muskrat Creek and High Ore Creek). In addition, mine reclamation associated with Jack Creek was conducted in a manner to improve distribution of native cutthroat while maintaining the isolated fishery upstream of the toxic reach of stream.

> **Response to Comment #2**
> The suggested information along with most of the language provided within the comment has been added to the Fish Passage Barrier discussion within **Section 6.2** (formally **Section 6.1.1**) as follows:
>
> ***Fish Passage Barrier***
> *Impairment caused by fish passage barriers is most often related to channel obstacles such as impoundments or perched culverts at road crossings. The impairments are addressed by modification or removal of the barriers or operational changes to allow migration of fish and other aquatic life. Any fish barrier removal must be done in coordination with state and federal fishery representatives since fish passage barriers can beneficially isolate native fish populations, protecting them from non-native invasive species. For example, the Montana FWP has worked with the USFS and the BLM on two projects to improve native cutthroat trout isolation by constructing physical barriers in Muskrat Creek and High Ore Creek.*
>
> *In the Boulder watershed toxic barriers due to mine discharge create another form of fish barrier. Toxic fish barriers have been identified within at least three tributaries where the toxic barrier isolates native cutthroat from non-native trout (Jack Creek, High Ore Creek, Little Boulder River).*

> *Although maintenance of toxic stream conditions does not represent a desirable method for isolating native fish species, future projects to address toxic stream conditions should incorporate necessary barrier construction or other methods to maintain appropriate native fish isolation. For example, mine reclamation work associated with Jack Creek was conducted in a manner to improve distribution of native cutthroat while maintaining the isolated fishery upstream of the toxic reach of stream.*

Comment #3
Section 7.1, Water Quality Restoration Objectives: FWP believes that this section should include a more complete discussion to prioritize restoration objectives for aquatic life, including fish. For example, Jack Creek restoration related to the Bullion Mine has positive and negative implications for improving water quality in Jack Creek and Basin Creek, but such a project could eliminate a toxic barrier currently protecting a native cutthroat trout fishery upstream of the Bullion Mine. Therefore, water quality improvements in various tributaries may have unforeseen consequences on the fishery and these should be identified in a prioritized manner.

Response to Comment #3
Development of the specific priority details is outside the scope of this TMDL document. As stated in **Section 7.1**, *once TMDLs are established, restoration begins with development of a watershed restoration plan (WRP). A WRP is an analytical framework for restoring water quality in impaired waters by reducing loading from pollutant sources (U.S. Environmental Protection Agency, 2008). A WRP focuses on achieving the TMDLs presented in this document, addresses related water quality problems with local interest, and helps develop a detailed and locally organized process for prioritizing, funding, and completing restoration projects.*

Section 7.1.1 goes on present a bullet list of essential WRP elements that includes *expressed support for meeting other natural resource goals linked to water quality such as riparian grazing controls, timber harvest management, and road erosion abatement.* To address specific elements of your comment, the following bullet has been added to the list of essential WRP elements: ***Development of detailed restoration objectives focused on protection of native aquatic life species, including consideration of native fish isolation goals (see Section 6.2).***

Note that the above response to Comment #1 results in edits to **Section 6.2** (formally **Section 6.1.1**) that address some aspects of Comment #2. Also, within **Section 7.2.1** the Montana Department of Fish, Wildlife, and Parks (FWP) is identified as one of the agencies vital to restoration efforts in the Boulder-Elkhorn TPA. This should help provide significant opportunity for FWP involvement with restoration planning and priority setting within a WRP or other restoration/remediation planning documents.

Comment #4
Section 7.2.2, Metals Restoration Strategy: FWP believes that incremental clean-up of mine waste throughout various tributaries cumulatively improves water quality in the Boulder River upstream of the town of Boulder, and monitoring of the fishery from the 1970's to the 1990's has shown gradual improvements. The strategy of implementing streamside tailing removal seems to have been a priority during this work. However, adit discharge of toxic water remains to be a difficult, if not impossible, task. The Metals Restoration Strategy section could benefit from more discussion of streamside tailings, adit discharge, natural reduction in toxicity, new mine activity, or other factors. In addition, past mine reclamation projects have used the Luttrell Pit as a repository for mine waste due to the long term

stability of the site. Some discussion of the long term effectiveness of this repository at the top of the watershed also seems warranted. Specifically, the accountability of the various agencies cooperating with the Luttrell Pit repository would be useful to the long term effectiveness of this strategy for disposing of mine waste.

Response to Comment #4
As discussed in the response to Comment #2 (above), development of the specific priority details is outside the scope of this TMDL document and the information provided should be integrated within development of a future WRP and/or within specific remediation plans. This approach is also covered in **Section 7.2.2** where it is stated: *Rather than a detailed discussion of specific BMPs, this section describes general restoration programs and funding sources applicable to mining sources of metals loading. Past efforts have produced abandoned mine site inventories with enough descriptive detail to prioritize the properties contributing the largest metals loads.*

Regarding the Luttrell Pit, the following language has been incorporated into the **Section 8.1** discussion on restoration effectiveness monitoring: *Restoration effectiveness monitoring should not be limited to surface water quality monitoring and should include evaluation of all aspects and assumptions of each remediation activity. For example, the continued use of the Luttrell Pit as a repository should include site stability along with surface and groundwater quality monitoring. A monitoring strategy that clearly identifies the roles and responsibilities of various cooperating agencies needs to be developed and/or maintained for all significant remediation sites.*

Comment #5
Section 8.0, Monitoring: Fishery studies by F. Nelson (1976) and Farag et al (1997) and invertebrate studies by Gardner (1970's) and Gless (1990's) provide some long term perspective on trends of aquatic health related to mine waste in the Boulder. Context of recovery in future monitoring could benefit from using these data and some of their study locations. FWP could provide fishery monitoring at some of these historic sampling locations, if needed.

Response to Comment #5
The language in the above comment has been used to supplement **Section 8.1**, *Restoration Effectiveness Monitoring*. The following paragraph has been added to this section:

Fishery, invertebrate and other aquatic life studies and associated trend analyses also represent an important monitoring strategy component to evaluate watershed health in relation to mine remediation activities. Fishery studies by F. Nelson (1976) and Farag et al (1997) and invertebrate studies by Gardner (1970's) and Gless (1990's) can provide some long term perspective on trends of aquatic health related to mine waste in the Boulder watershed. Future fishery and aquatic health assessments could benefit from using these data. FWP personnel represent an important resource for coordinating, planning and performing monitoring activities at historical and other sampling locations within the watershed.

Private Citizen 1; Comments #6 through #7

Comment #6 (paraphrased)
I find no mention on the mine waste overburden at the first "topographical gravity shelf" on the lower valley; that is from Boulder to about 5-miles south of Boulder along the Boulder riverbanks and extending hundreds of yards from the current river location. This mine waste overburden ranges from 18in to 3ft in depth and has resulted from flood event mine waste transport... particularly due to dam failures upstream and 100-yr flood events. I have soil sample results at various soil depths showing high concentrations of heavy metals including As, Pb and Cd. I also have area photos depicting the damage. For nearly 20-years nothing would grow in this area and in many areas this is still the case. The soils just beneath the surface are contaminated with heavy metals. I would be happy to share these soil sample results in an effort to broaden the scope of this plan.

Response to Comment #6
Section 6.1 of the public comment document includes discussion of breached dams and impacted streams and floodplains, including the Boulder River in the area you mention. Based on this **Section 6.1** information and your comment, the following paragraph has been added to the **Section 5.3.2** general discussion on metals loading from mine sources:

During the above periods, tailings were often impounded in and adjacent to stream courses. Breached tailings impoundments have delivered tens of thousands of cubic yards of tailings to downstream reaches and floodplain areas of Jack Creek, Basin, Cataract, High Ore Creek, and Elkhorn creeks, and the lowest three segments of the Boulder River. Large flood events have also contributed to the downstream channel and floodplain distribution of contaminated tailings and other mine wastes throughout the Boulder River watershed.

Comment #7 (paraphrased)
There is mine waste along the rail bed extending from Butte to Helena. This mine waste was most likely shipped from Butte or possibly Basin. The ore is clearly visible in many locations near Boulder, Amazon, Wicks and Corbin areas. However these deposits have a reduced effect on the Boulder River when compared to deposits in the river, on the river banks and in the river floodplain.

Response to Comment #7
The existence of mine waste along the railroad lines is identified as a potentially significant source for Bison Creek (**Sections 5.7.7** and **Appendix F2.9.1**). Railroad grade fill material consisting of metal-contaminated mine tailings is also identified as a significant source justifying a remediation priority for the Boulder River upstream of the town of Boulder in **Section 7.2.2.3**.

Private Citizen 2; Comment #8

Comment #8 (paraphrased; most of the provided comment was outside the scope of the document)
As a Montana landowner, we support no increases in regulations that affect our lands or anyone else's lands. There is enough red tape and government regulation.

Response to Comment #8
The TMDL does not create new regulation, but can impact how existing regulation is implemented, specifically for permitted surface water point sources. TMDL implementation is discussed in **Section 4.5** where it is stated: *The Clean Water Act (CWA) and Montana state law*

(Section 75-5-703 of the Montana Water Quality Act) require wasteload allocations to be incorporated into appropriate discharge permits, thereby providing a regulatory mechanism to achieve load reductions from point sources. Nonpoint source reductions linked to load allocations are not required by the CWA or Montana statute, and are primarily implemented through voluntary measures.