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.

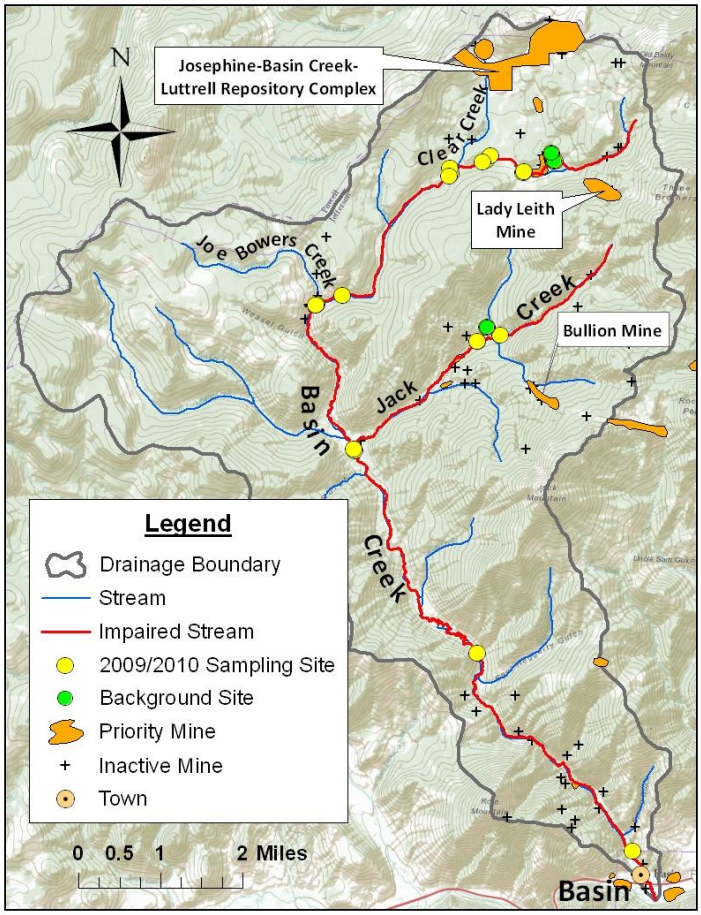

Figure F-1. The Basin Creek watershed, monitoring sites, and mining sources

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.

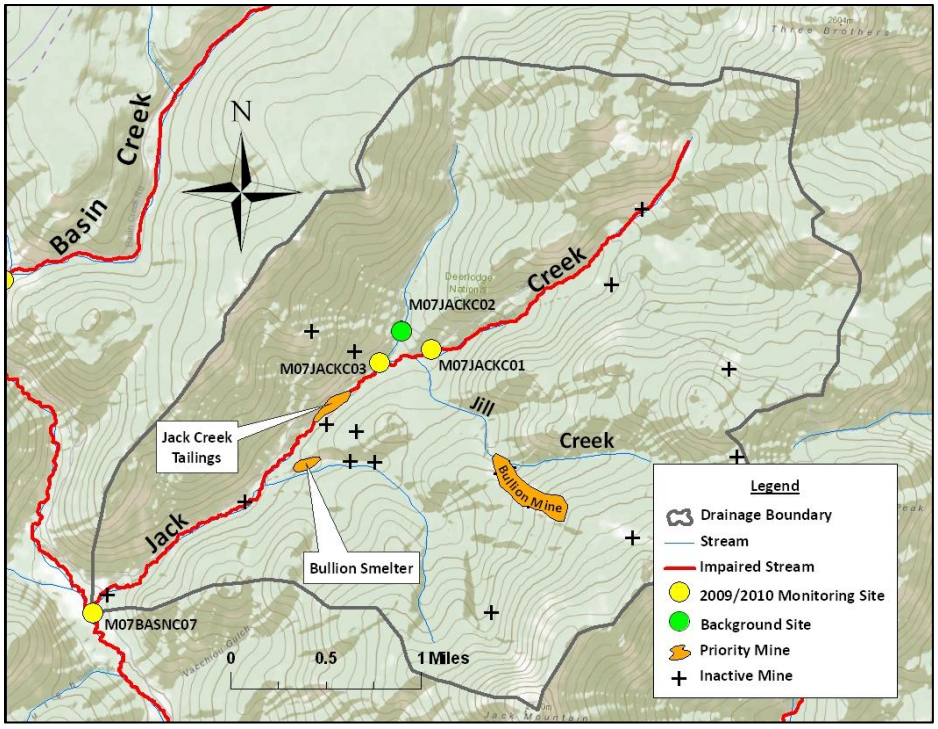

Figure F-2. Jack Creek watershed, monitoring sites, and mining sources

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.

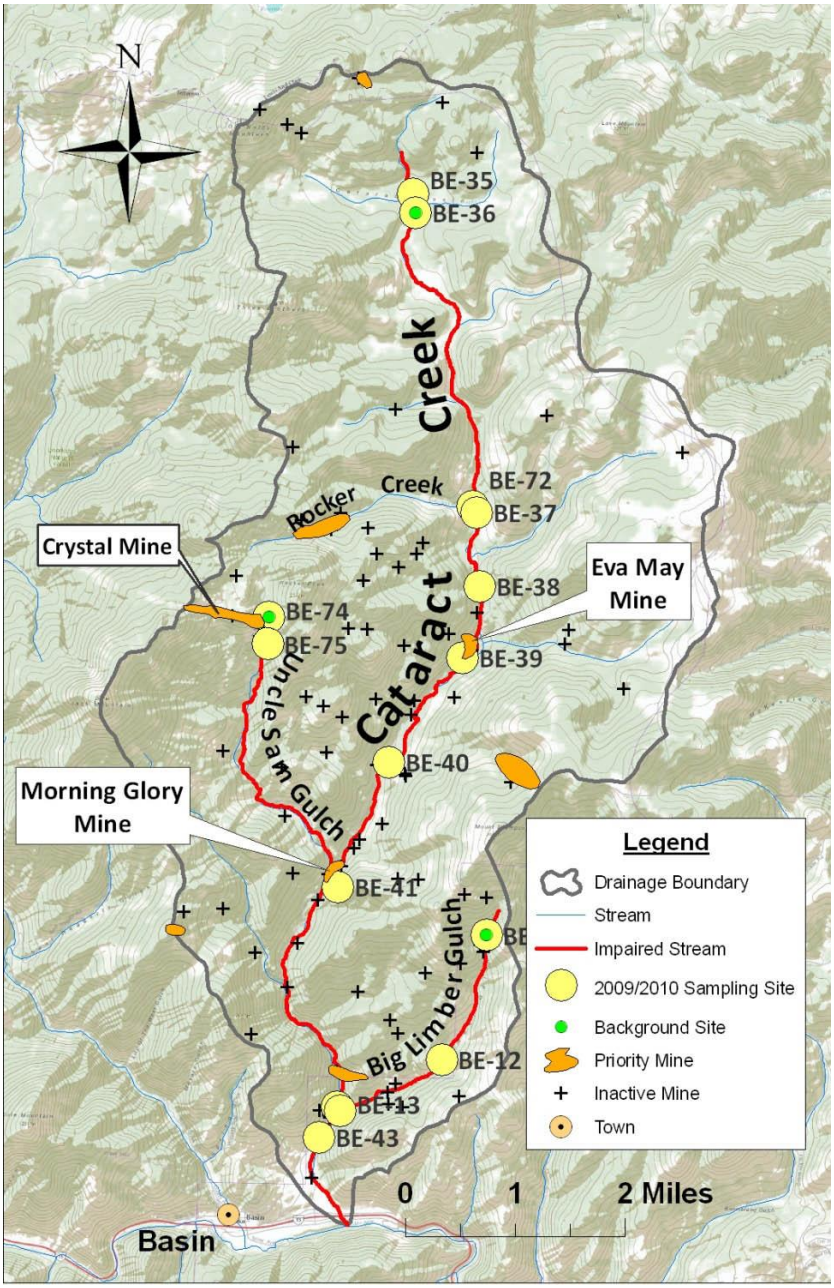

Figure F-3. Cataract Creek watershed, monitoring sites, and mining sources

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.

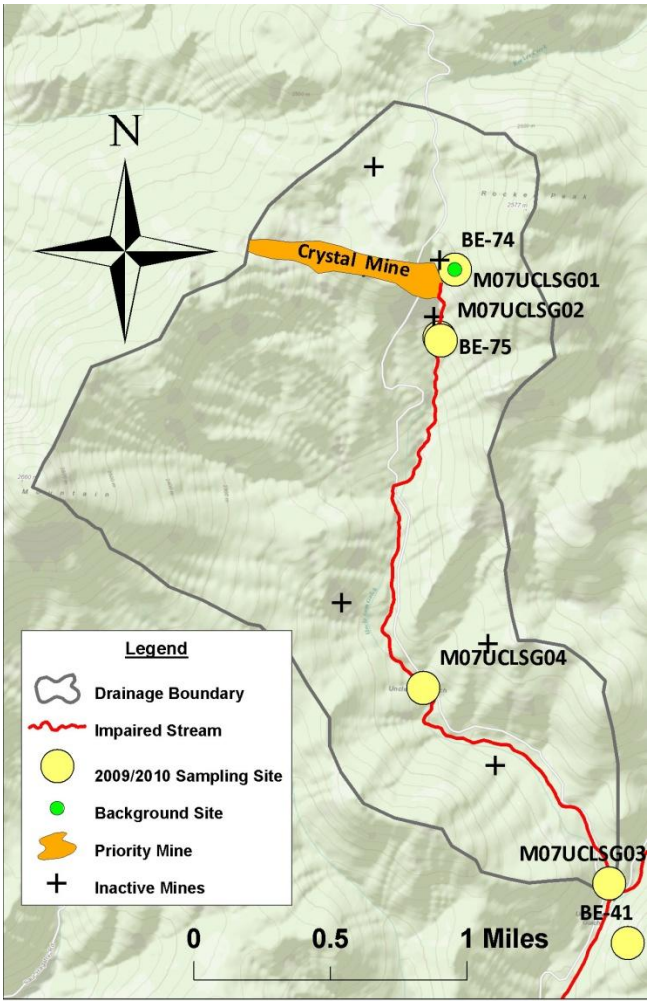

Figure F-4. The Uncle Sam Gulch watershed, monitoring sites and mining sources.

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.

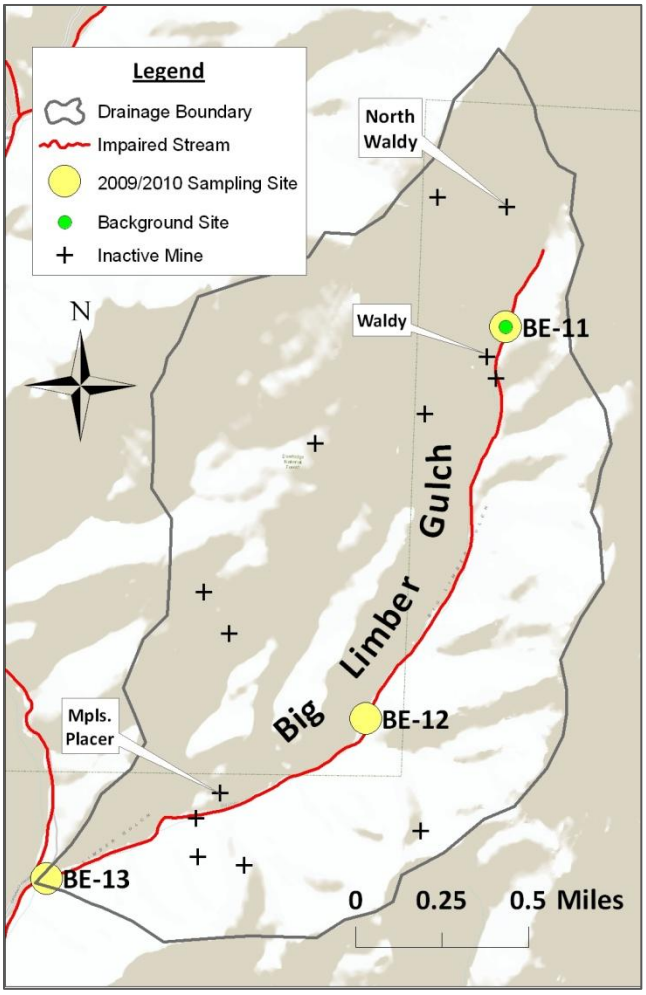

Figure F-5. The Big Limber Gulch watershed, monitoring sites, and mining sources

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.

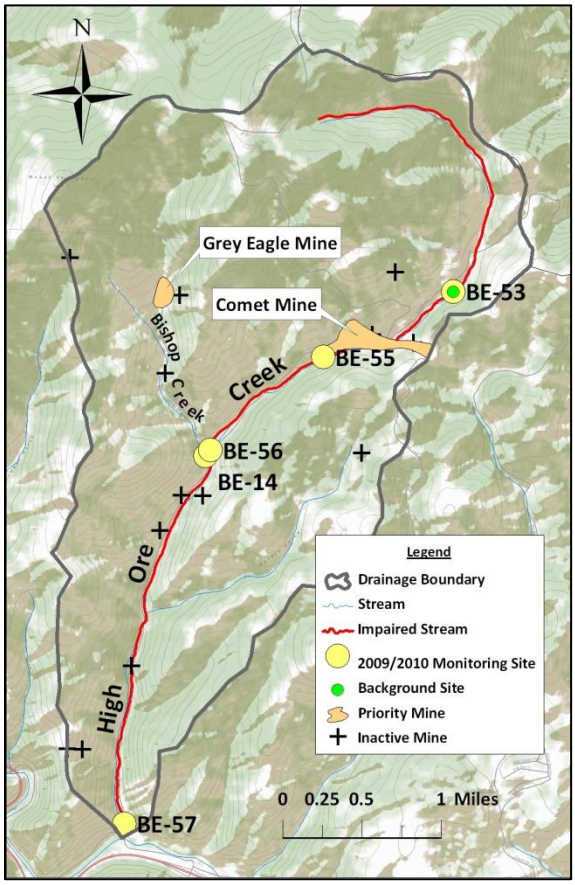

Figure F-6. The High Ore Creek watershed, monitoring sites, and mining sources.

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.

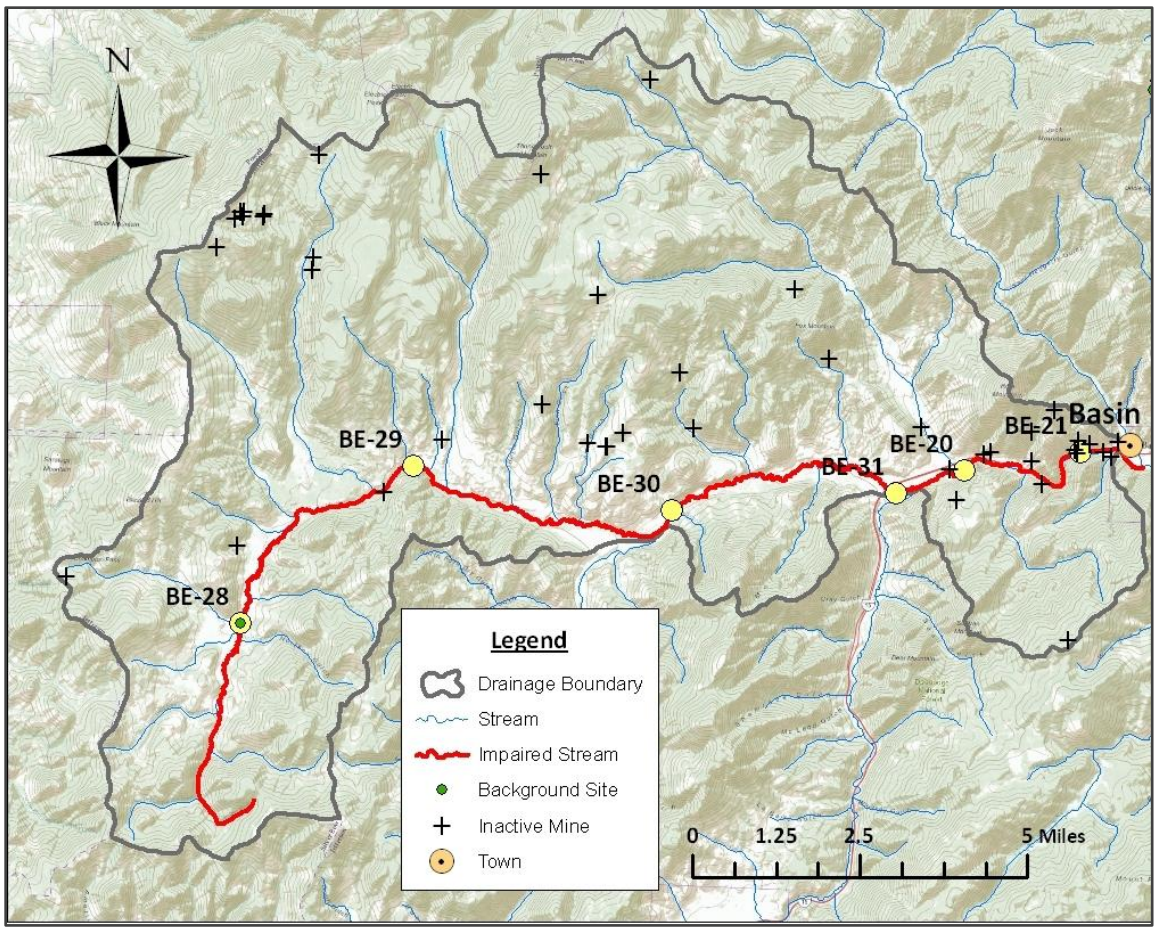

Figure F-7. The upper Boulder River watershed, monitoring sites, and mining sources.

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.

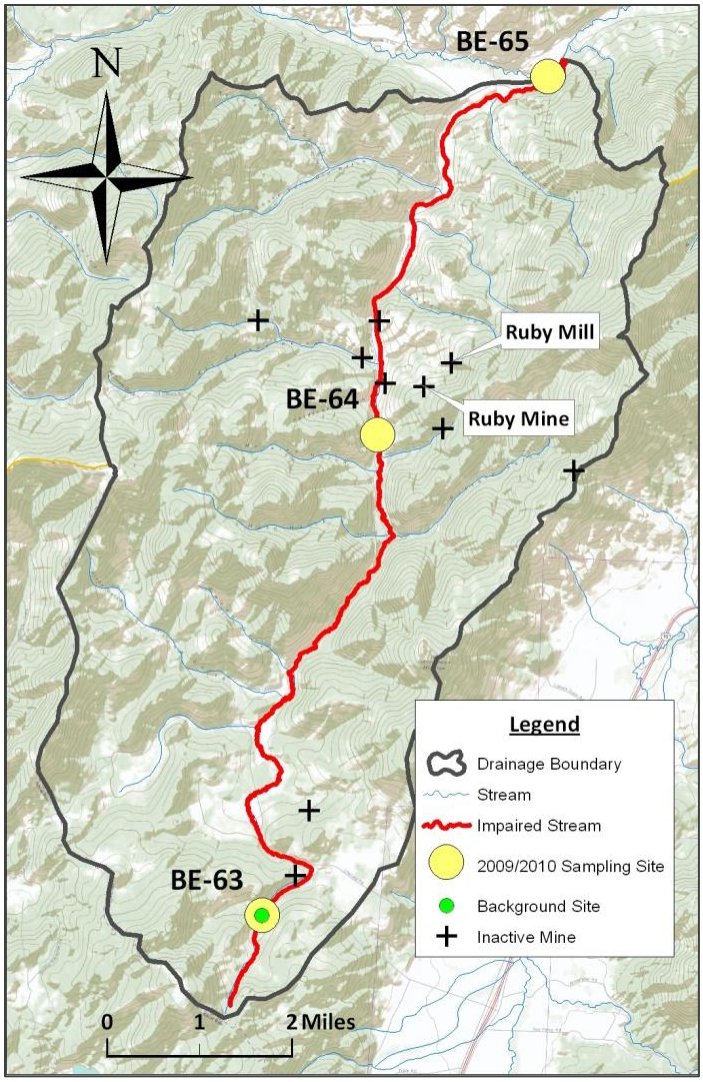

Figure F-8. The Lowland Creek watershed, monitoring sites, and mining sources.

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.

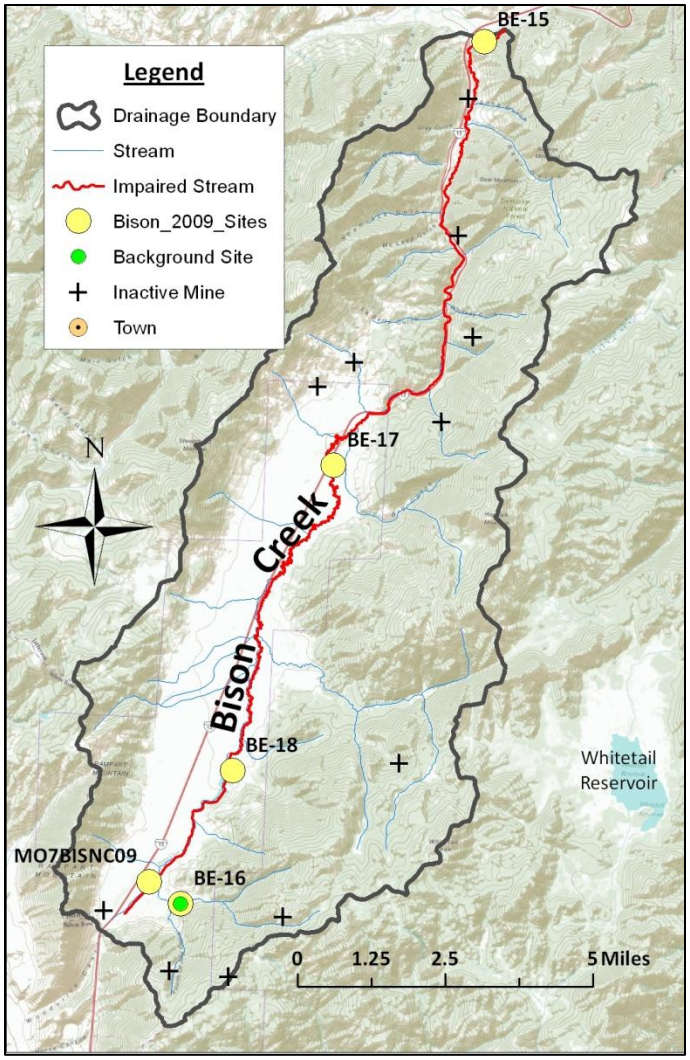

Figure F-9. The Bison Creek watershed, monitoring sites, and mining sources.

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.

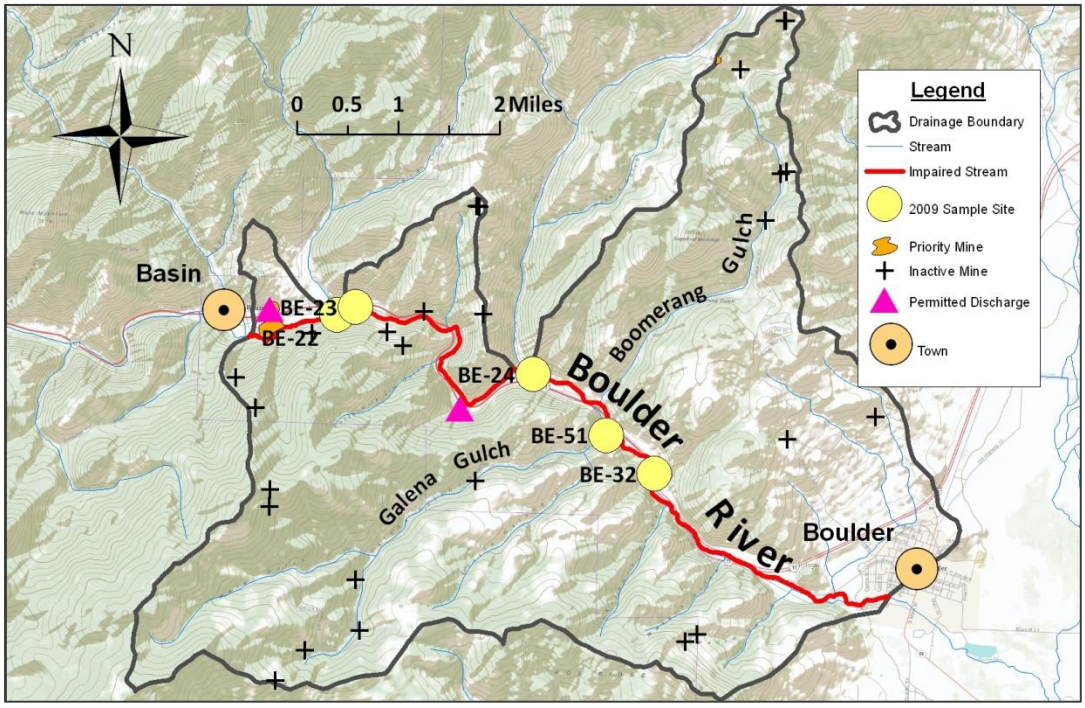

Figure F-10. The watershed for the Boulder River from Basin Creek to the town of Boulder, monitoring sites, and mining sources.

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.

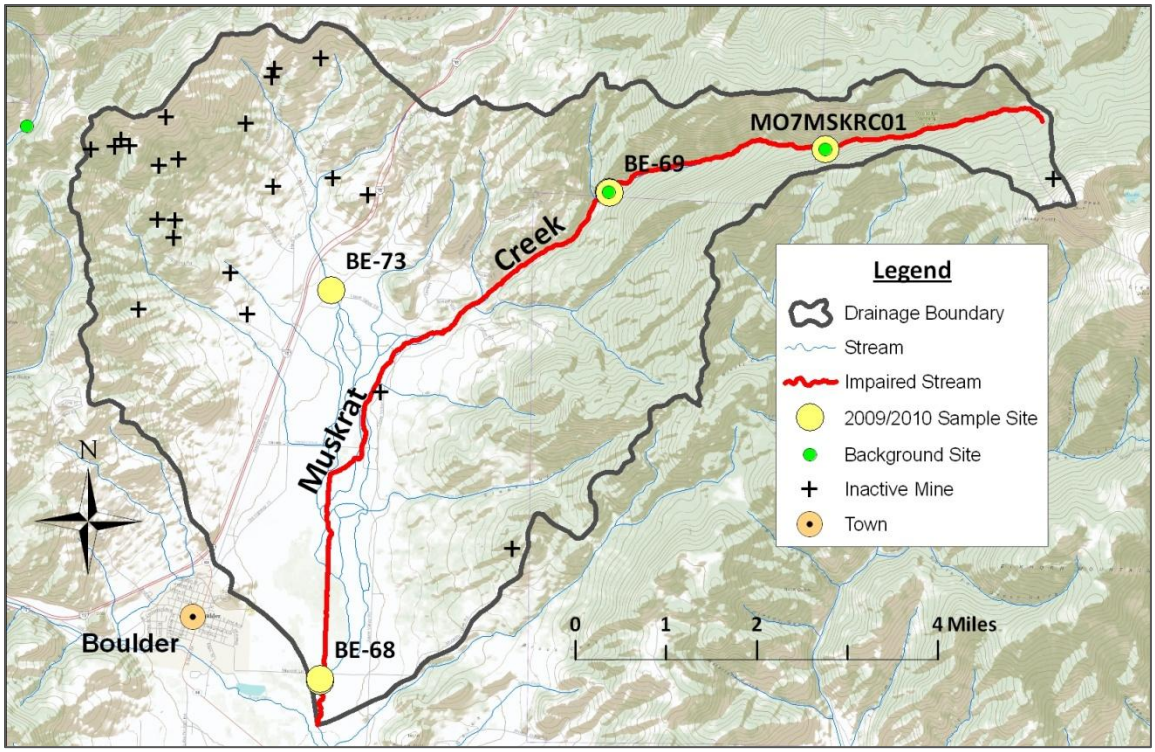

Figure F-11. The Muskrat Creek watershed, metals monitoring sites, and mining sources.

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.

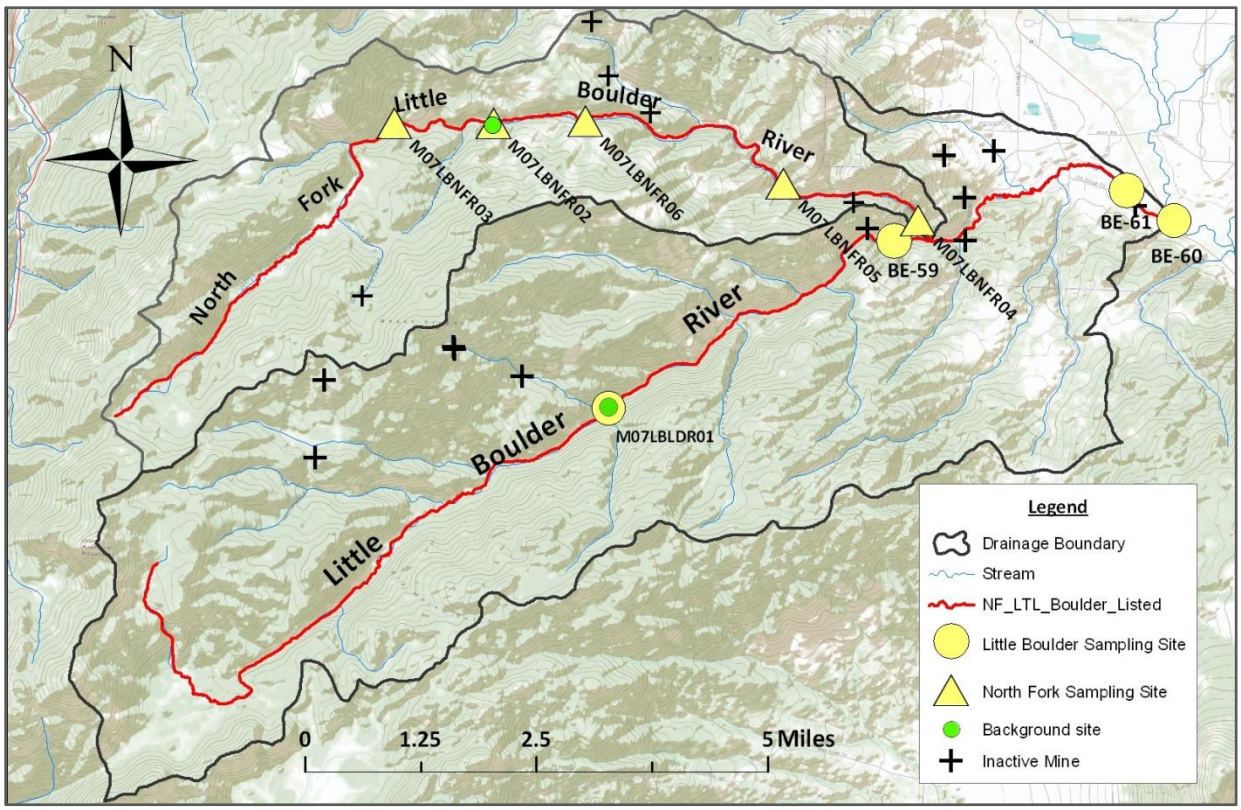

Figure F-12. The Little Boulder River watershed, monitoring sites, and mining sources.

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.

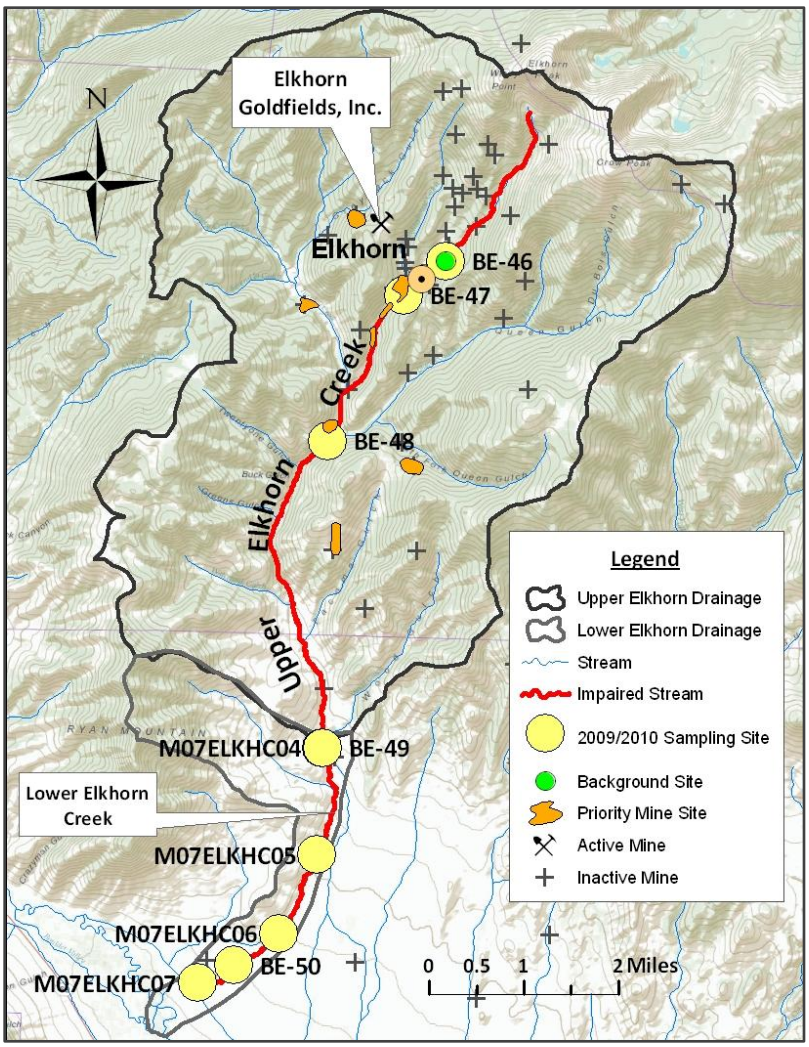

Figure F-13. Upper and lower Elkhorn Creek watersheds, monitoring sites, and mining sources.

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^3s 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.

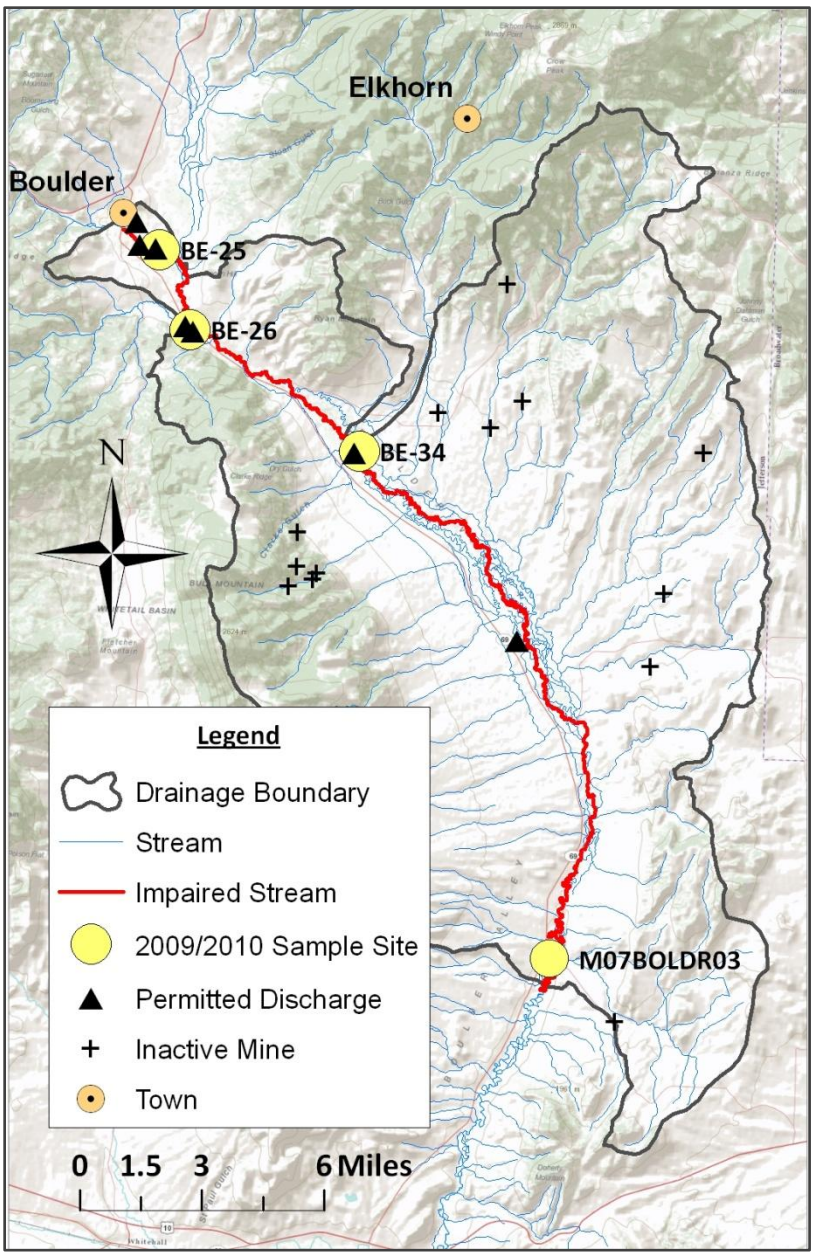

Figure F-14. Boulder River (MT41E001_22) watershed, monitoring sites, permitted discharges, and mining sources.

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 50th 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.

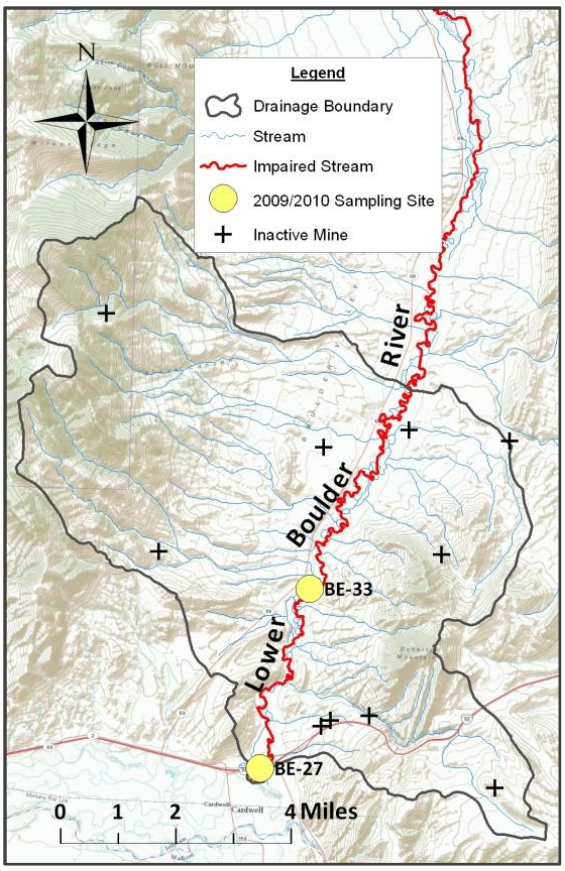

Figure F-15. Lower Boulder River watershed, monitoring sites, and mining sources.

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.

F3.0 REFERENCES

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