

APPENDIX M – SOURCE ASSESSMENT AND TARGET DEPARTURE ANALYSIS

TABLE OF CONTENTS

M1.0 Introduction.....	M-3
M2.0 Source Assessment and Target Departures by Stream	M-3
M2.1 West Fork Rock Creek (MT76E002_030)	M-4
M2.1.1 West Fork Rock Creek Sources	M-5
M2.1.2 West Fork Rock Creek Target Departures	M-6
M2.1.3 West Fork Rock Creek TMDL Summary	M-7
M2.2 Basin Gulch (MT76E002_080)	M-7
M2.2.1 Basin Gulch Sources.....	M-8
M2.2.2 Basin Gulch Target Departures.....	M-9
M2.2.3 Basin Gulch TMDL Summary.....	M-9
M2.3 Quartz Gulch (MT76E002_070)	M-10
M2.3.1 Quartz Gulch Sources	M-10
M2.3.2 Quartz Gulch Target Departures	M-10
M2.3.3 Quartz Gulch TMDL Summary	M-11
M2.4 Eureka Gulch (MT76E002_090)	M-11
M2.4.1 Eureka Gulch Sources	M-12
M2.4.2 Eureka Gulch Target Departures	M-12
M2.4.3 Eureka Gulch TMDL Summary	M-12
M2.5 Sluice Gulch (MT76E002_110).....	M-13
M2.5.1 Sluice Gulch Sources.....	M-14
M2.5.2 Sluice Gulch Target Departures	M-14
M2.5.3 Sluice Gulch TMDL Summary.....	M-15
M2.6 Flat Gulch (MT76E002_120)	M-16
M2.6.1 Flat Gulch Sources	M-17
M2.6.2 Flat Gulch Target Departures	M-17
M2.6.3 Flat Gulch TMDL Summary	M-18
M2.7 Scotchman Gulch (MT76E002_100)	M-19
M2.7.1 Scotchman Gulch Sources	M-20
M2.7.2 Scotchman Gulch Target Departures.....	M-20
M2.7.3 Scotchman Gulch TMDL Summary	M-21
M3.0 References	M-21

LIST OF TABLES

Table M-1. West Fork Rock Creek TMDL Decision Factors and TMDL Conclusion	M-6
Table M-2. Ratios of measured sediment metals concentrations to PELs for sediment samples from four West Fork Rock Creek sampling sites.	M-7
Table M-3. Metals listing status and TMDL conclusions for West Fork Rock Creek.....	M-7
Table M-4. Basin Gulch TMDL Decision Factors and TMDL Conclusions	M-9
Table M-5. Metals listing status and TMDL conclusions for Basin Gulch	M-9
Table M-6. Quartz Gulch TMDL Decision Factors and TMDL Conclusions.....	M-10
Table M-7. Ratios of measured sediment metals concentrations to PELs for a sediment sample from Quartz Gulch.	M-11
Table M-8. Metals listing status and TMDL conclusions for Quartz Gulch	M-11
Table M-9. Hardness (mg/L), pH, dissolved aluminum, and total recoverable metal analysis results (µg/ML) for the July, 2004, Eureka Gulch sample.....	M-12
Table M-10. Metals listing status and TMDL conclusions for Eureka Gulch.....	M-13
Table M-9. Sluice Gulch TMDL Decision Factors and TMDL Conclusions	M-15
Table M-10. Ratios of measured sediment metals concentrations to PELs for sediment samples from Sluice Gulch.....	M-15
Table M-11. Metals listing status and TMDL conclusions for Sluice Gulch.....	M-16
Table M-12. Flat Gulch TMDL Decision Factors and TMDL Conclusions.....	M-18
Table M-13. Ratios of measured sediment metals concentrations to PELs for sediment samples from Flat Gulch.	M-18
Table M-14. Metals listing status and TMDL conclusions for Flat Gulch	M-18
Table M-15. Scotchman Gulch TMDL Decision Factors and TMDL Conclusions.....	M-20
Table M-16. Ratios of measured sediment metals concentrations to PELs for sediment samples from Scotchman Gulch.	M-21
Table M-17. Metals listing status and TMDL conclusions for Scotchman Gulch	M-21

LIST OF FIGURES

Figure M-1. West Fork Rock Creek watershed, monitoring sites, and mining sources	M-5
Figure M-2. Eureka Gulch, Quartz Gulch, and Basin Gulch watersheds, section boundaries, monitoring sites, and mining sources.....	M-8
Figure M-3. Sluice Gulch watershed, monitoring sites, and mining sources.....	M-14
Figure M-4. Flat Gulch watershed, stream extent, and monitoring sites.....	M-17
Figure M-5. Scotchman Gulch watershed, stream extent, monitoring sites, and mining sources.....	M-19

M1.0 INTRODUCTION

This appendix summarizes the sources assessment and target departures for the metals impaired streams of the Rock Creek TMDL planning area (TPA). The target departure is the difference between water quality and stream sediment data from impaired streams and water quality and stream sediment targets for metals (**Section 8.4** of main document). 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 8-4 of the TMDL Document**). 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 metal impairment causes in the 2012 Integrated Report (Montana Department of Environmental Quality, 2012), the departure analysis is based on data for a core list of nine metals parameters that include 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 L**.

Placer mining has affected many streams in the planning area. However, a number of sites on selected stream segments are sufficiently remote enough from mining disturbances 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.

M2.0 SOURCE ASSESSMENT AND TARGET DEPARTURES BY STREAM

Assessment of existing metals sources is needed to develop load allocations to specific source categories. DEQ’s monitoring and assessment record (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2010) is the principal basis for stream impairment listings. Most of the metals impairments are based on water column chemistry data collected by DEQ or its contractors during 2004 and from 2009 through 2012. Sediment chemistry data, collected by DEQ monitoring and assessment field crews from 2009 through 2012, is available from samples collected under both high- and low-flow conditions from streams or their tributaries with metals impairment causes. DEQ assessment data was supplemented by STORET and NWIS data collected between 2001 and 2011.

The below sections describe the most significant natural and human-caused sources in more detail, provide nutrient loading estimates for natural and human-caused source categories to nutrient-impaired stream segments, and establish TMDLs and load allocations to specific source categories for the following streams.

Departures from target values are summarized below for 7 streams in the Rock Creek 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 8.4.3** of the main document, 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. For example, since there is no human health criterion for aluminum, an “NA” is entered in the corresponding cell in each table.

The order of stream discussions is northward from the West Fork of Rock Creek, to Eureka Creek and its Basin Gulch and Quartz Gulch tributaries, followed by Sluice Creek and Flat, Scotchmen, and Miners Gulches. 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 8.4** of the main document.

M2.1 WEST FORK ROCK CREEK (MT76E002_030)

The West Fork of Rock Creek is listed as impaired by mercury in the 2012 Integrated Report (Montana Department of Environmental Quality, 2012). The stream extends for 25.2 miles from its headwaters in the Sapphire Mountains to its confluence with Rock Creek. **Figure M-1** shows the West Fork Rock Creek watershed, recent surface water sample sites, and locations of mine-related sources of metals loading.

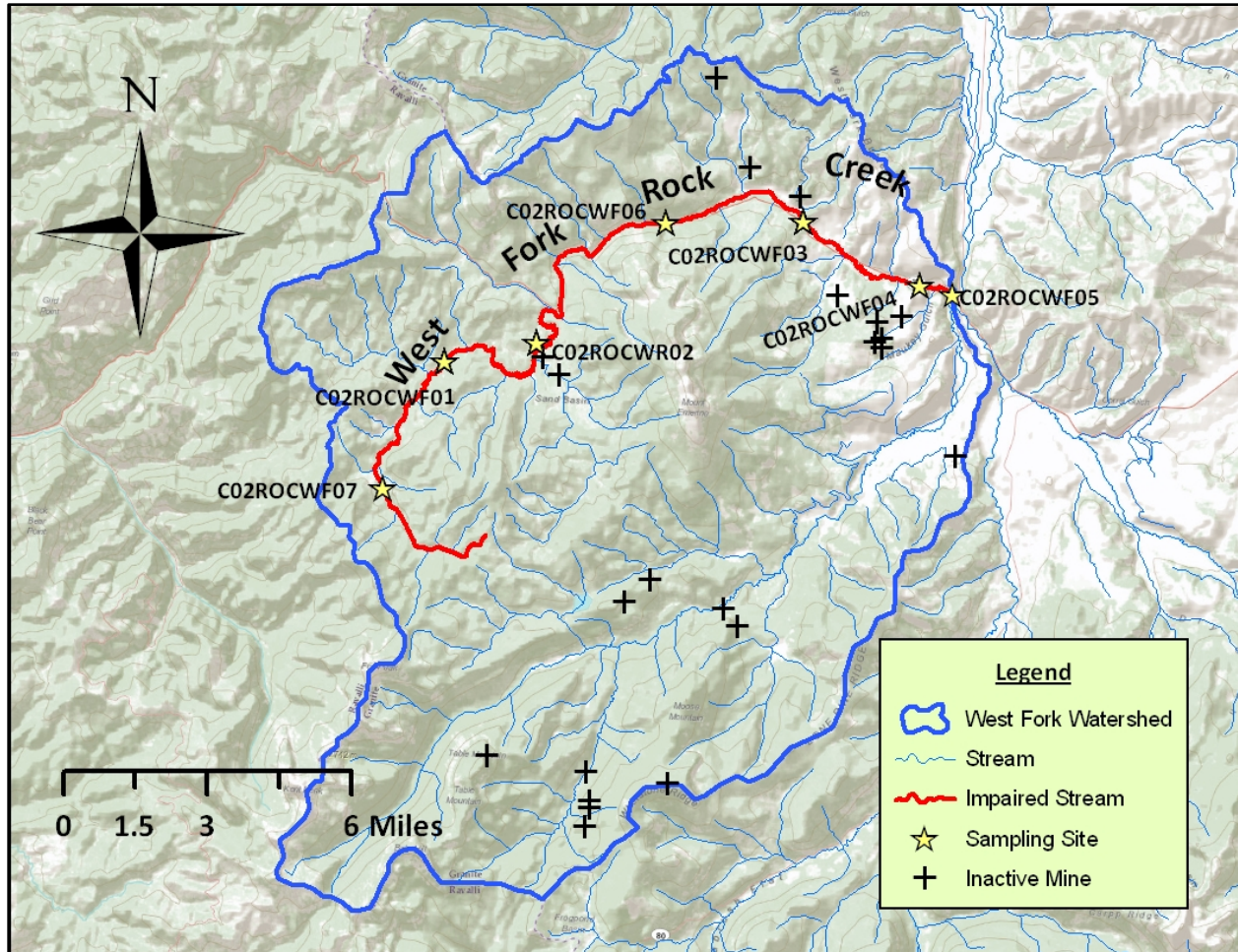


Figure M-1. West Fork Rock Creek watershed, monitoring sites, and mining sources

The West Fork is a fourth order Rock Creek tributary that drains about 178 square miles in the southern Sapphire Mountain Range. The geology of the drainage consists of a thick sequence of Precambrian sedimentary rocks that were thrust-faulted eastward and later intruded by a large granitic mass in the upper watershed and smaller volcanic outcrops to the north and east.

M2.1.1 West Fork Rock Creek Sources

The MBMG database lists 21 inactive and abandoned mines in the West Fork watershed. Most of these are past placer gold mines in stream sediments. Placer mining for gold that began in the 1860s led to the discovery of placer deposits of sapphires along the lower West Fork and a number of gulches draining the northeastern portion of the watershed. Placer mining for sapphires peaked during the early 1900s and continues as a tourist attraction along the lower West Fork.

A number of placer quarries in the Anaconda and Sapphire gulch drainages supply screened gravel for a tourism-based gem washing operation located off of Skalkaho Road on Sapphire Gulch Lane near the confluence of Sapphire Gulch and West Fork Rock Creek. The operation is open 7 days per week from June through October. A quarry area on Anaconda Gulch, owned by C³ LLC, holds an exploration license (#628) and a small miners exclusion (#119). An operating permit for a placer operation for gemstones recovery on the West Fork Rock Creek floodplain near the confluence of Anaconda Gulch is held by

Skalkaho Grazing, Inc. The permit (#44) is currently suspended by the DEQ, Environmental Management Bureau due to a reclamation bonding shortfall.

A couple of small lode deposits for gold recovery are located in the Maukey Gulch tributary of the lower West Fork. Current conditions at these properties consist of small, mine-related hillslope disturbances, associated access roads, and areas of timber harvest in the gulch headwaters. Two inactive mines in the Sand Basin area of the West Fork are described as titanium and columbium rare earth prospects. No related surface disturbances are apparent in the area.

The West Fork Rock Creek water quality dataset includes between 18 records from each of 7 monitoring sites (**Figure M-1**). All sites were established by DEQ monitoring and assessment efforts. Water samples were collected during high- and low-flow periods during 2009 and 2010. The sediment metals analysis record consists of 8 samples; there are two samples each for sites C02ROCWF01, C02ROCWF02, C02ROCWF03, and C02ROCWF04.

M2.1.2 West Fork Rock 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 M-1** summarizes the results of the target departure analysis in terms of critical TMDL decision factors. The far right column in the table contains TMDL development conclusions.

Table M-1. West Fork Rock 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	15	Y	N	NA	NA	Y	Unlisted	TMDL
Arsenic	15	N	N	N	N	Y	Unlisted	No TMDL
Cadmium	15	N	N	N	N	Y	Unlisted	No TMDL
Copper	15	N	N	N	N	Y	Unlisted	No TMDL
Iron	15	N	NA	NA	NA	Y	Unlisted	No TMDL
Lead	15	N	N	N	N	Y	Unlisted	No TMDL
Mercury	3	N	N	N	N	Y	Listed	No TMDL
Silver	15	NA	N	N	NA	Y	Unlisted	No TMDL
Zinc	15	N	N	N	N	Y	Unlisted	No TMDL

There are no human health criteria or aquatic life criteria exceedances for any of the 9 metal parameters among the recent surface water samples collected the West Fork Rock Creek. There was three water column target exceedance for aluminum. Aluminum was reported as 90 ug/L at three locations which is slightly above the CAL of 87 ug/L. Three exceedances in a sample set of 15 samples yields a chronic exceedance rate of %20, which is above the %10 exceedance requiring TMDL development.

Table M-2 summarizes the sediment chemistry data as the ratios of the metal concentrations measured in 8 sediment samples, to the PEL concentration recommended of metals parameters in fresh water stream sediment. For example, the value of 0.12 for arsenic at site C02ROCWF01 in the first row of the table is obtained by dividing the measured arsenic value of 2 micrograms per gram, ($\mu\text{g/g}$) by the arsenic PEL of 17 $\mu\text{g/g}$ ($2 \mu\text{g/g} / 17 \mu\text{g/g} = 0.12$). If the measured value is equal to the PEL, the ratio of the two

values equals 1. Where values in the sediment chemistry tables are less than or equal to 1, the measured metal concentration is less than the corresponding PEL. Where the table values are greater than one, the metal concentration in the sample exceeds the PEL. The monitoring site identification numbers, site locations, and sediment metals ratios are arranged in upstream to downstream order in the table. Sediment chemistry data are given by stream segment in **Appendix L**.

Table M-2. Ratios of measured sediment metals concentrations to PELs for sediment samples from four West Fork Rock Creek sampling sites.

SITE ID	Site Location	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc
C02ROCWF01	0.5 mile below	0.12	< 0.3	< 0.1	0.10	<0.5	0.07
C02ROCWF01	Bowles Creek	< 0.50	< 0.3	< 0.1	< 0.05	< 0.1	< 0.06
C02ROCWF02	0.4 mile below Sand	0.29	0.06	< 0.1	0.12	0.27	0.10
C02ROCWF02	Basin Creek	< 0.50	< 0.3	< 0.1	< 0.05	< 0.1	0.08
C02ROCWF03	0.1 mile below	0.41	0.06	< 0.1	0.12	0.19	0.10
C02ROCWF03	Sapphire Gulch	< 0.50	< 0.3	< 0.1	< 0.05	< 0.1	< 0.06
C02ROCWF04	0.4 mile upstream of	0.24	< 0.3	< 0.1	0.10	0.17	0.08
C02ROCWF04	Maukey Gulch	< 0.50	< 0.3	< 0.1	< 0.05	< 0.1	< 0.06

Since all ratios in the table are less than 1, all sediment metals concentrations at all 4 sampling sites are less than the PELs. Sediment metals concentrations do not indicate the presence of elevated metals in West Fork Rock Creek stream sediment.

M2.1.3 West Fork Rock Creek TMDL Summary

The listing status and TMDL conclusions for metals in the West Fork Rock Creek are summarized in **Table M-3**.

Table M-3. Metals listing status and TMDL conclusions for West Fork Rock Creek

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	New Listing	Y
Arsenic	Not a Cause	N
Cadmium	Not a Cause	N
Copper	Not a Cause	N
Iron	Not a Cause	N
Lead	Not a Cause	N
Silver	Not a Cause	N
Zinc	Not a Cause	N
Mercury	Remove Current Listing	N
Number of Metals TMDLs Required		1

M2.2 BASIN GULCH (MT76E002_080)

Basin Gulch, and an adjacent drainage, Quartz Gulch, are first order headwater tributaries of Eureka Gulch. Each of the three stream segments is a separate water quality assessment unit described in this and subsequent sections. Basin Gulch extends from its headwaters for about 1.5 miles to its confluence with Quartz Gulch. The Basin Gulch watershed area is approximately 500 acres; Quartz Gulch is about 1,600 acres. Eureka Gulch below the Quartz Gulch-Basin Gulch confluence drains about 200 acres, making the entire Eureka Gulch watershed area about 2,300-acres. **Figure M-2** shows the watershed areas, section boundaries, recent sample sites, and locations of mine-related sources in Basin, Quartz, and Eureka gulches.

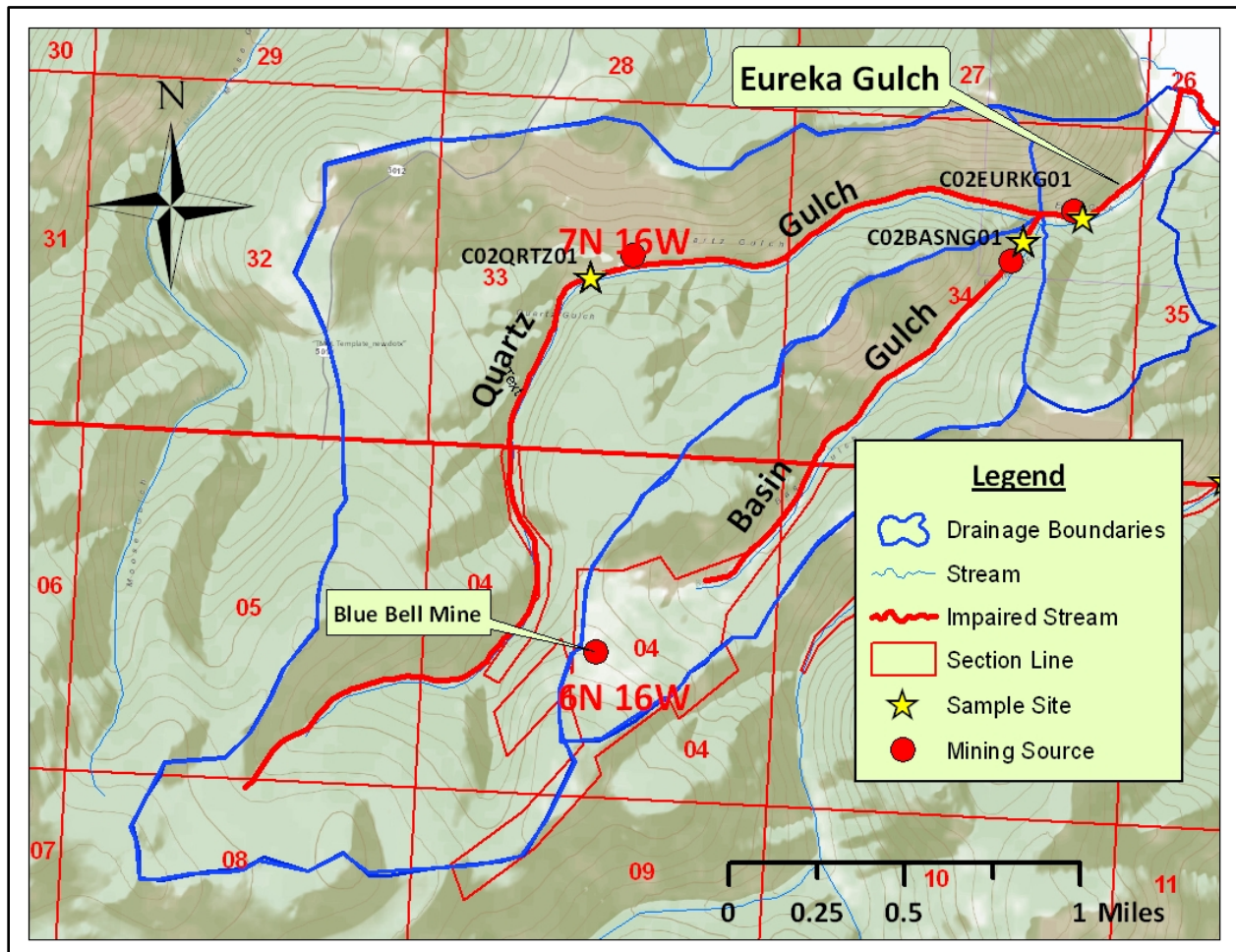


Figure M-2. Eureka Gulch, Quartz Gulch, and Basin Gulch watersheds, section boundaries, monitoring sites, and mining sources.

M2.2.1 Basin Gulch Sources

The MBMG database lists 4 inactive mines in the Eureka Gulch watershed. Two of these properties, the Blue Bell Mine and a downstream mill tailings site are in Basin Gulch. The Blue Bell Mine (**Figure M-2**) is a former underground silver mine consisting of two shallow hillside drifts. Marvin et al, (1995) describe an abandoned mine property referred to as the “Basin/Quartz Gulch Placer and Mill Tailings.” Though not described in detail, the site contained a breached tailings impoundment, streamside tailings deposits, and other mining wastes. The Gold Hill Placer & Quartz Hill Placer is listed as an active placer mine operating for gold recovery in upper Basin Gulch under a small miner exclusion statement (SMES) provided by DEQ (#46-139).

A DEQ field assessment conducted on July 28, 2004, described most of the drainage bottom as consisting of a re-graded placer mine with sparse vegetation cover and no discernible stream channel. An existing road crossing serves as a check dam across the drainage bottom with an additional check dam farther downstream. Both impoundments are described in the assessment summary as potential sources of large sediment loads during high-flow events. The most recent entry in the SMES file is a past-

due notice of the required annual report. A letter from the mine operator dated May 25, 2011, stated a desire not to renew the SMES.

M2.2.2 Basin Gulch Target Departures

Basin Gulch has no current metals impairment causes listed in the 2012 Integrated Report (Montana Department of Environmental Quality, 2012). Current impairment is due to alteration in streamside or littoral vegetative covers. The recent water quality dataset for Basin Gulch includes 6 records containing metals and low level mercury analysis results for samples collected in 2010 and 2011. All samples were collected at site C02BASNG10 located 500 feet upstream of the Basin Gulch mouth. **Table M-4** summarizes the results of the target departure analysis in terms of TMDL decision factors. The far right column in **Table M-4** specifies a TMDL development conclusion based on the decision factors for each of nine metal parameters.

Table M-4. Basin Gulch 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	Unlisted	No TMDL
Arsenic	6	N	N	Y	NA	Y	Unlisted	As TMDL
Cadmium	6	N	N	N	NA	Y	Unlisted	No TMDL
Copper	6	N	N	N	NA	Y	Unlisted	No TMDL
Iron	6	N	NA	NA	NA	Y	Unlisted	No TMDL
Lead	6	N	N	N	NA	Y	Unlisted	No TMDL
Mercury	6	N	N	N	NA	Y	Unlisted	No TMDL
Silver	6	NA	N	N	NA	Y	Unlisted	No TMDL
Zinc	6	N	N	N	NA	Y	Unlisted	No TMDL

All 6 of the arsenic results exceeded the human health criterion of 10 µg/L, indicating the need for an arsenic TMDL. Although there are human-caused sources present, the 6 samples contained less than detectable amounts of the remaining 8 metal parameters. Sediment chemistry data are not available for Basin Gulch.

M2.2.3 Basin Gulch TMDL Summary

The listing status and TMDL conclusions for metals in Basin Gulch are summarized in **Table M-5**. An arsenic TMDL is required in Basin Gulch.

Table M-5. Metals listing status and TMDL conclusions for Basin Gulch

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	Not a Cause	N
Arsenic	New Listing	Y
Cadmium	Not a Cause	N
Copper	Not a Cause	N
Iron	Not a Cause	N
Lead	Not a Cause	N
Silver	Not a Cause	N
Zinc	Not a Cause	N
Mercury	Not a Cause	N
Number of metals TMDLs Required		1

M2.3 QUARTZ GULCH (MT76E002_070)

Quartz Gulch is a headwater tributary of Eureka Gulch (**Figure M-2**). Quartz Gulch extends for 3.4 miles from its headwaters in the Sapphire Mountains to its confluence with Basin Gulch. This confluence is the beginning of Eureka Gulch. Quartz Gulch is listed in the 2012 Integrated Report (Montana Department of Environmental Quality, 2012) as being impaired by elevated mercury, sediment, and alteration in streamside vegetative covers.

M2.3.1 Quartz Gulch Sources

The MBMG abandoned mines database lists the “American Eagle Co. Placer Claims” as the only inactive mine property in Quartz Gulch. No distinguishing features of the property can be identified from 2011 aerial imagery. The Gold Hill Placer & Quartz Hill Placer is listed as an active mine operating in Section 4, Township 7 North, Range 16 East under a SMES (#46-139). Section 4 occurs in the upper reaches of both Basin Gulch and Quartz Gulch and the placer operation for gold recovery could be active in both drainages.

A DEQ field assessment of the ephemeral stream dated July 29, 2004, describes a placer mined drainage bottom with no discernible channel in the upper reaches and a constructed channel farther downstream that has been relocated to the edge of the drainage bottom. The drainage is a potential sediment source during high flow flows until the channel is reestablished.

M2.3.2 Quartz Gulch Target Departures

Quartz Gulch is listed in the 2012 Integrated Report (Montana Department of Environmental Quality, 2012) as being impaired due to mercury, sediment, and alteration in streamside or littoral vegetative covers. The recent water quality dataset for Quartz Gulch includes 12 records containing metals and low level mercury analysis results for samples collected in 2010 and 2011. All samples were collected at site C02QRTZG01 located about 1.4 miles upstream of the mouth. **Table M-6** summarizes the results of the target departure analysis in terms of TMDL decision factors, with TMDL development conclusions in the far right column of the table.

Table M-6. Quartz Gulch 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	Y	N	NA	NA	Y	Unlisted	AI TMDL
Arsenic	8	N	N	N	Y	Y	Unlisted	No TMDL
Cadmium	8	N	N	N	N	Y	Unlisted	No TMDL
Copper	8	N	N	N	N	Y	Unlisted	No TMDL
Iron	8	N	NA	NA	NA	Y	Unlisted	No TMDL
Lead	8	Y	N	N	N	Y	Unlisted	Pb TMDL
Mercury	8	N	N	N	Y	Y	Listed	No TMDL
Silver	8	NA	N	N	NA	Y	Unlisted	No TMDL
Zinc	8	N	N	N	Y	Y	Unlisted	No TMDL

Two samples in 8 (25%) exceed the CAL criterion of 87 µg/L for aluminum. One sample in 8 (12%) exceed the CAL criterion of 0.57 for lead, based on a hardness value of 26 mg/L. Other water column metals concentrations are either less than detectable concentrations, or at or below metals target values.

A single sediment sample is available from site C02QRTZG01. **Table M-7** 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.

Table M-7. Ratios of measured sediment metals concentrations to PELs for a sediment sample from Quartz Gulch.

SITE ID	Site Location	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc
C02ROCWF01	1.4 miles U/S of mouth	61.80	0.31	0.19	0.34	2.06	2.80

The sediment sample contains an extremely high concentration of arsenic (1,050 µg/g) compared with the sediment arsenic PEL of 17 µg/g. Though not as extreme as the arsenic level, the mercury and zinc concentrations in the sediment also exceeded the PEL values. Despite the elevated sediment concentrations of arsenic, mercury, and zinc, the water column concentrations of these metals are less than the most restrictive target values.

M2.3.3 Quartz Gulch TMDL Summary

The listing status and TMDL conclusions for metals in Quartz Gulch are summarized in **Table M-8**. TMDLs are required for aluminum and lead in Quartz Gulch.

Table M-8. Metals listing status and TMDL conclusions for Quartz Gulch

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	New Listing	Y
Arsenic	Not a Cause	N
Cadmium	Not a Cause	N
Copper	Not a Cause	N
Iron	Not a Cause	N
Lead	Not a Cause	Y
Silver	Not a Cause	N
Zinc	Not a Cause	N
Mercury	Listed	N
Number of metals TMDLs Required		2

The data record for mercury should be reevaluated to determine whether this metal persists as an actual impairment cause in Quartz Creek.

M2.4 EUREKA GULCH (MT76E002_090)

Eureka Gulch is a second order tributary of Rock Creek. The stream extends for 1.9 miles from the confluence of Basin and Quartz gulches to Rock Creek (**Figure M-2**). Eureka Gulch is listed as impaired in the 2012 Integrated Report (Montana Department of Environmental Quality, 2012) because of drinking water impairments caused by elevated arsenic and mercury. Non-metal impairments of Eureka Gulch in 2012 include sediment and alteration of streamside vegetative covers.

The Eureka Gulch data set consists of a single sample collected at site C02EURKG01 during July of 2004. Water quality monitoring since 2004 has recorded no flow in Eureka Gulch. The streambed and floodplain are altered by placer mining that has partially diverted surface flow into excavated pits.

M2.4.1 Eureka Gulch Sources

The MBMG abandoned mines database lists the “Basin and Quartz Creek Placers” as the single inactive mine in Eureka Gulch. Potentate Mining, LLC, started work under Exploration License #00739 to test for placer gold in Eureka gulch. They are currently placer mining under SMES #46-144. The operation is approved to disturbed 2.6 acres. Potentate holds an amount of unobligated bond for potential expansion of the disturbance. The Braach Placer is operating in lower Eureka Gulch (S35 T7N R16W) for gold, sapphires, and garnets under a SMES (#46-139) from DEQ. An exploration license (#00709) for the same commodities at the same location was issued by DEQ on 11/30/2009 and has not been renewed. The entire bottom of Eureka Gulch is described in a July 29, 2004, inspection by DEQ as a regraded and poorly vegetated placer mine disturbance with two excavated mine pits connected by a constructed channel. Standing water is retained in the pits and no flow was observed in the connecting channel.

M2.4.2 Eureka Gulch Target Departures

Eureka Gulch is listed in the 2012 Integrated Report (Montana Department of Environmental Quality, 2012) as being impaired by elevated arsenic, mercury, sediment, and alteration in streamside or littoral vegetative covers. The recent water quality dataset for Eureka Gulch consists of a single record for a sample collected at site C02EURKG10 (on July 29th, 2004. Site C02QRTZG01 is located about 200 meters downstream of the mouth of Basin Gulch (**Figure M-2**). **Table M-9** contains the hardness, pH and metal analysis results for the Eureka Gulch sample.

Table M-9. Hardness (mg/L), pH, dissolved aluminum, and total recoverable metal analysis results (µg/L) for the July, 2004, Eureka Gulch sample.

Station ID	Hardness	pH	Aluminum (Diss)	Arsenic	Cadmium	Copper	Lead	Iron	Zinc
C02EURKG10	156	6.57	<100	16	<0.1	1.0	<0.5	<10	<10

Since the method detection limit for aluminum (100 µg/L) is higher than the 87 µg/L chronic criterion, the aluminum result cannot be used to assess aquatic life support. The arsenic result exceeds the human health criterion of 10 µg/L. All other metal concentrations in the sample are less than targets. Sediment chemistry data are not available for Eureka Gulch.

The listing of mercury as an impairment causes stems from samples collected on May 20th, 1997, that contained 200 and 400 µg/L at separate sample locations. Mercury analysis was not performed on a sample collected during the 2004 inspection.

M2.4.3 Eureka Gulch TMDL Summary

The human health criterion exceedance for arsenic requires development of an arsenic TMDL. Since more recent data for mercury are not available, a mercury TMDL will be developed to address the current mercury impairment listing. The listing status and TMDL conclusions for metals in Eureka Gulch are summarized in **Table M-10**.

Table M-10. Metals listing status and TMDL conclusions for Eureka Gulch

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	Not a Cause	N
Arsenic	Listed	Y
Cadmium	Not a Cause	N
Copper	Not a Cause	N
Iron	Not a Cause	N
Lead	Not a Cause	N
Silver	Not a Cause	N
Zinc	Not a Cause	N
Mercury	Listed	Y
Number of metals TMDLs Required		2

M2.5 SLUICE GULCH (MT76E002_110)

Sluice Gulch is a second order tributary of Rock Creek. The stream extends for 6.3 miles from its headwaters in the John Long Mountains to its mouth. The drainage area is just under 7 square miles. Sluice Gulch is listed as impaired in the 2012 Integrated Report (Montana Department of Environmental Quality, 2012) because of elevated arsenic. Non-metal impairments of Sluice Gulch in 2012 include sediment, nitrate plus nitrite nitrogen, and alteration of streamside vegetative covers. The Sluice Gulch metals data set consists of 8 samples collected at 5 sites (**Figure M-3**) during July of 2004 and during June and September of 2010.

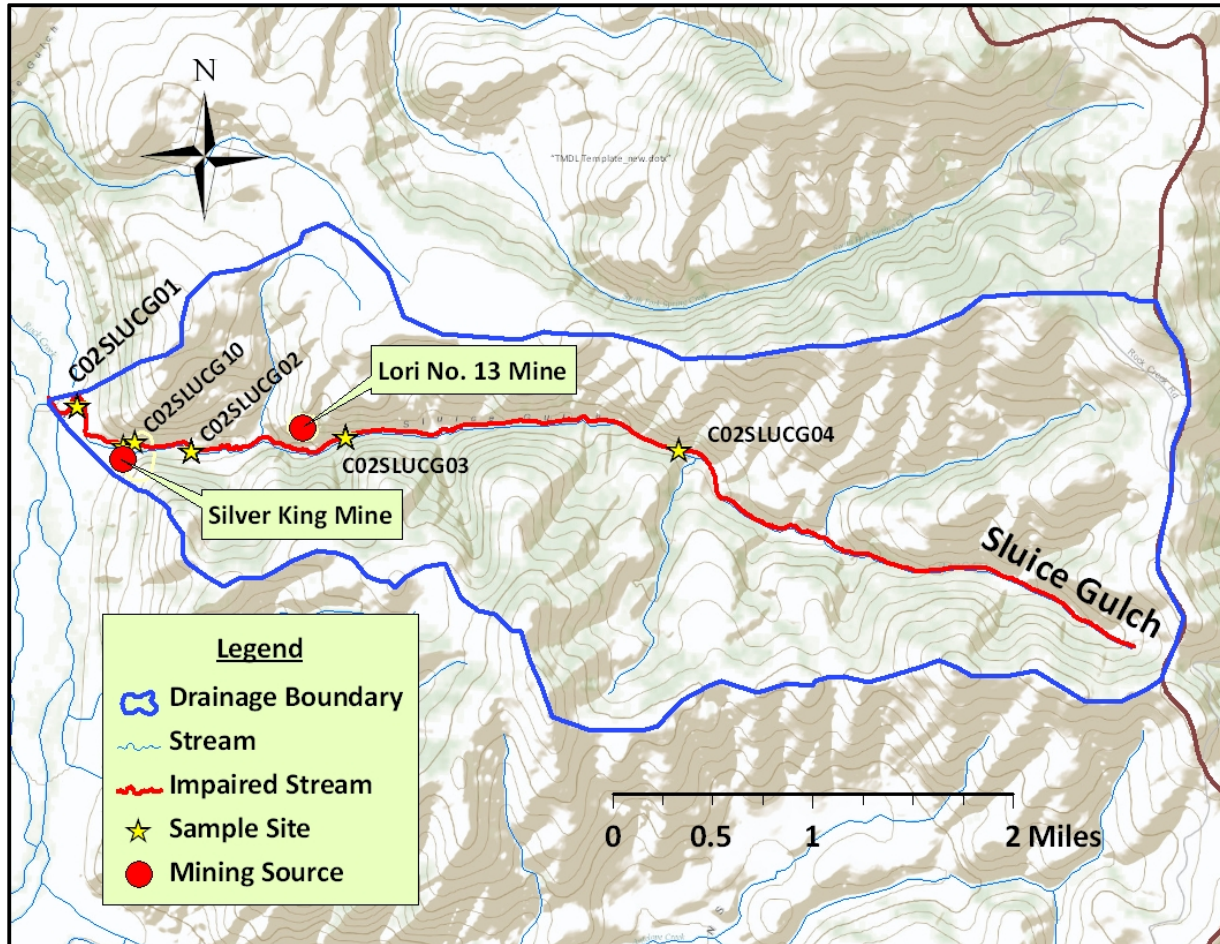


Figure M-3. Sluice Gulch watershed, monitoring sites, and mining sources.

M2.5.1 Sluice Gulch Sources

The MBMG abandoned mines database lists two inactive mines in the Sluice Gulch drainage: the Silver King Mine and the Lori No. 13. The Silver King is a former gold and silver lode mine occupying about 18 acres on the south flank of Sluice Gulch where the drainage enters the Upper Willow Creek valley. The mine consists of access roads, operating benches, 5 adit openings, and 30,000 cubic yards of waste rock in several dumps. A 1993 field assessment reported one of the adits discharging at about 50 gallons per minute. Analysis of the adit water indicated elevated copper (Pioneer Technical Services, Inc., 1995). Sluice Gulch water samples collected in 1993 both above and below the mine exceeded the 10 µg/L human health criterion for arsenic. Other metal concentrations were within water quality standards.

Approximately one mile upstream of the Silver King Mine is the Lori No. 13 that consists of a single dry adit and a re-vegetated waste rock dump containing about 700 cubic yards (Pioneer Technical Services, Inc., 1995). The mine disturbs about 9 acres on the north side of the gulch and is about 800 feet from Sluice Gulch surface water. Both the Silver King and Lori N. 13 are ranked as priority mine sites that have potential human health and safety hazards.

M2.5.2 Sluice Gulch Target Departures

Sluice Gulch is listed in the 2012 Integrated Report (Montana Department of Environmental Quality, 2012) as being impaired due to arsenic, sediment, nitrite plus nitrate nitrogen, and alteration in

streamside vegetative covers. The recent water quality dataset for Sluice Gulch contains 8 metals analysis records for samples collected in 2004 and 2010. All samples were collected at the 5 sites shown in **Figure M-3**. **Table M-9** summarizes the results of the target departure analysis in terms of TMDL decision factors.

Table M-9. Sluice Gulch 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	Unlisted	No TMDL
Arsenic	8	N	N	Y	Y	Y	Listed	As TMDL
Cadmium	8	N	N	N	N	Y	Unlisted	No TMDL
Copper	8	Y	N	N	N	Y	Unlisted	Cu TMDL
Iron	8	N	NA	NA	NA	Y	Unlisted	No TMDL
Lead	8	N	N	N	N	Y	Unlisted	No TMDL
Mercury	8	N	N	N	N	Y	Unlisted	No TMDL
Silver	8	NA	N	N	NA	Y	Unlisted	No TMDL
Zinc	8	N	N	N	N	Y	Unlisted	No TMDL

All 8 results for arsenic exceeded the human health criterion of 10 µg/L. One in 8 results copper exceeded the chronic aquatic life criterion. Other water column metals concentrations are either less than detectable concentrations, or at or below metals target values.

Sediment chemistry results are available for 4 samples from the sites listed in **Table M-10**. The values in the table express the sediment chemistry data as the ratios of the metal concentrations measured in the samples, to the PEL concentration recommended of metals parameters in fresh water stream sediment.

Table M-10. Ratios of measured sediment metals concentrations to PELs for sediment samples from Sluice Gulch.

SITE ID	Site Location	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc
C02SLUCG01	near mouth	1.1	0.1	0.1	0.2	< 0.10	0.2
C02SLUCG10	¼ mile upstream from mouth	0.6	< 0.1	0.1	0.1	--	0.1
C02SLUCG02	¼ mile upstream from Silver King Mine	1.3	0.1	0.1	0.2	< 0.10	0.2
C02SLUCG03	1.7 miles above mouth	1.8	0.1	0.1	0.2	< 0.10	0.2

Sediment chemistry samples from 3 of 4 sites exceeded the PEL values for arsenic in fresh water stream sediment. The magnitude of the arsenic exceedances increases downstream. Three of 4 mercury values are less than PELs; the mercury value from site C02SLUCG10 is not used due to a high method detection limit applied to the 2004 sample.

M2.5.3 Sluice Gulch TMDL Summary

The human health criterion exceedance for arsenic and chronic aquatic life criteria exceedances for copper require development of TMDLs for these 2 metal parameters. The listing status and TMDL conclusions for metals in Sluice Gulch are summarized in **Table M-11**.

Table M-11. Metals listing status and TMDL conclusions for Sluice Gulch

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	Not a Cause	N
Arsenic	Listed	Y
Cadmium	Not a Cause	N
Copper	New Listing	Y
Iron	Not a Cause	N
Lead	Not a Cause	N
Silver	Not a Cause	N
Zinc	Not a Cause	N
Mercury	Listed	N
Number of metals TMDLs Required		2

M2.6 FLAT GULCH (MT76E002_120)

Flat Gulch is a first order tributary of Rock Creek. The stream extends for 3 miles from its headwaters on the east flank of Ram Mountain to its mouth on Rock Creek. The drainage area is approximately 3 square miles. Flat Gulch is listed as impaired in the 2012 Integrated Report (Montana Department of Environmental Quality, 2012) because of nutrients (nitrogen and phosphorus) and sediment. The Flat Gulch metals data set consists of 13 samples collected at 4 sites during July of 2004 and during low-flow periods of 2009, 2010, and 2011. **Figure M-4** shows the Flat Gulch drainage area, stream extent, and sampling locations.

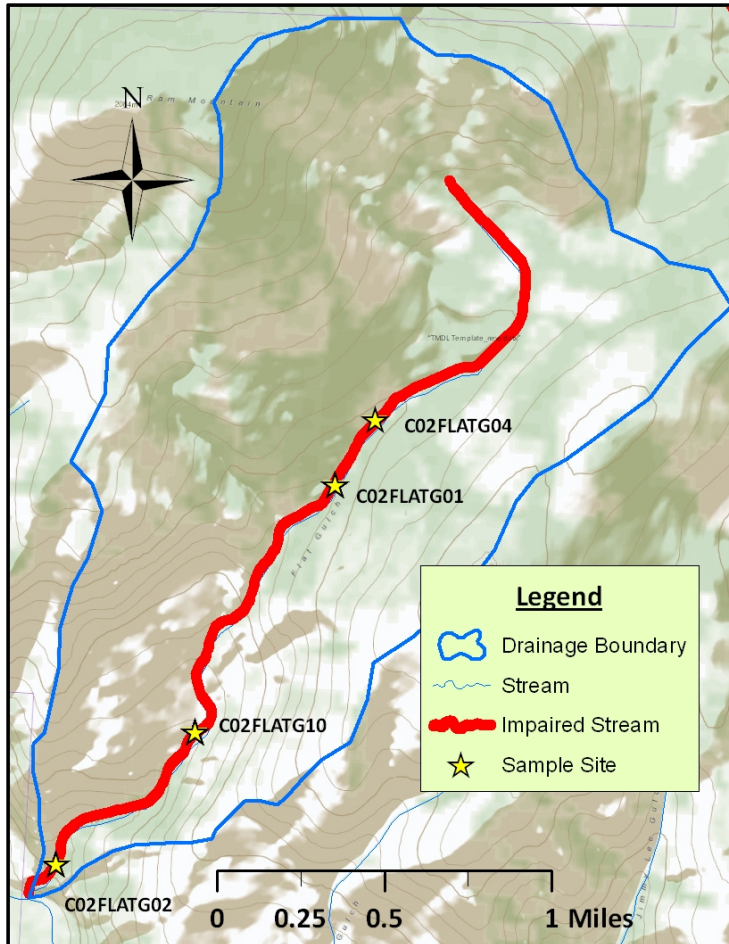


Figure M-4. Flat Gulch watershed, stream extent, and monitoring sites.

M2.6.1 Flat Gulch Sources

There are no abandoned mines described in the Flat Gulch drainage in either the MBMG or DEQ abandoned mine databases. Aluminum exceedances were reported during high flow conditions, suggesting that aluminum is bound in the sediment and only becomes mobile when there is a significant disturbance (high flow events). Therefore, metals loading (Fe and Hg) is likely to be associated with local sources of sediment. The analysis report of stream base parameters and bank erosion conditions in Flat Gulch (Water & Environmental Technologies, 2012) describes extensive streambank trampling by domestic livestock in both the upper and lower drainage. Timber harvesting and the associated road network are also a common upper basin land use. The density of discernible forest access and logging roads on 2011 aerial imagery of the drainage is approximately 3.5 miles per square mile. Timber harvest, livestock grazing, and limited past placer mining are described as potential sediment sources in the lower assessment reach.

M2.6.2 Flat Gulch Target Departures

Flat Gulch is listed in the 2012 Integrated Report (Montana Department of Environmental Quality, 2012) as being impaired due to sediment, total Kjeldahl nitrogen, and total phosphorus. The recent water quality dataset for Flat Gulch contains 13 metals analysis records for samples collected in 2004 and 2009-2011. All samples were collected at the 4 sites shown in **Figure M-4**. **Table M-12** summarizes the results of the target departure analysis in terms of TMDL decision factors.

Table M-12. Flat Gulch 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 (Sediment related) Sources Present	2012 303(d) Listing Status	TMDL Decision
Aluminum	13	Y	N	NA	NA	Y	Unlisted	Al TMDL
Arsenic	13	N	N	N	N	N	Unlisted	No TMDL
Cadmium	13	N	N	N	N	N	Unlisted	No TMDL
Copper	13	N	N	N	N	N	Unlisted	No TMDL
Iron	8	Y	NA	NA	NA	Y	Unlisted	Fe TMDL
Lead	13	N	N	N	N	N	Unlisted	No TMDL
Mercury	0	N	N	N	N	Y	Unlisted	No TMDL
Silver	13	NA	N	N	NA	N	Unlisted	No TMDL
Zinc	13	N	N	N	N	N	Unlisted	No TMDL

Twelve of the 13 results for dissolved aluminum have method detection limits low enough to determine compliance with the chronic aquatic life criterion (87 µg/L). Four of these 12 results (30%) exceed the chronic aquatic life target. All 13 results for arsenic are less than the human health criterion of 10 µg/L. Two of 7 results for iron exceed the chronic aquatic life criterion of 1,000 µg/L. Other water column metals concentrations are either less than detectable concentrations, or at or below metals target values.

Sediment chemistry results are available for three samples from the sites listed in **Table M-13**. The values in the table express the sediment chemistry data as the ratios of the metal concentrations measured in the samples, to the PEL concentration recommended of metals parameters in fresh water stream sediment. Since all values in the table are less than 1, sediment chemistry concentrations are all less than the corresponding PEL indicator.

Table M-13. Ratios of measured sediment metals concentrations to PELs for sediment samples from Flat Gulch.

SITE ID	Site Location	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc
C02FLATG01	2 miles above mouth	0.3	< 0.015	0.1	0.1	0.16	0.1
C02FLATG10	1 mile above mouth	0.2	< 0.015	0.1	0.1	0.16	0.1
C02FLATG02	near mouth	0.2	< 0.015	0.1	0.1	0.14	0.1

M2.6.3 Flat Gulch TMDL Summary

The chronic aquatic life criteria exceedances for aluminum and iron require development of TMDLs for these two metals. The listing status and TMDL conclusions for metals in Flat Gulch are summarized in **Table M-14**.

Table M-14. Metals listing status and TMDL conclusions for Flat Gulch

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	New Listing	Y
Arsenic	Not a Cause	N
Cadmium	Not a Cause	N
Copper	New Listing	N

Table M-14. Metals listing status and TMDL conclusions for Flat Gulch

Metal	Listing Status	TMDL Needed? (Y/N)
Iron	New Listing	Y
Lead	Not a Cause	N
Silver	Not a Cause	N
Zinc	Not a Cause	N
Mercury	Remove Current Listing	N
Number of metals TMDLs Required		2

M2.7 SCOTCHMAN GULCH (MT76E002_100)

Scotchman Gulch is a first order tributary of Upper Willow Creek. The stream extends for 6.9 miles from its headwaters in the Sapphire Mountains. The drainage is predominantly a forested watershed with mixed forest and grassland and hay production acreage in the lower watershed. The Scotchman Gulch drainage area is approximately 5.7 square miles. Scotchman Gulch is listed as impaired in the 2012 Integrated Report (Montana Department of Environmental Quality, 2012) because of nutrients (phosphorus) and sediment. **Figure M-5** shows the Scotchman Gulch drainage area, stream extent, sampling locations, and potential mining sources of metals loading.

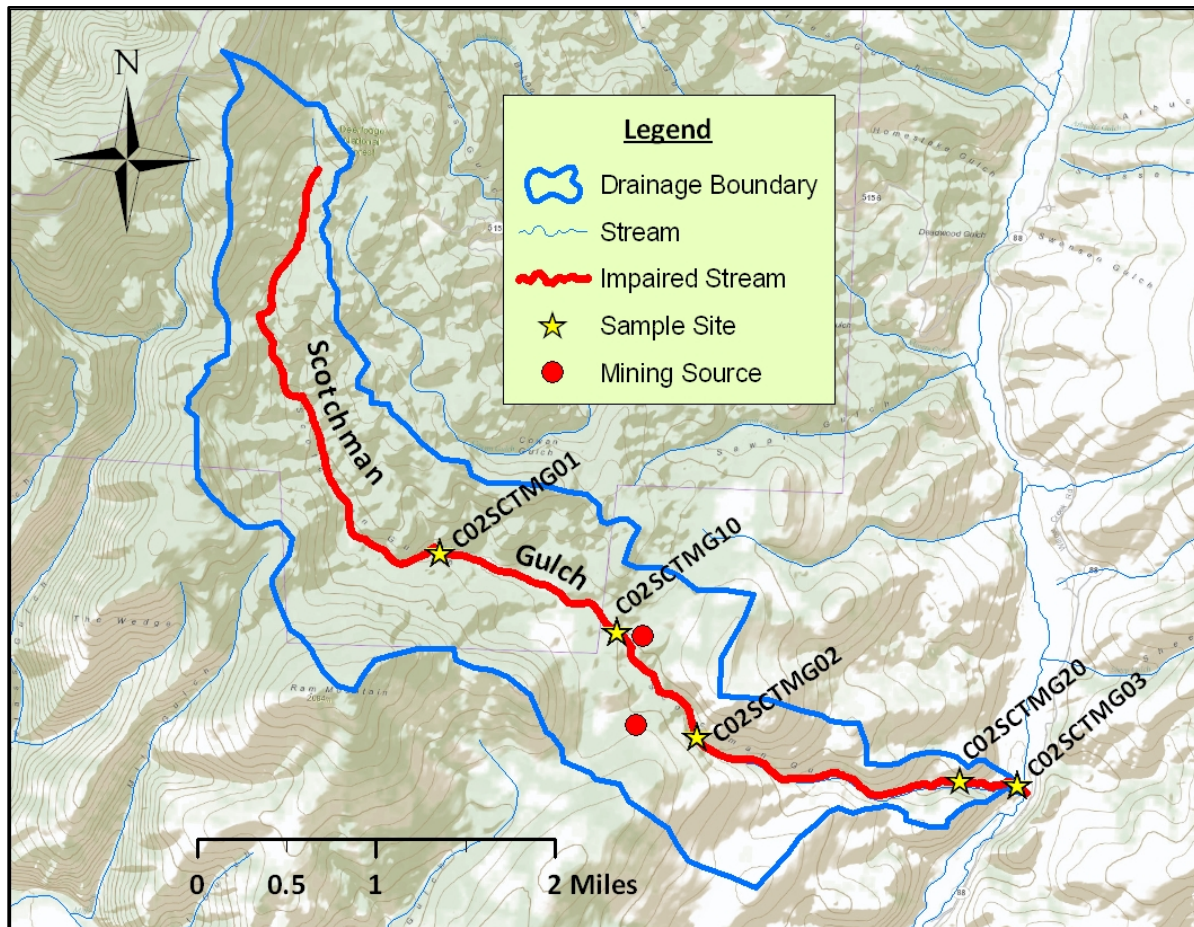


Figure M-5. Scotchman Gulch watershed, stream extent, monitoring sites, and mining sources.

M2.7.1 Scotchman Gulch Sources

Two abandoned placer mining operations appear in the DEQ abandoned mine database. The locations of these placer operations are depicted as red circles in **Figure M-5**. The property nearer sampling site C02SCTMG10 consists of stabilized coarse aggregate piles, near the stream and remnants of wooden water conveyance structures from past placer mining. Evidence of breached channel impoundments occur farther downstream and fine sediment accumulations may be related to past placer mining. The stream channel conditions reflect heavy past grazing pressure that has been more recently controlled by electrified and conventional fencing. Some timber harvesting has occurred in the lower reaches of the forested portion of the drainage. Near the mouth the land adjacent to the channel is used for hay production. Aluminum exceedances were reported during high flow conditions, suggesting that aluminum is bound in the sediment and only becomes mobile when there is a significant disturbance (high flow events). Therefore, metals loading (Fe and Hg) is likely to be associated with local sources of sediment such as fine sediment deposition resulting from past mining and livestock grazing.

M2.7.2 Scotchman Gulch Target Departures

The metals data set for Scotchman Gulch consists of 13 samples collected at 5 sites (**Figure M-5**) during August of 2004 and low-flow periods of 2009, 2010, and 2011. **Table M-15** summarizes the results of the target departure analysis in terms of TMDL decision factors.

Table M-15. Scotchman Gulch 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	16	Y	N	NA	NA	Y	Unlisted	AI TMDL
Arsenic	16	N	N	N	N	N	Unlisted	No TMDL
Cadmium	16	N	N	N	N	N	Unlisted	No TMDL
Copper	14	N	N	N	N	N	Unlisted	No TMDL
Iron	12	N	NA	NA	NA	Y	Unlisted	No TMDL
Lead	16	N	N	N	N	N	Unlisted	No TMDL
Mercury	0	N	N	N	N	Y	Unlisted	No TMDL
Silver	16	NA	N	N	NA	N	Unlisted	No TMDL
Zinc	13	N	N	N	N	N	Unlisted	No TMDL

Four of the 16 aluminum results (31%) exceed the 87 µg/L chronic aquatic life criterion. No sample contained detectable concentrations of cadmium, lead, or silver. The concentrations of other metal parameters were either less than method detection levels or within the most restrictive target value.

Eight sediment chemistry samples are available from 4 of the Scotchman Gulch sample sites. The values in **Table M-16** express the sediment chemistry data as the ratios of the metal concentrations measured in the samples, to the PEL concentration recommended of metals parameters in fresh water stream sediment. Since all numeric values in the table are equal to or less than 1, no sediment chemistry concentrations exceed the corresponding PEL values.

Table M-16. Ratios of measured sediment metals concentrations to PELs for sediment samples from Scotchman Gulch.

SITE ID	Site Location	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc
C02SCTMG01	Headwaters	0.2	< 0.07	0.05	0.07	--	0.07
C02SCTMG01		0.4	< 0.07	0.05	0.07	0.19	0.08
C02SCTMG10	50 above of Scotchman Gulch	1.0	< 0.07	0.05	0.08	--	0.15
C02SCTMG10	Road crossing	0.6	< 0.07	0.05	0.07	0.25	0.12
C02SCTMG02	1 mile below National Forest boundary	0.3	< 0.07	0.07	0.08	0.19	0.12
C02SCTMG02		0.4	< 0.07	0.07	0.08	0.16	0.11
C02SCTMG03	Near mouth	0.3	< 0.07	0.05	0.08	0.12	0.12
C02SCTMG03		0.3	< 0.07	0.06	0.08	0.10	0.14

M2.7.3 Scotchman Gulch TMDL Summary

The chronic aquatic life criteria exceedance for aluminum requires development of a TMDL for aluminum in Scotchman Gulch. The listing status and TMDL conclusions for metals in Scotchman Gulch are summarized in **Table M-17**.

Table M-17. Metals listing status and TMDL conclusions for Scotchman Gulch

Metal	Listing Status	TMDL Needed? (Y/N)
Aluminum	New Listing	Y
Arsenic	Not a Cause	N
Cadmium	Not a Cause	N
Copper	Not a Cause	N
Iron	Not a Cause	N
Lead	Not a Cause	N
Silver	Not a Cause	N
Zinc	Not a Cause	N
Mercury	Remove Current Listing	N
Number of metals TMDLs Required		1

M3.0 REFERENCES

Marvin, Richard K., John J. Metesh, Jeffrey D. Lonn, James Madison, and Robert Wintergerst. 1995. Abandoned-Inactive Mines Program: Deerlodge National Forest, Volume III: Flint Creek and Rock Creek Drainage. Butte, MT: Montana Bureau of Mines and Geology.

Montana Department of Environmental Quality. 2010. Circular DEQ-7: Montana Numeric Water Quality Standards. Helena, MT: Montana Department of Environmental Quality. <http://www.deq.state.mt.us/wqinfo/Standards/CompiledDEQ-7.pdf>.

-----. 2012. Montana 2012 Final Water Quality Integrated Report. Helena, MT: Montana Department of Environmental Quality. http://cwaic.mt.gov/wq_reps.aspx?yr=2012qryld=95193. Accessed 10/25/2012.

Montana Department of Environmental Quality, Water Quality Planning Bureau. 2010. Montana 2010 Final Water Quality Integrated Report. Helena, MT: Montana Department of Environmental

Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau.
WQPBDMSRPT-03 Rev.

Pioneer Technical Services, Inc. 1995. Abandoned Hardrock Mine Priority Sites, 1995 Summary Report.
Helena, MT: Montana Department of State Lands, Abandoned Mine Reclamation Bureau.
<http://deg.mt.gov/AbandonedMines/priority.mcp>. Accessed 4/1995.

Water & Environmental Technologies. 2012. Analysis of Base Parameter Data and Erosion Inventory
Data for Sediment TMDL Development Within the Rock TPA. Helena, MT: Montana Department
of Environmental Quality.