Beaverhead Metals TMDLs

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Beaverhead River
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ABBREVIATIONS AND ACRONYMS

Symbol or Unit of Measure	Definition
cfs	Cubic Feet per Second
lbs/day	Pounds per Day
mg/L	Milligrams Per Liter
µg/L	Micrograms per Liter
#	Number
>	Greater Than
<	Less Than
≥	Greater Than or Equal To
%	Percent

Abbreviation or Acronym	Definition
Al	Aluminum
AL	Aquatic Life
AAL	Acute Aquatic Life
ARM	Administrative Rules of Montana
As	Arsenic
BLM	Bureau of Land Management (Federal)
BMP	Best Management Practice
CD	Conservation District
Cd	Cadmium
CAL	Chronic Aquatic Life
CFR	Code of Federal Regulations
Cu	Copper
CWA	Clean Water Act
DEQ	Department of Environmental Quality (Montana)
D	Dissolved
DNRC	Department of Natural Resources & Conservation (Montana)
EPA	Environmental Protection Agency (U.S.)
EQIP	Environmental Quality Incentives Program
Fe	Iron
FWP	Fish, Wildlife & Parks (Montana)
GIS	Geographic Information System
HUC	Hydrologic Unit Code
IR	Integrated Report (Montana Water Quality)
LA	Load Allocation
MARS	Montana Aquatic Resources Services, Inc.
MBMG	Montana Bureau of Mines and Geology
MCA	Montana Code Annotated
MOS	Margin of Safety
MPDES	Montana Pollutant Discharge Elimination System
MT DEQ	Montana Department of Environmental Quality
N/A	Not Applicable
NHD	National Hydrography Dataset

Abbreviation or Acronym	Definition
NRCS	Natural Resources Conservation Service (U.S. Dept. of Agriculture)
Pb	Lead
PEL	Probable Effects Level
SME	Small Miner Exclusion
SMCRA	Surface Mining Control and Reclamation Act
STATSGO	State Soil Geographic Database
TMDL	Total Maximum Daily Load
TPA	TMDL Planning Area (Beaverhead)
TR	Total Recoverable
TSS	Total Suspended Solids
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGS	United States Geological Survey
Wat Grp	Watershed Group (Beaverhead Watershed Committee)
WLA	Wasteload Allocation
Zn	Zinc

How This Document is Organized and What it Contains

This document addresses all the required components of a TMDL and includes an implementation and monitoring strategy, as well as a strategy to address impairment causes other than metals. The TMDL components are summarized within the main body of the document. Additional technical details are contained in the appendices.

This document is organized into three parts, in addition to a preceding document summary. Use the tables below to determine which part(s) to read to find the information most useful to you.

Document Part	Read for:
Part 1	Introductory information that provides the context for this document and defines the total maximum daily load (TMDL) process
Part 2	The TMDL components and how they are derived
Part 3	Information on ways to improve water quality in the Beaverhead River watershed and information on developing a local water quality restoration plan

Part 1 – Introductory Information

Document Section	Section Contents
Section 1.0 Project Overview	Explains why DEQ writes TMDLs and provides a summary of what water quality impairments are addressed and a table of what TMDLs are included in this document
Section 2.0 Beaverhead River Watershed Description	Describes the physical characteristics and social profile of the watershed
Section 3.0 Montana Water Quality Standards	Discusses the water quality standards that apply to the Beaverhead River watershed and the TMDLS in this document
Section 4.0 Defining TMDLs and Their Components	Defines the components of TMDLs and how each is developed

Part 2 – TMDL Components

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

PART 3 – WATER QUALITY RECOMMENDATIONS

Document Section	**Section Contents**
Section 6.0 Water Quality Improvement Plan and Monitoring Strategy	Discusses water quality restoration objectives and a strategy to meet the identified objectives and TMDLs. Describes a water quality monitoring plan for strengthening source assessment and increasing available data as well as evaluating the long-term effectiveness of the Beaverhead TMDLs and any implemented restoration projects.
Section 7.0 Public Participation & Public Comments	Describes other agencies and stakeholder groups who were involved with the development of this document and the public participation process used to review the draft document. Addresses comments received during the public review period.
Section 8.0 References	Provides a list of references used in this document.

Document Summary

This document presents a total maximum daily load (TMDL) and framework water quality improvement plan for nine impaired tributaries to the Beaverhead River.

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

The Beaverhead TMDL Planning Area encompasses the Beaverhead River watershed (fourth-code hydrologic unit code 10020002), which begins at the outlet of the Clark Canyon Reservoir and flows northeast 79.5 miles before joining the Big Hole River to form the Jefferson River. The planning area is bounded by the Pioneer Mountains on the west, the Ruby Range to the east, and the Snowcrest Range and Blacktail Mountains to the south.

DEQ determined that a number of tributaries do not meet the applicable water quality standards. The scope of the TMDLs in this document address problems with metals, and 16 TMDLs are included that address 16 pollutant impairments (**Table DS-1**). Although DEQ recognizes that there are other pollutant listings for the Beaverhead TMDL Planning Area, this document addresses only those impairments identified in **Tables DS-1** and **1-1**. Future TMDL projects may require additional TMDLs for this TMDL planning area (**Table 1-2**).

Metals
Metals TMDLs were prepared for nine waterbody segments within seven streams in the Beaverhead TMDL Planning Area. Elevated concentrations of metals may impair the support of multiple beneficial uses for a waterbody. Elevated concentrations of metals can have a toxic, carcinogenic, or bio-concentrating effect on biota within aquatic ecosystems, and humans and wildlife can suffer acute and chronic effects from consuming water or fish with elevated metals concentrations. DEQ's water quality assessment methods for metals impairments are designed to evaluate the most sensitive use, thus ensuring protection of all designated uses. For metals, the most sensitive uses are drinking water and aquatic life.

The concentration of metals for most streams in the Beaverhead TPA does not violate the human health standard, but does violate the standard for protecting aquatic life at long-term exposure. Therefore, TMDLs were prepared indicating the amount of metals that must be reduced at example flows to meet the aquatic life standard. The exceptions were Steel Creek and West Fork Blacktail Creek, which exceeded the human health standard for arsenic. For these streams, TMDLs were prepared describing the amount of arsenic that must be reduced at example flows to meet the human health standard.

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

Although most water quality improvement actions are based on voluntary measures, federal law specifies permit requirements developed to protect narrative water quality criterion, a numeric water quality criterion, or both, to be consistent with the assumptions and requirements of wasteload allocations (WLAs) on streams where TMDLs have been developed and approved by EPA. A WLA for a permitted metals discharge is included for Upper Stone Creek.

Table DS-1. List of Impaired Waterbodies and their Impaired Uses in the Beaverhead TMDL Planning Area with Completed Metals TMDLs Contained in this Document

Waterbody (Assessment Unit)	Waterbody ID (Assessment Unit ID)	TMDL Prepared	TMDL Pollutant Category	Impaired Use(s)
Grasshopper Creek headwaters to mouth (Beaverhead River)	MT41B002_010	Lead	Metals	Aquatic Life
Rattlesnake Creek, from the Dillon PWS off-channel well T7S R10W S11 to the mouth (Van Camp Slough)	MT41B002_090	Copper	Metals	Aquatic Life
		Lead	Metals	Aquatic Life
Rattlesnake Creek, Headwaters to Dillon PWS off-channel well, T7S R10W S11	MT41B002_091	Lead	Metals	Aquatic Life, Drinking water
Spring Creek, headwaters to mouth (Beaverhead River)	MT41B002_080	Iron	Metals	Aquatic Life
Steel Creek, headwaters to mouth (Driscoll Creek), T6S R12W S18	MT41B002_160	Arsenic	Metals	Aquatic Life, Drinking Water
Stone Creek, Left and Middle Fork to un-named tributary, T6S R7W S34	MT41B002_132	Iron	Metals	Aquatic Life
Stone Creek, Un-named tributary at T6S R7W S34 to Staudaher Bishop Ditch	MT41B002_131	Aluminum	Metals	Aquatic Life
		Copper	Metals	Aquatic Life
		Iron	Metals	Aquatic Life
Wellman Creek, headwaters to mouth (Grasshopper Creek)	MT41B002_150	Aluminum	Metals	Aquatic Life
		Cadmium	Metals	Aquatic Life
		Copper	Metals	Aquatic Life
		Lead	Metals	Aquatic Life
		Zinc	Metals	Aquatic Life
West Fork Blacktail Deer Creek, Headwaters to mouth (Blacktail Deer Creek)	MT41B002_060	Arsenic	Metals	Drinking Water

PART 1
INTRODUCTORY INFORMATION

1.0 PROJECT OVERVIEW

This document presents an analysis of water quality information and establishes total maximum daily loads (TMDLs) for metals problems in the Beaverhead TMDL Planning Area (TPA). **Figure 1-1** below shows a map of the Beaverhead River watershed.

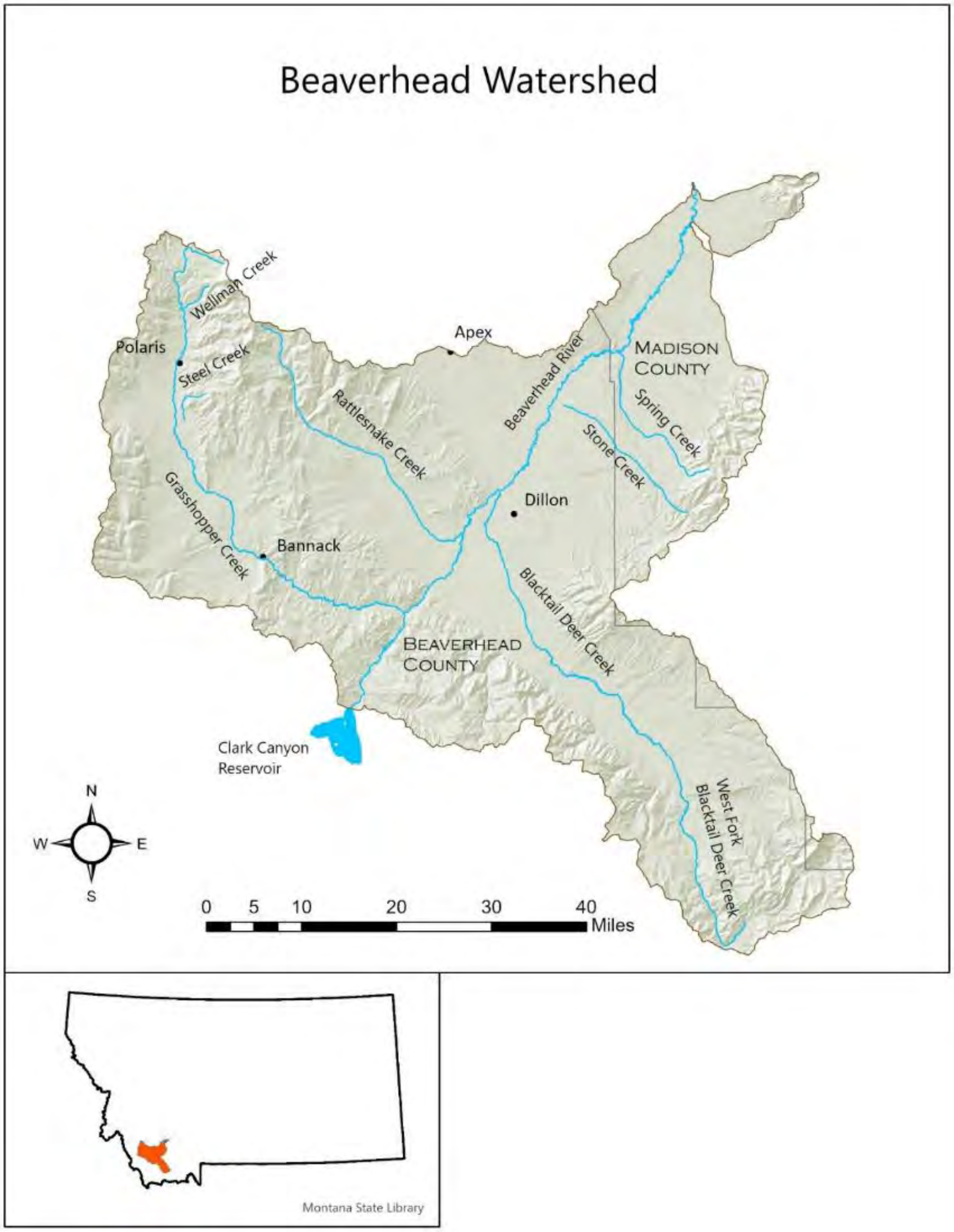

Figure 1-1. Location of the Beaverhead River Watershed

1.1 Why We Write TMDLs

The Montana Department of Environmental Quality (DEQ) is charged with protecting a clean and healthy environment. This includes actions that protect, maintain, and improve water quality, consistent with the Montana Water Quality Act and the federal Clean Water Act. In 1972, the U.S. Congress passed the Water Pollution Control Act, more commonly known as the Clean Water Act (CWA). The CWA's goal is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The CWA requires each state to designate uses of their waters and to develop water quality standards to protect those uses.

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

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

Each waterbody in Montana has a set of designated uses from the list above. Montana has established water quality standards to protect these uses, and a waterbody that does not meet one or more standards is called an impaired water. Each state must monitor their waters to track if they are supporting their designated uses, and every two years DEQ prepares a Water Quality Integrated Report (IR), which lists all impaired waterbodies and their identified impairment causes. Impairment causes fall within two main categories: pollutant and non-pollutant. A pollutant is any substance introduced into a waterbody that harms water quality for a specific use, such as aquatic life. Common pollutants include metals or nutrients. A non-pollutant is a change in the environment caused by humans that affects the waterbody or biological community, such as removing riparian vegetation or blocking fish passage.

Montana's biennial IR identifies all of the state's impaired waterbody segments. The 303(d) list portion of the IR includes all of those waterbody segments that have been evaluated as being impaired by a pollutant or non-pollutant. Both Montana state law (Section 75-5-701, Montana Code Annotated (MCA) of the Montana Water Quality Act) and section 303(d) of the federal Clean Water Act require the development of TMDLs for impaired waterbodies when water quality is impaired by a pollutant. TMDLs are not required for non-pollutant causes of impairment.

A TMDL is the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. **Section 4.0** provides more detail on TMDL development and the required TMDL components. In Montana, restoration strategies and monitoring recommendations are also incorporated in TMDL documents to help facilitate TMDL implementation (**Section 6.0**).

1.2 Water Quality Impairments and TMDLs Addressed by this Document

Table 1-1 below lists the impairment causes from the "2018 Water Quality Integrated Report" (DEQ, 2018) that are addressed in this document (also see **Figure 1-1**). TMDLs are completed for each waterbody – pollutant combination, and this document contains 16 TMDLs that address metals pollutant impairments on nine waterbody segments (**Table 1-1**).

Table 1-1. Water Quality Impairment Causes for the Beaverhead TMDL Planning Area Addressed within this Document

Waterbody (Assessment Unit)[1]	Waterbody ID (Assessment Unit ID)	Impairment Cause	Pollutant Category	Impairment Cause Status
Grasshopper Creek headwaters to mouth (Beaverhead River)	MT41B002_010	Lead	Metals	TMDL completed
Rattlesnake Creek, from the Dillon PWS off-channel well T7S R10W S11 to the mouth (Van Camp Slough)	MT41B002_090	Copper	Metals	TMDL completed
		Lead	Metals	TMDL completed
Rattlesnake Creek, headwaters to Dillon PWS off-channel well, T7S R10W S11	MT41B002_091	Lead	Metals	TMDL completed
Spring Creek, headwaters to mouth (Beaverhead River)	MT41B002_080	Iron	Metals	TMDL completed
Steel Creek, headwaters to mouth (Driscoll Creek), T6S R12W S18	MT41B002_160	Arsenic	Metals	TMDL completed
Stone Creek, Left and Middle Fork to un-named tributary, T6S R7W S34	MT41B002_132	Iron	Metals	TMDL completed
Stone Creek, Un-named tributary at T6S R7W S34 to Staudaher Bishop Ditch	MT41B002_131	Aluminum	Metals	TMDL completed
		Copper	Metals	TMDL completed
		Iron	Metals	TMDL completed
Wellman Creek, headwaters to mouth (Grasshopper Creek)	MT41B002_150	Aluminum	Metals	TMDL completed
		Cadmium	Metals	TMDL completed
		Copper	Metals	TMDL completed
		Lead	Metals	TMDL completed
		Zinc	Metals	TMDL completed
West Fork Blacktail Deer Creek, headwaters to mouth (Blacktail Deer Creek)	MT41B002_060	Arsenic	Metals	TMDL completed

[1] All assessment units within Montana's Water Quality Integrated Report are indexed to the National Hydrography Dataset (NHD)

1.3 Completed TMDLs and Future TMDL Development

Although DEQ recognizes that there are other pollutant listings for this TMDL planning area without completed TMDLs (**Table 1-2**), this document only addresses those identified in **Table 1-1** above. This is because DEQ sometimes develops TMDLs in a watershed at varying phases, with a focus on one or more specific pollutant types. **Table 1-2** below indicates TMDLS that are to be addressed in a future project. In addition, sediment TMDLs were previously completed in 2012 for the following waterbodies in the Beaverhead TMDL Planning Area: Beaverhead River, Blacktail Deer Creek, Clark Canyon Creek, Dyce

Creek, Farlin Creek, French Creek, Rattlesnake Creek, Reservoir Creek, Scudder Creek, Spring Creek, Steel Creek, Stone Creek, Taylor Creek, West Fork Blacktail Deer Creek, and West Fork Dyce Creek (DEQ 2012). A temperature TMDL was also completed in 2014 for the Beaverhead River from Grasshopper Creek to the mouth (DEQ 2014).

Table 1-2. Water Quality Impairment Causes for the Beaverhead TMDL Planning Area to be Addressed in a Future Project

Waterbody (Assessment Unit) [1]	Waterbody ID (Assessment Unit ID)	Impairment Cause	Pollutant Category
Beaverhead River, Clark Canyon Dam to Grasshopper Creek	MT41B001_010	Total Nitrogen	Nutrients
		Total Phosphorous	Nutrients
Beaverhead River, Grasshopper Creek to mouth (Jefferson River)	MT41B001_020	Total Nitrogen	Nutrients
		Total Phosphorous	Nutrients
Blacktail Deer Creek, headwaters to mouth (Beaverhead River)	MT41B002_030	Temperature	Temperature
		Total Nitrogen	Nutrients
Clark Canyon Creek, headwaters to mouth (Beaverhead River), T9S R10W S28	MT41B002_110	Total Phosphorous	Nutrients
Dyce Creek, confluence of East and West Forks to Grasshopper Creek	MT41B002_140	Total Nitrogen	Nutrients
		Total Phosphorous	Nutrients
Grasshopper Creek, headwaters to mouth (Beaverhead River)	MT41B002_010	Total Nitrogen	Nutrients
		Total Phosphorous	Nutrients
Rattlesnake Creek, from the Dillon PWS off-channel well T7S R10W S11 to the mouth (Van Camp Slough)	MT41B002_090	Total Nitrogen	Nutrients
		Total Phosphorous	Nutrients
Reservoir Creek, headwaters to mouth (Grasshopper Creek)	MT41B002_120	Total Nitrogen	Nutrients
		Total Phosphorous	Nutrients
Scudder Creek, headwaters to mouth (Grasshopper Creek), T6S R12W S19	MT41B002_180	Total Nitrogen	Nutrients
Spring Creek, headwaters to mouth (Beaverhead River)	MT41B002_080	Total Nitrogen	Nutrients
		Total Phosphorous	Nutrients
Steel Creek, headwaters to mouth (Driscoll Creek), T6S R12W S18	MT41B002_160	Total Nitrogen	Nutrients
		Total Phosphorous	Nutrients
Stone Creek, Un-named tributary at T6S R7W S34 to Staudaher Bishop Ditch	MT41B002_131	Total Nitrogen	Nutrients
		Total Phosphorous	Nutrients
		Nitrate/Nitrite	Nutrients

Table 1-2. Water Quality Impairment Causes for the Beaverhead TMDL Planning Area to be Addressed in a Future Project

Waterbody (Assessment Unit) [1]	Waterbody ID (Assessment Unit ID)	Impairment Cause	Pollutant Category
Stone Creek, Left and Middle Fork to un-named tributary, T6S R7W S34	MT41B002_132	Total Nitrogen	Nutrients
		Total Phosphorous	Nutrients
		Nitrate/Nitrite	Nutrients
Taylor Creek, headwaters to mouth	MT41B002_170	Total Nitrogen	Nutrients
		Total Phosphorous	Nutrients
West Fork Dyce Creek, headwaters to mouth (Dyce Creek)	MT41B002_070	Total Nitrogen	Nutrients

[1] All waterbody segments within Montana's Water Quality Integrated Report are indexed to the National Hydrography Dataset (NHD)

2.0 BEAVERHEAD TMDL PLANNING AREA DESCRIPTION

This document section provides a general overview of the physical and social characteristics of the Beaverhead TMDL Planning Area. Although certain information is current only through the 2016 to 2018 timeframe, the addition of more recently collected watershed description data would not affect overall TMDL development given the purpose of this section of the document.

2.1 PHYSICAL CHARACTERISTICS

The following information describes the physical characteristics of the Beaverhead TMDL Planning Area, including topography, hydrology, climate, and geology.

2.1.1 Location

The Beaverhead TMDL Planning Area (TPA) is located in Beaverhead County, with a small portion in Madison County, and includes the towns of Dillon and Twin Bridges (**Figure 1-1**). The Beaverhead TPA encompasses and matches the boundaries of the Beaverhead River watershed (fourth-code hydrologic unit code 10020002), which begins at the outlet of the Clark Canyon Reservoir and flows northeast 79.5 miles before joining the Big Hole River to form the Jefferson River. The TPA is bounded by the Pioneer Mountains on the west, the Ruby Range to the east, and the Snowcrest Range and Blacktail Mountains to the south.

2.1.2 Topography

Elevations in the planning area range from 4,600 feet above mean sea level at the confluence of the Beaverhead and Jefferson Rivers, to nearly 10,600 feet at the summit of Baldy Peak in the Pioneer Range. The majority of the planning area is between 5,000 and 7,000 feet, as shown in **Figure 2-1.**

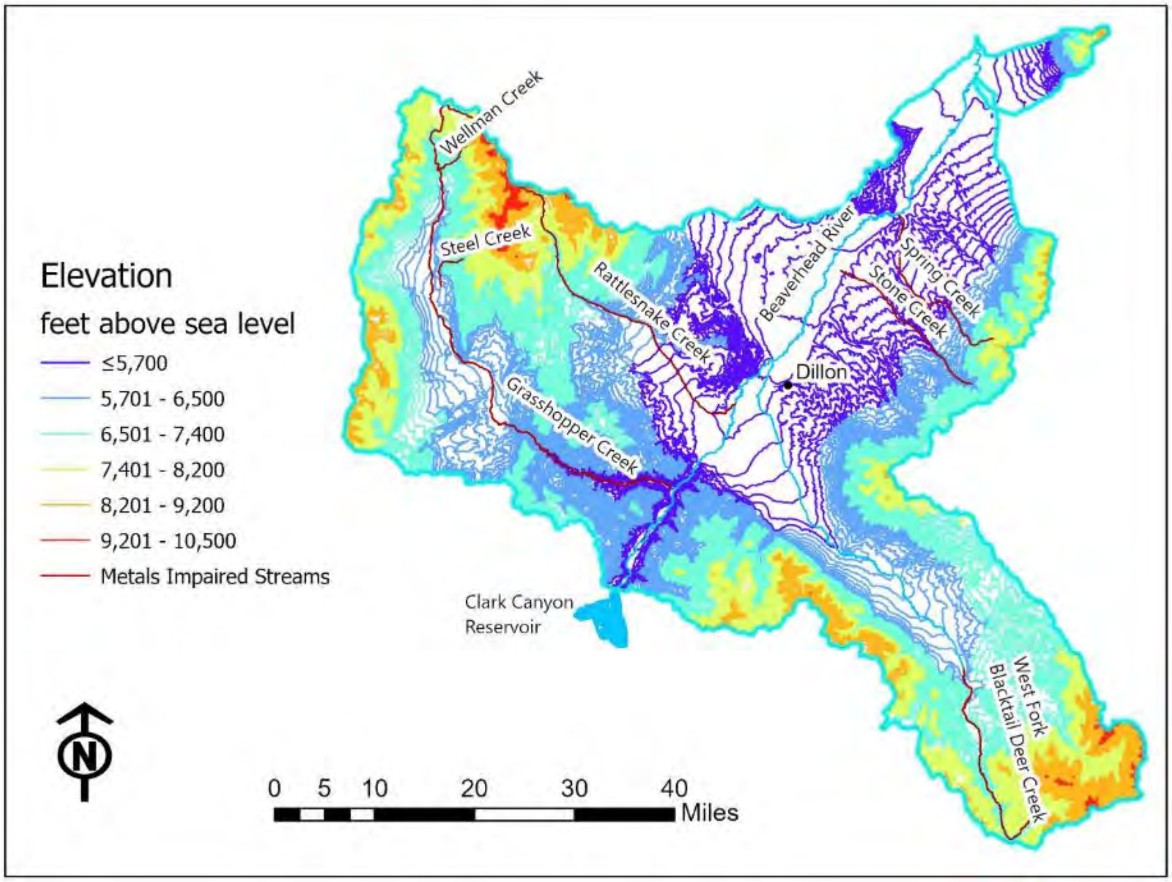

Figure 2-1. Topography of the Beaverhead TMDL Planning Area

2.1.3 Climate

Average precipitation in the watershed varies with elevation, from 9 inches/year in the valley to 39 inches/year at the highest elevations (**Figure 2-1**). Average snowfall ranges from 9 inches/year in the valley to 85.8 inches/year at higher elevations, according to 30-year average precipitation data (http://prism.oregonstate.edu/explorer/). May and June are consistently the wettest months of the year and winter precipitation is dominated by snowfall. Average annual precipitation of the TMDL planning area is mapped below in **Figure 2-2**. Temperature patterns reveal that July is the hottest month and January is the coldest throughout the watershed according to climate information collected at the Dillon Airport (**Figure 2-3**). Summertime highs are typically in the high seventies to low eighties F, and winter lows average 11 degrees F.

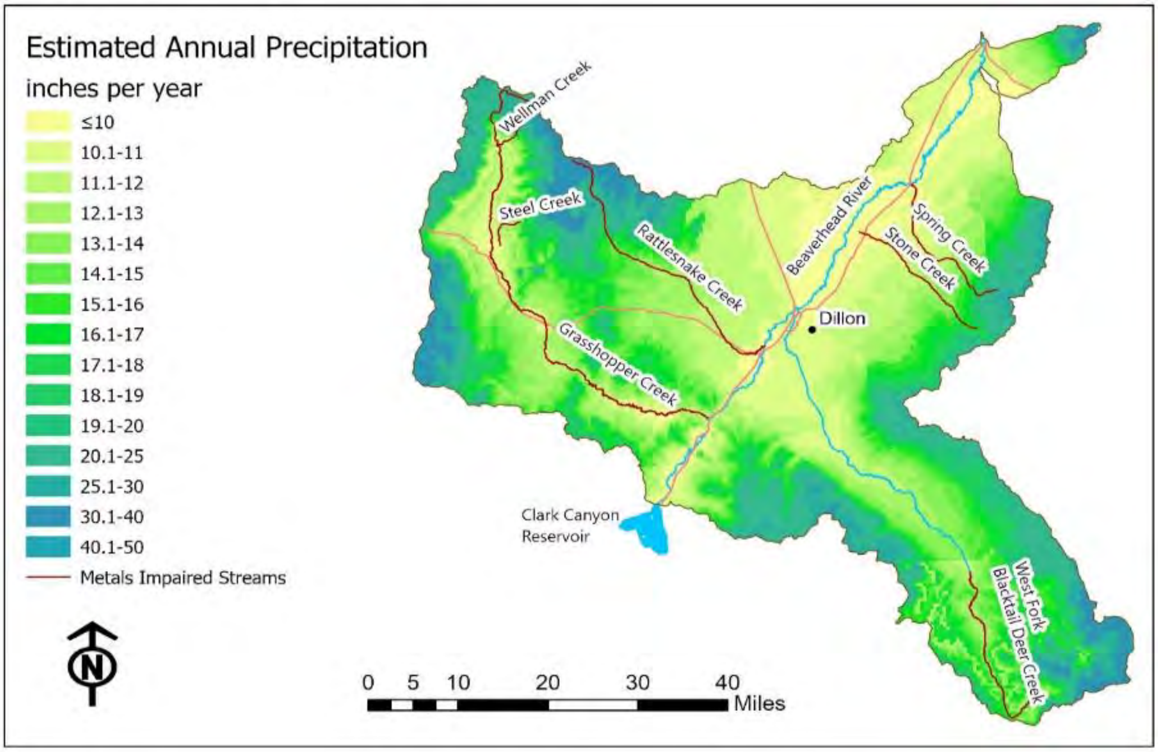

Figure 2-2. Average Annual Precipitation of the Beaverhead TMDL Planning Area

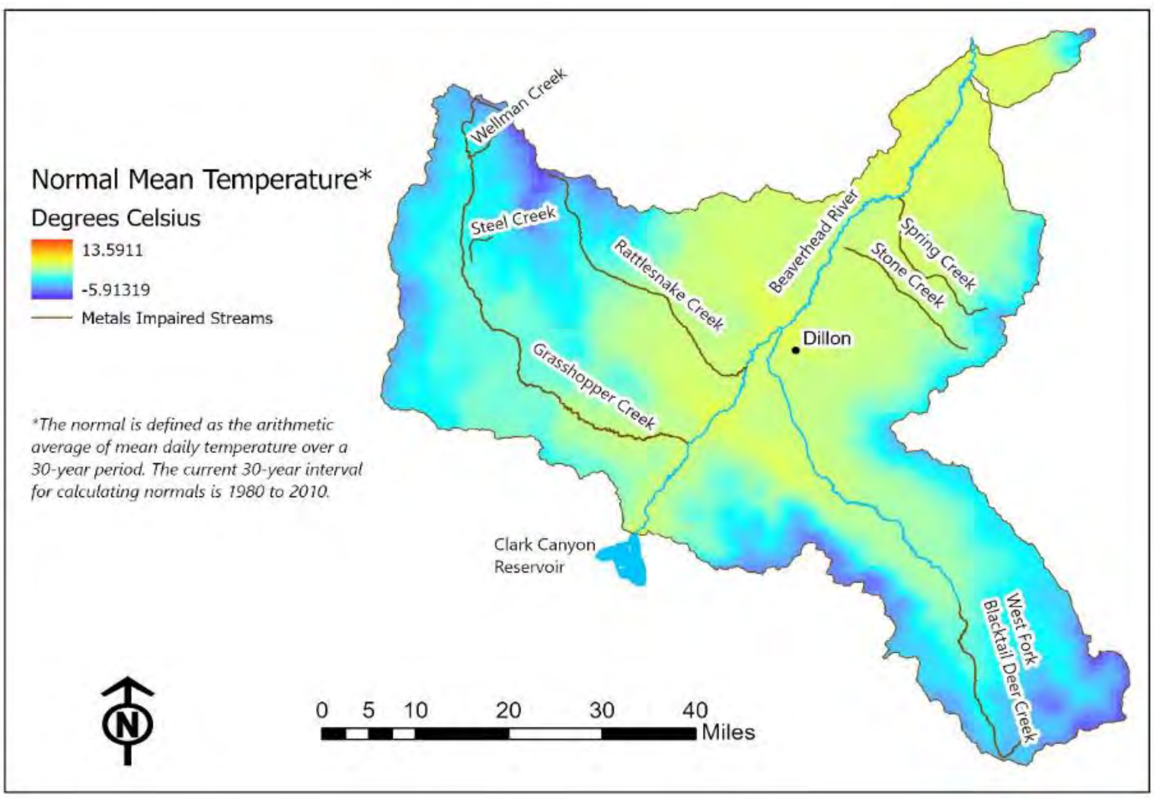

Figure 2-3. Average Annual Temperatures in the Beaverhead TMDL Planning Area

2.1.4 Hydrology

The Beaverhead River begins at the confluence of Horse Prairie Creek and the Red Rock River, since 1964 inundated by the Clark Canyon Reservoir. The Bureau of Reclamation built the dam and associated irrigation infrastructure in order to irrigate the bench east of Dillon. Below the dam, the Beaverhead River flows about 15 miles through a canyon before entering the Beaverhead Valley. Major tributary streams are Grasshopper Creek, Blacktail Deer Creek, and Rattlesnake Creek. The Ruby River drains into the Beaverhead River slightly over a mile south of Twin Bridges. The Big Hole River meets the Beaverhead River just north of Twin Bridges. The confluence of the Beaverhead and Big Hole Rivers marks the start of the Jefferson River.

The Bureau of Reclamation's East Bench Unit irrigates 49,800 acres via the diversion dam at Barretts (Rogers, 2008). Minimum discharges usually occur during late summer and often result in late-season shortages of irrigation water (Kendy and Tresch, 1996).

Operation of the Clark Canyon Reservoir influences the flow regime in the Beaverhead River. This is demonstrated graphically in a hydrograph of Beaverhead River discharge, measured at USGS gaging station 06016000 (Beaverhead River at Barretts). The peak of the hydrograph is shifted later in the year, reflecting controlled release of stored water. The low flow regime is fairly stable, reflecting average low-flow discharge from the reservoir. Diversion of river water to the East Bench Unit irrigation system is reflected at gaging stations further downstream, such as 06017000 (Beaverhead River at Dillon). Reduced flows are distinct between April and November, resulting in an inverted hydrograph.

The State of Montana Fish, Wildlife and Parks (MT FWP) maintains a list of Montana streams that support important fisheries or contribute to important fisheries (i.e. provide spawning and rearing habitats) that are significantly dewatered. Dewatering refers to a reduction in streamflow below the point where stream habitat is adequate for fish. The list was initially prepared by MT FWP in 1991 from field observations and revised in December 1997. The revised list includes 207 streams and 2,614 stream miles that are chronically dewatered and 87 streams and 1,242 stream miles that are periodically dewatered. The two categories of dewatering are "chronic" – streams where dewatering is a significant problem in virtually all years and "periodic" – streams where dewatering is a significant problem only in drought or water-short years.

Most man-made dewatering occurs during the irrigation season (July-September) and although most dewatering is the result of irrigation withdrawals, a few of the streams listed are dewatered through dam regulation for agriculture or power production, or by natural causes. The number of miles of a given stream may vary from year to year depending on the amount of water available in the stream system. Dewatered streams identified in the Beaverhead TMDL Planning Area include: the Beaverhead River (62.5 miles), Blacktail Deer Creek (38.6 miles), Rattlesnake Creek (7.9 miles) and Grasshopper Creek (28.3 miles). A total of 137.3 miles of stream are reported dewatered in the planning area. This includes both chronic and periodic dewatering. Chronic dewatering is limited to the lower reaches of Rattlesnake and Blacktail Deer Creeks and the Beaverhead River below Dillon. Dewatered streams are shown on **Figure 2-4.**

The tributary streams generally are not monitored by U.S. Geological Survey (USGS) gaging stations. Their streamflow generally follows a hydrograph typical for the region, highest in May and June. These are the months with the greatest amount of precipitation and snowmelt runoff. Streamflow begins to decline in late June or early July, reaching minimum flow levels in September when streams may go dry.

Streamflow begins to rebound in October and November when fall storms supplement the base-flow levels. However, water withdrawals may affect these patterns.

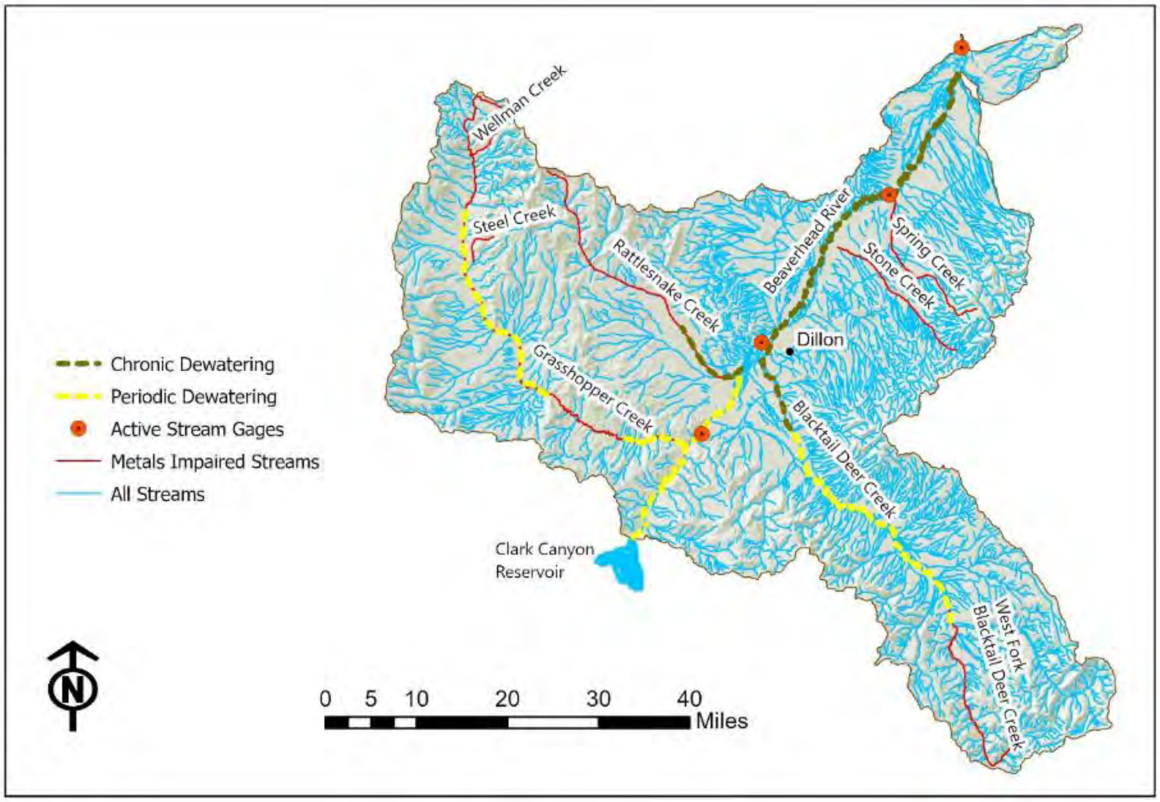

Figure 2-4. Locations of Dewatering and Stream Gauges in the Beaverhead TMDL Planning Area

2.1.5 Geology and Soils

The planning area includes a diverse assemblage of geologic units, and is representative of the geology of southwestern Montana in general. The planning area's physiography includes high alpine mountains, broad pediments or terraces, and wide alluvial valleys. Detailed discussion of the bedrock geology exposed in the mountains is beyond the scope of this report. Tertiary valley fill deposits, with some volcanic and pre-belt gneiss related rocks, dominate the planning area (**Figure 2-5**).

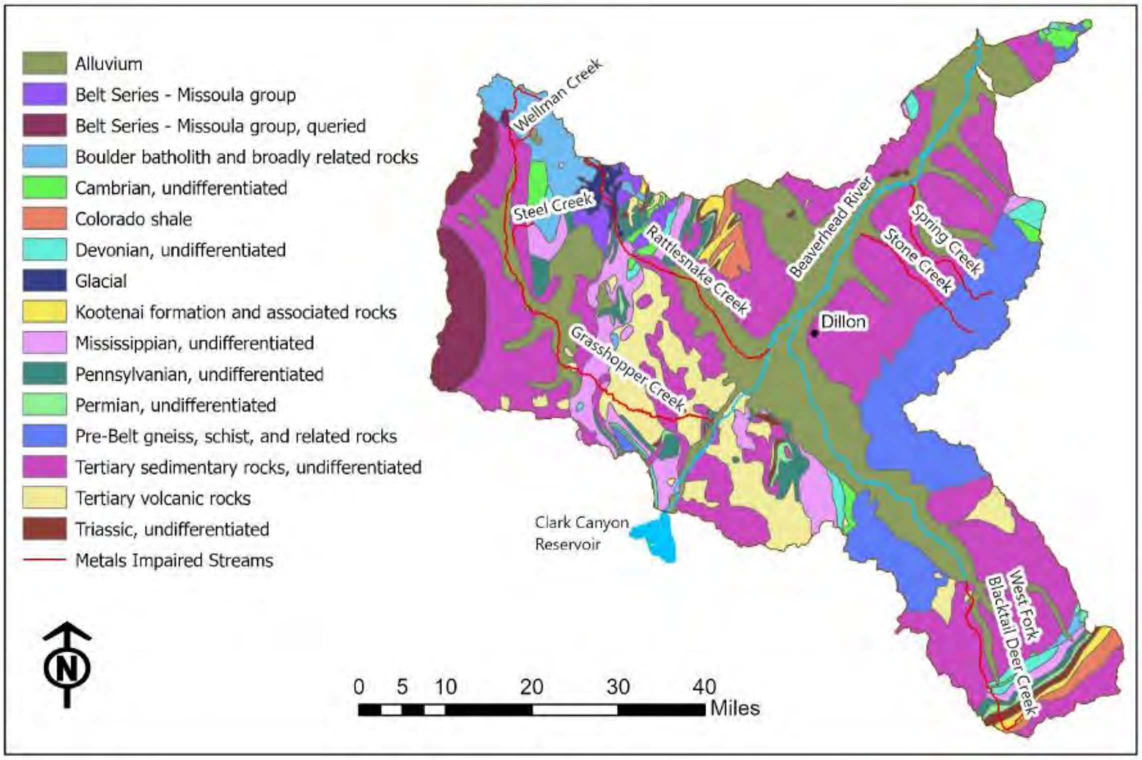

Figure 2-5. Generalized Geology of the Beaverhead TMDL Planning Area

The USGS Water Resources Division created a dataset of hydrology-relevant soil attributes (Schwarz and Alexander, 1995), based on the USDA Natural Resources Conservation Service (NRCS) STATSGO soil database. The STATSGO data is intended for small-scale (watershed or larger) mapping, and is too general to be used at scales larger than 1:250,000. It is important to realize, therefore, that each soil unit in the STATSGO data may include up to 21 soil components. Soil analysis at a larger scale should use NRCS SSURGO data. The soil attributes considered in this characterization are erodibility and slope. Soil erodibility is based on the Universal Soil Loss Equation (USLE) K-factor (Wischmeier and Smith, 1978). K-factor values range from 0 to 1, with a greater value corresponding to greater potential for erosion. Susceptibility to erosion is mapped on **Figure 2-6**, with soil units assigned to the following ranges: low (0.0-0.2), moderate-low (0.2-0.29) and moderate-high (0.3-0.4). Values of >0.4 are considered highly susceptible to erosion. No values greater than 0.4 are mapped in the TPA.

Low susceptibility soils compose 10% of the TPA; moderate-low susceptibility soils comprise 73% of the TPA, and the remaining 17% is mapped with moderate-high susceptibility soils. No high susceptibility soils are mapped in the TPA. Low susceptibility soils are associated with the Pioneer Range and the Tertiary sediments on the pediment flanking the Ruby Range.

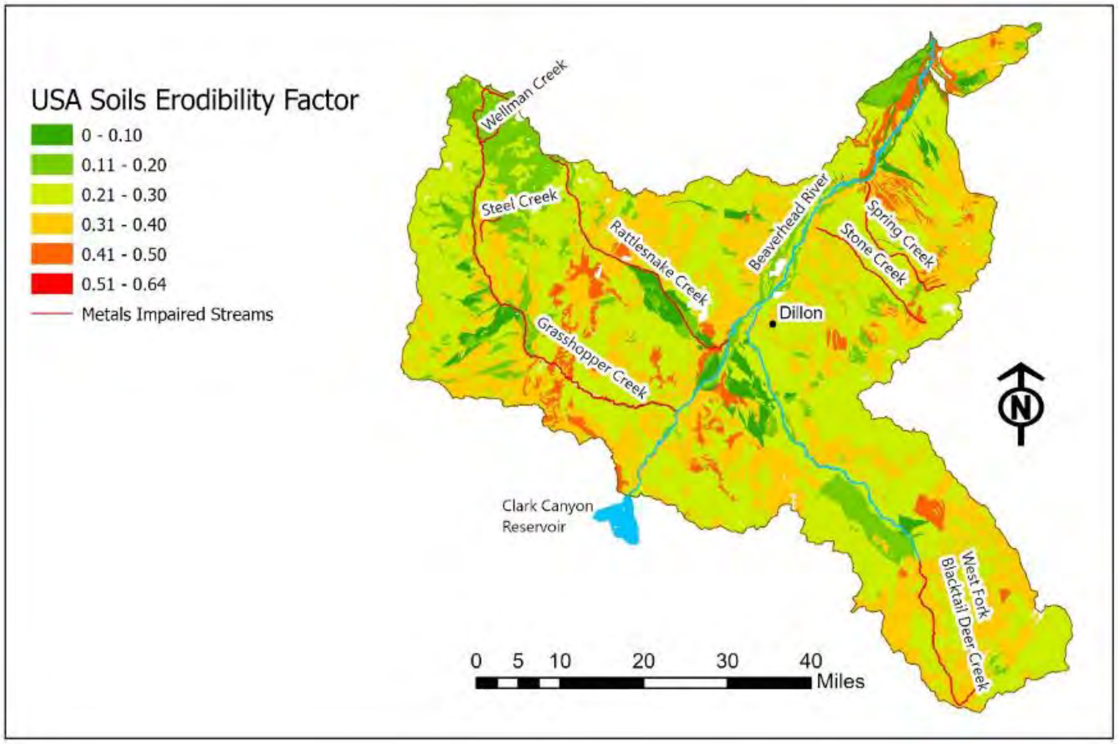

Figure 2-6. Soil Erodibility of the Beaverhead TMDL Planning Area

2.2 Ecological Profile

This section describes the ecology of the Beaverhead TMDL Planning Area, including the ecoregions mapped within it, land cover, fire history, and fish species of concern.

2.2.1 Ecoregions

The TPA is located in the Middle Rockies Level III Ecoregion. Eight Level IV Ecoregions are mapped within the TPA (Woods, et al., 2002), as shown on **Figure 2-7.** These include: Barren Mountains (17e), Alpine Zone (17h), Dry Intermontane Sagebrush Valleys (17aa), Dry Gneissic-Schistose-Volcanic Hills (17ab), Big Hole (17ac), Forested Beaverhead Mountains (17ae), Pioneer-Anaconda Ranges (17ag), and Eastern Pioneer Sedimentary Mountains (17ah).
https://www.epa.gov/eco-research/ecoregion-download-files-state-region-8#pane-24 .

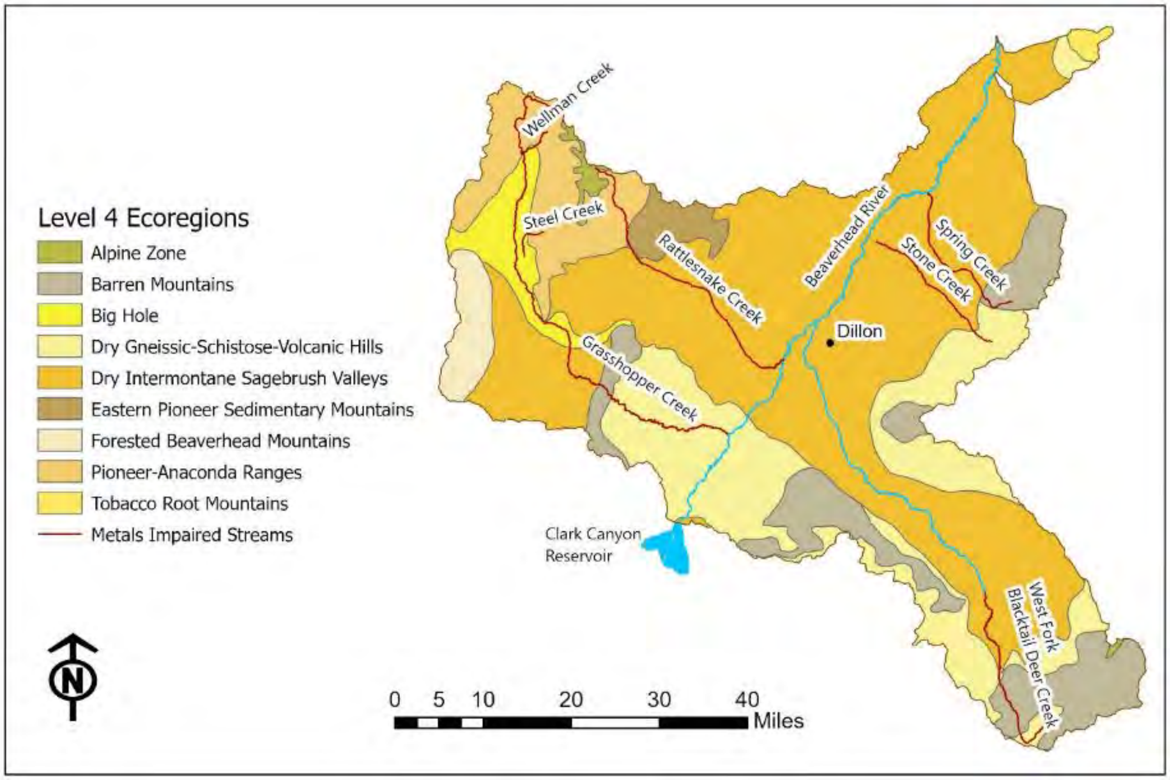

Figure 2-7. Level IV Ecoregions in the Beaverhead TMDL Planning Area

2.2.2 Land Cover

Historic land uses included mining, fur trapping and agriculture, primarily ranching. Current land use in the watershed is dominated by agricultural cattle production, with less significant grain cropping and potato production. A large portion of the upper watershed is used for rangeland. The floodplains of the major tributaries are irrigated for hay and alfalfa production and pasture. Irrigation canals installed in the mid to late twentieth century provide water for irrigation from the Beaverhead River, much of which is derived from Clark Canyon Reservoir. Other land uses in the basin are recreation, logging, and mining. The most intensive recreation use is fall big game hunting, especially in the upper Blacktail Deer Creek drainage. Mining has been and is still an important land use in the basin and a potential source of impairment to water quality. A large operating mine is located in the Stone Creek watershed.

Major transportation corridors in the planning area include Interstate 15 and Highway 41.

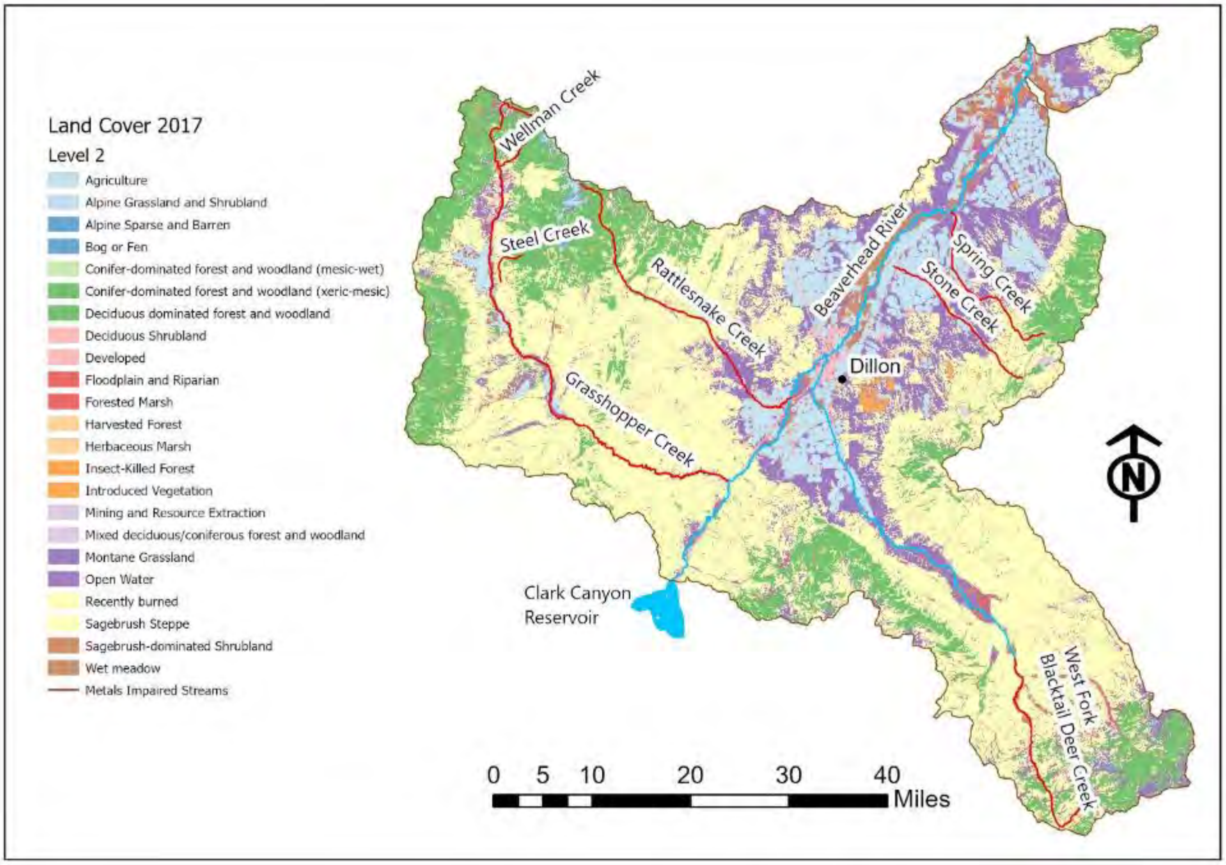

Figure 2-8. Land Cover in the Beaverhead TMDL Planning Area

The majority of the planning area is mapped with shrub/scrub and grassland landcover. The lowland areas are dominated by hay/pasture and small grain cultivation, and the upland areas are covered with evergreen forest. Land cover is mapped below in **Figure 2-8**, based on the 2017 version of a map developed by the Montana Heritage Program: https://mslservices.mt.gov/Geographic_Information/Data/DataList/datalist_Details.aspx?did={B24A26F3-0BAD-42FC-858A-426FD5DF1063}.

2.2.3 Fire History

The planning area experienced a relatively large fire in 2006, the Clark Canyon fire, which burned 15,345 acres in the Blacktail Mountains. These and other fires of greater than 400 acres are shown in **Figure 2-9.**

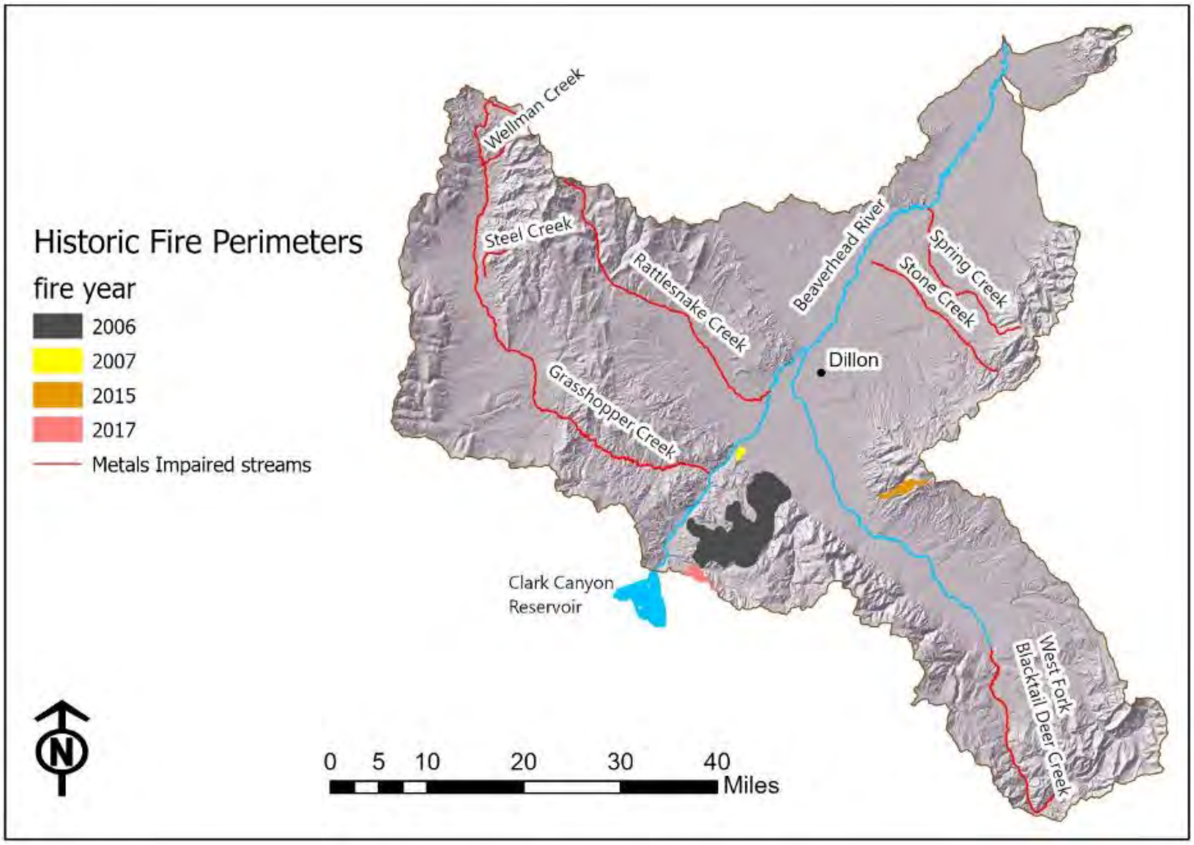

Figure 2-9. Fire History (2005-2019) of the Beaverhead TMDL Planning Area

2.2.4 Fish Distribution

Montana Fish, Wildlife and Parks report Westslope cutthroat trout in the planning area, generally in upland tributary streams. Yellowstone cutthroat trout has also been reported from East Fork Blacktail Deer Creek, and Arctic grayling have been reported in the mainstem Beaverhead River. The metals streams with western cutthroat trout reported include Stone and Spring Creeks and tributaries to Grasshopper and Rattlesnake Creek. Fish distribution is shown on **in Figure 2-10.**

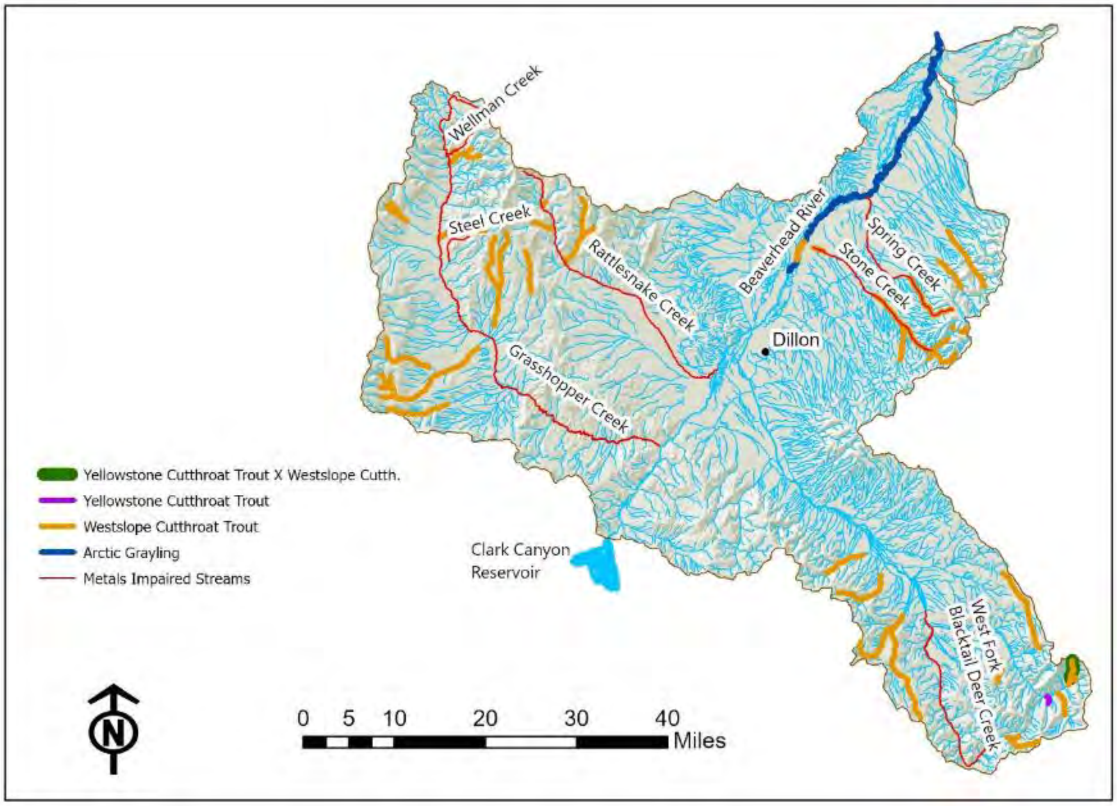

Figure 2-10. Westslope Cutthroat Trout, Yellowstone Cutthroat Trout, and Arctic Grayling Distribution in the Beaverhead TMDL Planning Area

2.3 Social Profile

The following section describes the human geography of the planning area. This includes population distribution, land ownership, and land management.

2.3.1 Population Density

As of the 2010 census, 9,246 people resided in Beaverhead County (**Figure 2-11**). Dillon is the largest municipality in the Beaverhead Watershed. As of the 2010 census, the population of Dillon was 4,134, a modest increase from the 2000 census. Other towns in the watershed include Bannack, Polaris, Argenta, Grant, and Twin Bridges. Twin Bridges is the second largest population center, with 400 residents.

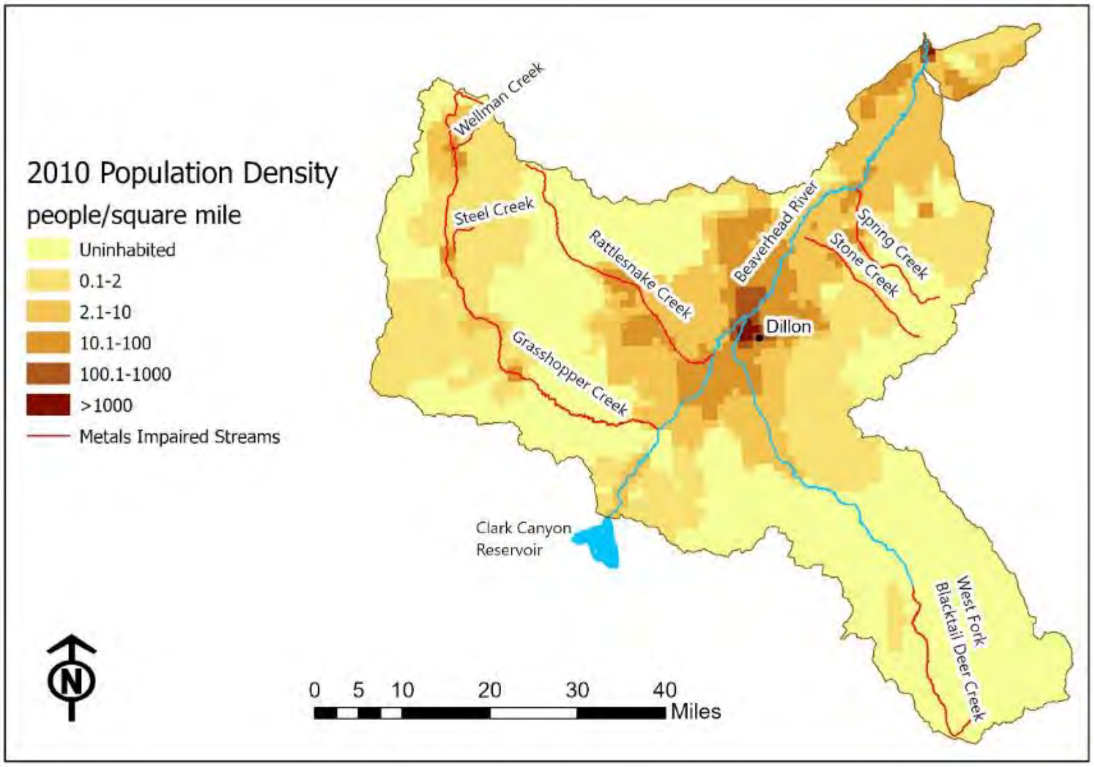

Figure 2-11. Population Density in the Beaverhead TMDL Planning Area

2.3.2 Land Management

Roughly 39% of the planning area is under federal management (24% BLM; 15% USFS), 15% is state lands (including FWP managed lands and surface waters), and about 46% is in private ownership (**Figure 2-12**). In general, USFS lands occupy the higher, timbered areas, and the lower elevations are mostly private lands with some BLM and State Trust Lands. The US Bureau of Reclamation owns and manages the Clark Canyon Reservoir.

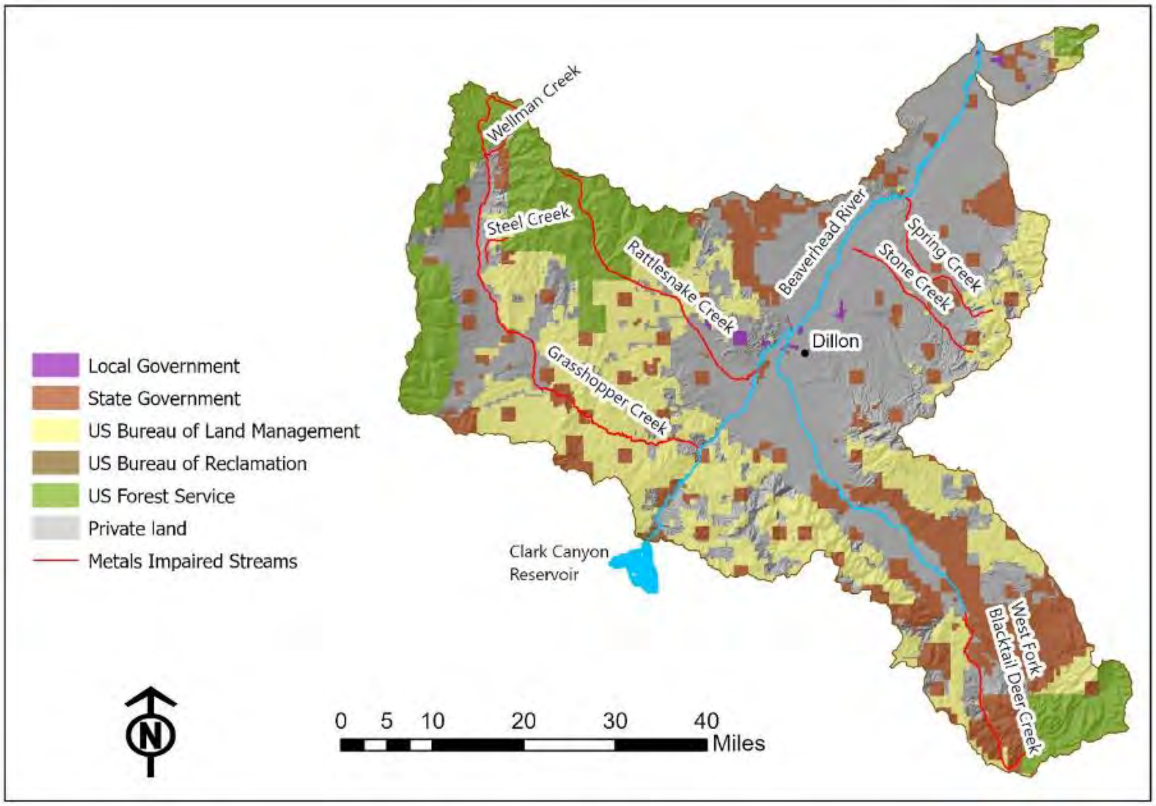

Figure 2-12. Land Management in the Beaverhead TMDL Planning Area

2.3.3 Agricultural Land Use

Irrigated lands are present in the watershed, using both flood irrigation and pivot irrigation methods (**Figure 2-13**). This map is based on the Department of Revenue's 2019 Final Land Classification (FLU), which is used for land valuation. In early 2009, all agriculture producers who own private parcels in the state were mailed maps of their parcels in agriculture or forestry use with instructions to return maps that were incorrectly classified. Department of Revenue Technicians updated the database based on the feedback from landowners. Since 2010 the data continues to be actively updated on a yearly basis using the most current imagery available and/or per land classification change requests from landowners and county agricultural and forest appraisal staff.

Grazing is common on both private lands and forested public lands. BLM and USFS grazing allotments are shown on the map, totaling 138 and 559 square miles, respectively (**Figure 2-14**). Private grazing operations are not specifically identified; however, much of the gray area on the map includes private land where grazing occurs.

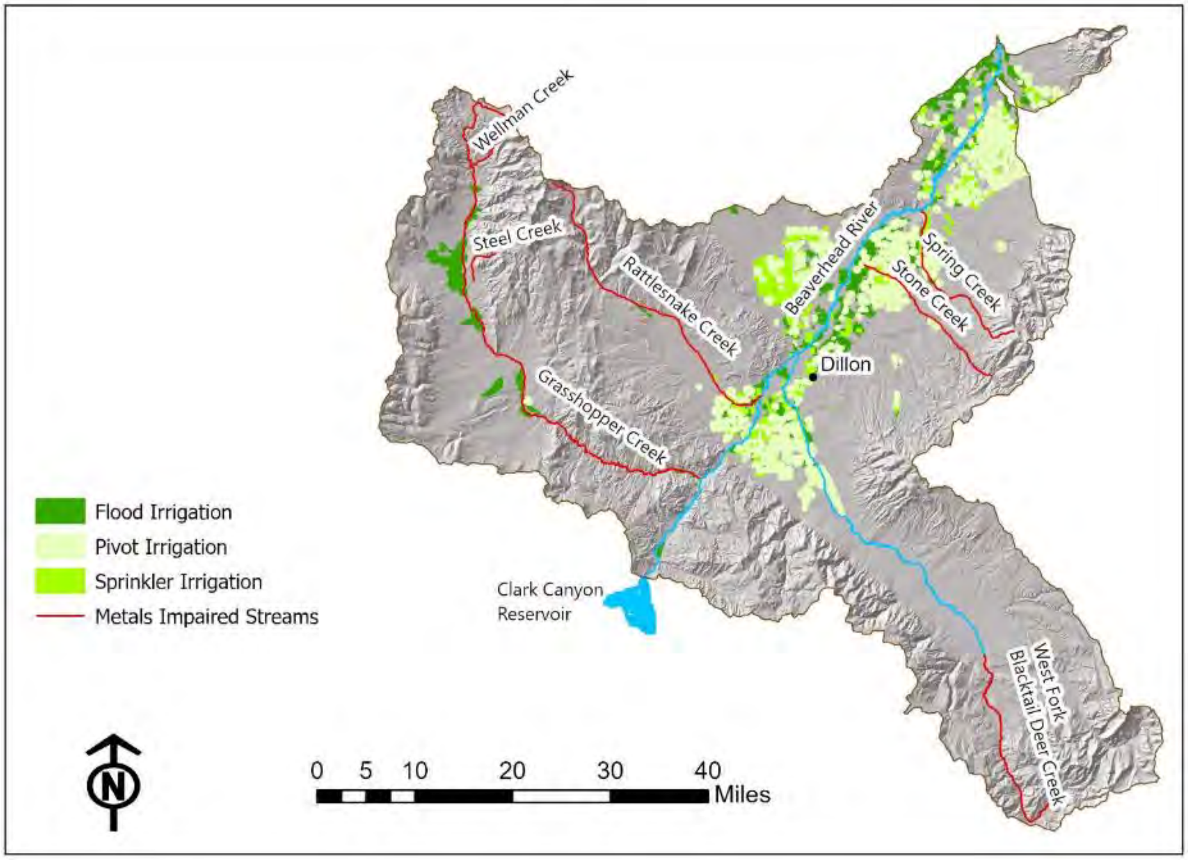

Figure 2-13. Irrigated Lands in the Beaverhead TMDL Planning Area

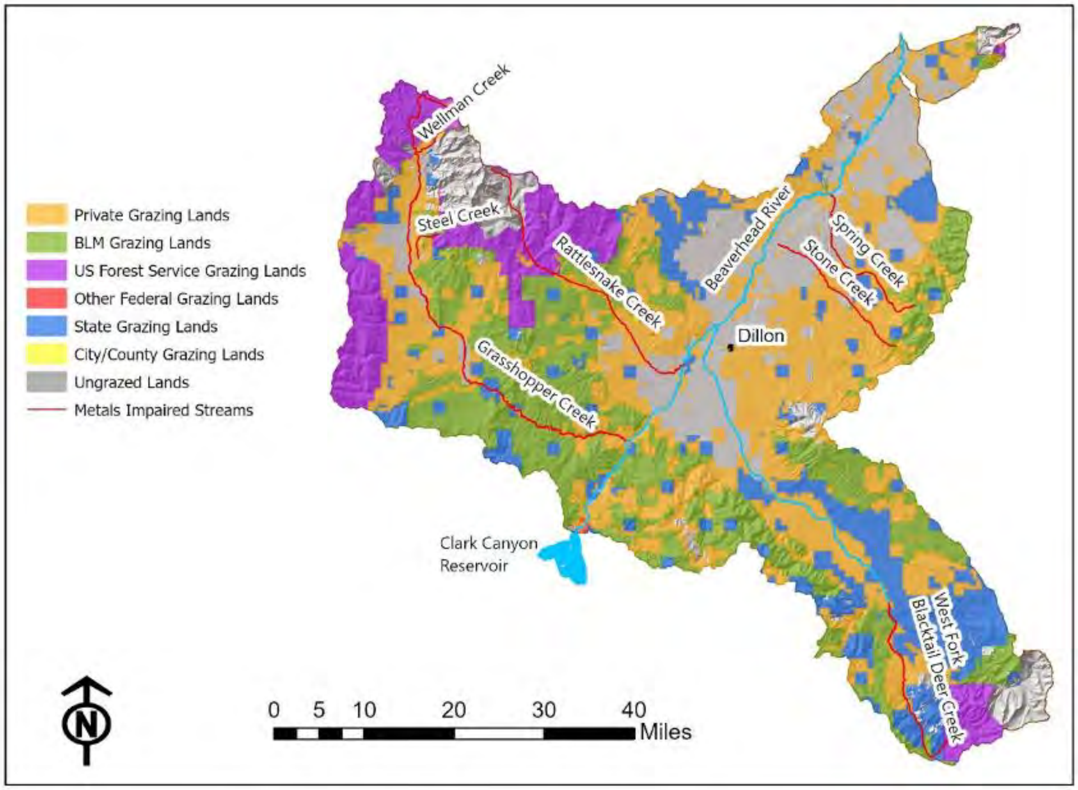

Figure 2-14. Grazing Activity in the Beaverhead TMDL Planning Area

2.3.4 Wastewater Discharges

Sources of pollution originating from a point source wastewater discharge are permitted and regulated through the Montana Pollutant Discharge Elimination System (MPDES) administered by Montana DEQ. The goal of the MPDES program is to control point source discharges of wastewater such that water quality in state surface water is protected. Levels of water quality that are required to maintain the various beneficial uses of state surface waters are set forth in the state's water quality standards. There are two types of discharge permits: general and individual.

A MPDES General Permit is a permit for wastewater discharges associated with common activities, such as concentrated animal feeding operations and storm water discharges from construction or industrial activity. Authorizations for General Permits are issued if a facility or activity falls within the guidelines of the existing permit. Individual MPDES Permits regulate wastewater discharges from point sources that do not fall under the guidelines for a General Permit. The individual permitting process is more rigorous, as individual permits address the specific conditions of the facility or activity needing authorization.

All point sources of wastewater discharge are required to obtain and comply with MPDES permits. The effluent limitations and other conditions for certain categories of wastewaters are required to be treated to federally-specified minimum levels based on available and achievable water treatment technologies. Additionally, effluent limits and permit conditions are established to protect beneficial uses and applicable water quality standards. Each MPDES permit issued is designed to protect the state surface water quality at the point of discharge. In addition, recognizing the dynamic nature of streams and the potential additive or cumulative effects of pollutants, MPDES permits also address stream reach or basin-wide pollution problems. If a TMDL has been developed for a waterbody, any wasteload allocations (WLAs) are incorporated into the applicable MPDES permits with discharges into that waterbody.

There are three facilities in the Beaverhead TMDL Planning Area with individual MPDES permits to discharge into surface waters. There is one individual groundwater discharge permit. In addition, there are nine authorizations under Concentrated Animal Feeding Operation (CAFO) and Industrial Stormwater general permits. These facilities do not regularly discharge into surface water but have the potential during some storm events. These facilities are required to apply best management in order to reduce the likelihood and amount of pollutant discharges (**Table 2-1** and **Figure 2-15**).

Of the permits, only individual permits held by Barretts Minerals (MT0029891) and Beaverhead Talc Mine (MT0027821) and the general permit held by Barretts Minerals (MTR000510) are associated with metals-impaired streams having TMDLs in this document. The discharges associated with these permits are discussed in **Section 5.5.6** pertaining to Upper Stone Creek.

Table 2-1. Beaverhead TMDL Planning Area MPDES Permit Details

Facility Name	Permit Type	Permit Number	Permit Expiration Date	Receiving Waterbody
City of Dillon Wastewater Treatment Plant	Individual	MT0021458	June 30, 2022	Beaverhead River
Beaverhead Talc Mine	Individual	MT0027821	January 31, 2020; Administratively Extended; Undergoing bond release	Middle Fork Stone Creek
Barretts Minerals Inc.	Individual	MT0029891	May 31, 2019; Admin Extended	Left Fork Stone Creek
Barretts Minerals Inc.	Groundwater	MTX000094	August 31, 2024	Groundwater adjacent to Beaverhead River
Tilstra Ranch	CAFO	MTG010139	October 31, 2023	Irrigation Ditch to Jefferson River
Matador Cattle Company	CAFO	MTG010165	October 31, 2023	Blacktail Deer Creek
Diamond O Ranch	Stormwater Construction	MTG070695	October 31, 2023	Beaverhead River
Beaverhead Livestock Auction	CAFO	MTG010176	October 31, 2023	Beaverhead River
John Erb	CAFO	MTG010179	October 31, 2023	Beaverhead River
Big West Management Cattle Feeding Company	CAFO	MTG010212	October 31, 2023	Carter Creek
Barretts Minerals Regal Mine	Industrial Stormwater	MTR000509	January 31, 2023	Carter Creek
Barretts Minerals Incorporated	Industrial Stormwater	MTR000508	January 31, 2023	Beaverhead River

Table 2-1. Beaverhead TMDL Planning Area MPDES Permit Details

Facility Name	Permit Type	Permit Number	Permit Expiration Date	Receiving Waterbody
Barretts Minerals Treasure Mine	Industrial Stormwater	MTR000510	January 31, 2023	Left Fork Stone Creek

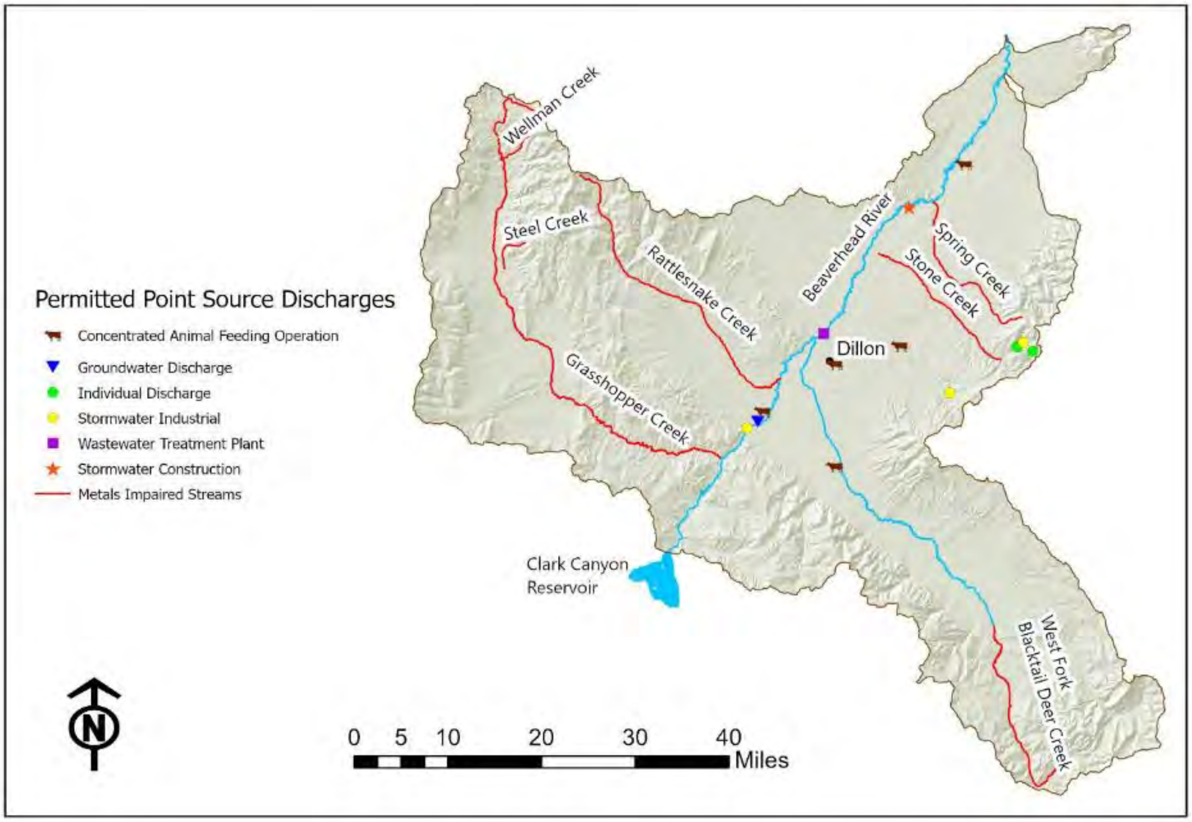

Figure 2-15. MPDES Permits in the Beaverhead TMDL Planning Area

3.0 Montana Water Quality Standards

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

Montana's water quality standards, and water quality standards in general, include three main parts:

1. Stream classifications and designated uses
2. Numeric and narrative water quality criteria designed to protect designated uses
3. Nondegradation provisions

Montana's water quality standards also incorporate prohibitions against water quality degradation as well as point source permitting and other water quality protection requirements.

Those water quality standards that apply to this document are reviewed briefly below. More detailed descriptions of Montana's water quality standards may be found in the Montana Water Quality Act (75-5-301,302 Montana Code Annotated (MCA)), Montana's Surface Water Quality Standards and Procedures (Administrative Rules of Montana (ARM) 17.30.601-670), and Regulatory Framework and Reference Condition Approach.

3.1 Stream Classifications and Designated Beneficial Uses

Stream classification is the assignment (designation) of a single group of uses to a waterbody based on the potential of the waterbody to support those uses. Designated uses, or beneficial uses, are simple narrative descriptions of water quality expectations or water quality goals. Montana waters are classified for multiple uses. All streams and lakes within the Beaverhead TMDL Planning Area are classified as A-1 or B-1 (ARM 17.30.623). In accordance with ARM 17.30.623, these waters are to be maintained suitable for:

- Culinary and food processing purposes after conventional treatment (Drinking Water)
- Bathing, swimming, and recreation (Primary Contact Recreation)
- Growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers (Aquatic Life)
- Agricultural and industrial water supply

While a waterbody might not actually be used for a designated use (e.g., drinking water supply), its water quality still must be maintained suitable for that designated use. More detailed descriptions of Montana's surface water classifications and designated uses are provided in **Appendix A**. DEQ's water quality assessment methods are designed to evaluate the most sensitive uses for each pollutant group addressed within this document, thus ensuring protection of all designated uses (Makarowski, 2019). For streams in western Montana, the most sensitive use assessed for metals is general aquatic life, but can sometimes be human health. DEQ determined that nine waterbody segments in the Beaverhead TMDL Planning Area do not meet the metals water quality standards (**Table 3-1**).

Table 3-1. Impaired Waterbodies and Their Impaired Designated Uses in the Beaverhead TMDL Planning Area

Waterbody (Assessment Unit)	Waterbody ID (Assessment Unit ID)	Impairment Cause[1]	Impaired Use[2]	Use Class
Grasshopper Creek, headwaters to mouth (Beaverhead River)	MT41B002_010	Lead	Aquatic Life	B-1
Rattlesnake Creek, from the Dillon PWS off-channel well T7S R10W S11 to the mouth (Van Camp Slough)	MT41B002_090	Copper, Lead, Cadmium[3]	Aquatic Life	B-1
Rattlesnake Creek, headwaters to Dillon PWS off-channel well, T7S R10W S11	MT41B002_091	Lead, Cadmium[3]	Aquatic Life, Drinking Water	A-1
Spring Creek, headwaters to mouth (Beaverhead River)	MT41B002_080	Iron	Aquatic Life	B-1
Steel Creek, headwaters to mouth (Driscoll Creek), T6S R12W S18	MT41B002_160	Arsenic	Aquatic Life, Drinking Water	B-1
Stone Creek, Left and Middle Fork to un-named tributary, T6S R7W S34	MT41B002_132	Iron	Aquatic Life	B-1
Stone Creek, Un-named tributary at T6S R7W S34 to Staudaher Bishop Ditch	MT41B002_131	Aluminum, Copper, Iron	Aquatic Life	B-1
Wellman Creek, headwaters to mouth (Grasshopper Creek)	MT41B002_150	Aluminum, Cadmium, Copper, Lead, Zinc, Arsenic	Aquatic Life	B-1
West Fork Blacktail Deer Creek, headwaters to mouth (Blacktail Deer Creek)	MT41B002_060	Arsenic	Aquatic Life, Drinking Water	B-1

[1] Only includes those pollutant impairments addressed by TMDLs in this document

[2] A full summary of beneficial use support information for each waterbody is contained at cwaic.mt.gov

[3] After a review of cadmium standards in 2018, this segment is no longer impaired; it will be removed from the 303(d) impaired waters list in 2020. No TMDL will be written.

It is important to note that waterbodies monitored by Montana DEQ are assigned an assessment unit (**Table 3-1**). Assessment units can be the full length of a stream, the full extent of a lake or reservoir, or they may be a portion of a lake or of a stream (a stream segment). Streams may be broken into individual segments, determined by a variety of factors such as stream length for very long streams, or lakes may be broken by ownership boundaries (tribal versus state, for example). For instance, both Stone Creek and Rattlesnake Creek or broke into upper and lower segments.

3.2 Numeric and Narrative Water Quality Standards

Montana's water quality standards include numeric and narrative criteria that protect the designated uses described above. Numeric standards define the allowable concentrations, frequency, and duration of specific pollutants so as not to impair designated uses.

Numeric standards apply to pollutants that are known to have adverse effects on human health or aquatic life (e.g., metals, organic chemicals, and other toxic constituents). Human health standards (HHSs) are set at levels that protect against long-term (lifelong) exposure via drinking water and other pathways such as fish consumption, as well as short-term exposure through direct contact such as swimming. Numeric standards for aquatic life include chronic and acute values. Chronic Aquatic Life (CAL) standards prevent long-term, low level exposure to pollutants. Acute Aquatic Life (AAL) standards protect from short-term exposure to pollutants. Numeric standards also apply to other designated uses such as protecting irrigation and stock water quality for agriculture.

Narrative standards are developed when there is insufficient information to develop numeric standards and/or the natural variability makes it impractical to develop numeric standards. Narrative standards describe the allowable or desired condition.

For the Beaverhead TMDL Planning Area, numeric standards are applied as the primary targets for metals impairment determinations and subsequent TMDL development. These targets address allowable water column chemistry concentrations. Narrative standards are also used to develop supplemental targets to address metals concentrations in stream sediment. **Section 5.4** defines the water quality criteria for the Beaverhead TMDL Planning Area.

3.3 Nondegradation Provisions

Nondegradation is addressed via the Nondegradation Policy within Montana state statute (75-5-303, MCA) and via Montana's nondegradation rules (ARM 17.30.7). The Nondegradation Policy states that existing uses of state waters and the level of water quality necessary to protect those uses must be maintained and protected. Montana nondegradation rules apply to any new or increased point or nonpoint source resulting in a change of existing water quality occurring on or after April 29, 1993 (ARM 17.30.702).

4.0 Defining TMDLs and Their Components

A total maximum daily load (TMDL) is a tool for implementing water quality standards and is based on the relationship between pollutant sources and water quality conditions. More specifically, a TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive from all sources and still meet water quality standards. The ultimate goal of the TMDL is to identify an approach to achieve and maintain water quality standards.

Pollutant sources are generally defined as two categories: point sources and nonpoint sources. Point sources are often linked to community wastewater treatment or industrial facilities with discernible, confined and discrete conveyances, such as pipes or ditches from which pollutants are being, or may be, discharged to a waterbody. Some sources such as return flows from irrigated agriculture are not included in this definition. Pollutant loading sources that do not meet the definition of a point source are considered nonpoint sources. Nonpoint sources are associated with diffuse pollutant loading to a waterbody and are often linked to runoff from agricultural, urban, or forestry activities, as well as streambank erosion and groundwater seepage that can occur from these activities. Natural background loading and atmospheric deposition are both considered types of nonpoint sources.

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

A TMDL is expressed by the equation: $TMDL = \Sigma WLA + \Sigma LA + MOS$, where:

ΣWLA is the sum of the wasteload allocation(s) (point sources)
ΣLA is the sum of the load allocation(s) (nonpoint sources)
MOS = margin of safety

TMDL development must include a margin of safety (MOS), which can be explicitly incorporated into the above equation as shown. Alternatively, the MOS can be implicit in the TMDL, meaning that the explicit MOS in the above equation is equal to zero and can therefore be removed from the above equation. A TMDL must also ensure that the waterbody will be able to meet and maintain water quality standards for all applicable seasonal variations (e.g., changes in pollutant loading during the year, or seasonal water quality standards).

Development of each TMDL has four major components:

- Determining water quality targets
- Quantifying pollutant sources
- Establishing the total allowable pollutant load
- Allocating the total allowable pollutant load to their sources

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

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

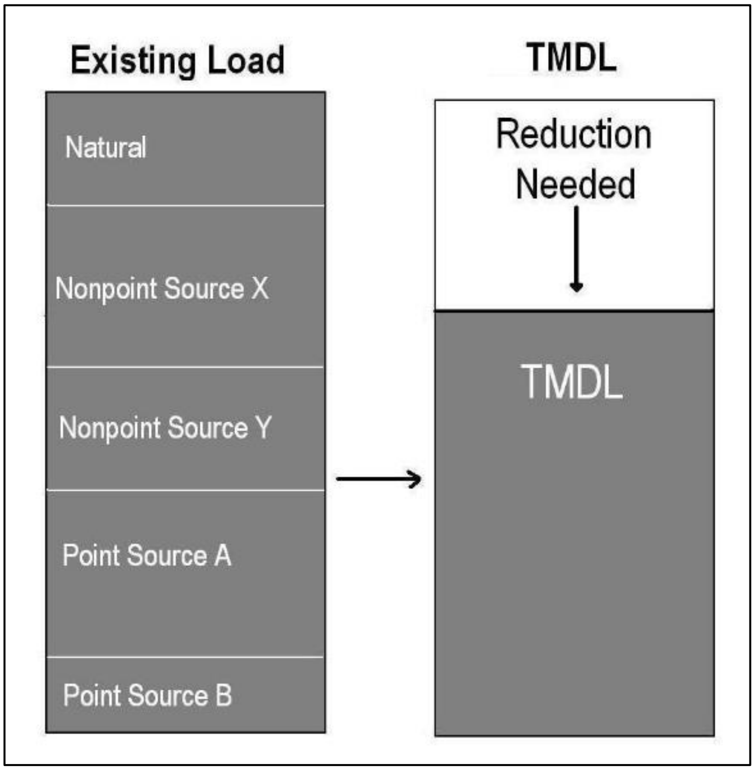

Figure 4-1: Schematic Example of TMDL Development

4.1 Developing Water Quality Targets

For each pollutant, TMDL water quality targets are applied to one or more parameters that link directly to the impaired beneficial use(s) and applicable water quality standard(s). For pollutants with established numeric water quality standards, the numeric value(s) are used as the TMDL targets. For pollutants with narrative water quality standard(s), the targets provide a numeric translation of how the narrative standard(s) applies to the waterbody. Comparing existing stream conditions to target values allows for a better understanding of the extent and severity of the problem.

4.2 Quantifying Pollutant Sources

The goal of TMDL source assessment is to identify all significant pollutant loading sources, including natural background loading, and quantify them so that the relative pollutant contributions can be determined. Because the effects of pollutants on water quality can vary throughout the year, assessing pollutant sources includes an evaluation of the seasonal variability of the pollutant loading. The source assessment helps to define the extent of the problem by linking the pollutant load to specific sources in the watershed.

Source assessments are conducted on a watershed scale and can vary in level of detail resulting in reasonably accurate estimates or gross allotments, depending on the data availability and the techniques used for predicting the loading (40 CFR 130.2(i)). Montana TMDL development often includes a combination of approaches, depending on the level of desired certainty for setting allocations and guiding implementation activities.

Nonpoint sources are quantified by source categories (e.g., eroding streambanks or unpaved roads) and/or by land uses (e.g., crop production or forestry). These source categories and land uses can be divided further by ownership, such as federal, state, or private. Alternatively, most, or all, nonpoint pollutant sources in a sub-watershed or source area can be combined for quantification and TMDL load allocation purposes.

Pollutant loading is typically quantified for each individual surface water point source permitted under the Montana Pollutant Discharge Elimination System (MPDES) program. Through MPDES permit requirements, point source dischargers provide discharge and other information that can be used for source assessment purposes. The allowable loading within each MPDES surface water permit condition must be consistent with the assumptions and requirements of the available WLA developed within the TMDL (40 CFR 122.44).

4.3 Establishing the Total Allowable Load

TMDL development requires a determination of the total allowable load over the appropriate time period necessary to comply with the applicable water quality standard(s). Per EPA requirements (40 CFR 130.2), "TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure." Where a stream is impaired by a pollutant for which numeric water quality criteria exist, the TMDL, or allowable load, is typically calculated as a function of streamflow and the numeric standard. This results in a mass per unit time TMDL expression such as pounds per day. This same approach can be applied when a numeric target is developed to interpret a narrative standard.

Although a "TMDL" is specifically defined as a "daily load," determining a daily load may not be consistent with the applicable water quality standard(s), or may not be practical from a water quality management perspective. Therefore, the TMDL will ultimately be defined as the total allowable loading during a time period that is appropriate for applying the water quality standard(s) and that is consistent with established approaches to properly characterize, quantify, and manage pollutant sources in a given watershed. For example, sediment TMDLs may be expressed as an allowable annual load.

Some narrative standards, such as those for sediment, often have a suite of targets. In many of these situations it is difficult to link the desired target values to highly variable, and often episodic, instream loading conditions. In such cases the TMDL is often expressed as a percent reduction in total loading based on source quantification results and an evaluation of load reduction potential (**Figure 4-1**). The degree by which existing conditions exceed desired target values can also be used to justify a percent reduction value for a TMDL.

Even if the TMDL is preferably expressed using a time period other than daily, an allowable daily loading rate will also be calculated to meet specific requirements of the federal Clean Water Act. Where this occurs, TMDL implementation and the development of allocations will still be based on the preferred time period, as noted above.

4.4 Determining Pollutant Allocations

Once the allowable load (the TMDL) is determined, that total must be divided among the contributing sources so that the sum of the allocations is equal to the TMDL, consistent with the above TMDL equation. For sediment, the allocations are often determined by quantifying feasible and achievable load reductions through application of a variety of best management practices (BMPs) and other reasonable conservation practices. Where a TMDL is variable based on streamflow, nonpoint source load allocations are often variable based on this same receiving streamflow. On the other hand, point source wasteload allocations are often based on conservative streamflow and discharge conditions and/or can be variable based on the point source discharge flow and a discharge concentration limit. Where the TMDL is a function of streamflow, the TMDL and allocations are calculated for example high and low flow stream conditions.

Figure 4-2 illustrates how the TMDL is allocated to different sources using WLAs for point sources and load allocations (LA) for natural and nonpoint sources. Although some flexibility in allocations is possible, the sum of all allocations must meet the TMDL for all segments of the waterbody. **Figure 4-2** shows multiple point and nonpoint source allocations. In Montana, nonpoint source allocations are sometimes grouped into one composite allocation. This composite load allocation approach is applied in cases where data is limited, there is significant source assessment uncertainty, and/or DEQ has determined that the best approach is to provide stakeholders with flexibility in addressing sources, allowing them to choose where to focus on improved land management practices and other remediation or restoration efforts.

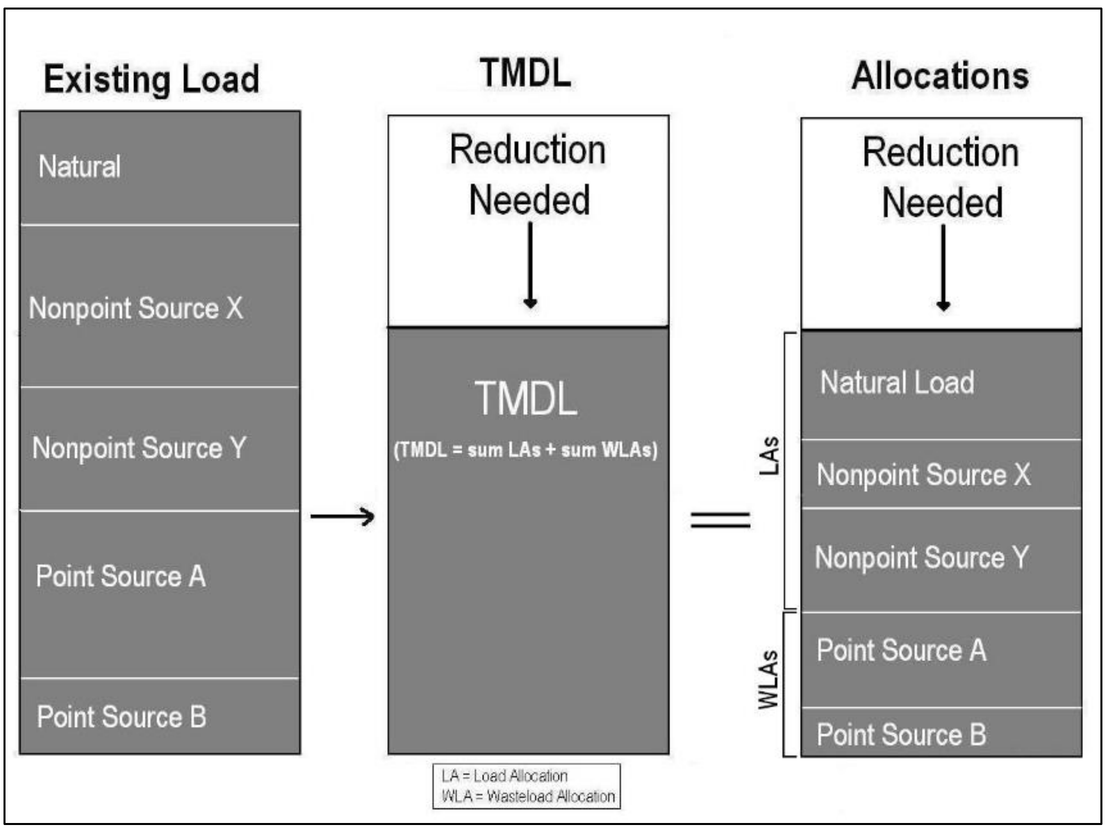

Figure 4.2: Schematic Diagram of a TMDL and its Allocations

4.5 Implementing TMDL Allocations

Montana law (Section 75-5-703, MCA of the Montana Water Quality Act) requires that wasteload allocations be incorporated into appropriate discharge permits, thereby providing a regulatory mechanism to achieve load reductions from point sources. Per federal regulation (40 CFR 122.44), the discharge permit effluent limits must be consistent with the assumptions and requirements of the available WLA developed within the TMDL.

Because of limited state and federal regulatory requirements, nonpoint source reductions linked to LAs are implemented primarily through voluntary measures, although there are some important nonpoint source regulatory requirements, such as Montana streamside management zone law and applicable septic system requirements.

This document contains several key components to assist stakeholders in implementing nonpoint source controls. **Section 6.0** provides a water quality improvement plan that discusses restoration. **Section 6.10** discusses potential funding sources that stakeholders can use to implement best management practices (BMPs) for nonpoint sources. Other site-specific pollutant sources are discussed throughout the document, and can be used to target implementation activities. DEQ's Nonpoint Source Program helps to coordinate water quality improvement projects for nonpoint sources of pollution throughout the state and provides resources to stakeholders to assist in nonpoint source BMPs. Montana's Nonpoint Source Management Plan (DEQ, 2017) further discusses nonpoint source implementation strategies at the state level.

DEQ uses an adaptive management approach to implement TMDLs to ensure that water quality standards are met over time (outlined in **Section 6.3**). This includes a monitoring strategy and an implementation review that is required by Montana statute (Section 75-5-703, MCA of the Montana Water Quality Act). TMDLs may be refined as new data become available, land uses change, or as new sources are identified.

PART 2
TMDL COMPONENTS

5.0 Metals TMDL Components

This portion of the document focuses on metals as an identified cause of water quality impairment in the Beaverhead TMDL Planning Area (TPA). It describes: (1) how excess metals impairs beneficial uses, (2) the affected stream segments, (3) the currently available data pertaining to metals impairments in the planning area, (4) the sources of metals based on recent studies, and (5) the metal TMDLs and their rationales.

5.1 Effects of Excess Metals on Beneficial Uses

Waterbodies with elevated metals concentrations can impair beneficial uses such as aquatic life, coldwater fisheries, and drinking water. Within aquatic ecosystems, elevated concentrations of metals can have a toxic, carcinogenic, or bio-concentrating effect on biota. Likewise, humans and wildlife can suffer acute and chronic effects from consuming water or fish with elevated metals concentrations. Because elevated metals concentrations can be toxic to plants and animals, high metals concentrations in irrigation or stock water may affect agricultural uses. Although arsenic and selenium are metalloids and nonmetals, they are treated as metals for TMDL development due to the similarity in sources, environmental effects and restoration strategies.

5.2 Stream Segments of Concern

A total of nine waterbody segments in the Beaverhead TPA are listed as impaired due to metals-related causes on the 2018 Montana 303(d) List (**Table 5-1**), all of which will be addressed in this document (DEQ, 2018).

Both the upper and lower portions of Rattlesnake Creek units (MT41B002_090 and MT41B002_091) were listed for cadmium on the 2018 303(d) List after showing elevated levels of cadmium during 2016 and 2017 sampling. Montana's water quality standards for cadmium were updated on 4/23/2018 to reflect changes in federal standards and were subsequently approved by EPA. Therefore, they are applicable under the Clean Water Act for usage in TMDLs. Based on these updates, neither segment now exceeds the cadmium standard. Cadmium will be delisted in both upper and lower Rattlesnake Creek segments in 2020. DEQ will not prepare TMDLs for cadmium in either segment of Rattlesnake Creek.

Of the nine stream segments addressed in this TMDL document, eight are classified by DEQ as B-1. Waters classified as B-1 are to be maintained suitable for drinking, culinary, and food processing purposes, after conventional treatment; bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply (ARM 17.30.623(1)).

The ninth segment, Upper Rattlesnake Creek, from the headwaters to the Dillon Public Water Supply off-channel well, is classified by DEQ as A-1. Waters classified as A-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment for removal of naturally present impurities. They must also be maintained suitable for bathing, swimming, and recreation; growth and propagation or salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply (ARM 17.30.622(1 and 2)).

Metals-related 303(d) listings in the Beaverhead TPA include arsenic, aluminum, cadmium, copper, iron, lead, and zinc (**Table 5-1**).

Table 5-1. Waterbody Segments with Metals Listings on the 2018 303(d) List

Waterbody (Assessment Unit)	Assessment Unit ID	Impairment Cause
Grasshopper Creek, headwaters to mouth (Beaverhead River)	MT41B002_010	Lead
Rattlesnake Creek, from the Dillon PWS off-channel well T7S R10W S11 to the mouth (Van Camp Slough)	MT41B002_090	Copper, Lead, Cadmium*
Rattlesnake Creek, headwaters to Dillon PWS off-channel well, T7S R10W S11	MT41B002_091	Lead, Cadmium*
Spring Creek, headwaters to mouth (Beaverhead River)	MT41B002_080	Iron
Steel Creek, headwaters to mouth (Driscoll Creek), T6S R12W S18	MT41B002_160	Arsenic
Stone Creek, Left and Middle Fork to un-named tributary, T6S R7W S34	MT41B002_132	Iron
Stone Creek, Un-named tributary at T6S R7W S34 to Staudaher Bishop Ditch	MT41B002_131	Aluminum, Copper, Iron
Wellman Creek, headwaters to mouth (Grasshopper Creek)	MT41B002_150	Aluminum, Cadmium, Copper, Lead, Zinc
West Fork Blacktail Deer Creek, headwaters to mouth (Blacktail Deer Creek)	MT41B002_060	Arsenic

*Impairment listing for cadmium will be removed in 2020 Water Quality Integrated Report

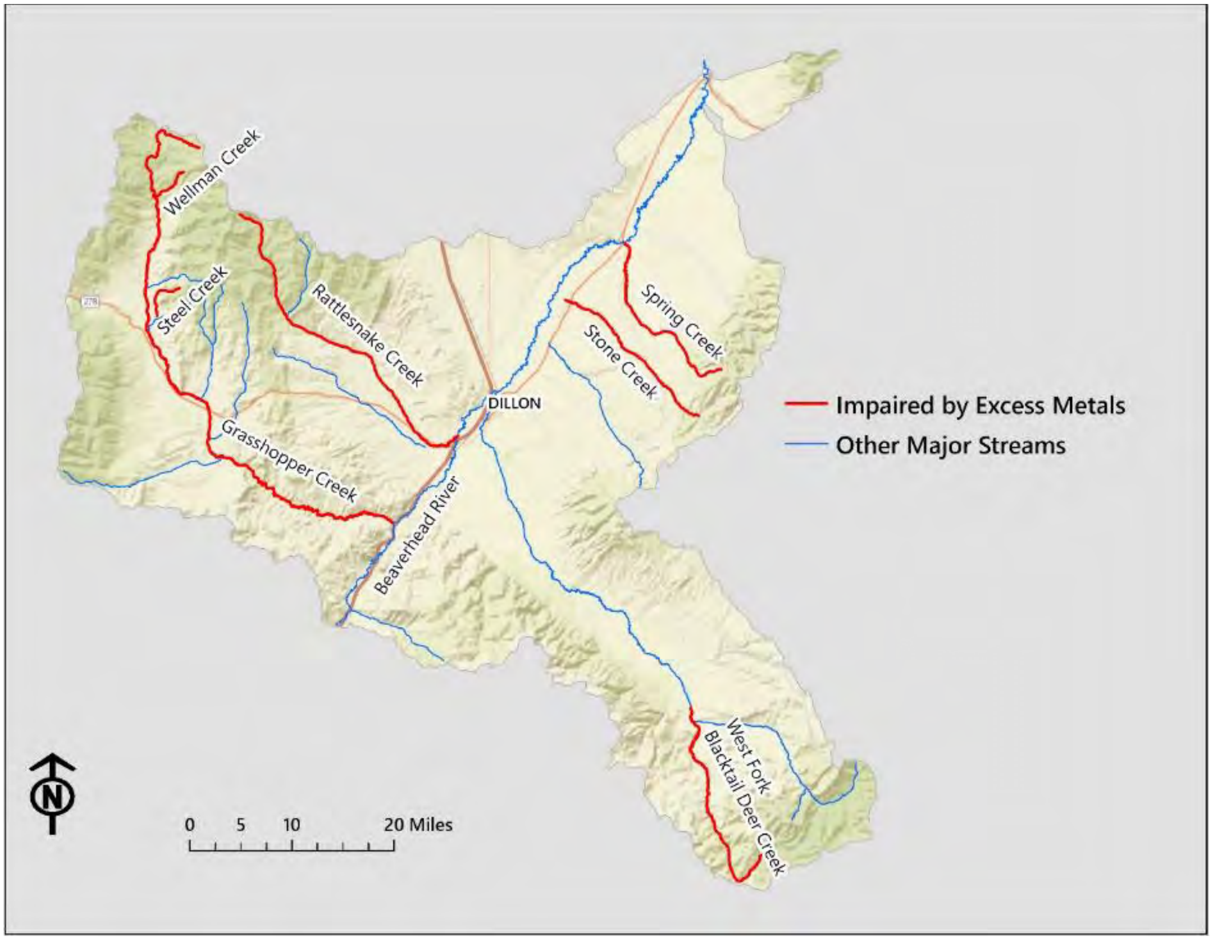

Figure 5-1. Waterbodies with a Metals Listing in the Beaverhead Watershed on the 2018 303(d) List

5.3 Water Quality Data and Information Sources

Water quality data used in TMDL development includes DEQ's assessment data collected since 2009 as well as other data available in the national Water Quality Portal (https://www.waterqualitydata.us/). **Table 5-2** provides a summary of data sources used in TMDL development. Summaries of water quality portal data are provided in **Sections 5.4.3.1** through **5.4.3.9** for each of the impaired waterbody segments. Water quality data used in developing the TMDLs can also be found in **Appendix B**.

Data collected prior to 2009 were used to aid in the initial coarse level source assessment and to help determine sampling locations for additional data collection, but are not used within this document in the existing data review due to potential data quality and reliability issues (e.g., reporting limits higher than water quality standards and uncertainty regarding collection, analysis and recording methods) and because conditions may have changed substantially since data collection. The exception was Steel Creek, in which a high arsenic value was recorded in 2004 and a TMDL was developed out of concern for public safety.

GIS data used in development of this document included the DEQ High Priority Abandoned Hardrock Mine sites, the DEQ Abandoned Hardrock Mines database, the DEQ Active Hardrock Mine sites, the

Montana Bureau of Mines and Geology (MBMG) Abandoned and Inactive Mines database, and Montana Pollutant Discharge Elimination System (MPDES) permitted point sources.

Table 5-2. Water Quality Data Evaluated for TMDL Development

Data Source and Data Year	Type of Data
Montana DEQ 2014-2017[1]	Water quality and metals sediment sampling for impairment determination and TMDL Development
National Water Quality Portal, (Beaverhead Watershed Committee, 2009)	Miscellaneous metals sampling data

[1]An exception was Steel Creek, in which data from an additional 2004 sampling event was included out of concern for human health

5.4 Water Quality Data and Comparison to Targets

This section describes the available water quality data and how it was compiled and evaluated for attainment of water quality targets. It presents the evaluation framework, metals water quality targets used in the evaluation, and metals targets attainment evaluations for each impaired waterbody.

5.4.1 Metals TMDL Evaluation Framework

Evaluating attainment of water quality standards for metals-related impairments, and subsequent determination of whether a TMDL is necessary for each waterbody segment involves three steps:

1. Evaluation of metals sources:

    Sources of metals in a watershed are both natural and anthropogenic. TMDLs are developed for waterbodies that are not meeting water standards, at least in part, due to human caused sources. Consequently, metals-impaired streams must demonstrate existence of significant anthropogenic metals sources to be appropriate candidates for TMDL development.

2. Development of numeric water quality targets that represent water quality conditions that are unimpaired for the pollutant of concern:

    A required component of TMDL plans is the establishment of numeric water quality criteria or *targets* that represent a condition that meets Montana's ambient water quality standards. Numeric targets are measurable water quality indicators that, either by themselves or in combination with others, reflect attainment of water quality criteria or represent a water quality condition that is unimpaired for the pollutant of concern. Metals water quality targets are presented in **Section 5.4.2**.

3. Comparison of existing data with water quality targets to evaluate water quality target attainment and, consequently, determine whether a TMDL is necessary:

    Attainment of water quality targets is evaluated by comparing existing water quality data and information to establish metals water quality targets. Where exceedances of water quality targets are documented, and there are anthropogenic sources, a TMDL is developed. If recent data indicate no impairment, the data is incorporated into 303(d) list files and the cause is removed from the list. If there are no recent target exceedances, but there is insufficient data to fully evaluate all seasonal flow conditions, then TMDL development may not be pursued and further monitoring is recommended.

5.4.2 Metals Water Quality Targets

Water quality targets for metals-related impairments in the Beaverhead TMDL Planning Area (TPA) consist of metals water quality targets (**Table 5-3**) and metals sediment quality targets (**Table 5-4**). Metals water quality targets are based on numeric acute and chronic metals water quality criteria for the protection of aquatic life and human health as defined in Circular DEQ-7 (Montana Department of Environmental Quality, 2019). The metals sediment quality targets are based on narrative criteria for toxins in sediment. Throughout this document, the terms "standard", "criteria" and "target" are used somewhat interchangeably.

5.4.2.1 Metals Water Quality Criteria

Metals numeric water quality criteria include values for protecting human health and for protecting aquatic life, and apply as water quality standards for the streams addressed within this Section due to their A-1 and B-1 classifications (**Section 3.0**). Aquatic life criteria include values for both acute and chronic effects. For any given pollutant, the most stringent of these criteria is adopted as the water quality target in order to protect all beneficial uses.

Hardness is a natural component of water that can influence the toxicity of metals. The higher the concentration of calcium and magnesium and other hardness-creating elements in rock and soils, the harder the water. Lime from agricultural fields can also increase hardness. Hardness-creating elements are non-toxic but normally absorb into living organisms more easily than toxic metals. If the water has high hardness, the amount of toxic metals that are absorbed into animals is generally less. This explains why the toxicity of most metals increases with decreasing hardness.

Water quality criteria (Acute Aquatic Life, Chronic Aquatic Life, Human Health) for each parameter of concern at water hardness values of 25 milligrams per liter (mg/L) and 100 mg/L respectively are shown in **Table 5-3** (with the exception of iron, aluminum, and arsenic which do not have a hardness-dependent standard). These criteria translate into the applicable water quality targets and are expressed in micrograms per liter (µg/L), which is equivalent to parts per billion.

Acute and chronic toxicity aquatic life criteria are intended to protect aquatic life uses, while the human health criteria is intended to protect drinking water uses. Aluminum criteria is based on estimates of the dissolved concentration, whereas the other criteria are based on the total recoverable (TR) concentration.

The evaluation process summarized below is derived from DEQ's Monitoring and Assessment program guidance for metals assessment methods.

- A waterbody is considered impaired if a single sample exceeds the human health target.
- If more than 10% of the samples exceed the AAL or CAL target, then the waterbody is considered impaired for that pollutant.
- If both the AAL and CAL target exceedance rates are equal to or less than 10%, for a given metal, then it is not considered a cause of aquatic life impairment to the waterbody. A minimum 8 samples are required, and samples must represent both high and low flow conditions.
- There are two exceptions to the 10% aquatic life exceedance rate rule: a) if a single sample exceeds the AAL target by more than a factor of two, the waterbody is considered impaired regardless of the remaining data set; and b) if the exceedance rate is greater than 10% but no anthropogenic metals sources are identified, management is consulted for a case-by-case review.

Table 5-3. Metals Numeric Water Quality Targets Applicable to the Beaverhead TMDL Planning Area

Metal of Concern	Aquatic Life Criteria (µg/L) at 25 mg/L Hardness		Aquatic Life Criteria (µg/L) at 100 mg/L Hardness		Human Health Criteria
	Acute	Chronic	Acute	Chronic	
Aluminum, Dissolved, pH 6.5 to 9.0 only	750	87	750	87	---
Arsenic, TR	340	150	340	150	10
Cadmium, TR	0.49	0.25	1.90	0.79	5
Copper, TR	3.79	2.85	13.90	9.32	1,300
Iron, TR	---	1,000	---	1,000	---
Lead, TR	13.98	0.545	81.65	3.18	15
Zinc, TR	37.0	37.0	119.8	119.8	7400

*TR = total recoverable

5.4.2.2 Metals Sediment Quality Criteria

Stream sediment data may also be indicative of impairment caused by elevated metals and are used as a supplementary indicator of impairment. In addition to directly impairing aquatic life that interacts with the elevated metals in the sediment, the elevated sediment values can also be an indicator of elevated concentrations of metals that become suspended during runoff conditions. This can be a particularly important supplemental indicator when high flow data is lacking. The state of Montana does not currently have numeric water quality criteria for metals in stream sediment, however general water quality prohibitions state that *"state surface waters must be free from substances…that will…create concentrations or combinations of materials that are toxic or harmful to aquatic life" (ARM 17.30.637(1)(d)).*

The National Oceanic and Atmospheric Administration (NOAA) developed Screening Quick Reference Tables for stream sediment quality that provides concentration guidelines for metals in freshwater sediment (see **Table 5-4**). Screening criteria concentrations come from a variety of studies and investigations, and are expressed in Probable Effects Levels (PEL). PELs represent the sediment concentration above which toxic effects to aquatic life frequently occur, and are calculated as the geometric mean of the 50th percentile concentration of the toxic effects data set and the 85th percentile of the no-effect data set (Buchman, 1999).

PELs act as a screening tool and secondary target that may assist in identification of elevated metals in stream. Where in-stream water quality data exceed water quality targets, sediment quality data provide supporting information, but are not necessary to verify impairment. Where water quality data are limited or does not show exceedances of water quality targets, sediment quality data may demonstrate impairment due to high levels of metals toxicity in stream sediments. **Table 5-4** contains the PEL values (mg/kg) for parameters of concern in the Beaverhead TMDL Planning Area. Note that there are no published PEL values for iron and aluminum.

Table 5-4. Screening Level Criteria for Sediment Metals Concentrations

Metal of Concern	Probable Effects Level (mg/kg)
Arsenic	17.0
Copper	197
Iron	--

Table 5-4. Screening Level Criteria for Sediment Metals Concentrations

Metal of Concern	Probable Effects Level (mg/kg)
Lead	91.3
Cadmium	4.9
Aluminum	--

5.4.3 Existing Conditions and Comparison to Targets

For each waterbody segment listed on the 2018 303(d) List for metals (**Table 5-1**), recent water quality data are evaluated relative to the water quality targets to make a TMDL development determination. In those cases where a value was reported as less than the detection limit, half of the detection limit was used for statistical purposes. This approach did not affect exceedance rates or impairment determinations since detection limits are below target values.

In early 2017, DEQ completed assessments for cadmium impairments in Rattlesnake Creek and Wellman Creek. Following completion of the assessments, Montana water quality standards for cadmium were revised in 2018. Neither segment of Rattlesnake Creek exceeds the revised standard, but Wellman Creek does exceed the revised standard. DEQ will not prepare cadmium TMDLs for the upper or lower segments of Rattlesnake Creek at this time, but will prepare a cadmium TMDL for Wellman Creek.

Water quality monitoring data collected by DEQ and other entities between 2009 and 2017 indicate that arsenic concentrations in West Fork Blacktail Deer Creek are above the Human Health criterion of 10 µg/L. DEQ has reviewed available information on potential sources of the elevated arsenic level. While there is no obvious anthropogenic source, there is past evidence of uranium/phosphate mining in the subwatershed, and this type of mining is known to contribute to high arsenic levels. Further, not all abandoned mines are accounted for within the DEQ and MBMG databases. DEQ will develop a TMDL for West Fork Blacktail Deer Creek with the assumption that it is impaired due to anthropogenic sources.

Between 2009 and 2017, DEQ attempted to collect water quality monitoring data to evaluate arsenic levels in Steel Creek. Unfortunately, due to low flows, only one sample from Steel Creek was ever obtained and analyzed (in 2009). While the sample did not show an exceedance of the human health criteria for arsenic, a historic sample collected in 2004 showed an exceedance. Out of caution for public safety, DEQ will prepare a TMDL for arsenic for Steel Creek, despite the relatively small amount of data available and age of the data (2004 and 2009 only) for this creek.

5.4.3.1 Grasshopper Creek (MT41B002_010)

Available Water Quality Data

Metals water quality data were used to evaluate attainment of water quality targets in Grasshopper Creek. Water quality data used for this evaluation were comprised of 2014 synoptic high and low flow sampling data collected by Montana DEQ for stream assessment and TMDL development, and data collected by the Beaverhead Watershed Committee in 2009 (**Tables 5-5 & 5-15**).

Table 5-5. Grasshopper Creek Metals Water Quality Data Summary

Measurement	Lead (TR)
# Samples	10
Minimum Concentration	<0.3 (µg/L)
Maximum Concentration	4.2 (µg/L)

Table 5-5. Grasshopper Creek Metals Water Quality Data Summary

Measurement	Lead (TR)
Median Concentration	0.4 (µg/L)
# Acute Aquatic Life Exceedances	0
Acute Aquatic Life Exceedance Rate	0.00%
# Chronic Aquatic Life Exceedances	2
Chronic Aquatic Life Exceedance Rate	20.00%
# Human Health Exceedances	0

TR = total recoverable

5.4.3.2 Upper Rattlesnake Creek (MT41B002_091)

Available Water Quality Data
Metals water quality data were used to evaluate attainment of water quality targets in Upper Rattlesnake Creek. Water quality data used for this evaluation were comprised of 2014 and 2015 synoptic high and low flow sampling data collected by Montana DEQ for waterbody assessment and TMDL development, data and collected by the Beaverhead Watershed Committee in 2009 (**Tables 5-6 & 5-16**).

In addition to water quality sampling, sediment samples were collected at sites BVD-RSC1 (a site meeting water quality standards) and BVD-RSC2 (a site exceeding water quality standards). The concentration measured at BCD-RSC1 was 20 µg /g, and the concentration measured at BVD-RSC2 was 567 µg/g. The sample at the site not exceeding the water quality standard also did not exceed the secondary target for lead in sediment, while the sample at the site exceeding the water quality standard did exceed for the secondary target for lead in sediment of 197 µg/g.

Table 5-6. Upper Rattlesnake Creek Metals Water Quality Data Summary

Measurement	Lead (TR)
# Samples	7
Minimum Concentration	0.1 (µg/L)
Maximum Concentration	19.8 (µg/L)
Median Concentration	2.8 (µg/L)
# Acute Exceedances	0
Acute Exceedance Rate	0.00%
# Chronic Exceedances	4
Chronic Exceedance Rate	57.14%
# Human Health Exceedances	1

TR = total recoverable

5.4.3.3 Lower Rattlesnake Creek (MT41B002_090)

Available Water Quality Data
Metals water quality were used to evaluate attainment of water quality targets in Lower Rattlesnake Creek. Water quality data used for this evaluation was comprised of recent 2014-2015 synoptic high and low flow sampling data collected by Montana DEQ for TMDL development, and data collected by the Beaverhead Watershed Committee in 2009 (**Tables 5-7 & 5-17**).

In addition to water quality samples, a sediment sample was taken at site BVD-RSC-3. The copper measured was 45 mg/kg, and the lead measured was 253 mg/kg. This sediment sample met the secondary target for copper in sediment (91.3 mg/kg), but exceeded the secondary target for lead in sediment (197 mg/kg).

Table 5-7. Lower Rattlesnake Creek Metals Water Quality Data Summary

Measurement	Copper (TR)	Lead (TR)
# Samples	9	9
Minimum Concentration	<1 (µg/L)	0.4 (µg/L)
Maximum Concentration	52 (µg/L)	14.8 (µg/L)
Median Concentration	2.9 (µg/L)	3.7 (µg/L)
# Acute Exceedances	1	0
Acute Exceedance Rate	11.11%	0%
# of Samples that are ≥ 2 X the Acute Standard	1	0
# Chronic Exceedances	1	6
Chronic Exceedance Rate	11.11%	66.66%
# Human Health Exceedances	0	0

TR = total recoverable

5.4.3.4 Spring Creek (MT41B002_080)

Available Water Quality Data
Metals water quality data were used to evaluate attainment of water quality targets in Spring Creek. Water quality data used for this evaluation was comprised of synoptic high and low flow sampling data collected by Montana DEQ for waterbody assessment and TMDL development from 2014-2015. (**Tables 5-8 & 5-18**)

Table 5-8. Spring Creek Metals Water Quality Data Summary

Measurement	Iron (TR)
# Samples	8
Minimum Concentration	30 (µg/L)
Maximum Concentration	1460 (µg/L)
Median Concentration	175 (µg/L)
# Acute Exceedances	0
Acute Exceedance Rate	0%
# of Samples that are ≥ 2 X the Acute Standard	0
# Chronic Exceedances	1
Chronic Exceedance Rate	12.5%
# Human Health Exceedances	NA

TR = total recoverable

5.4.3.5 Steel Creek (MT41B002_160)

Available Water Quality Data
Metals water quality data collected by DEQ in 2004 and 2009 were used to evaluate attainment of water quality targets in Streel Creek (**Tables 5-9 & 5-19**). Although only one sample exceeded the human health standard (in July 2004), this sample was twice the human health standard for arsenic (10 µg/L).

Only one sample has to exceed human health standards to be considered impaired. Due to DEQ's concern for human health, a TMDL will be written for Steel Creek.

Table 5-9. Steel Creek Metals Water Quality Data Summary

Measurement	Arsenic (TR)
# Samples	2
Minimum Concentration	1.6 (µg/L)
Maximum Concentration	22 (µg/L)
Median Concentration	11.8 (µg/L)
# Acute Exceedances	0
Acute Exceedance Rate	0%
# of Samples that are ≥ 2 X the Acute Standard	0%
# Chronic Exceedances	0
Chronic Exceedance Rate	0%
# Human Health Exceedances	1

TR = total recoverable

5.4.3.6 Upper Stone Creek(MT41B002_132)

Available Water Quality Data

Metals water quality data were used to evaluate attainment of water quality targets in Upper Stone Creek. Water quality data used for this evaluation was comprised of recent 2014-2015 synoptic high and low flow sampling data collected by Montana DEQ for waterbody assessment and TMDL development (**Tables 5-10 & 5-21**)

Table 5-10. Upper Stone Creek Metals Water Quality Data Summary

Measurement	Iron (TR)
# Samples	11
Minimum Concentration	220 (µg/L)
Maximum Concentration	4080 (µg/L)
Median Concentration	780 (µg/L)
# Acute Exceedances	0
Acute Exceedance Rate	0%
# Chronic Exceedances	4
Chronic Exceedance Rate	36.4%
# Human Health Exceedances	NA

TR = total recoverable

5.4.3.7 Lower Stone Creek (MT41B002_131)

Available Water Quality Data

Metals water quality data were used to evaluate attainment of water quality targets in Lower Stone Creek. Water quality data used for this evaluation was comprised of recent 2014-2017 synoptic high and low flow sampling data collected by Montana DEQ for waterbody assessment and TMDL development (**Tables 5-11 & 5-22**).

Table 5-11. Lower Stone Creek Metals Water Quality Data Summary

Measurement	Aluminum(D)	Copper (TR)	Iron(TR)
# Samples	8	8	8
Minimum Concentration	<4 (µg/L)	<1 (µg/L)	20 (µg/L)
Maximum Concentration	183 (µg/L)	20 (µg/L)	9960 (µg/L)
Median Concentration	15 (µg/L)	1 (µg/L)	125 (µg/L)
# Acute Exceedances	0	0	0
Acute Exceedance Rate	0%	0.00%	0.00%
# Chronic Exceedances	1	1	1
Chronic Exceedance Rate	12.5%	12.5%	12.5%
# Human Health Exceedances	NA	0	NA

TR = total recoverable; D = dissolved

5.4.3.8 Wellman Creek (MT41B002_150)

Available Water Quality Data
Metals water quality data were used to evaluate attainment of water quality targets in Wellman Creek. Water quality data used for this evaluation was comprised of recent 2014-2015 synoptic high and low flow sampling data collected by Montana DEQ for waterbody assessment and TMDL development (**Tables 5-12, 5-23 and 5-24**).

Table 5-12. Wellman Creek Metals Water Quality Data Summary

Measurement	Aluminum (D)	Cadmium (TR)	Copper (TR)	Lead (TR)	Zinc (TR)
# Samples	8	8	8	8	8
Minimum Concentration	< 9 (µg/L)	0.12 (µg/L)	3 (µg/L)	< 0.3 (µg/L)	41 (µg/L)
Maximum Concentration	166 (µg/L)	0.58 (µg/L)	48 (µg/L)	0.9 (µg/L)	219 (µg/L)
Median Concentration	34.5 (µg/L)	0.25 (µg/L)	13 (µg/L)	0.6 (µg/L)	106 (µg/L)
# Acute Exceedances	0	0	5	0	4
Acute Exceedance Rate	0.00%	0.00%	62.5%	0%	12.5
# Chronic Exceedances	1	1	6	2	4
Chronic Exceedance Rate	12.50%	12.50%	75.0%	25.00%	50%
# Human Health Exceedances	NA	0	0	0	0

TR = total recoverable; D=dissolved

5.4.3.9 West Fork Blacktail Deer Creek (MT41B002_060)

Available Water Quality Data
Metals water quality data were used to evaluate attainment of water quality targets in West Fork Blacktail Deer Creek. Water quality data used for this evaluation were comprised of data collected in 2009 and 2014 by DEQ and the Beaverhead Watershed Committee (**Tables 5-13 & 5-25**).

The data indicate that arsenic concentrations in portions of West Fork Blacktail Deer Creek are above the Human Health criterion of 10 µg/L. Only one sample has to exceed Human Health criteria to be considered impaired for arsenic according to DEQ's decision matrix in **Section 5.4.1**.

Table 5-13. West Fork Blacktail Deer Creek Metals Water Quality Data Summary

Measurement	Arsenic (TR)
# Samples	5
Minimum Concentration	1.3 (µg/L)
Maximum Concentration	16 (µg/L)
Median Concentration	12 (µg/L)
# Acute Aquatic Life Exceedances	0
Acute Aquatic Life Exceedance Rate	0.00%
# Chronic Aquatic Life Exceedances	0
Chronic Aquatic Life Exceedance Rate	0.00%
# Human Health Exceedances	3

TR = total recoverable

5.4.4 Metals Target Attainment Evaluation and TMDL Development Summary

Nine individual stream segments are listed as impaired for metals-related impairments in the Beaverhead TMDL Planning Area (**Table 5-1**); TMDLs were prepared for all nine of these segments, representing 16 waterbody/pollutant combinations.

5.5 Source Assessment

This section provides the approach and results of the source assessment, which characterizes the type and extent of sources contributing to metals loading to impaired streams. This section also establishes the basis for TMDL development and allocations to specific source categories in each of the subwatersheds identified in **Table 5-1**. Source characterization and assessment to determine the major sources in each of the metal impaired waterbodies was accomplished by using monitoring data, aerial photos, Geographic Information System (GIS) analysis, field reconnaissance and literature reviews. Assessment of existing metals sources is needed to understand load allocations (LAs), and potential load reductions for different source categories. Source characterization links metals sources to loading and supports the formulation of the allocation portion of the TMDL.

The source assessment examined water quality data under various hydrologic conditions in order to characterize water chemistry metal conditions. Concentrations of metals typically increase during high flows as metals enter through tailings, adits (mine entrances), and streamed sediments. Total suspended solids often increase in conjunction with the increase in metals concentrations, when metals are resuspended from sediments or washed into the stream from overland flow. Except for aluminum (which has standard based on the dissolved fraction), these metals bound to sediments are considered part of the overall metals load. In some cases, high flows may decrease concentrations as metal inputs are diluted with rainwater or groundwater. However, metals can also enter the stream from groundwater. While groundwater discharges of metals into streams tend to occur year-round, they are more apparent during low flow when surface water inputs are minimal.

Decreases in stream flow due to seasonal variation or water withdrawals can also have complex effects on metals concentrations in streams. If water is removed from a stream with a high metals concentration and tributary or groundwater inputs downstream have a low metals concentration, this will decrease the overall concentration of metals. However, if a metals source enters a stream that is already experiencing low flow, this will increase the overall concentration of metals.

One of the biggest impacts that flow and seasonal impacts can have is indirect through changes in hardness. As hardness increases, the toxicity (or harmfulness to humans and aquatic life) of most metals decreases. Streams tend to naturally increase in hardness from upstream to downstream, as calcium and other elements that increase hardness are contributed from soils and agricultural practices.

Historical mining in the Beaverhead TPA has been identified as the major contributing source of metals to the impaired waters. There are 463 abandoned mines within the Beaverhead watershed according to the MBMG and DEQ abandoned mines databases. Because the DEQ mining database and MBMG essentially contained the same list of mines, often with slightly differing coordinates, only the mines in the MBMG database are displayed on the source assessment maps. A total of 238 of these abandoned mines occur in the subwatersheds of the metals-impaired segments, which are evaluated in this document. Abandoned mines largely include lode mines and placer mines. Lode mines refer to when the target metal is embedded within the rock and must be extracted. Placer mines refer to deposits that have naturally separated from the rock and can essentially be sifted out. A mill site is often located adjacent to lode or placer sites and may be used to process the mining material.

This source assessment identifies the known location of abandoned mines as well as priority abandoned mines, active hardrock mines, opencut mines, and holders of Montana Pollutant Discharge Elimination System (MPDES) permits that release metals to surface waters (**Table 5-14**). The locations of small miner exclusion and exploration exploratory activities are also identified. Abandoned mines (including priority) are the largest contributor to metals in the Beaverhead Metals TPA. Hardrock, opencut, small mining, and exploration activities that discharge to surface waters are required to have a MPDES permit. However, in most cases opencut, small miner exclusion (SME), and exploration activities are considered to contribute zero or negligible amounts of metals to surface waters as required by applicable state laws while MPDES permits often accompany active hardrock mining permits. **Section 5-5** describes how abandoned mines, other human-caused sources, and MPDES permitted facilities are accounted for in developing the TMDLS. More detail on active hardrock and opencut mines in each subwatershed provided in **Section 5.5.1** to **Section 5.5.9**. A brief description of these mining activities is below:

<u>Abandoned mines</u>
Abandoned mines are inactive mines that ceased operation prior to the passage of modern mining regulations. Abandoned mine sites may range from small ground disturbances to areas with adits (old mining entrances which can be dry or discharging) and/or tailings and waste rock piles of different sizes. Waste rock dumps and tailings occur mainly in upland areas; however, they can also occur in the floodplain, streamside, or in stream channels. Depending on the parent geology, site stability, level of remediation and or re-vegetation, the capacity of these sites to leach metals and/or generate acid mine drainage and the associated effects of mining wastes on stream water quality can vary greatly.

<u>Priority mines</u>
Four priority mines are found in the Beaverhead Metals TPA study area. Priority mines are abandoned mines that have been identified specifically by Montana DEQ to have potential threats to the environment or public safety.

<u>Active hardrock mines</u>
Four active hardrock mines are found in the Beaverhead Metals TPA study area. Other permits may accompany a hardrock mining operator permit, including MPDES permits. The associated MPDES permits are often referred to in order to understand impacts to surface waters. Hardrock mining operator permits are obtained for mines that disturb more than 5 acres of surface and include quarries,

roads, and processing areas (MCA 82-4-301). The exception is mines that excavate gravel, soil, clay scoria, bentonite, or peat, which require an opencut mining permit instead. Hardrock mining permits require environmental baseline information, an operating plan, and a reclamation plan. All activity must be bonded, and an environmental review must be conducted. Obtaining a permit is a lengthy process that generally takes 9 to 12 months but can take years.

Opencut mines

Two opencut mines are found in the Beaverhead Metals TPA study area. Opencut mining permits are specifically for gravel, soil, clay scoria, bentonite, or peat, while hardrock mining permits cover all other materials. Opencut mines are those that strip or excavate more than 10,000 cubic yards of soil, overburden or mine material from a site (MCA 82-4-403(7)). Open cut mining permit holders must ensure that surface water and groundwater will be given appropriate protection, consistent with state law, from deterioration of water quality and quantity that may arise as a result of the opencut operation.

MPDES discharges

Any entity that wishes to discharge water to a surface water of the state must first obtain a Montana Pollutant Discharge Elimination System (MPDES) permit. MPDES permits regulate wastewater by limiting the quantities of pollutants to be discharged in order to protect public health and aquatic life (MCA 75-5-101). Three MPDES permittees are located within the metals-impaired subwatersheds. All three permits are present within the Upper Stone Creek subwatershed of the Beaverhead Metals TPA area. These include one general stormwater permit and two individual permits. A general permit is a permit for discharges associated with common activities, such as construction or industrial activity. Authorizations for general permits are issued if a facility or activity falls within the guidelines of the existing permit including limited discharges during rare events. Individual MPDES permits regulate discharges from point sources that do not fall under the guidelines for a general permit. The individual permitting process is more rigorous, as individual permits address the specific conditions of the facility or activity needing authorization. Individual MPDES permittees are required to report on the concentration and amount of discharge leaving their facilities.

Small Miner Exclusions and Exploration Activities

Nine Small Miner Exclusion and three Exploration permits are found in the Beaverhead Metals TPA study area. Small Miner Exclusions are not permits but notarized affidavits to miners, which attest they will disturb less than 5 acres of surface (MCA 82-4-301). An exploration license is intended for exploratory operations to assess the feasibility of mining and can include surface disturbance as well as trenches, tunnels, and adits (MCA 82-4-332).

Table 5-14 MPDES and Mining Permits in the Subwatersheds with Metals TMDLs

Type	Permit /ID Number	Name	Watershed
Individual MPDES	MT0029891	Barretts Minerals Inc	Upper Stone Creek
Individual MPDES	MT0027821	Imerys Talc Mine	Upper Stone Creek
General MPDES	MTR000510	Barretts Treasure Mine	Upper Stone Creek
Priority	01-092	Garrett Hill	Grasshopper
Priority	01-031	Goldleaf/Priscilla	Grasshopper
Priority	01-006	Apex Millsite	Grasshopper
Priority	01-00	Ermont Mines/Millsite	Lower Rattlesnake

Table 5-14 MPDES and Mining Permits in the Subwatersheds with Metals TMDLs

Type	Permit /ID Number	Name	Watershed
Opencut	61	Badger Pass Pit (BLM)	Lower Rattlesnake
Opencut	1907	Wetherbee (Madison Co)	Spring Creek
Hardrock	154	Bon Accord Gold/Silver	Grasshopper
Hardrock	13	Regal Mine-Barretts	Upper Stone Creek
Hardrock	75	Beaverhead Mine-Imerys	Upper Stone Creek
Hardrock	78	Treasure Mine-Barretts	Upper Stone Creek
Exploration	733	ABM	Lower Rattlesnake
Exploration	714	Groundhog Mining	Upper Rattlesnake
Exploration	506	EE Nelson	Upper Rattlesnake
Small Miner Exclusion	18-095	Bruce Cox	Grasshopper
Small Miner Exclusion	18-145b	GMEC	Grasshopper
Small Miner Exclusion	18-136	Trelis	Grasshopper
Small Miner Exclusion	18-143	Cy Brass	Grasshopper
Small Miner Exclusion	18-132	Tabor	Grasshopper
Small Miner Exclusion	18-139	Shipman	Lower Rattlesnake
Small Miner Exclusion	18-076	Dillon Mining and Milling	Lower Rattlesnake
Small Miner Exclusion	18-138	Tillmac	Upper Rattlesnake
Small Miner Exclusion	18-127b	Hunt	Upper Rattlesnake

5.5.1 Grasshopper Creek Source Assessment (MT41B002_010)

Grasshopper Creek originates at an elevation of approximately 7,800 feet along the Pioneer Mountain range and flows to the southeast into the Beaverhead River. The approximately 60-mile reach of Grasshopper Creek from the headwaters to the confluence with the Beaverhead River is listed as impaired for lead.

This subwatershed is primarily in public ownership by the U.S. Forest Service (USFS) and the Bureau of Land Management (BLM) **(Figure 5-2)**.

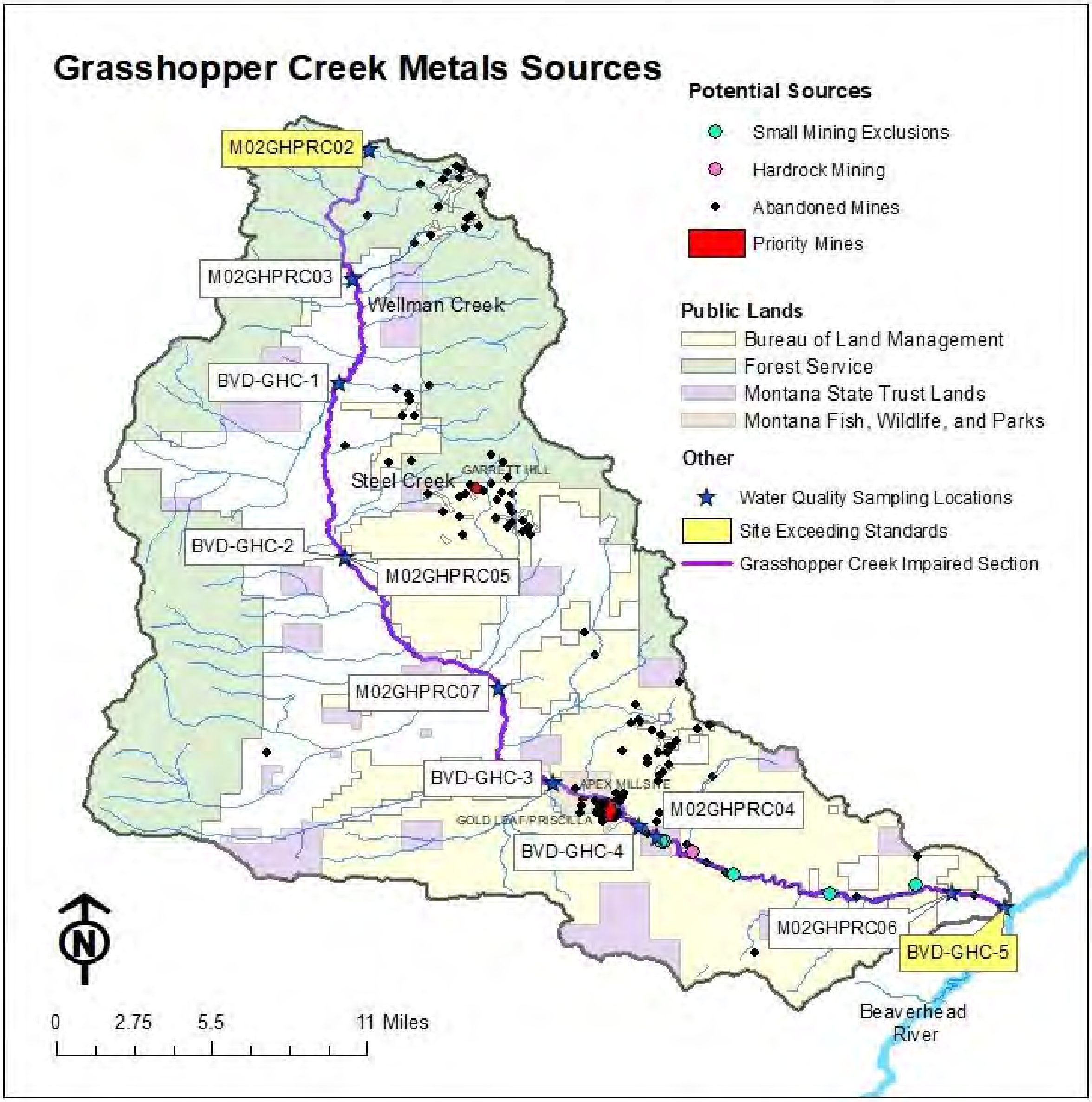

Figure 5-2. Grasshopper Creek Subwatershed Potential Metals Sources and Sampling Locations, with Sampling Locations Exceeding Metals Standards in Yellow

Metals Sources

DEQ and MBMG records indicate that there are 115 abandoned mines in the Grasshopper Creek Subwatershed (**Figure 5-2**).

The headwaters (above the confluence with Wellman Creek) contains 15 lode mines and one geothermal mine. The mines are located on USFS land or private inholdings within USFS land. The middle section from the confluence of Billings Creek to the confluence of Taylor Creek contains 44 mines, 38 of which are lode mines. Ownership in this section is approximately equally divided by USFS, BLM, and private entities, and the mines are located in all three ownership categories. The lower section from Taylor Creek to the confluence with the Beaverhead River contains 49 lode mines and 6 mines of placer or mixed pacer/ lode type, which are primarily on BLM lands or inholdings.

<u>Priority mines</u>
Three priority mines are present in the Grasshopper Creek Subwatershed. These include the Garrett Hill, Apex Millsite, and Goldleaf/Priscilla mines.

Apex Millsite (No. 01-006)
Approximately 79,900 cubic yards of tailings are associated with this site. Previous sampling has documented elevated levels of arsenic copper, lead, and zinc in the tailings. A Montana Comprehensive Environmental Cleanup and Responsibility Act response occurred in 1989, which consisted of consolidating and containing tailings. The tailings impoundments are considered to be in fair condition, although they are on the edge of the 100 -year flood plain of Grasshopper Creek. Monitoring well data has not documented any exceedances of standards, although elevated arsenic concentrations have been recorded. No observed releases have been documented to Grasshopper Creek.

Garrett Hill (No. 01-092)
The Garrett Hill site is located on BLM land adjacent to West Fork Dyce Creek, which flows into Grasshopper Creek. No water quality data or detailed information is available for this site.

Goldleaf Priscilla (No. 01-031)
The Goldleaf Priscilla site contains approximately 89,000 cubic yards of tailings in two separate impoundments. There are approximately 267, 500 cubic yards of waste rock associated with this site. The following metals exceed at least three times background levels in at least one of the tailings piles: Arsenic, cobalt, iron, lead, cadmium, copper, mercury, and antimony. Grasshopper Creek flows from west to east through this site. Observed releases to the creek have been documented for copper and zinc, but no specific exceedance of standards has been documented.

<u>Hardrock Mines</u>
Bon Accord (No. 154)
Reports from DEQ’s Bureau of Hardrock Mining indicate this mine is currently inactive, and inspection reports show revegetation of the area. This mine does not have any documented discharges to surface waters.

Spatial and Seasonal Trends
Spatial and seasonal trends, and water quality exceedances were based on samples in 2009 by the Beaverhead Watershed Committee and during 2014 by Montana DEQ. The sampling locations that exceeded the water quality standards for lead in Grasshopper Creek are the most upstream and most downstream sampling locations.

The low hardness contributed to the exceedance of the lead standard at the upstream headwater location, M02GPRC02. Even moderate concentrations of lead can have chronic health effects at the low hardness value of 19 mg/L, which was measured during this sampling event on 7/28/2014. Potential sources upstream of this site are unknown. The sampling site below the confluence with Wellman Creek (M02GHPRC03) met water quality standards even though Wellman Creek is itself impaired for metals. Despite high concentrations, Wellman Creek delivers relatively low loads to Grasshopper Creek due to low flow.

Continuing downstream from the Wellman Creek confluence, hardness values increased, which is likely due to inputs from natural geologic sources and agriculture. Despite some moderate (~1 µg/L) concentrations of lead downstream, lead standards were not exceeded for most of Grasshopper Creek. This can be partly attributed to the high hardness values, which contributed to lower toxicity. The exception is the most downstream sampling location (BVD-GHC-5) immediately above the confluence with the Beaverhead River, which exceeded the lead standard.

The exceedance for site BVD-GHC-5, the most downstream site, occurred during high flow when suspended sediment concentrations were higher, suggesting that metals suspended from the sediment contributed to the high concentrations. The source of this lead can be most likely attributed to abandoned mines near the mouth of Grasshopper Creek. Based on the spatial location of this impairment, it is probable that this impairment is not entirely from priority mines.

Water quality data used in developing the TMDL for Grasshopper Creek is provided below in **Table 5-15** and can be found at the water quality portal (https://www.waterqualitydata.us/) and in **Appendix B** of this document.

Table 5-15. Grasshopper Creek Metals Water Quality Data and Target Exceedances, from Upstream to Downstream

Site ID	**Collecting Entity**	**Sampling Date**	**Hardness** (mg/L)	**Flow** (cfs)	**Lead** (µg/L) **TR**	**TSS** (µg/L)
M02GHPRC02	MT DEQ	7/28/2014	19	0.37	**0.9***	4
M02GHPRC03	MT DEQ	7/30/2014	21	5.1	< .3	< 4
BVD-GHC-1	Wat Grp	6/3/2009	18.7	160.37	0.4	6
BVD-GHC-2	Wat Grp	6/3/2009	28.2	182.51	0.3	6
M02GHPRC07	MT DEQ	9/8/2014	88	18.61	< .3	< 4
BVD-GHC-3	Wat Grp	6/2/2009	64	1121.2	0.5	24
BVD-GHC-4	Wat Grp	6/2/2009	66.8	7.18	1.1	35
M02GHPRC04	MT DEQ	7/31/2014	91	41.09	< .3	7
M02GHPRC06	MT DEQ	9/9/2014	118	56.45	0.4	6
BVD-GHC-5	Wat Grp	6/3/2009	93.4	332.72	**4.2***	87.9

TSS = Total Suspended Solids; MT DEQ=Montana DEQ; Wat Grp=Beaverhead Watershed Committee
* Values denoted by an asterisk exceed chronic water quality targets

5.5.2 Upper Rattlesnake Creek Source Assessment (MT41B002_091)

Upper Rattlesnake Creek originates in the Pioneer Mountains before flowing southeast into the Beaverhead River. The approximately 18-mile segment of upper Rattlesnake Creek from the headwaters to water quality sampling site M02RATSC06 downstream of Argenta is considered impaired for lead.

The predominant ownership in Upper Rattlesnake Creek is in USFS and BLM land, with a minor proportion in private land. (**Figure 5-3**). Some residential development is present near the settlement of Argenta.

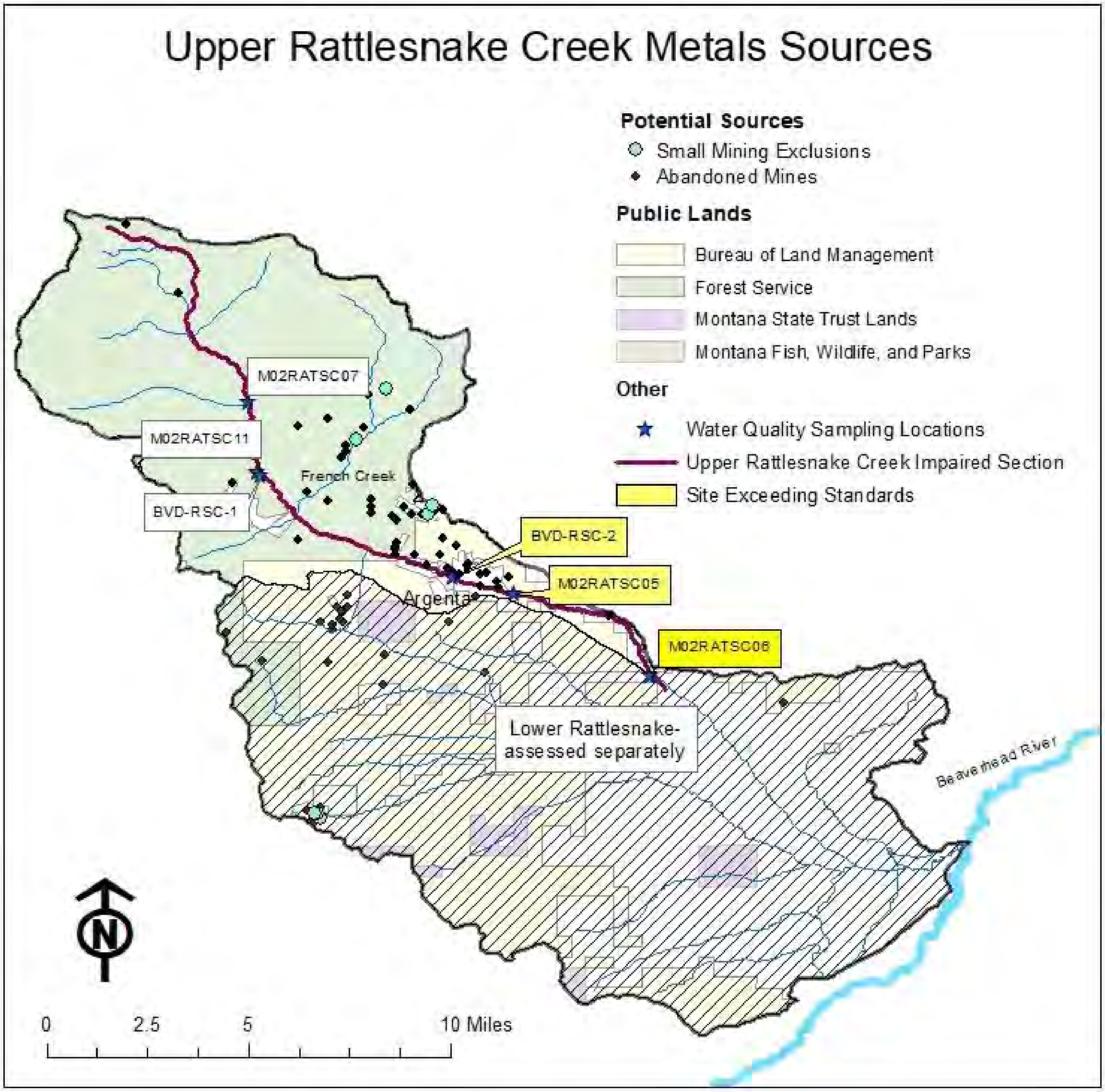

Figure 5-3. Upper Rattlesnake Creek Subwatershed Potential Metals Sources and Sampling Locations, with Sampling Locations Exceeding Metals Standards in Yellow

Metals Sources

According to the DEQ and MBMG databases, approximately 54 abandoned mines exist in the Upper Rattlesnake Creek drainage. (**Figure 5-3**). These include 50 lode mines, two placer mines, one phosphate mine, and one uranium mine. A large concentration of mines is present in the French Creek subwatershed and another large concentration are present in the flood plain and small drainages flowing directly to Upper Rattlesnake Creek near the town of Argenta. No priority mines, open cut mines, or MPDES-permitted mines are present in the Upper Rattlesnake Creek subwatershed.

Both the water quality and sediment data support an abandoned mine source of lead downstream of the confluence with French Creek. All water quality sites downstream of French Creek do not meet the lead standards, while sites upstream of the confluence do meet the standard. Sediment data similarly indicates that BVD-RSC-1, upstream of the French Creek Confluence, is meets the standard for lead.

BVD-RSC2, downstream of the confluence with French Creek and immediately upstream of Argenta, does not meet the standard for lead.

Spatial and Seasonal Trends
Spatial and seasonal trends, and water quality exceedances were based on samples collected from 2009-2015. Hardness values were relatively low at all sampling events. Even moderate levels of metals may be toxic to aquatic life at these low hardness values. For lead, water quality standards were exceeded at sampling events representing both high and low flows. All sampling points exceeding water quality standards were located downstream of the confluence with French Creek, suggesting that abandoned mines in French Creek or between French Creek and Argenta are a source of lead.

Water quality data used in developing the TMDL for Upper Rattlesnake Creek is provided below in **Table 5-16** and can be found at the water quality portal (https://www.waterqualitydata.us/)

Table 5-16. Upper Rattlesnake Creek Metals Water Quality Data and Target Exceedances, from Upstream to Downstream

Site ID	**Collecting Entity**	**Sampling Date**	**Hardness** (mg/L**)**	**Flow** (cfs)	**Lead** (µg/L) **TR**	**TSS** (mg/L)
M02RATSC07	MTDEQ	8/20/2014	25	10.34	< .3	< 4
BVD-RSC-1	Wat Grp	6/3/2009	12.1	63.48	0.1	2.8
M02RATSC11	MTDEQ	8/24/2015	24	14.59	< .3	< 4
BVD-RSC-2	MTDEQ	6/22/2009	37.2	134.17	**2.8***	7
M02RATSC05	MTDEQ	7/31/2014	59	33.06	**19.8***	26
M02RATSC06	MTDEQ	8/20/2014	82	13.53	**4.1***	4
M02RATSC06	MTDEQ	8/24/2015	68	15.51	**2.9***	< 4

TSS = Total Suspended Solids; MT DEQ=Montana DEQ; Wat Grp=Beaverhead Watershed Committee
* Values denoted by an asterisk exceed water quality targets

5.5.3 Lower Rattlesnake Creek Source Assessment (MT41B002_090)

Rattlesnake Creek flows southeast into the Beaverhead River. The approximately 9.5 miles of lower Rattlesnake Creek from the Dillon Public Water Supply near Argenta to the Van Camp Slough at the mouth of Rattlesnake Creek is listed as impaired for copper and lead.

The predominant ownership in Lower Rattlesnake Creek is BLM and Private Lands (**Figure 5-4**). The land cover is almost predominately sagebrush steppe. The majority of the BLM lands in this area have livestock grazing allotments, and livestock grazing also occurs on some private lands in the subwatershed. Intensive cropland is present near the mouth of Rattlesnake Creek, including many pivot irrigation systems resulting in water withdrawals.

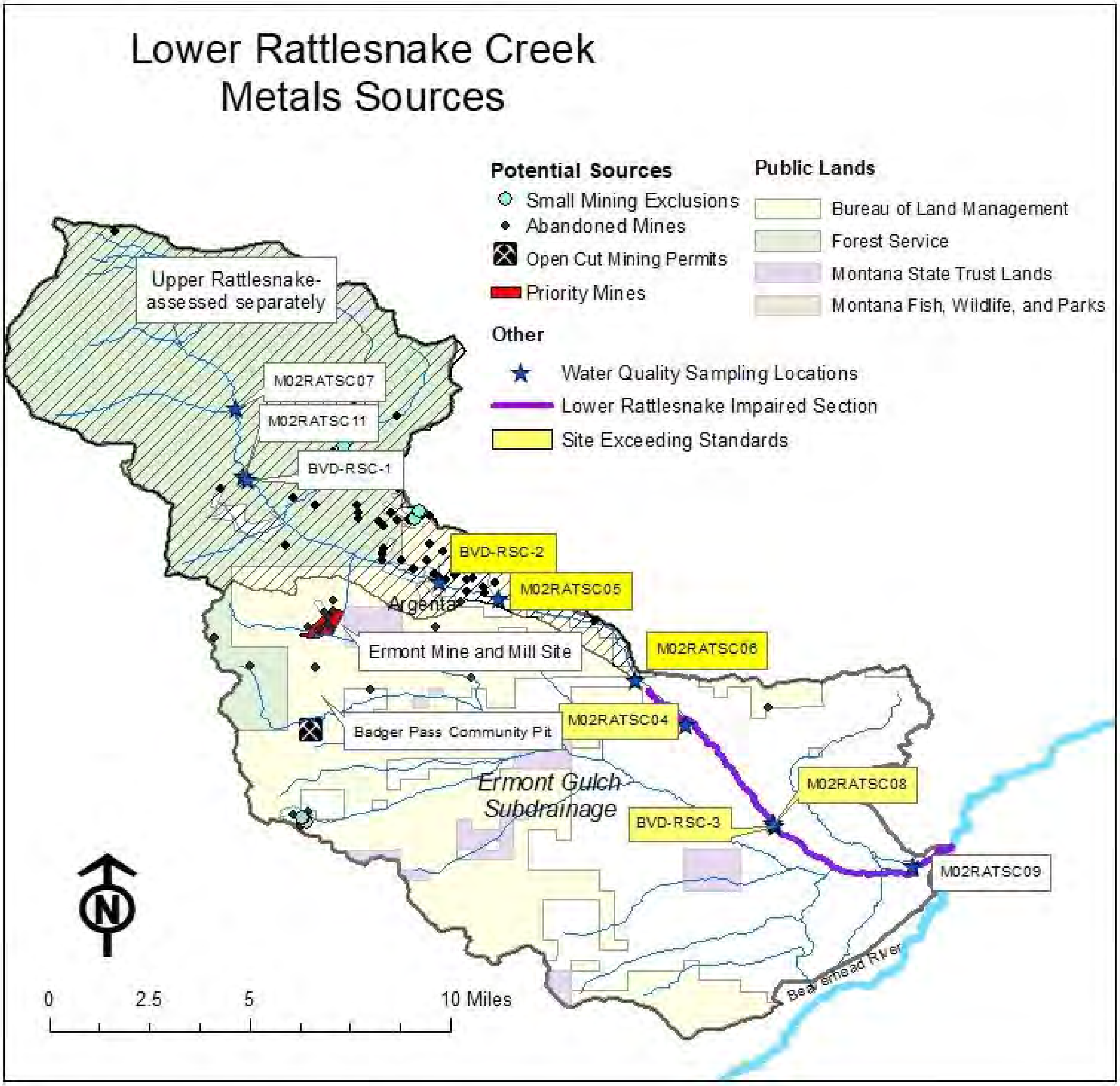

Figure 5-4. Lower Rattlesnake Creek Subwatershed Potential Metals Sources and Sampling Locations, with Sampling Locations Exceeding Metals Standards in Yellow

Metals Sources

According to the DEQ and MBMG databases, approximately 25 abandoned mines exist in the Lower Rattlesnake Creek drainage upstream of the Lower Rattlesnake Creek impaired section (**Figure 5-4**). These include 20 lode mines, 1 placer mine, 1 phosphate mine, and 3 mill mines. With the exception of one lode mine, these are all present in the Ermont Gulch subdrainage. One opencut and one priority mine are also present in the subwatershed.

Abandoned mines are also present in Upper Rattlesnake Creek, which is a source to Lower Rattlesnake Creek. According to the DEQ and MBMG databases, approximately 54 abandoned mines exist in the drainage Upper Rattlesnake Creek drainage. These include 50 lode mines, two placer mines, one phosphate mine, and one uranium mine. Water quality data indicate that the primary source of lead in Lower Rattlesnake Creek is the Upper Rattlesnake drainage. However, given that no sites exceeded the standard for copper in Upper Rattlesnake Creek, the source of copper in the Lower Rattlesnake impaired segment may within the Lower Rattlesnake subwatershed. Only the most upstream site was found to exceed the standard for copper, despite sampling on the same date at downstream sites. This finding indicates a potential localized source of copper near the location of sampling, that may be diluted downstream. The source of copper could be evaluated with further sampling.

During the course of sampling one sediment sample was evaluated at site BVD-RSC-3. This sediment sample met the copper target but not the lead target, which supported the water quality findings at this site. This sediment result, combined with a high TSS value, indicates that much of the lead may be in resuspended sediments.

Open Cut Mines

Badger Pass Community Pit (No. 61)

There is one small “opencut” mine in the subwatershed, the Badger Pass Community Pit, permit number 61. Opencut mines are those that strip or excavate more than 10,000 cubic yards of soil, overburden or mine material from a site. It is the responsibility of the permit holder to adhere to the conditions of the permit and ensure that surface and groundwater are not being impacted.

Priority Mines

Ermont Mine and Millsite (No. 01-005)

One priority mine and its associated mill site are present in the Lower Rattlesnake Creek drainage. The Ermont Mine and Millsite is located in the headwaters of the Ermont Gulch drainage. The Ermont Gulch drainage meets Rattlesnake Creek two miles upstream of its confluence with the Beaverhead River. Approximately 200,000 cubic yards of tailings are present at this site. During a visit in June 1993, uncovered tailings had metals concentrations that were three times background concentrations. However, no discharging adits were present at the visit. A dry drainage was identified, but no samples could be taken due to the absence of flowing water. The nearest flowing water present on the visit was over a mile from the site.

Exceedances were observed above the confluence with Ermont Gulch subdrainage, but not below this confluence. Based on these water quality results, this priority mine is not the main source of metals to Lower Rattlesnake Creek. However, no samples from the most downstream site (M02RATSC09) were collected during a high flow event when run-off from mine tailings is often higher. Therefore, further sampling may be needed to verify this assumption.

Spatial and Seasonal Trends

Spatial and seasonal trends, and water quality exceedances were based on samples collected from 2009-2015. Each site above the confluence with Ermont Gulch exceeded water quality standards for at least one metal pollutant during at least one sampling event, while the site sampled below the confluence with Ermont Gulch (M01RSTS09) did not exceed water quality standards. At the sites exceeding standards, lead was exceeded during both high and low flow events. Copper standards were exceeded at the headwater site (M2RATSC04) during a high flow event in August. This sampling event coincided with a low hardness value.

Due to withdrawals from agriculture and other uses, flows at sites near the mouth were extremely low during the majority of sampling events in 2014 and 2015, despite higher flows upstream. A decrease in metals concentrations coincided with these withdrawals, suggesting that water high in metals was removed from the creek as inputs from several small tributaries low in metals entered. Thus, water use practices may be influencing the metals concentrations at the mouth of Lower Rattlesnake Creek, although additional sampling is needed to verify these complex interactions.

Even though the Ermont Gulch subdrainage contains a priority mine, the site downstream of where this subdrainage enters Lower Rattlesnake Creek met water quality standards. It therefore is likely that a significant source of metals in Lower Rattlesnake Creek is Upper Rattlesnake Creek and not the Ermont Gulch subdrainage. However, additional sampling at high flows would verify this source.

Water quality data used in developing the TMDL for Lower Rattlesnake Creek is provided below in **Table 5-17** and can be found at the water quality portal (https://www.waterqualitydata.us/) and in **Appendix B** of this document.).

Table 5-17. Lower Rattlesnake Creek Metals Water Quality Data and Target Exceedances, from Upstream to Downstream

Site ID	**Collecting Entity**	**Sampling Date**	**Hardness** (mg/L)	**Flow** (cfs)	**Copper** (µg/L) **TR**	**Lead** (µg/L) **TR**	**TSS** (mg/L)
M02RATSC04	MT DEQ	5/27/2015	54	26.32	3	**12.2***	17
M02RATSC04	MT DEQ	8/24/2015	13	18.55	**52***	**1.5***	5
BVD-RSC-3	Wat Grp	6/2/2009	51.2	20.94	2.9	**10***	22
M02RATSC08	MTDEQ	8/21/2014	89	2.24	2	**3.7***	4
M02RATSC08	MTDEQ	5/27/2015	53	14.86	5	**14.8***	30
M02RATSC08	MTDEQ	7/8/2015	64	3.62	2	**7.6***	17
M02RATSC08	MTDEQ	8/24/2015	82	1.61	1	1.4	5
M02RATSC09	MTDEQ	9/9/2014	179	0.04	< 1	0.4	23
M02RATSC09	MTDEQ	5/27/2015	102	0.6	3	2.1	12

TSS = Total Suspended Solids; MT DEQ=Montana DEQ; Wat Grp=Beaverhead Watershed Committee
* Values denoted by an asterisk exceed water quality targets

5.5.4 Spring Creek Source Assessment (MT41B002_080)

Spring Creek originates in the Ruby Mountains flowing northwest into the Beaverhead River. The 15.6 miles of Spring Creek from the headwaters to the mouth is considered impaired for Iron. The watershed is predominately privately owned with approximately 20% in Montana State Trust Lands and 20% in BLM lands, with the remainder in private lands (**Figure 5-5**).

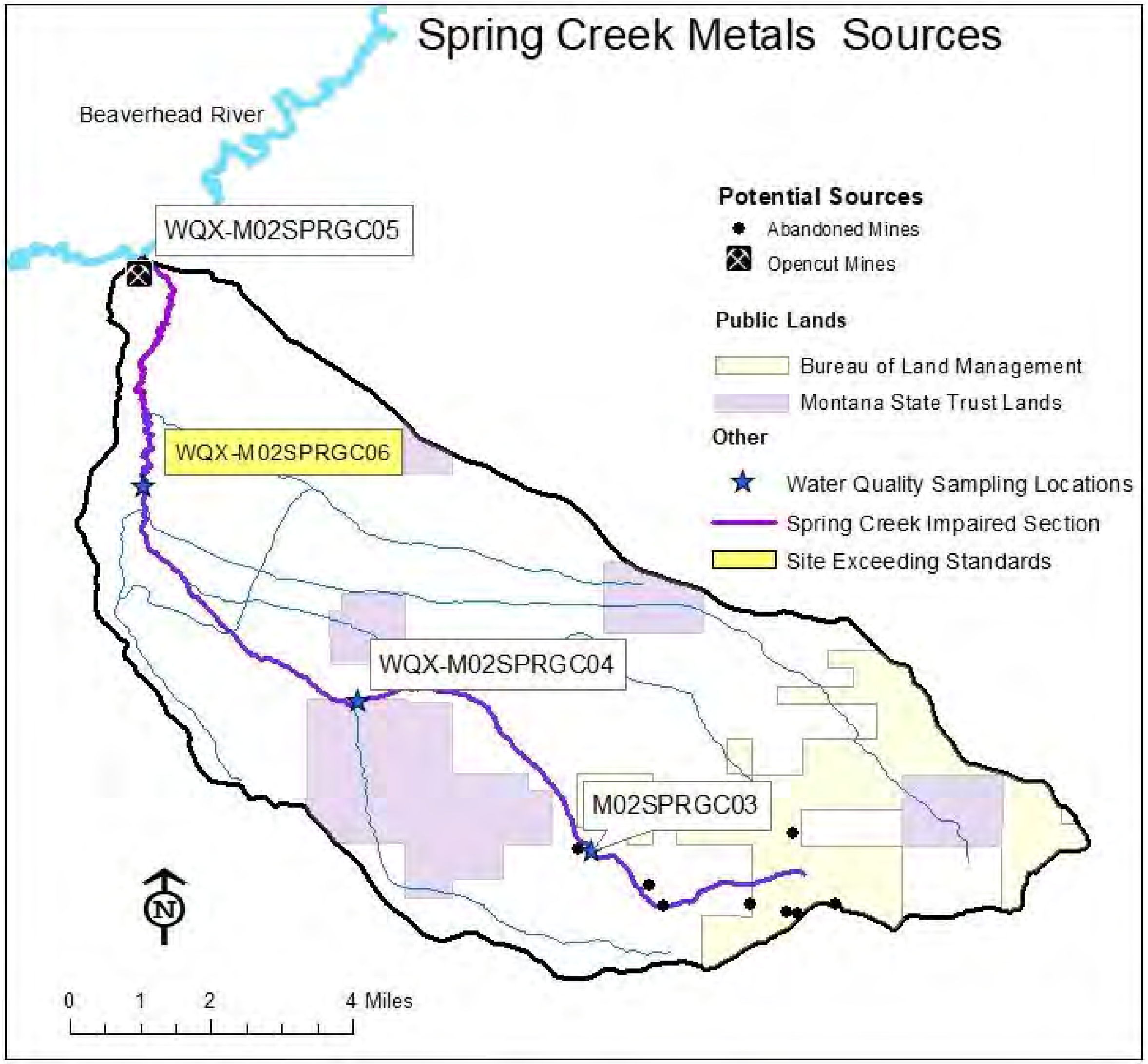

Figure 5-5. Spring Creek Subwatershed Potential Metals Sources and Sampling Locations, with Sampling Locations Exceeding Metals Standards in Yellow

Metals Sources

According to the DEQ and MBMG databases, 9 known abandoned mines are present in the Spring Creek drainage (**Figure 5-5**). These include 5 lode mines, 3 talc mines, and one clay mine. These are present in the uppermost headwaters and are on both BLM and private lands. One opencut mining site, Wetherbee, is also present at the mouth of Spring Creek, but does not have any permitted discharges. No priority mines are present in the Spring Creek drainage.

<u>Opencut Mines</u>

Wetherbee Mine (No. 1907)

There is one small “opencut” mine in the subwatershed, operated by the County of Madison Roads Department. Opencut mines are those that strip or excavate more than 10,000 cubic yards of soil, overburden or mine material from a site. This particular mine is a gravel operation managed by the Bureau of Land Management. Pursuant to 82-4-434 (3) (l), MCA, an Open Cut Mining permit holder must ensure that “surface water and ground water will be given appropriate protection, consistent with state law, from deterioration of water quality and quantity that may arise as a result of the opencut operation." As such it is the responsibility of the permit holder to adhere to the conditions of the permit and ensure that surface and groundwater are not being impacted.

Spatial and Seasonal Trends
Spatial and seasonal trends, and water quality exceedances were based on samples collected in 2014 and 2015. Hardness increased with increasing distance downstream, reflecting potential inputs from agricultural run-off. One site, M02SPRGC03, located in the downstream portion of the subwatershed exceeded water quality standards for iron during a high flow event. This sampling event coincided with a high total suspended solids concentration.

Flows at the most downstream site were extremely low during sampling events in 2014 and 2015, potentially due to water withdrawals. Based on the source assessment and available water quality data, abandoned mines are contributing to the exceedance of the iron standard in Spring Creek. However, complex interactions between water withdrawals and water quality are present.

Water quality data used in developing the TMDL for Spring Creek is provided below in **Table 5-18** and can be found at the water quality portal (https://www.waterqualitydata.us/).

Table 5-18. Spring Creek Water Quality Data and Target Exceedances, From Upstream to Downstream

Site ID	**Collecting Entity**	**Sampling Date**	**Hardness** (mg/L)	**Flow** (cfs)	**Fe** (µg/L) **TR**	**TSS** (mg/L)
M02SPRGC03	MTDEQ	8/19/2014	171	0.38	290	8
M02SPRGC04	MTDEQ	8/19/2014	189	1.08	40	< 2
		5/28/2015	208	1.12	690	30
M02SPRGC06	MTDEQ	8/21/2014	328	2.99	50	< 4
		5/28/2015	329	3.56	**1460***	64
M02SPRGC05	MTDEQ	8/21/2014	553	0.58	60	< 4
		5/28/2015	526	0.06	30	< 4
		7/6/2015	427	0.91	340	18

TSS = Total Suspended Solids; MT DEQ=Montana DEQ; Wat Grp=Beaverhead Watershed Committee
* Values denoted by an asterisk exceed water quality targets

5.5.5 Steel Creek Source Assessment (MT41B002_160)

Steel Creek is part of the Grasshopper Creek subwatershed. It meets Driscoll Creek, which becomes Scudder Creek before flowing into Grasshopper Creek. The 3.6 miles of Steel Creek is considered impaired for arsenic.

The Steel Creek subwatershed is comprised of USFS and BLM lands in the headwaters and private land in the lower section **(Figure 5-6**).

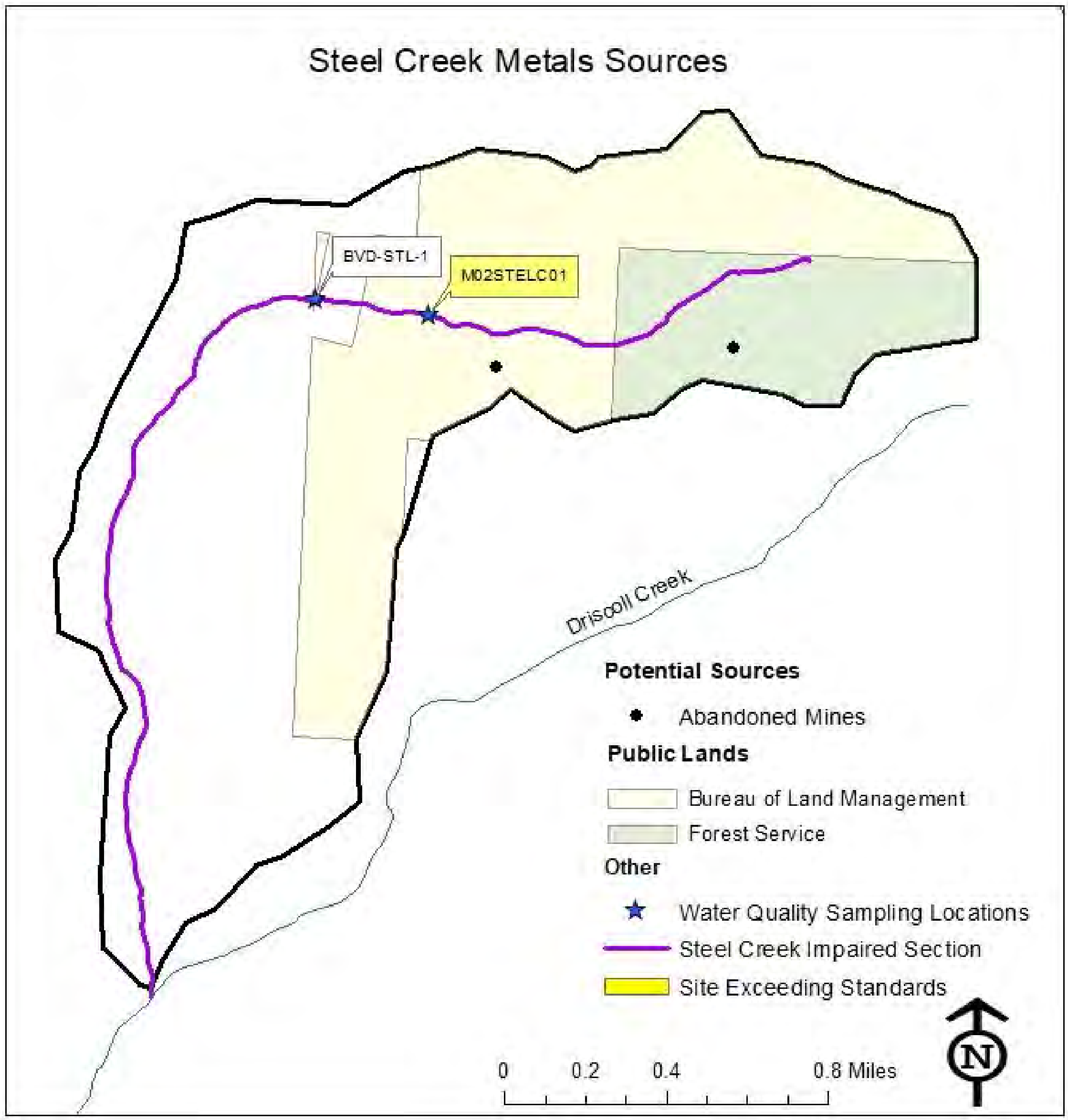

Figure 5-6. Steel Creek Subwatershed Potential Metals Sources and Sampling Locations, with Sampling Locations Exceeding Metals Standards in Yellow

Metals Sources

Only two sites have been sampled in Steel Creek, one in 2004 and one in 2009. The most upstream site, M02STELC01, had an exceedance twice the human health criteria for Arsenic in 2004. Two known abandoned mines are located in the upper portion of this subwatershed, which potentially contribute to the exceedance of the arsenic criteria in Steel Creek. Site visits indicated that Steel Creek is dry or has extremely low flow for much of the year. No priority mines, open cut mines, or MPDES-permitted mines are present in the Steel Creek subwatershed.

Spatial and Seasonal Trends

Given few sampling points, spatial and seasonal trends could not be determined. However, data indicate that Steel Creek is characterized by very low flows. Water quality data used in developing the TMDL for

Steel Creek are provided below in **Table 5-19** and can be found at the water quality portal (https://www.waterqualitydata.us/).

Table 5-19. Steel Creek Water Quality Data and Target Exceedances, from Upstream to Downstream

Site ID	**Collecting Entity**	**Sampling Date**	**Hardness** (mg/L)	**Flow** (cfs)	**As (µg/L) TR**	**TSS** (mg/L)
M02STELC01	MTDEQ	7/13/2004	230	0.05	**22***	3280
BVD-STL-1	WatGrp	6/4/2009	NA	**	1.6	38.2

TSS = Total Suspended Solids; MTDEQ=Montana DEQ; Wat Grp=Beaverhead Watershed Committee
* Values denoted by an asterisk exceed human health targets
** Too low to be adequately measured

5.5.6 Upper Stone Creek Source Assessment (MT41B002_132)

Stone Creek originates along the foothills of the Ruby Mountain Range. The approximately seven miles of upper Stone Creek from the headwaters to the confluence of an unnamed tributary is listed as impaired for iron.

The upper portion of Stone Creek contains a combination of BLM lands, state lands, and private lands, with the majority of ownership being in private lands (**Figure 5-7**). Large sections of cropland also occur adjacent to the creek in this lower section, with water withdrawals.

Metals Sources

According to DEQ and the Montana Bureau of Mines and Geology (MBMG) GIS coverages, 31 abandoned mines exist in the upper Stone Creek drainage (**Figure 5-9**), which are concentrated in the headwaters. Many are within close proximity of the creek. A total of 23 of the mines are lode mines, four are feldspar mines, and four are talc mines. No priority mines or open cut mines are present in the Upper Stone Creek subwatershed. Two hardrock permits are present in the subwatershed. Three MPDES permits are present, and one of these permittees has a measurable discharge to the creek. The primary sources of iron to Upper Stone Creek are abandoned mines and the permitted discharge.

<u>MPDES Permits</u>

Three permitted mines are present in Stone Creek subwatershed (**Table 5-20**), including two individual permits (MT0029891 and MT0027821) and one general permit MTR000510.

A Montana Pollutant Discharge Elimination System (MPDES) General Permit is a permit for discharges associated with common activities, such as concentrated animal feeding operations and storm water discharges from construction or industrial activity. Authorizations for general permits are issued if a facility or activity falls within the guidelines of the existing permit. In this case, the general permit MT000510 is a stormwater permit and it is assumed that the discharge to Left Fork Stone Creek is zero except during extremely high flow conditions.

Individual MPDES Permits regulate discharges from point sources that do not fall under the guidelines for a general permit. The individual permitting process is more rigorous, as individual permits address the specific conditions of the facility or activity needing authorization. The concentrations of contaminants leaving individual permitted facilities must be monitored and reported on by the permittee.

Water quality data collected at the Barretts Minerals (MT0029891) site indicates the presence of iron in discharge water entering Left Fork Stone Creek. However, there was previously insufficient data to determine whether iron had the potential to exceed the standard. The mine is now required to include iron in its list of water quality data evaluated quarterly, and iron will be evaluated as part of the permit renewal which will occur in the next few years. A wasteload allocation for this point discharge will be included in the TMDL based on effluent data collected at the mine.

Water quality data collected at the Imerys site (MT0027821) does not indicate the presence of iron in discharge water entering Middle Fork Stone Creek. This mine is no longer operational and has initiated the process of obtaining a bond release by DEQ, after which it will not require a MPDES permit.

Table 5-20. Metals Point Source Permits in the Beaverhead TMDL Planning Area

Permit Number	Type	Name	Latitude	Longitude
MT0027821	Miscellaneous Nonmetallic Minerals	IMERYS TALC MINE	45.228056	-112.308056
MT0029891	Miscellaneous Nonmetallic Minerals	BARRETTS MINERALS INC	45.229444	-112.308333
MTR000510	Miscellaneous Nonmetallic Minerals	BARRETS MINERALS TREASURE MINE	45.22833	-112.31167

<u>Hardrock Mining Permits</u>

Beaverhead Mine-Imerys (No. 75)

This talc mine is associated with MPDES permit MT0027821. This mine ceased operation in 1999 but still has an active permit as of July 2020. They have stabilized their slopes and are initiating a hard rock mining bond release and MPDES termination. Iron was never a parameter of concern while they were in operation, as data collected at the mine showed barely detectable levels of iron leaving the outfalls. Therefore, a wasteload allocation will not be included for this mine.

Treasure Mine-Barretts (No. 78)

This hardrock mining permit is associated with MPDES permits MTR0029891 and MTR000510, with the hardrock mining permits covering material-moving activities and the MPDES permits covering discharges to surface waters. Iron has been detected in discharges to Left Fork Stone Creek and will be considered a point source in the TMDL with a wasteload allocation.

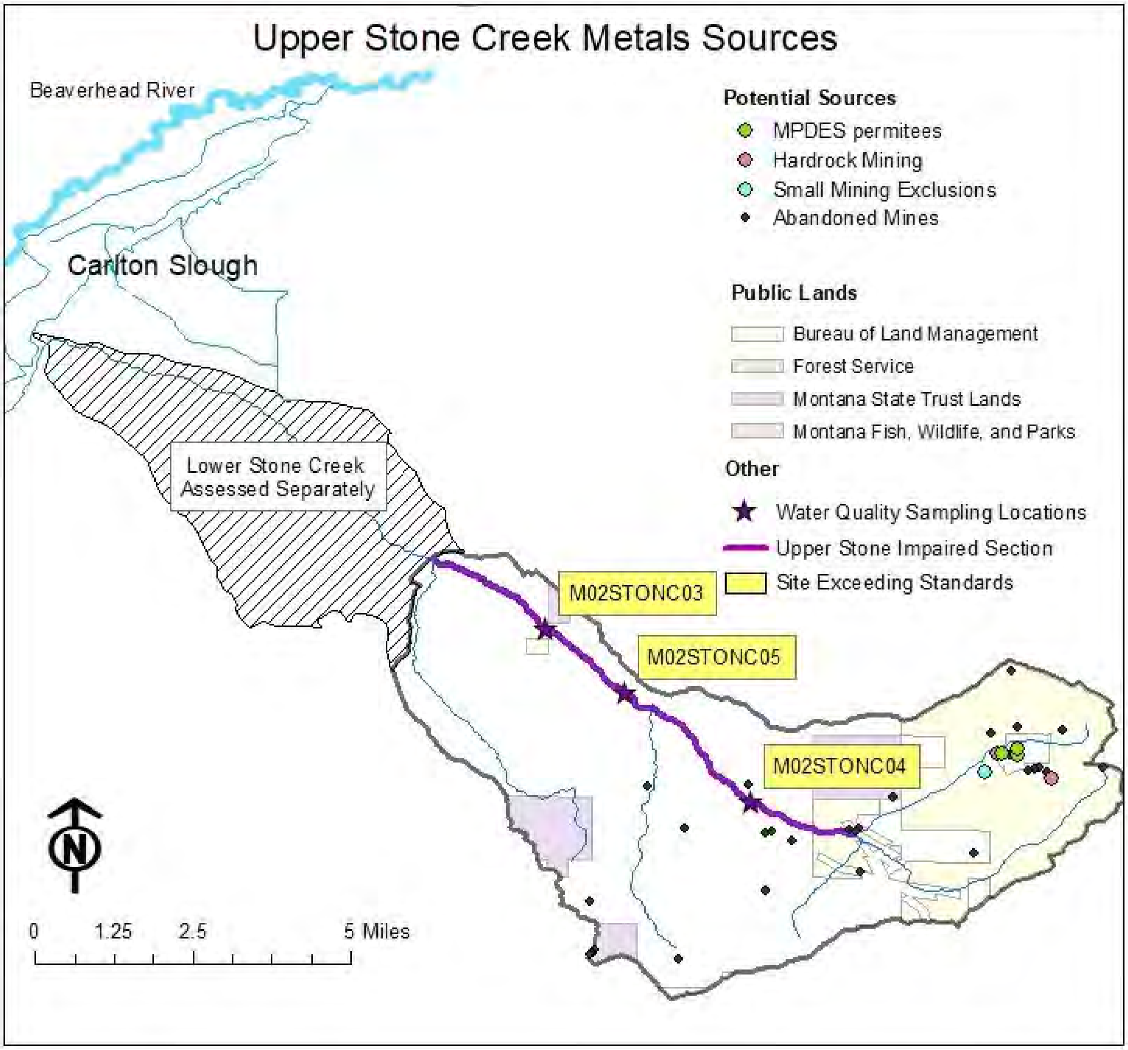

Figure 5-7. Upper Stone Creek Subwatershed Potential Metals Sources and Sampling Locations.

Spatial and Seasonal Trends

Sampling efforts in upper Stone Creek occurred during 2014 and 2015, where Upper Stone Creek was found to exceed the iron chronic metal standard. The highest iron concentrations occurred more frequently in the spring during high flow events. However, the iron chronic metal standard was exceeded during sampling events that occurred during both low and high flows. Exceedances occurred for at least one sampling event at each of the three locations sampled.

Water quality data used in developing the TMDL for Upper Stone Creek is provided below in **Table 5-21** and can be found at the water quality portal (https://www.waterqualitydata.us/)

Table 5-21. Upper Stone Creek Water Quality Data and Target Exceedances, from Upstream to Downstream

Site ID	Collecting Entity	Sampling Date	Hardness (mg/L)	Flow (cfs)	Iron (µg/L) TR	TSS (mg/L)
M02STONC04	MTDEQ	8/6/2014	213	1.42	860	20
		5/27/2015	191	2.04	**1730***	31
		7/22/2015	222	0.58	350	10
		8/25/2015	227	0.71	**1280***	36
M02STONC05	MTDEQ	8/6/2014	230	1.77	**1030***	26
		7/16/2015	225	0.95	780	20
		8/25/2015	237	0.58	250	6
M02STONC03	MTDEQ	8/6/2014	230	0.65	420	8
		5/27/2015	226	1.71	**4080***	101
		7/22/2015	245	0.27	320	11
		8/25/2015	231	0.21	220	6

TSS = Total Suspended Solids; MT DEQ = Montana DEQ; Wat Grp=Beaverhead Watershed Committee
* Values denoted by an asterisk exceed water quality targets

5.5.7 Lower Stone Creek Source Assessment (MT41B002_131)

Stone Creek is a tributary to the Carlton Slough, which ultimately flows into the Beaverhead River. The approximately 6.5 miles of Lower Stone Creek from an unnamed tributary to the Staudaher Bishop Ditch is listed as impaired for aluminum, copper, and iron. Spatial and seasonal trends, and water quality exceedances were based on samples collected in 2014 through 2017.

The Lower Stone Creek portion of the subwatershed is almost exclusively privately owned, with small parcels also owned by Montana State Trust Lands and BLM. Approximately half of the landcover is shrubland or sagebrush/steppe, and the other half is in cropland with some large-scale pivot agriculture applications near the lower portion which flows into Carlton Slough (**Figure 5-8**). These activities both withdraw and add significant amounts of water to Lower Stone Creek at different spatial locations and timeframes within the year.

Metals Sources

According to the MBMG database, no abandoned mines are present in Lower Stone Creek subwatershed. No priority mines, open cut mines, or MPDES-permitted mines are present in the Lower Stone Creek subwatershed. Therefore, the source of metals to Lower Stone Creek subwatershed is primarily the Upper Stone Creek subwatershed. A total of 31 abandoned mines are present in the Upper Stone Creek subwatershed. Three hardrock permits are present in Upper Stone Creek, which are associated with mining operations. Two individual MPDES permit and one MPDES general stormwater permit have been issued in Upper Stone Creek (**Section 5.5.6**).

A general permit is also present in an adjacent drainage, from which some water is potentially added to Lower Stone Creek subwatershed via an irrigation system. However, as with all general stormwater permits, the discharge associated with this general permit is effectively zero during the majority of conditions.

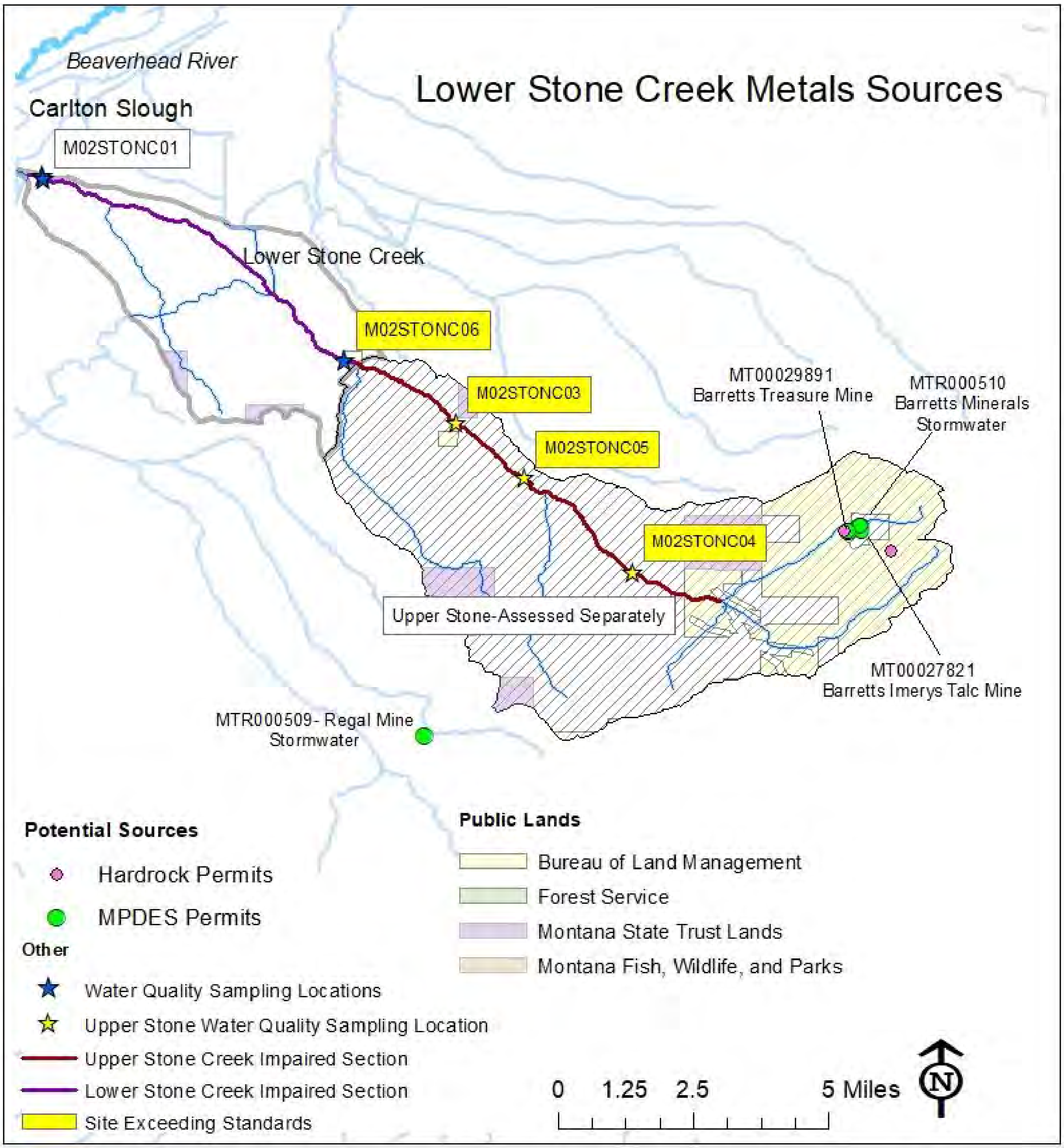

Figure 5-8. Lower Stone Creek Subwatershed Potential Metals Sources and Sampling Locations, with Sampling Locations Exceeding Metals Standards in Yellow

Spatial and Seasonal Trends

All exceedances of water quality standards were observed at the upstream sampling location, during a single high flow sampling event in April. Given that no known abandoned mine drainages are present in the Lower Stone Creek subwatershed, it is likely that the source of metals is abandoned mines and permitted discharges is from the Upper Stone Creek subwatershed. However, Upper Stone Creek did not exceed water quality standards for aluminum and copper. Therefore, it is possible that a source of copper and aluminum is the unnamed tributary that enters upper Stone Creek below the most downstream sampling point within Upper Stone Creek. Further water quality sampling would be needed to verify this source. The sampling point immediately upstream of the Carlton Slough exhibited much higher flows than the upstream site, which may be partly due to irrigation water reentering the creek. It did not show a metals exceedance, which may be attributed to this dilution.

Water quality data used in developing the TMDL for Lower Stone Creek is provided below in **Table 5-22** and can be found at the water quality portal (https://www.waterqualitydata.us/)

Table 5-22. Lower Stone Creek Water Quality Data and Target Exceedances, from Upstream to Downstream

Site ID	**Collecting Entity**	**Sampling Date**	**Hardness** (mg/L)	**Flow** (cfs)	**Aluminum** (µg/L) **D**	**Copper** (µg/L) **TR**	**Iron** (µg/L) **TR**	**TSS** (mg/L)
M02STONC06	MT DEQ	8/6/2014	211	0.10	16	2	110	<5
		7/14/2015	199	0.03	30	2	90	<4
		4/20/2017	244	0.96	**183***	**20***	**9960***	290
M02STONC01	MT DEQ	9/10/2014	379	5.64	9	1	30	<4
		5/27/2015	369	2.96	9	1	160	6
		7/23/2015	378	3.97	30	1	140	8
		8/26/2015	364	3.21	30	< 1	20	<4
		4/20/2017	344	4.45	4	8	300	45

TSS = Total Suspended Solids; MT DEQ=Montana DEQ; Wat Grp=Beaverhead Watershed Committee
* Values denoted by an asterisk exceed water quality targets

5.5.8 Wellman Creek Source Assessment (MT41B002_150)

Wellman Creek flows southwest into Grasshopper Creek. The three miles of Wellman Creek from the headwaters to the confluence of Grasshopper Creek is considered impaired for aluminum, cadmium, copper, zinc, and lead.

The predominant ownership in the upper 50% of the subwatershed is USFS lands with private inholdings. A small portion of the USFS lands are in grazing allotments. The lower 50% of the subwatershed is in private lands, and residential properties are present near the confluence with Grasshopper Creek. The subwatershed also contains a small proportion of State Trust Lands (**Figure 5-9**).

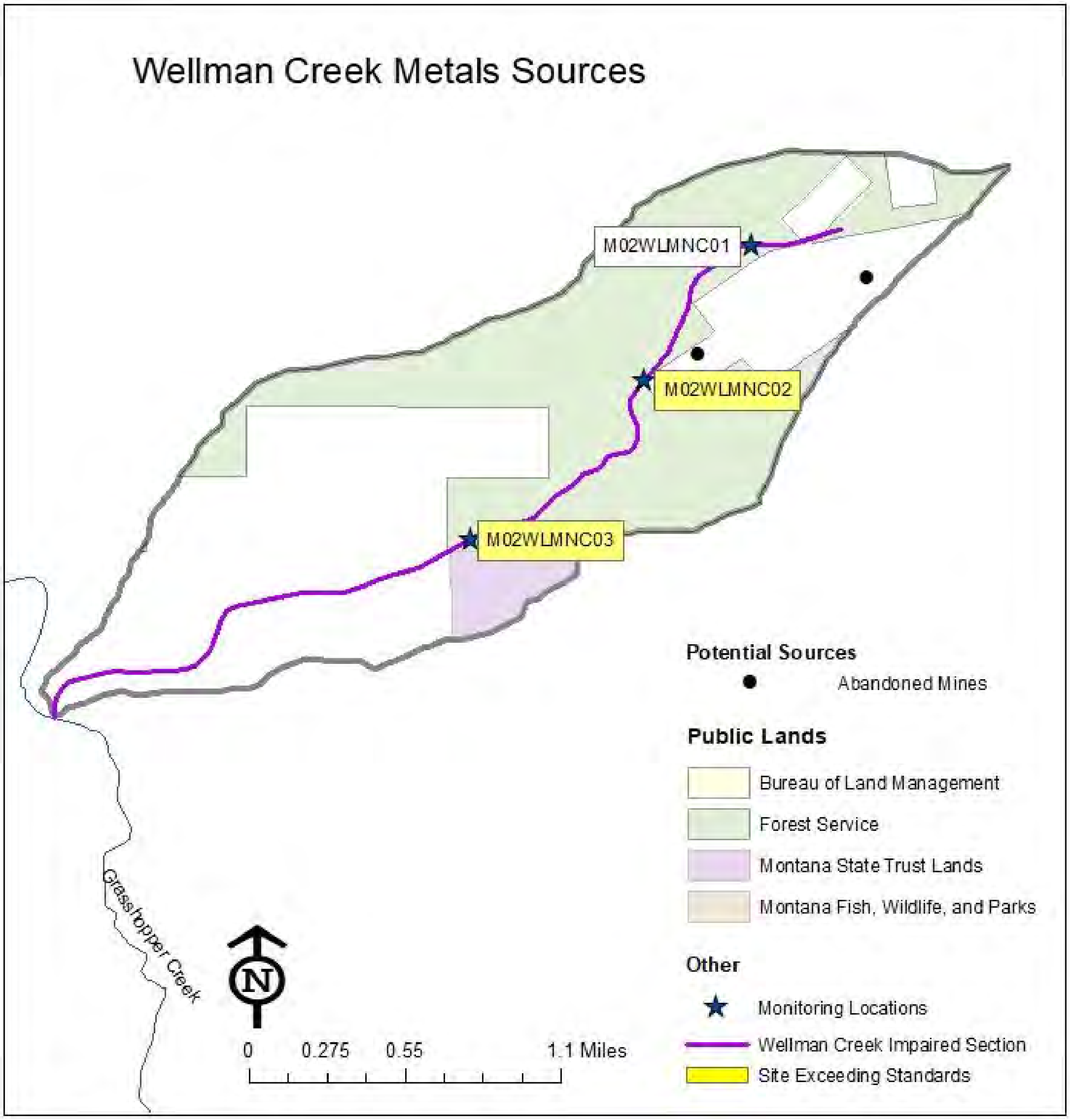

Figure 5-9. Wellman Creek Subwatershed Potential Metals Sources and Sampling Locations, with Sampling Locations Exceeding Metals Standards in Yellow.

Sources

According to the DEQ and MBMG databases, two abandoned lode mines are present in Wellman Creek (**Figure 5-9**). These are both on private lands. No priority mines, open cut mines, or MPDES-permitted mines are present in the Wellman Creek subwatershed, suggesting that the source of metals is abandoned mines.

Spatial and Seasonal Trends

Spatial and seasonal trends, and water quality exceedances were based on samples collected in 2014 and 2015. The highest concentrations of each metal exceeding water quality standards were observed downstream of the water sample point M02LMNC02, during the low flow period. Concentrations decreased (but still exceeded for 4 out of 5 metals criteria), at the downstream sample point of M02WLMNC03. The most upstream headwater site M02LMNC01 did not exceed water quality standards. This finding suggests a localized input of metals immediately above M02LMNC02, which is below the two abandoned mines. However, higher concentrations at low flows compared to high flows suggest that metals may have already been flushed out of this localized source by the time the high flow samples were collected, and/or may be coming from groundwater.

Water quality data used in developing the TMDL for Wellman Creek is provided below in **Table 5-23** and **Table 5-24** and can be found at the water quality portal (https://www.waterqualitydata.us/).

Table 5-23. Wellman Creek Water Quality Data and Target Exceedances for Aluminum (Al), Copper (Cu), and Cadmium (Cd), from Upstream to Downstream

Site ID	**Collecting Entity**	**Sampling Date**	**Hardness** (mg/L)	**Flow** (cfs)	**Al** (µg/L) **D**	**Cu** (µg/L) **TR**	**Cd** (µg/L) **TR**	**TSS** (mg/L)
M02WLMNC01	MTDEQ	7/29/2014	97	1.00	35	3	0.12	14
		5/27/2015	72	0.20	< 9	4	0.12	4
M02WLMNC02	MTDEQ	7/29/2014	80	0.02	34	**13***	0.23	<4
		5/27/2015	62	0.30	**166***	**48***	**0.58***	<4
		7/6/2015	85	0.80	50	**16***	0.28	<4
M02WLMNC03	MTDEQ	7/29/2014	72	1.00	< 9	**10***	0.21	<4
		5/27/2015	60	0.21	67	**22***	0.29	11
		7/6/2015	83	0.10	< 30	**13***	0.26	<4

TSS = Total Suspended Solids; MT DEQ=Montana DEQ; Wat Grp=Beaverhead Watershed Committee
* Values denoted by an asterisk exceed water quality targets

Table 5-24. Wellman Creek Water Quality Data and Target Exceedances for Lead (Pb) and Zinc (Zn), from Upstream to Downstream

Site ID	**Collecting Entity**	**Sampling Date**	**Hardness** (mg/L)	**Flow** (cfs)	**Pb** (µg/L) **TR**	**Zn** (µg/L) **TR**	**TSS** (mg/) **TR**
M02WLMNC01	MTDEQ	7/29/2014	97	1.00	0.8	47	14
		5/27/2015	72	0.20	0.9	41	4
M02WLMNC02	MTDEQ	7/29/2014	80	0.02	<0.3	**126***	<4
		5/27/2015	62	0.30	**3.3***	**219***	<4
		7/6/2015	85	0.80	0.4	**132***	<4
M02WLMNC03	MTDEQ	7/29/2014	72	1.00	0.4	82	<4
		5/27/2015	60	0.21	**1.9***	**121***	11
		7/6/2015	83	0.10	<0.3	91	<4

TSS = Total Suspended Solids; MT DEQ=Montana DEQ; Wat Grp=Beaverhead Watershed Committee
* Values denoted by an asterisk exceed water quality targets

5.5.9 West Fork Blacktail Deer Creek Source Assessment (MT41B002_060)

West Fork Blacktail Deer Creek originates at an elevation of approximately 9600 feet along the foothills of the Gravelly Range and flows to the north to meet the East Fork Blacktail Deer Creek. The approximately 19-mile reach of West Fork Blacktail Deer Creek from the headwaters to the confluence with East fork of Blacktail Deer Creek is listed as impaired for arsenic.

This subwatershed is primarily in public ownership by Montana State Trust Lands and U. S. Forest Service (**Figure 5-10)**.

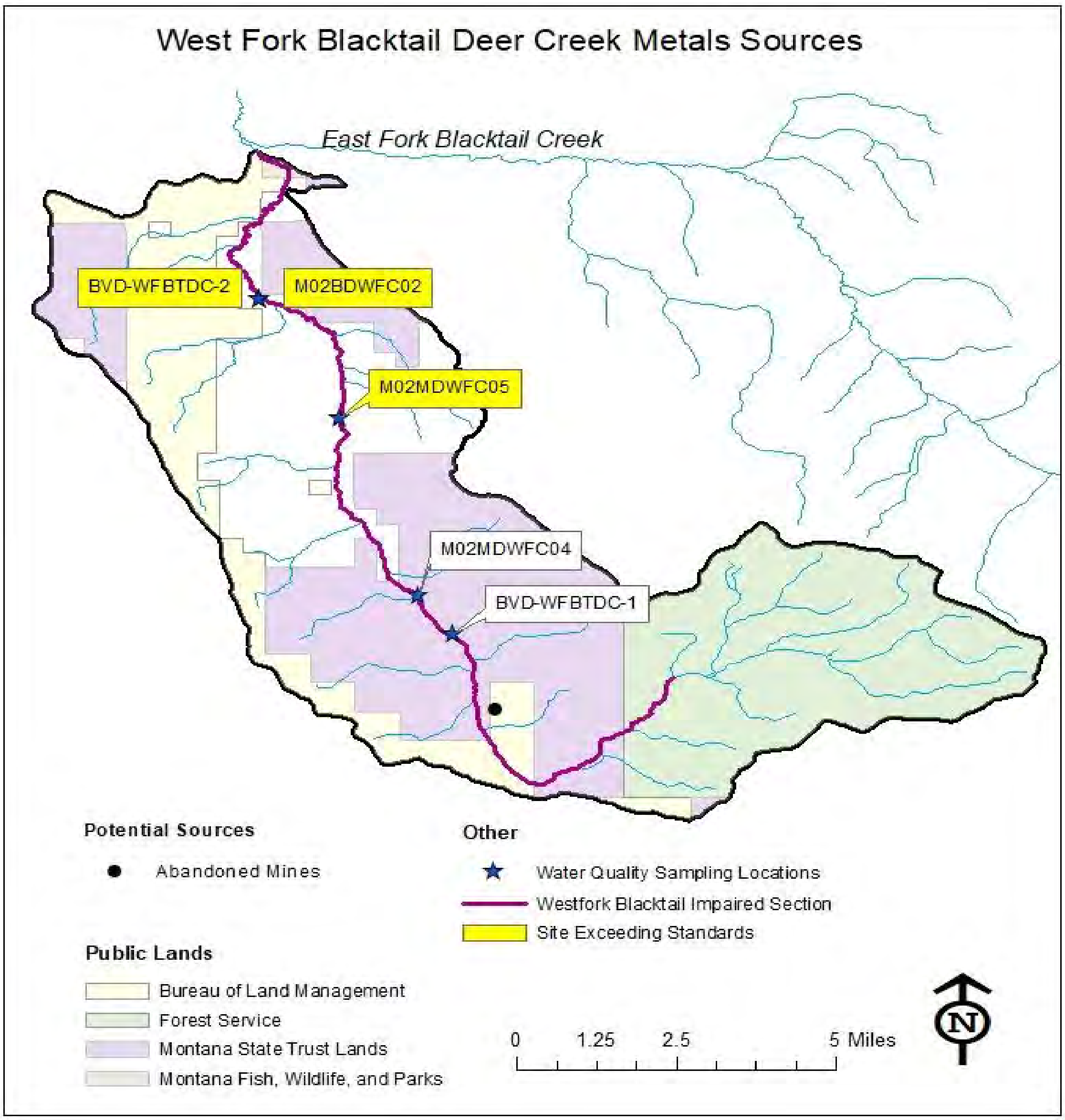

Figure 5-10. West Fork Blacktail Deer Creek Subwatershed Potential Metals Sources and Sampling Locations, with Sampling Locations Exceeding Metals Standards in Yellow

Metals Sources

Water quality data indicate a metals source downstream of site M02MDWFC04. Only one abandoned mine is present in the subwatershed, and this mine is located upstream of sites that both meet and do not meet water quality standards. Not all historic abandoned mines in Montana have been accounted for in the MBMG and DEQ abandoned mines databases. The documented abandoned mine was a uranium/phosphate mine, which is known to contribute to arsenic contamination of surface waters. It is probable that other similar mines were present in the area historically and therefore abandoned mines are contributing to high arsenic in West Fork Blacktail Deer Creek.

Water quality data used in developing the TMDL for West Fork Blacktail Deer Creek are provided below in **Table 5-25** and can be found at the water quality portal (https://www.waterqualitydata.us/) and in **Appendix B** of this document.

Spatial and Seasonal Trends

Exceedance of the arsenic standard occurred at low and high flow. All sites downstream of M02MDWFC04 exceeded the arsenic standard, indicating a source downstream of this site. However, no known abandoned mines are located downstream of M02MDWFC04. Therefore, the source may be an abandoned mine not in the MBMG or DEQ databases

Table 5-25. West Fork Blacktail Deer Creek Metals Water Quality Data and Target Exceedances, from Upstream to Downstream

Site ID	**Collecting Entity**	**Sampling Date**	**Hardness** (mg/L)	**Flow** (cfs)	**Arsenic** (µg/L) **TR**	**TSS** (µg/L)
BVD-WFBTDC-1	Wat Grp	6/1/2009	--	23.6	1.3	51
M02MDWFC04	MT DEQ	8/5/2014	264	7.34	2	--
M02MDWFC05	MT DEQ	8/5/2014	369	10.89	**16***	--
BVD-WFBTDC-2	Wat Grp	6/1/2009	280	41.15	**12***	88.5
M02BDWFC02	MT DEQ	8/5/2014	383	8.59	**16***	--

TSS = Total Suspended Solids; MT DEQ=Montana DEQ; Wat Grp=Beaverhead Watershed Committee
* Values denoted by an asterisk exceed human health target

5.6 Approach to Total Maximum Daily Loads

This section describes the general approach used for TMDL development and presents TMDLs for each of the waterbody-pollutant combinations under different flow conditions. **Section 5.7** describes in further detail the specific TMDLS for each waterbody-pollutant combination and outlines the allocations to each pollutant category. **Section 5.7** also discusses loading estimates and load allocations established for high and low flow scenarios, depending on when each pollutant was exceeded. Loading estimates and allocations are based on observed water quality data and flow conditions measured during these time periods.

Because streamflow varies seasonally, TMDLs are not expressed as a static value, but as an equation of the appropriate target multiplied by flow as shown in **Equation 6-1**:

Equation 6-1: TMDL (lbs/day) = (X) (Y) (0.0054)

*X = lowest applicable water quality target in µg/L (**Table 5-26**)*
Y = streamflow in cubic feet per second (cfs)
0.0054 = conversion factor

Table 5-26. Formulas used to determine water quality targets for development of TMDLs

Metal	**Lowest Applicable Target**	**Equation**
Aluminum	• Chronic aquatic life standard (87 µg/L)	NA
Arsenic	• Human health standard (10 µg/L)	NA
Cadmium	• Chronic aquatic life standard (varies according to water hardness)	• = EXP(0.7977*(LN(hardness))-3.909)
Copper	• Chronic aquatic life standard (varies according to water hardness)	• = EXP(0.8545*(LN(hardness))-1.702)
Iron	• Chronic aquatic life standard (constant of 1000 µg/L)	• = 1000 µg/L
Lead	• Hardness less than 339 mg/L as CaCO3, chronic aquatic life standard applies • Hardness equal to or greater than 339 mg/L as CaCO3, human health standard applies (constant of 15 µg/L)	• = EXP(1.273*(LN(hardness))-4.705) • = 15 µg/L
Zinc	• Acute and chronic aquatic life standards are identical and therefore apply equally (both vary equally according to hardness)	• = EXP(0.8473*(LN(hardness))+0.884)

As flow increases, the allowable load (TMDL) increases as shown by the example **Figure 5-11** for lead. Graphs detailing the change in allowable load for each pollutant are found in **Appendix C**. It is important to remember that the TMDLs in these figures are based on the applicable water quality standard (**Table 5-26)**, and that the allowable load increases with flow and in many cases, is hardness-dependent. For all metals in the Beaverhead TPA, the lowest applicable standard was the chronic aquatic life standard, with the exception of arsenic in Steel Creek and West Fork Blacktail Deer Creek, which was the human health standard.

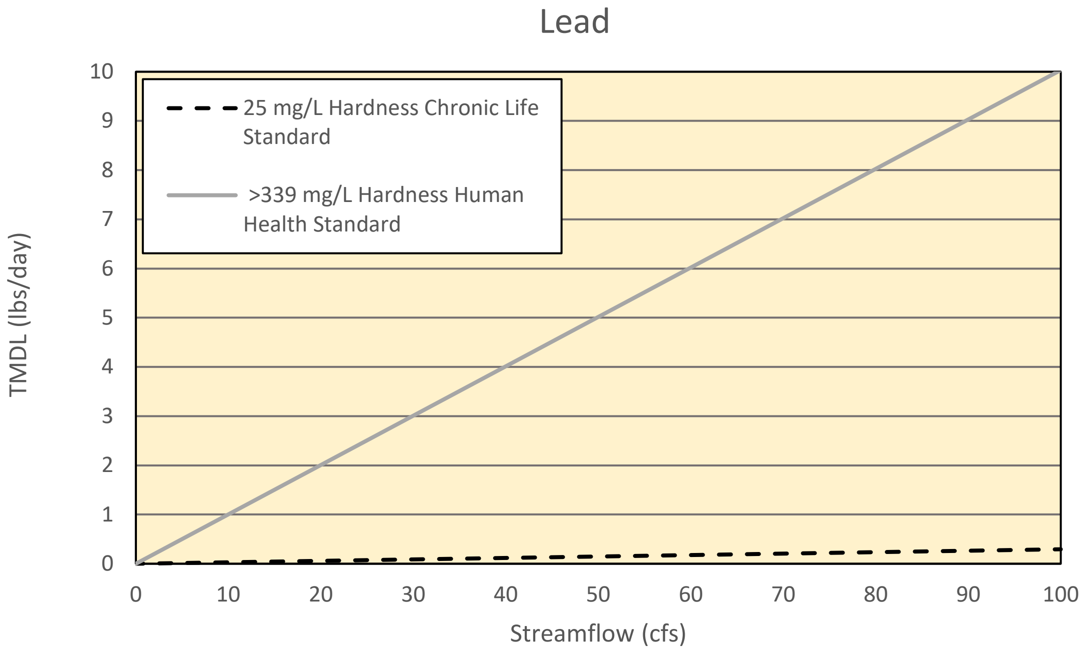

Figure 5-11. Graph Illustrating the TMDL for Lead at Different Hardness and Flow Levels; Refer to Appendix C for Similar Graphs for Other Pollutants

5.6.1 Metals Allocations

Metals TMDLs are allocated to point (wasteload allocations) and nonpoint (load allocations) sources. The TMDL is comprised of the sum of the load allocations (LA) and wasteload allocations (WLA) to all significant point and nonpoint metals sources (natural and human), plus a margin of safety (MOS) that accounts for uncertainties in loading and receiving water analyses. WLAs are allowable pollutant loads that are assigned to permitted and non-permitted point sources. LAs include the pollutant load from naturally occurring sources.

In addition to metals load allocations, the TMDL must also take into account the seasonal variability of metals loads and adaptive management strategies in order to address uncertainties inherent in environmental analyses. This is accomplished through the use of a margin of safety (MOS) in the TMDL calculation. These elements are combined in the following equation:

Equation 6-2: TMDL = ΣLA + ΣWLA + MOS

LA = Load allocation or the portion of the TMDL allocated to natural background (LA_{nb}) and upstream sources (LA_{up})
WLA=Wasteload allocation to abandoned mines and human sources (Comp WLA_{AB+HS}), and point sources with active permits (WLA_{ACTIVE})
MOS = Margin of Safety

The MOS is an accounting of uncertainty about the relationship between metals loads and receiving water quality. An implicit MOS, as discussed later in **Section 5-8**, is applied to all metals TMDLs.

Therefore, the explicit MOS in the above equation is equal to zero and no longer included within the equation and discussion of allocations in this section.

Metals allocations are based on metal sources, which include the following:

- Natural background (non-anthropogenic sources such as influences from local geology)
- Active mines, including those permitted by DEQ and those that fall under the small miner exclusion and open cut permits
- Abandoned mines and other human sources
    - in-stream, and floodplain metals deposits from historical mining operations
    - drainage/runoff from abandoned mines, including adits (entrances)and tailings (waste piles)
    - upland disturbances form human activities (agriculture, recreation)
    - nonpoint sources, which can accelerate erosion of mineralized soils

5.6.1.1 Natural Background Loading (LA_{NB})

Natural background loading of metals occurs as a result of regional and local geologic conditions. Therefore, natural background loading will be accounted for separately from other human-caused sources in final TMDL allocations.

Natural concentrations were estimated from DEQ water quality sampling sites with similar natural geology as the TMDL streams in the Beaverhead Watershed. ArcGIS was used to identify which of these sites has no known history of mining upstream. If multiple water quality samples existed for a site, median values across all dates were used to determine and assign a value. Background concentrations for setting the load allocation to natural background were determined by taking the 75^{th} percentile of median values across sites. This method assumed natural concentrations to be in the higher range of data values collected. A list of reference sites and raw values used in calculations are found in **Appendix B.**

The natural background load is equal to the natural background allocation under all conditions in this document and can be calculated for each flow for each stream as follows:

Equation 6-3: LA_{NB} = Natural Background Load Allocation (lbs/day) = (X) (Y) (k)
*X= Natural background concentration in µg/L (provided in **Table 5-27**)*
Y= streamflow in cubic feet per second
k = conversion factor of 0.0054

If future monitoring allows for determination of a more representative natural background loading contribution, or indicates different background concentrations than indicated in **Table 5-27**, the allocations may be changed via an adaptive management process.

Table 5-27. Natural Background Concentrations used in TMDL Allocations

Parameter	Sample Count	75^{th} Percentile Concentration (µg/L)
Aluminum (Dissolved) (µg/L)	7	50.0
Arsenic (Total) (µg/L	10	3.50
Cadmium (Total) (µg/L)	7	0.030
Copper (Total) (µg/L)	9	1.00

Table 5-27. Natural Background Concentrations used in TMDL Allocations

Parameter	Sample Count	75th Percentile Concentration (µg/L)
Iron (Total) (µg/L)	9	240.00
Lead (Total) (µg/L)	9	0.50
Zinc (Total) (µg/L)	8	2.95

5.6.1.2 Active Mines (WLA_{Active})

Loading sources associated with active mining operations are similar to abandoned mines (dispersed tailings, waste rock piles). However, for the metals impaired segments in the Beaverhead TPA, they are general not as widespread or abundant as abandoned mine sources. Unlike abandoned mines, loading from active mines requires an individual Montana Pollutant Discharge Elimination System (MPDES) surface water discharge permit. General permits are considered to have a loading of zero the majority of the time. Individual permittees are required to provide a record of potential contaminants leaving their facilities. The WLA_{ACTIVE} allocation is estimated by summing the load for each outfall associated with individual permittees. The load is based on the water quality standard and estimated flow associated with the outfall.

Equation 6-4: WLA_{ACTIVE} = ΣWasteload Allocation from Individual Active Permits (lbs/day) = (X) (Y) (k)
*X= Water quality standard in µg/L (provided in **Table 5-26**)*
Y= flow from all outfall
k = conversion factor of 0.0054

5.6.1.3 Abandoned Mines and Other Human Caused Sources (Comp WLA_{AB+HS})

In the case of the metals impaired subwatersheds in the Beaverhead TPA, there is not enough data from individual abandoned mines to allocate a percentage of the TMDL to an individual site. Many or all the metals sources could fall under the definition of a nonpoint source and thus be addressed via one or more load allocations (LAs). However, because the available information is insufficient to rule out the possible existence of features at abandoned mine sites that meet the Clean Water Act definition of a point source, which is "a discernible, confined, and discrete conveyance…from which pollutants are or may be discharged (40 CFR 122.2), a WLA allocation will be applied to account for loading form abandoned mines.

There are also a number of human activities that take place in these subwatersheds that may be mobilizing metals via increased erosion. These potential human-caused sources are diffuse low impact sources (roads, activities associated with agriculture, other sediment/metals producing sources). In most cases, the connection between these land disturbances and their potential contributions of metals pollution is not clear. However, these sources cannot be completely discounted as potential metals loading pathways or sources.

The contribution from all historical mining activities (e.g. abandoned mines, waste rock, tailings, etc.) and all other human caused metals sources (agriculture, roads etc.) in a contributing area or entire watershed is grouped into a composite WLA for abandoned mines and human sources. This approach is based on the assumption that reductions in metals loading can be achieved through the remediation of the abandoned mines and the use of best management practices (BMPs) to control the other pollutant loads. The composite $CompWLA_{AB+HS}$ is determined by calculating the difference between the TMDL and the sum of the natural background load and the load from any active permitted mines or upstream sources (**Section 5.6.1.4**).

5.6.1.4 Upstream Subwatersheds (LA_{UP})

For the Lower Rattlesnake Creek high flow allocations, a portion of the existing load was allocated to Upper Rattlesnake Creek using the following equation.

Equation 6-5: LA_{UP} = Upstream Allocation (lbs/day) = (X) (Y) (k) - Upstream Natural Load
X= Metals concentration in µg/L (Target concentration for Lower Rattlesnake Creek)
Y= streamflow in cubic feet per second (contribution of flow from Upper Rattlesnake Creek)
k = conversion factor of 0.0054

The upstream natural load was determined by multiplying the reference concentration (**Table 5-27**) by the upstream contribution (15.5 cfs) of Upper Rattlesnake Creek, and by the conversion factor (0.0054).

The upstream contribution at low flows not be determined due to complex interactions between stream flow and metals concentrations potentially related to water withdrawals.

5.6.2 Metals TMDL Examples for Metals Listed Streams in the Beaverhead TPA

TMDLs address impairments that are a result of water quality standard exceedances. With the exception of TMDLs for Upper Stone Creek (which had active MPDES permits) and Lower Rattlesnake Creek (which had a metals allocation to Upper Rattlesnake Creek), metals allocations consisted of a composite WLA to abandoned mines and other human sources and a LA to natural background metals sources. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 5.8,** and therefore equal to zero in the TMDL equation. Metals TMDLs are described by the following equation:

Equation 6-6: $TMDL = LA_{NB} + LA_{up} + WLA_{ACTIVE} + Comp\ WLA_{AB+HS}$

LA_{NB} = Load allocation to natural background sources
LA_{UP} = Load allocation to upstream subwatershed (Lower Rattlesnake only)
WLA_{ACTIVE} =Wasteload allocation from active mines, if applicable
Comp WLA_{AB+HS} = Wasteload allocation to abandoned mining point sources and all other human sources

In order to determine the percent reduction needed, the TMDL must be compared to the Existing Load, which depends on the current metals concentration:

Equation 6-7: Existing load (lbs/day) = (X) (Y) (0.0054)
X = Metal concentration in water (µg/L) (highest for given flow conditions; see below)
Y = streamflow in cubic feet per second (cfs)

Low-flow sampling conditions were considered to occur when the stream flow was less than 50% of the maximum flow collected at the site, where high flow conditions were considered to occur when the stream flow was greater than 50% of the maximum flow at the site. The following steps were used to calculate wasteload allocations and amount of reductions needed to meet water quality standards:

Step 1: Use equations in **Table 5-26** to determine the concentration of the pollutant that is toxic at the lowest hardness value measured for the low and high flow conditions.

Step 2: Multiply the concentration in step 1 by the highest stream flow within the low and high flow conditions, and conversion factor (**Equation 6-2**) to obtain the TMDL.
Step 3: Calculate the natural background load allocation (LA_{NB}) using **Equation 6-3** using concentrations in **Table 5-27** and the stream flows used in step 2.
Step 4: Calculate the permitted wasteload (WLA_{ACTIVE}) using flow data from permitted outfalls, if applicable (**Equation 6-4**)
Step 5: Calculate the LA_{UP} using flow data and concentrations from the upstream waterbody ID, if applicable.
Step 6: Subtract the LA_{NB}, LA_{UP}, and any WLA_{ACTIVE} from the TMDL to determine the Comp WLA_{AB+HS}
Step 7: a) The percent reduction needed is the reduction in anthropogenic loading needed to meet water quality criteria:
(Existing Load –TMDL) / (Existing Load) * 100

Using the highest stream flow and concentrations measured within the low and high flow conditions allowed for a significant margin of safety by basing the example TMDL on a maximum amount of loading previously measured at the site. However, in several cases, a different range of concentrations and flow estimates were used as described in the following paragraph and also in **Section 5.7**.

For Grasshopper Creek, water quality data indicated that the low flow impairment occurred at the most upstream site, where the high flow impairment occurred at the most downstream site. Therefore, the low flow allocation was based on water quality and flow data collected at the most upstream site, whereas the high flow allocation was based on data collected at the most downstream site. For Upper Rattlesnake Creek, TMDL calculations were based on water quality and flow data collected at sites downstream of BVD-RSC-2, because data indicated a source downstream of this site. For Steel Creek, the TMDL calculation at low and high flow was based on the only flow ever collected, and the maximum concentration of arsenic collected. For Lower Stone Creek, the TMDL calculations were based on water quality and flow data collected at M02STONC06, due to water additions below this site. For Wellman Creek, the TMDL calculations at low and high flows were based on metals concentrations at the sample site M02WLMNC02, because data indicated a source of metals immediately above this site and potential dilution downstream of the site.

These TMDL examples are examples based on previously measured water quality data and streamflow data, but do not represent all conditions that could occur. Refer to **Appendix C** for example TMDLs with increasing stream flow.

5.7 TMDL Allocations

The following section describes the TMDLs and metals allocation for West Fork Blacktail Deer, Grasshopper, Upper Rattlesnake, Lower Rattlesnake, Spring, Steel, Upper Stone, Lower Stone, and Wellman creeks. Metals TMDLs are presented herein and summarized in **Tables 5-28** through **5-37**. A TMDL is a calculation of the maximum pollutant load a waterbody can receive while maintaining water quality standards (**Section 5.6**). The TMDLs presented below are based on the most stringent applicable water quality criteria identified in **Table 5-26** and an example streamflow and/or hardness. To determine the TMDL at a different streamflow and hardness, refer to **Table 5-26** and **Appendix C.**

In the sections that follow, a loading summary and source load allocations are provided for each waterbody-pollutant combination for which a TMDL is prepared. Loading summaries are based on the sample data used for metals target evaluations. For each waterbody-pollutant combination, water quality and flow volume data are used to calculate metals loading estimates and the required percent load reduction to achieve the TMDL. Load estimations and allocations are based on a limited data set and are assumed to approximate general metals loading during high and low flow conditions. Refer to **Appendix C** for specific data and calculations used in developing allocations.

5.7.1 Grasshopper Creek Allocations (MT41B002_010)

TMDLs for Grasshopper Creek address impairments that are a result of lead water quality standard exceedances. No readily identifiable sources are present from human activities or active mines. Therefore, metals allocations for Grasshopper Creek consist of a composite WLA to abandoned mines and other human sources and an LA to natural background metals sources. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 5.8,** and therefore equal to zero in the TMDL equation in **Section 5.6**.

Water quality data indicate that the most upstream exceedance of the standard was largely influenced by the low hardness levels, and that the most downstream exceedance (only at high flows) is potentially related to a source near the mouth. Therefore, the low flow condition was based on hardness and flow collected at the most upstream site of M02GHPRC02, and the high flow condition was based on the lowest hardness and highest flow values downstream of BVD-GH3. The TMDL for lead is exceeded at high and low flow events (**Table 5-28**).

Table 5-28. Grasshopper Creek: Metals TMDLs and Allocations for Example Flow Conditions

Parameter	Flow*	Existing Load (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	Percent Reduction Needed
Lead	Low	0.0018	0.0011	0.001	0.0001	39%
	High	7.55	3.36	0.90	2.46	55%

*Example conditions based upon: low flow =0.37 cfs; low flow hardness=25; high flow=332.72 cfs; high flow hardness=66

5.7.2 Upper Rattlesnake Creek Allocations (MT41B002_091)

TMDLs for Upper Rattlesnake Creek address impairments that are a result of lead water quality standard exceedances. No readily identifiable sources are present from human activities or active mines. Therefore, metals allocations for Upper Rattlesnake Creek consist of a composite WLA to abandoned mines and other human sources and an LA to natural background metals sources. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 5.8,** and therefore equal to zero in the TMDL equation in **Section 5.6**.

Example total maximum daily loads were based on metals concentrations at sites downstream of BVD-RSC-2, because field sampling suggested a source downstream of this site. The TMDL for lead is exceeded at low and high flow events (**Table 5-29**).

Table 5-29. Upper Rattlesnake Creek: Metals TMDLs and Allocations for Example Flow Conditions

Parameter	Flow**	Existing Load (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	Percent Reduction Needed
Lead	Low	3.53	0.29	0.09	0.20	92%
	High	14.35	0.65	0.36	0.28	96%

Table 5-29. Upper Rattlesnake Creek: Metals TMDLs and Allocations for Example Flow Conditions

Parameter	Flow**	Existing Load (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	Percent Reduction Needed

**Example conditions for lead based upon: low flow=33.06 cfs; low flow hardness=59; high flow=134.17 cfs; high flow hardness=37

5.7.3 Lower Rattlesnake Creek Allocations (MT41B002_090)

TMDLs for Lower Rattlesnake Creek address impairments that are a result of copper and lead water quality standard exceedances. No readily identifiable sources are present from human activities or active mines. Therefore, metals allocations for Lower Rattlesnake Creek consist of a composite WLA to abandoned mines and other human sources and an LA to natural background metals sources. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 5.8,** and therefore equal to zero in the TMDL equation in **Section 5.6.1.**

For the high flow example, a portion of the existing copper and lead load was allocated to Upper Rattlesnake Creek (LA_{up}) by multiplying the estimated discharge from Upper Rattlesnake Creek (15.5 cfs) by the respective water quality standard (copper=2.85 µg/L; lead=0.55 µg/L), and by conversion factor (0.0054), then subtracting the natural load (**Appendix C**).

The actual measured concentrations were also used to estimate the amount of existing load from Upper Rattlesnake Creek (in parenthesis in **Table 5-30**). This was estimated by using maximum concentrations of copper and lead measured in Upper Rattlesnake Creek to estimate the actual load (4 µg/L and 19.8 µg/L respectively), and subtracting the estimated natural load from Upper Rattlesnake Creek.

Water quality data indicate that Upper Rattlesnake Creek contributes approximately 3% of the copper load and 94% of the lead load to Lower Rattlesnake Creek during high flows.

The allocation to upper Rattlesnake Creek at low flows could not be determined due to complex interactions between water withdrawals and water quality, and therefore at low flows the allocation to Upper Rattlesnake Creek is considered part of the Comp $WLA_{AB+HS.}$

The TMDL for copper is exceeded at high flow events, and the TMDL for lead is exceeded at high and low flow events (**Table 5-30**).

Table 5-30. Lower Rattlesnake Creek: Metals TMDLs and Allocations for Example Flow Conditions

Parameter	Flow	Existing Load* (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	LA_{up} (lbs/day) **	Percent Reduction Needed
Copper	Low	0.04	0.12	0.02	0.10	ND	0%
	High	7.4	0.41	0.14	0.11	0.16 (0.25)	94%
Lead	Low	0.15	0.035	0.01	0.025	ND	76%
	High	1.73	0.077	0.071	0.002	0.004 (1.62)	96%

*Example conditions for copper and lead based upon: low flow=3.62 cfs; low flow hardness=64; high flow=26.3 cfs; high flow hardness=25

Table 5-30. Lower Rattlesnake Creek: Metals TMDLs and Allocations for Example Flow Conditions

Parameter	Flow	Existing Load* (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	LA_{up} (lbs/day) **	Percent Reduction Needed

**Example conditions for upstream allocations based upon: high flow=15.5 cfs; standard @hardness 25, lead = 0.55 µg/L copper = 2.85 µg/L; actual load in parenthesis is based on max concentrations in Upper Rattlesnake
ND=LA_{up} could not be determined due to complex flow interactions; it is considered part of WLA_{AB+HS}

5.7.4 Spring Creek Allocations (MT41B002_080)

TMDLs for Spring Creek address impairments that are a result of iron water quality standard exceedances. No readily identifiable sources are present from human activities or active mines. Therefore, metals allocations for Spring Creek consist of a composite WLA to abandoned mines and other human sources and an LA to natural background metals sources. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 5.8,** and therefore equal to zero in the TMDL equation in **Section 5.6**.

The TMDL for iron is exceeded at high flow events (**Table 5-31**).

Table 5-31. Spring Creek: Metals TMDLs and Allocations for Example Conditions

Parameter	Flow**	Existing load (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	Percent Reduction Needed
Iron	Low	4.17	6.05	1.45	4.60	0%
	High	28.07	19.22	4.61	14.61	31%

** Example conditions for high and low flow based upon: low flow =1.12 cfs; high flow =3.56 cfs

5.7.5 Steel Creek Allocations (MT41B002_160)

TMDLs for Steel Creek address impairments that are a result of arsenic water quality standard exceedances. No readily identifiable sources are present from human activities or active mines. Therefore, metals allocations for Steel Creek consist of a composite WLA to abandoned mines and other human sources and an LA to natural background metals sources. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 5.8,** and therefore equal to zero in the TMDL equation in **Section 5.6**. The flow used in the example is the only flow that has been measured in Steel Creek.

The TMDL for arsenic is exceeded during the example flow event (**Table 5-32**).

Table 5-32. Steel Creek: Metals TMDLs and Allocations for Example Conditions

Parameter	Flow**	Existing load (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	Percent Reduction Needed
Arsenic	Low/High	0.0059	0.0027	0.0009	0.0018	54%

** Example conditions based upon: low/high flow=0.05 cfs

5.7.6 Upper Stone Creek Allocations (MT41B002_132)

TMDLs for Upper Stone Creek address impairments that are a result of iron water quality standard exceedances. Therefore, metals allocations for Upper Stone Creek consist of a composite WLA to abandoned mines and other human sources, a WLA to active mines, and a LA to natural background metals sources. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 5.8,** and therefore equal to zero in the TMDL equation in **Section 5.6**.

To determine WLA_{ACTIVE} for low and high flows, the WLA for each outfall associated with MPDES permits (**Table 5-33**) was determined using the following equation:

WLA=Outfall flow (cfs) * Iron Criteria (1000 µg/L) * 0.0054

Based on a review of mining operations, iron was not identified as a parameter of concern at The Imerys mining site (individual permit MT0027821). Further, the MPDES permittee has applied for termination its permit. Therefore, this permittee was not allocated a WLA. In addition, Barretts Minerals Treasure Mine was not allocated a WLA for general permit MTR000510 because it is a stormwater permit and rarely discharges.

Water quality data from Barretts Minerals Treasure mine (individual permit MT0029891) indicate that this permittee discharges iron into Left Fork Stone Creek. For the TMDL example, a wasteload allocation was estimated based on outfall data collected by individual permittee during similar streamflows as was used to develop the TMDLs. Outfall flows were summed to obtain the WLA_{ACTIVE} during each flow condition (**Tables 5-33**). Because the water quality data collected by the permittee are near the iron standard, it is recommended that the permittee continue to collect extensive iron data and that any future permittees in Upper Stone Creek be held to the iron criteria in order to maintain water quality in Upper Stone Creek. **Figure 5-12** shows example WLA_{ACTIVE} amounts that should be allocated at different outfall flows. The flow used to calculate the natural background load was the estimated flow upstream of the point source. The water discharged from the mine may also contain some background iron, but it is considered to be incorporated into the allocation for WLA_{ACTIVE}.

The TMDL for iron in Upper Stone Creek is exceeded at high and low flows (**Table 5-34).**

Table 5-33. Calculation of WLA_{Active} for Upper Stone Creek Permit No. MT0029891

ID	Outfall Flow (cfs)	Target Concentration	WLA
Low Flow			
Outfall1	0.60	1000	3.24
Outfall2	0.13	1000	0.70
		WLA_{ACTIVE}	**3.94**
High Flow			
Outfall1	0.93	1000	5.02
Outfall2	0.62	1000	3.35
		WLA_{ACTIVE}	**8.37**

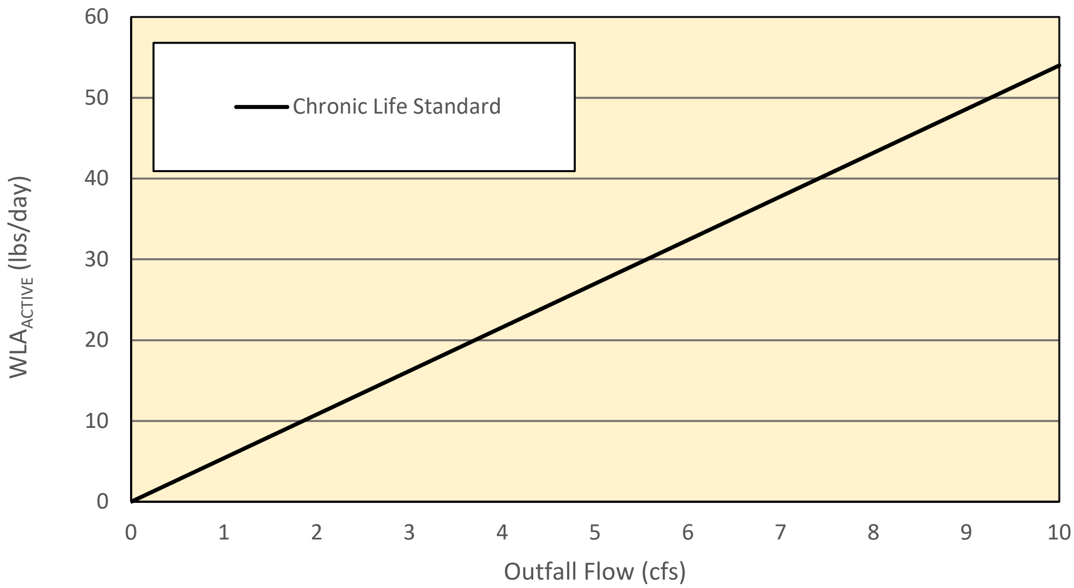

Figure 5-12. WLA_{ACTIVE} for Example Outfall Flows in Upper Stone Creek.

Table 5-34. Upper Stone Creek: Example Metals TMDLs and Allocations

Parameter	Flow**	Existing Load (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	WLA_{ACTIVE} (lbs/day)	Percent Reduction Needed
Iron	Low	6.57	5.13	0.29	0.90	3.94	22%
	High	44.95	11.01	0.64	2.01	8.37	75%

**Example conditions for high and low flow based upon: low flow=0.95 cfs; high flow=2.04 cfs

5.7.7 Lower Stone Creek Allocations (MT41B002_131)

TMDLs for Lower Stone Creek address impairments that are a result of aluminum, copper, and iron water quality standard exceedances. Based MBMG and MPDES databases, no abandoned or active mines are present in the Lower Stone Creek subwatershed. Water quality data indicate that Upper Stone Creek contributes a significant amount of the load of metals to Lower Stone Creek and contains both abandoned mines and active mines. However, the load allocation from Upper Stone Creek could not be calculated from existing water quality due to complicated water withdrawals and additions that occur starting in the lower portion of Upper Stone Creek. The $CompWLA_{AB+HS}$ is considered to include sources from abandoned mines and human activities in both Upper and Lower Stone Creek subwatersheds, with the understanding that most of the load is coming from Upper Stone Creek.

Metals allocations for Lower Stone Creek consist of a composite WLA to abandoned mines and other human sources and an LA to natural background metals sources. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 5.8,** and therefore equal to zero in the TMDL equation in **Section 5.6**.

The example TMDL was based on water quality and stream flow data collected at upstream site M02STONC06. Concentrations monitored at the downstream site did not exceed standards, potentially because of irrigation water additions diluting the metals concentrations at the downstream sites. The aluminum, copper, and iron TMDLs were all exceeded at high flows, but not at low flows (**Table 5-35**).

Table 5-35. Lower Stone Creek: Example Metals TMDLs and Allocations

Parameter	Flow**	Existing Load (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	LAup (lbs/day)	Percent Reduction Needed
Aluminum	Low	0.01	0.05	0.03	0.02	ND	0.0%
	High	0.95	0.45	0.26	0.19	ND	52.5%
Copper	Low	0.001	0.009	0.0005	0.0085	ND	0.0%
	High	0.103	0.087	0.005	0.082	ND	16%
Iron	Low	0.06	0.54	0.13	0.41	ND	0.0%
	High	51.63	5.18	1.24	3.94	ND	90%

**Example conditions for high and low flow based upon: low flow=0.10 cfs; low flow hardness=199; high flow=0.96 cfs; high flow hardness=199

ND=LA_{up} could not be determined due to complex flow interactions; it is considered part of WLA_{AB+HS}

5.7.8 Wellman Creek Allocations (MT41B002_150)

TMDLs for Wellman Creek address impairments that are a result of copper, cadmium, lead, aluminum, and zinc water quality standard exceedances. No readily identifiable sources are present from human activities or active mines. Therefore, metals allocations for Wellman Creek consist of a composite WLA to abandoned mines and other human sources and an LA to natural background metals sources. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 5.8,** and therefore equal to zero in the TMDL equation in **Section 5.6.1**.

The highest exceedance of standards for all metals occurred at a site immediately downstream of an abandoned mine source. Given the presence of an abandoned mine immediately above this source, the highest concentration at this sample site (M02WLMNC02, 5/27/2015) were used to estimate examples TMDLs for both high and low flows, and the lowest hardness value from this site were used to set targets based on chronic water quality criteria.

The TMDL for copper, and cadmium, lead, aluminum, and zinc, are estimated to be exceeded at low and high flows (**Table 5-36**).

Table 5-36. Wellman Creek: Example Metals TMDLs and Allocations

Parameter	Flow**	Existing Load (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	Percent Reduction Needed
Copper	Low	0.078	0.010	0.002	0.008	87%
	High	0.207	0.027	0.004	0.022	87%
Cadmium	Low	0.00094	0.00030	0.00005	0.00025	68%
	High	0.0025	0.0008	0.0001	0.0007	68%
Lead	Low	0.0053	0.0027	0.0008	0.0019	50%

Table 5-36. Wellman Creek: Example Metals TMDLs and Allocations

Parameter	Flow**	Existing Load (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	Percent Reduction Needed
	High	0.014	0.007	0.002	0.005	50%
Aluminum	Low	0.27	0.14	0.08	0.06	48%
	High	0.72	0.38	0.22	0.16	48%
Zinc	Low	0.355	0.129	0.004	0.125	64%
	High	0.95	0.34	0.01	0.33	64%

**Example conditions for high and low flow based upon: low flow=0.3 cfs; low flow hardness=62; high flow=0.8 cfs; high flow hardness=62

5.7.9 West Fork Blacktail Deer Creek Allocations (MT41B002_060)

TMDLs for West Fork Blacktail Deer Creek address impairments that are a result of arsenic water quality standard exceedances. There are no readily identifiable human caused metals sources or active mines. Therefore, metals allocations for West Fork Blacktail Deer Creek consist of a composite WLA to abandoned mines and other human sources and an LA to natural background metals sources. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 5.8,** and therefore equal to zero in the TMDL equation in **Section 5.6**.

Water quality data indicate a source downstream of the one abandoned mine present in the MBMG database. Many abandoned mines are present in the landscape that have never been identified. The one documented abandoned mine was a uranium/phosphate mine. This type of mining is a known contributor to arsenic contamination of surface waters. In development of the TMDL, the high arsenic concentration was considered to be human-caused due to a probable undocumented abandoned mine source.

The TMDL for arsenic was exceeded at high and low flows (**Table 5-37**).

Table 5-37. West Fork Blacktail Deer Creek: Metals TMDLs and Allocations for Example Flow Conditions

Parameter	Flow**	Existing Load (lb/day)	TMDL (lbs/day)	LA_{NB} (lbs/day)	Comp WLA_{AB+HS} (lbs/day)	Percent Reduction Needed
Arsenic	Low	0.74	0.46	0.16	0.30	38%
	High	3.59	2.24	0.78	1.46	38%

**Example conditions based upon: low flow =8.59 cfs; high flow=41.50 cfs

5.8 Seasonality and Margin of Safety

All TMDL documents must consider the seasonal variability (seasonality) and influence of varying water flows on water quality impairment conditions, TMDLs and allocations. TMDL development must also incorporate a margin of safety (MOS) to account for uncertainties in pollutant sources and other watershed conditions, and ensure (to the degree practicable) that the TMDL components and requirements are sufficiently protective of water quality and beneficial uses. This section describes the considerations of seasonality and an MOS in the Beaverhead TPA metals TMDL development process.

5.8.1 Seasonality

Seasonality addresses the need to ensure year-round designated use support. Seasonality is considered for assessing loading conditions and for developing water quality targets, TMDLs, and allocation schemes. In general, it is considered typical for high flows to occur in spring and the lowest flows to occur in summer, near the time of water withdrawals. However, high and low flows can occur at any time. For metals TMDLs, consideration of streamflow is important because metals loading pathways and water hardness change from high to low flow conditions. During high flows, overland flow and erosion of metals-contaminated soils and mine wastes tend to be the major cause of elevated metals concentrations. During low flow, groundwater and/or adit discharges may be a more significant contributing source of elevated metals concentrations. Additional loading sources that are dependent on streamflow and/or seasonality include contributions such as stormwater runoff and natural background. Seasonality/flow effects addressed in this document as follows:

- Metals concentrations and loading conditions are evaluated for both high flow and low flow conditions. DEQ's assessment method uses a combination of both high and low flow sampling for target evaluation since abandoned mines and other metals sources can lead to elevated metals loading during high and/or low flow conditions.
- Metals TMDLs incorporate streamflow as part of the TMDL equation.
- Metals concentration targets apply year-round, with monitoring criteria for target attainment developed to address flow-related seasonal water quality extremes associated with loading and hardness variations.
- A sediment chemistry target is often applied as a supplemental indicator to help capture impacts from episodic metals loading events that could be attributed to high flow runoff conditions.
- When applicable, targets, TMDLs and load reduction needs are developed for example high and low flow conditions. The TMDL equation incorporates all potential flow conditions that may occur during any season.

5.8.2 Margin of Safety

The MOS is to ensure that TMDLs and allocations are sufficient to sustain conditions that will support designated uses. All metals TMDLs incorporate an implicit MOS in several ways, using conservative assumptions throughout the TMDL development process, as summarized below:

- DEQ's assessment process includes a mix of high and low flow sampling since abandoned mines and other metals sources may contribute to elevated metals loading during high and/or low flow stream conditions. The seasonality considerations help identify the low range of hardness values and thus the lower range of applicable TMDL values shown within the TMDL graphs and captured within the example TMDLs.
- Target attainment, refinement of allocations, and, in some cases, impairment validations and TMDL-development decisions are all based on an adaptive management approach that relies on future monitoring and assessment for updating planning and implementation efforts.
- Although a 10% exceedance rate is allowed for chronic and acute based aquatic life targets, the TMDLs are set so the lowest applicable target is satisfied 100% of the time. This focuses remediation and restoration efforts toward 100% compliance with all targets, thereby providing an MOS for the majority of conditions where the most protective (lowest) target value typically linked to the numeric aquatic life or human health standard. As part of this, the existing water

quality conditions and needed load reductions are based on the highest measured value for a given flow condition in order to consistently achieve the TMDL.
- The monitoring results used to estimate existing water quality conditions are instantaneous measurements used to estimate a daily load, whereas CAL standards are based on average conditions over a 96-hour period. This provides an MOS since a four-day loading limit could potentially allow higher daily loads in practice.
- The lowest or most stringent numeric water quality standard was used for TMDL target and impairment determination for all waterbody – pollutant combinations. This ensures protection of all designated beneficial uses.
- Sediment metals concentration criteria were used as a supplemental indicator target. This helps ensure that episodic loading events were not missed as part of the sampling and assessment activity.
- The TMDLs are based on numeric water quality standards developed at the national level via EPA and incorporate an MOS necessary for the protection of human health and aquatic life.

5.9 Uncertainty and Adaptive Management

The environmental analysis conducted as part of TMDL development include inherent uncertainties: accuracy of field and laboratory data, for example. Data concerns are managed by DEQ's data quality objectives process. The use of data quality objectives ensures that the data is of known (and acceptable) quality. The data quality objectives process develops criteria for data performance and acceptance that clarify study intent, define the appropriate type of data, and establish minimum standards for the quality and quantity of data.

The accuracy of source assessments and loading analyses is another source of uncertainty. An adaptive management approach that revisits, confirms, or updates loading assumptions is vital to maintaining stakeholder confidence and participation in water quality improvement. Adaptive management uses updated monitoring results to refine loading analysis, to further customize monitoring strategies and to develop a better understanding of impairment conditions and the processes that affect impairment. Adaptive management recognizes the dynamic nature of pollutant loading and water quality response to remediation.

Adaptive management also allows for continual feedback on the progress of restoration and the status of beneficial uses. Additional monitoring and resulting refinements to loading will also provide a measure of success.

The metals TMDLs developed for the Beaverhead TMDL Planning Area are based on future attainment of water quality standards. In order to achieve this, all significant sources of metals loading must be addressed via all reasonable land, soil, and water conservation practices. DEQ recognizes however, that in spite of all reasonable efforts, this may not be possible due to natural background conditions and/or the potential presence of unalterable human-caused sources that cannot be fully addressed via reasonable remediation approaches. For this reason, an adaptive management approach is adopted for all metals targets described within this document. Under this adaptive management approach, all metals impairments that required TMDLs will ultimately fall into one of the categories identified below:
- Restoration achieves the metal pollutant targets and all beneficial uses are supported.
- Targets are not attained because of insufficient controls; therefore, impairment remains, and additional source remedies are needed.

- Targets are not attained after all reasonable BMPs and applicable abandoned mine remediation activities are applied. Under these circumstances, site-specific standards may be necessary.
- Targets are unattainable due to naturally occurring metals sources. Under this scenario, site-specific water quality standards and/or the reclassification of the waterbody may be necessary. This would then lead to a new target (and TMDL) for the pollutant(s) of concern, and the new target would reflect the background condition.

The Abandoned Mines Section of DEQ's Remediation Division will lead abandoned mine restoration projects funded by provisions of the Surface Mine Reclamation and Control Act of 1977.

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

PART 3
WATER QUALITY IMPROVEMENT RECOMMENDATIONS

6.0 Water Quality Improvement Plan and Monitoring Strategy

6.1 Purpose of Improvement and Monitoring Strategy

This section describes an overall strategy and specific on-the-ground measures designed to restore water quality beneficial uses and attain metals water quality standards for streams in the Beaverhead TMDL Planning Area. The strategy includes general measures for reducing loading from identified nonpoint sources of metals and historical inactive mining activities in the project area. Effective monitoring is integral to these implementation measures and the foundation of an adaptive management approach. Having a monitoring strategy in place allows for feedback on the effectiveness of restoration activities, the amount of pollutant load reduction (whether TMDL targets are being met), if all significant sources have been identified, and whether attainment of TMDL targets is feasible. Data from long-term monitoring programs also provide technical justifications to modify restoration strategies, targets, or allocations where appropriate.

This section should further assist stakeholders in developing or expanding upon an existing watershed restoration plan (WRP) that will provide more detailed information about restoration goals and monitoring plans related to metals within the Beaverhead River watershed. The WRP may encompass broader goals than the water quality improvement strategy outlined in this document, such as goals related to sediment, temperature, or nutrient impairments. The intent of the WRP is to serve as a locally organized "road map" for watershed activities, prioritizing types of projects, sequences of projects, and funding sources towards achieving local watershed goals. Within the WRP, local stakeholders identify and prioritize streams, tasks, resources, and schedules for applying BMPs. As restoration efforts and results are assessed through watershed monitoring, this strategy should be adapted and revised by stakeholders based on new information and ongoing improvements.

6.2 Role of DEQ, Other Agencies, and Stakeholders

DEQ does not implement TMDL pollutant-reduction projects for nonpoint source activities, but may provide technical and financial assistance for stakeholders interested in improving their water quality. Successful implementation of TMDL pollutant-reduction projects requires collaboration among private landowners, land management agencies, and other stakeholders. DEQ will work with participants to use the TMDLs as a basis for developing locally driven WRPs, administer funding specifically to help support water quality improvement and pollution prevention projects, and help identify other sources of funding.

Because most nonpoint source reductions rely on voluntary measures, it is important that local landowners, watershed organizations, and resource managers work collaboratively with local and state agencies to achieve water quality restoration goals and to meet TMDL targets and load reductions. Specific stakeholders and agencies that may be vital to restoration efforts for streams discussed in this document include:

- Barretts Minerals
- Beaverhead Conservation District
- Beaverhead Watershed Committee
- Bureau of Land Management (BLM) Bureau of Reclamation BOR)
- Montana Aquatic Resources Services

- Montana Bureau of Mines and Geology (MBMG)
- Montana Department of Environmental Quality (DEQ)
- Montana Department of Natural Resources and Conservation (DNRC)
- Montana Department of Fish, Wildlife & Parks (FWP)
- Montana Department of Transportation (DOT)
- Montana State University Extension Water Quality Program
- Montana Trout Unlimited
- Natural Resources and Conservation Service (NRCS)
- U.S. Fish & Wildlife Service (USFWS)
- U.S. Army Corps of Engineers
- U.S. Environmental Protection Agency (EPA)
- U.S. Forest Service (USFS)

6.3 Adaptive Management and Uncertainty

The implementation goals and monitoring strategy presented in this section provide a starting point for the development of more detailed planning efforts regarding restoration and monitoring needs; it does not assign monitoring responsibility. Recommendations provided are intended to assist local land managers, stakeholder groups, and federal and state agencies in developing appropriate plans to meet the water quality improvement goals outlined in this document.

In accordance with the Montana Water Quality Act (MCA 75-5-703 (7) and (9)), DEQ is required to assess the waters for which TMDLs have been completed and restoration measures or BMPs have been applied to determine whether compliance with water quality standards has been attained, water quality is improving, or if revisions to current goals are necessary. This aligns with an adaptive management approach that is incorporated into DEQ's assessment and water quality impairment determination process. The Watershed Protection Section administers and monitors TMDL implementation and works with local watershed groups to identify waterbodies where there have been sufficient activities to warrant an evaluation of current stream conditions.

Adaptive management, as discussed throughout this document, is a systematic approach for improving resource management by learning from management outcomes, and allows for flexible decision making. There is an inherent amount of uncertainty involved in the TMDL process, including: establishing water quality targets, calculating existing pollutant loads and necessary LAs, and determining effects of BMP implementation. Use of an adaptive management approach based on continued monitoring of project implementation helps manage resource commitments and achieve success in meeting the water quality standards and supporting all water quality beneficial uses. This approach further allows for adjustments to restoration goals, TMDLs, and/or allocations, as necessary.

For an in-depth look at the adaptive management approach, view the U.S. Department of the Interior's (DOI) technical guide and description of the process at: https://mylearning.nps.gov/library-resources/adaptive-management-applications-guide/. **Figure 6-1** below is a visual explanation of the iterative process of adaptive management (Williams et al., 2009).

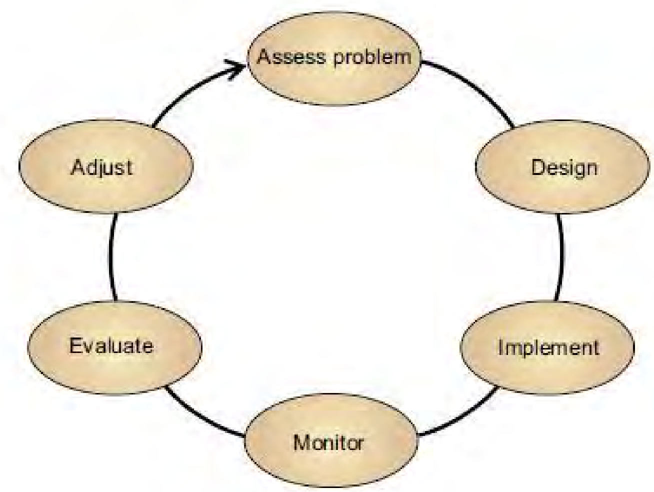

Figure 6-1. Diagram of the Adaptive Management Process

Funding for future implementation and monitoring is uncertain and can vary with economic and political changes. Prioritizing monitoring activities depends on funding opportunities and stakeholder priorities for restoration. Once restoration measures have been implemented for a waterbody with an approved TMDL and given time to take effect, DEQ will conduct a formal evaluation of the waterbody's impairment status and determine whether TMDL targets and water quality standards are being met.

6.4 Water Quality Restoration and Monitoring Objectives

The water quality restoration objective for the Beaverhead TMDL Planning Area is to reduce metals loads as identified throughout this document in order to meet the water quality standards and TMDL targets for full recovery of beneficial uses for all impaired streams. Meeting the metals TMDLs provided in this document will achieve this objective for the identified metals pollutant-impaired streams. Based on the assessment provided in this document, the TMDLs can be achieved through proper implementation of appropriate BMPs for both point and nonpoint sources, and restoration of abandoned mine sites.

Specific objectives for watershed restoration activities should be identified by local watershed groups and other stakeholders through the development of a WRP. A WRP can provide a framework strategy for water quality restoration and monitoring in the Beaverhead River watershed, focusing on how to meet conditions that will likely achieve the TMDLs presented in this document, as well as other water quality issues of interest to local communities and stakeholders. WRPs identify considerations that should be addressed during TMDL implementation and should assist stakeholders in developing a more detailed adaptive plan in the future.

The EPA requires nine minimum elements for a WRP. A complete description can be found at http://www.epa.gov/region9/water/nonpoint/9elements-WtrshdPlan-EpaHndbk.pdf and are summarized here:

1. Identification of the causes and sources of pollutants
2. Estimated load reductions expected based on implemented management measures
3. Description of needed nonpoint source management measures

4. Estimate of the amounts of technical and financial assistance needed
5. An information/education component
6. Schedule for implementing the nonpoint source management measures
7. Description of interim, measurable milestones
8. Set of criteria that can be used to determine whether loading reductions are being achieved over time
9. A monitoring component to evaluate effectiveness of the implementation efforts over time

This document provides, or can serve as an outline, for many of the required elements for addressing metals water quality impairments. Water quality goals for metals are detailed in **Section 5.0**, which include water quality targets as measures for long-term effectiveness monitoring. These targets specify satisfactory conditions to ensure protection and/or recovery of beneficial uses of waterbodies in the Beaverhead TMDL Planning Area. It is presumed that meeting all water quality targets will achieve the water quality goals for each impaired waterbody.

After sediment TMDLs were developed for the Beaverhead Watershed in 2012, the Beaverhead Watershed Committee completed a WRP in 2014. This document describes opportunities to improve water quality from various pollutants and sources. Several projects have already been implemented to address sediment, temperature, and nutrients but continued success will be necessary to meet water quality standards. While there was little discussion of addressing metals in the WRP and no mine reclamation projects have been undertaken to address many of the metals impairments described in this document, the Beaverhead Watershed Committee is working to prioritize sites for clean-up. In 2019, they completed a study of Grasshopper Creek, from Bannack downstream to its confluence with the Beaverhead River, to identify priority source areas to address excess metals and sediment resulting from extensive past mining activities.

6.5 Overview of Management Recommendations

TMDLs were completed for metals on the West Fork Blacktail Deer, Grasshopper, Rattlesnake, Spring, Steel, Stone, and Wellman Creeks. Other tributaries to the upper segment of the Beaverhead River may be in need of restoration or pollutant reduction, but insufficient information about them precludes TMDL development at this time. The following sub-sections describe some generalized recommendations for implementing projects to achieve the TMDLs in this document. Details specific to each stream and related impairments are found within **Section 5.0**.

In general, restoration activities can be separated into two categories: active and passive. Passive restoration allows natural succession to occur within an ecosystem by removing a source of disturbance. Fencing off riparian areas from cattle grazing is a good example of passive restoration. Active restoration, on the other hand, involves accelerating natural processes or changing the trajectory of succession. For example, historic placer mining often resulted in the straightening of stream channels and piling of processed rock on the streambank. These impacts would take so long to recover passively that active restoration methods involving removal of waste rock and rerouting of the stream channel would likely be necessary to improve stream and water quality conditions. In general, passive restoration is preferable because it is generally more cost effective, less labor intensive, and will not result in short term increase of pollutant loads as may occur from active restoration activities. However, in many metals-related cases, active restoration is the only feasible mechanism for achieving desired goals; these activities must be assessed on a case by case basis (Nature Education, 2013).

Past metal mining is the principal sources of excess metals loading in the Beaverhead tributaries
To date, state government agencies have funded and completed reclamation projects associated with past mining. Statutory mechanisms and corresponding government agency programs will continue to have the leading role for future restoration of historical mining areas. Restoration of metals sources is typically conducted under state and federal cleanup programs. Rather than a detailed discussion of specific BMPs, general restoration programs and funding sources applicable to mining sources of metals loading are provided in **Section 6.10.** Past efforts through DEQ's abandoned mine land program and by the Montana Bureau of Mines and Geology have produced abandoned mine site inventories with enough descriptive detail to prioritize the properties contributing the largest metals loads, which are the priority mines described in this document. However, water quality data indicate that there are many significant sources other than these priority mines. Additional monitoring needed to further describe impairment conditions and loading sources is addressed in **Section 6.7**.

6.6 Restoration Approaches by Source

General management recommendations are outlined below for the major sources of human caused pollutant loads for the waterbodies included in this project. The WRP developed by local watershed groups should contain more detailed information on restoration goals and specific management recommendations that may be required to address key pollutant sources. BMPs are usually identified as a first effort for nonpoint sources such as cattle grazing, and further monitoring and evaluation of activities and outcomes, as part of an adaptive management approach will be used to determine if further restoration approaches are necessary to achieve water quality standards. Monitoring is an important part of the restoration process for both passive and active restoration strategies, and monitoring recommendations are outlined in **Section 6.7**.

6.6.1 Mining

The Beaverhead River watershed and Montana more broadly, have a legacy of mining that continues today. Mining activities may have impacts that extend beyond increased metal concentrations in the water. Channel alteration, riparian degradation, and runoff and erosion associated with mining can lead to sediment, habitat, nutrient, and temperature impacts as well. The need for further characterization of impairment conditions and loading sources is addressed through the monitoring plan in **Section 6.7**.

A number of state and federal regulatory programs have been developed over the years to address water quality problems stemming from historic mines, associated disturbances, and metal refining impacts. Some regulatory programs and approaches that may be applicable to the Beaverhead TMDL Planning Area include:

- The Montana Abandoned Mine Lands (AML) Reclamation Program
- The Montana Comprehensive Environmental Cleanup and Responsibility Act (CECRA), which incorporates additional cleanup options under the Controlled Allocation of Liability Act (CALA) and the Voluntary Cleanup and Redevelopment Act (VCRA).

6.6.2.1 The Surface Mining Control and Reclamation Act (SMCRA)

DEQ's Abandoned Mines Lands program is responsible for reclamation of abandoned mines in Montana. The AML reclamation program is funded through the Surface Mining Control and Reclamation Act of 1977 (SMCRA). SMCRA funding is collected as a per ton fee on coal production that is then distributed to states by the federal Office of Surface Mining Reclamation and Enforcement. Funding eligibility is based on land ownership and date of mining disturbance. Eligible abandoned coal mine sites have a priority for reclamation construction funding over eligible non-coal sites. Areas within federal Superfund sites and areas where there is a reclamation obligation under state or federal laws are not eligible for expenditures from the abandoned mine reclamation program. **Table 6-1** lists the priority abandoned mines within the Beaverhead TMDL Planning Area. Additional information about each mine can be found on DEQ's AMLs website at: https://deq.mt.gov/Land/abandonedmines/priority

Table 6-1. Priority Abandoned Mine Sites in the Beaverhead TMDL Planning Area

Site Name	Receiving Stream	Disturbance Area (acres)	Watershed
Garrett Hill	Grasshopper	63	Beaverhead
Goldleaf/Priscilla	Grasshopper	226	Beaverhead
Apex Millsite	Grasshopper	14	Beaverhead
Ermont Mine/Millsite	Lower Rattlesnake	161	Beaverhead

6.6.2 Grazing

Grazing in areas with elevated metals concentrations from historic mining activity has the potential to increase sediment-bound metals loads to waterbodies, but these effects can be mitigated with appropriate management. Development of riparian grazing management plans should be a goal for anyone that operates livestock and does not currently have such plans. Private land owners may be assisted by state, county, federal, and local conservation groups to establish and implement appropriate grazing management plans. Note that riparian grazing management does not necessarily eliminate all grazing in riparian corridors. In some areas however, a more limited management strategy may be necessary for a period of time in order to accelerate reestablishment of a riparian community with the most desirable species composition and structure.

Every livestock grazing operation should have a grazing management plan. The NRCS Prescribed Grazing Conservation Practice Standard (Code 528) recommends the plan include the following elements (Natural Resource Conservation Service, 2010):

- A map of the operation showing fields, riparian and wetland areas, winter feeding areas, water sources, animal shelters, etc.
- The number and type of livestock
- Realistic estimates of forage needs and forage availability
- The size and productivity of each grazing unit (pasture/field/allotment)
- The duration and time of grazing
- Practices that will prevent overgrazing and allow for appropriate regrowth
- Practices that will protect riparian and wetland areas and associated water quality
- Procedures for monitoring forage use on an ongoing basis
- Development plan for off-site watering areas

Reducing grazing pressure in riparian and wetland areas and improving forage stand health are the two keys to preventing nonpoint source pollution from grazing. Grazing operations should use some or all of the following practices:

- Minimizing or preventing livestock grazing in riparian and wetland areas
- Providing off-stream watering facilities or using low-impact water gaps to prevent 'loafing' in wet areas
- Managing riparian pastures separately from upland pastures

- Installing salt licks, feeding stations, and shelter fences in areas that prevent 'loafing' in riparian areas and help distribute animals
- Replanting trodden down banks and riparian and wetland areas with native vegetation (this should always be coupled with a reduction in grazing pressure)
- Rotational grazing or intensive pasture management that takes season, frequency, and duration into consideration

The following resources provide guidance to help prevent pollution and maximize productivity from grazing operations:

- U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) located in Dillon
- Montana State University Extension Service
- DEQ Watershed Protection Section (Nonpoint Source Program)

The key strategy of the recommended grazing BMPs is to develop and maintain healthy riparian and wetland vegetation and minimize disturbance of the streambank and channel. Riparian buffers reduce the rate of runoff, promote infiltration of the soil (instead of delivering runoff directly to the stream), and intercept pollutants. The primary recommended BMPs are limiting livestock access to streams and stabilizing the stream at access points, providing off-site watering sources when and where appropriate, planting native stabilizing vegetation along streambanks, and establishing and maintaining riparian buffers. Although bank revegetation is a preferred BMP, in some instances bank stabilization may be necessary prior to planting vegetation.

6.6.3 Water Use

Streams can also be listed as impaired for flow regime modification when irrigation withdrawal management leads to base flows that are too low to support the beneficial uses designated for that system. This could result in dry channels or extreme low flow conditions unsupportive of fish and aquatic life. Low flow conditions absorb thermal radiation more readily and increase stream temperatures, which in turn creates dissolved oxygen conditions too low to support some species of fish. In the Beaverhead watershed, water withdrawals may either increase or decrease the concentration of metals. The concentration decreases if water high in metals is withdrawn and additional water enters downstream. The concentration may increase if water low in metals is withdrawn and water high in metals enters downstream. Water quality data indicate that the metals concentrations in the Beaverhead watershed are greatly affected by these water withdrawals and additions, but further data is needed to understand these complex interactions.

It is up to local users, agencies, and entities to voluntarily improve instream flows through water and land management, which may include irrigation efficiency improvements and/or instream water leases that result in reduced amounts of water diverted from streams.

6.7 Strengthening Source Assessment and Increasing Available Data

The objectives for future monitoring in the Beaverhead TPA include:

- Strengthen the spatial understanding of sources for future restoration work by collecting data at additional spatial locations, which will also improve source assessment analysis for future TMDL review

- Collect additional data including the same locations during different seasons (and streamflows), to understand the impact of water withdrawals and water additions to metals concentrations
- Use consistent collection methods, and share information among agencies and watershed groups allows for common threads in discussion and analysis
- Track restoration projects as they are implemented and assess their effectiveness
- Expand the understanding of unsampled streams throughout the Beaverhead TPA beyond those where TMDLs have been developed and address issues
- Collect additional data downstream of priority mines to better understand their contribution to metals impairments

6.7.1 Strengthening Source Assessment

The identification of pollutant sources was conducted largely through tours of the watershed, assessments of aerial photographs, the incorporation of geographic information system information and reviewing and analyzing available data. Limited field-verification of the available data was able to be conducted. In many cases, assumptions were made based on known watershed conditions and extrapolated throughout the planning area. The following actions are recommended:

- Refinement of the sampling approach and locations to better partition pollutant loading from discrete sources within tributaries. This may require more seasonally stratified sampling or a more detailed field reconnaissance and follow-up sampling.
- DEQ recommends additional monitoring of all metals parameters in all tributaries of the Beaverhead River watershed. Additional monitoring of metals water quality data will yield a better understanding of metals source locations in the watershed.
- A more detailed characterization of historical mining activities and human caused land disturbances directed at defining these sources as area of potential metals loading.
- A more detailed assessment may allow for the verification that abandoned mines are causing the high arsenic levels in Steel Creek and West Fork Blacktail Deer Creek, and that there is not a natural source.

6.7.2 Increasing available data and temporal resolution

Infrequent sampling events at a small number of sampling sites may provide some indication of overall water quality. However, regularly scheduled sampling at consistent locations, under a variety of seasonal conditions is the best way to assess overall stream health and monitor change. In particular, metals concentrations in the Beaverhead TPA are largely affected by water withdrawals and additions. Understanding these effects will require more frequent sampling.

6.7.3 Watershed Wide Analyses

Recommendations for monitoring in the Beaverhead TPA should not be confined to only those streams addressed within this document. The water quality targets presented in this document are applicable to all streams in the watershed, and the absence of a stream from the state's impaired waters list does not necessarily imply that the stream fully supports all beneficial uses. Furthermore, as conditions change over time and land management evolves, consistent data collection methods throughout the watershed will allow resource professionals to identify problems as they occur, and to track improvements over time. Additional collection is some of the smaller tributaries may also help identify the sources of impairments.

6.7.4 Further Sampling Downstream of Specific Priority Mines and Abandoned Mines

The descriptions of several of the priority abandoned mines in **Table 6-1** are based on information collected during early 1990s site inventories completed by DEQ's Abandoned Mine Lands program (Montana Department of Environmental Quality, Abandoned Mine Lands Bureau, 2014). Additional site reconnaissance and monitoring of discrete sources is needed to better understand sources of metals loading and develop remediation strategies. The following bulleted items describe source assessment information that could improve our understanding of loading at the priority mine sites, and also other abandoned mine sites in the project area.

- A more detailed characterization of mine tailings associated with the abandoned and priority mines in the Beaverhead TMDL Planning Area.
- A more detailed surface water monitoring regime directed at defining sources of metals pollution from the waterbodies that collect runoff from abandoned mine and priority mine sites.
- Refinement of the sampling approach and locations at individual mine sites to better partition pollutant loading from discrete sources within the broader mine site. This may require more seasonally stratified sampling or a more detailed field reconnaissance and follow-up sampling to locate stream segments that represent background loading.

While remediation activities have taken place in the Beaverhead TMDL Planning Area, data are still often limited depending on the stream and pollutant of interest. Infrequent sampling events at a small number of sampling sites may provide some indication of overall water quality and habitat condition. However, regularly scheduled sampling at consistent locations, under a variety of seasonal conditions is the best way to assess overall stream health and monitor change.

Additional monitoring may be helpful to better partition pollutant loading at mine sites with multiple sources, such as those having permitted discharges versus more diffuse runoff from mine waste accumulations. The needed refinements may require more sampling or a more detailed field reconnaissance and follow-up sampling to better locate stream segments representing background loading. Specifically, this sampling should include

- Increased frequency of storm event monitoring
- Stormwater monitoring should take place downstream of priority mines, abandoned mines of interest, and the permitted point source on Stone Creek

6.8 Consistent Data Collection and Methodologies

Data have been collected throughout the Beaverhead TMDL Planning Area for many years by DEQ and the Beaverhead Watershed Committee. Wherever possible, it is recommended that the type of data and methodologies used to collect and analyze the information be consistent so as to allow for comparison to TMDL targets and track progress toward meeting TMDL goals.

DEQ is the lead agency for developing and conducting impairment status monitoring; however, other agencies or entities may work closely with DEQ to provide compatible data. Water quality impairment determinations are made by DEQ, but data collected by other sources can be used in the impairment determination process. The information in this section provides general guidance for future impairment status monitoring and effectiveness tracking. Future monitoring efforts should consult DEQ on updated monitoring protocols. Improved communication between agencies and stakeholders will further improve accurate and efficient data collection.

It is important to note that monitoring recommendations are based on TMDL-related efforts to protect water quality beneficial uses in a manner consistent with Montana's water quality standards. Other regulatory programs with water quality protection responsibilities may impose additional requirements to ensure full compliance with all appropriate local, state, and federal laws. For example, reclamation of a mining related source of metals under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and CECRA typically requires source-specific sampling requirements, which cannot be defined at this time, to determine the extent of and the risk posed by contamination, and to evaluate the success of specific remedial actions.

Metals monitoring should use appropriate analytical methods and include sediment metals chemistry, hardness, pH, discharge, and TSS. Field procedures for sample collection can be found in DEQ's Standard Operating Procedure for Sample Collection for Chemistry Analysis: Water, Sediment, and Biological Tissue. (Makarowski, 2019)

6.9 Effectiveness Monitoring for Restoration Activities

As restoration activities are implemented, monitoring is valuable to determine if restoration activities are improving water quality and aquatic habitat and communities. Monitoring can help attribute water quality improvements to restoration activities and ensure that restoration activities are functioning effectively. Restoration projects will often require additional maintenance after initial implementation to ensure functionality. It is important to remember that degradation of aquatic resources happens over many decades and that restoration is often also a long-term process. An efficiently executed long-term monitoring effort is an essential component to any restoration effort.

Due to the natural high variability in water quality conditions, trends in water quality are difficult to define and even more difficult to relate directly to restoration or other changes in management. Improvements in water quality or aquatic habitat from restoration activities will most likely be evident in fine sediment deposition and channel substrate embeddedness, changes in channel cumulative width/depths, improvements in bank stability and riparian habitat, changes in communities and distribution of fish and other bio-indicators, and changes in water column metals concentrations. Specific monitoring methods, priorities, and locations will depend heavily on the type of restoration projects implemented, landscape or other natural setting, the land-use influences specific to potential monitoring sites, and budget and time constraints.

As restoration activities begin throughout the project area, pre- and post- monitoring to understand the change that follows implementation will be necessary to track the effectiveness of specific projects. Monitoring activities should be selected such that they directly investigate those subjects that the project is intended to effect, and when possible, linked to targets and allocations in the TMDL. For example, as bank erosion from cattle grazing is addressed or bank stabilizations projects are implemented after mine tailings removal, pre- and post- bank erosion analyses on the subject banks will be valuable to understand the extent of improvement and the amount of sediment-bound metals concentrations reduced.

Recommendations for monitoring in the project area should not be confined to only those streams addressed within this document. The water quality targets presented in this document are applicable to all streams in the watershed where metals sources may be present, and the absence of a stream from the state's impaired waters list does not necessarily imply that the stream fully supports all beneficial uses. Furthermore, as conditions change over time and land management evolves, consistent data collection methods throughout the watershed will allow resource professionals to identify problems as they occur, and to track improvements over time.

6.10 Potential Funding and Technical Assistance Sources

Prioritization and funding of restoration or water quality improvement projects is integral to maintaining restoration activities and monitoring project successes and failures. Several government agencies and also a few non-governmental organizations fund or can provide assistance with watershed or water quality improvement projects or wetlands restoration projects.

Numerous other funding opportunities exist for addressing nonpoint source pollution. Information regarding funding opportunities from state agencies is contained in Montana's Nonpoint Source Management Plan DEQ, 2017) and information regarding additional funding opportunities can be found at http://www.epa.gov/nps/funding.html.

DEQ issues a call for proposals every year to award Section 319 project funds administered under the federal CWA. The primary goal of the 319 program is to restore water quality in waterbodies whose beneficial uses are impaired by nonpoint source pollution and whose water quality does not meet state standards. 319 funds are distributed competitively to support the most effective and highest priority projects. In order to receive funding, projects must directly implement a DEQ-accepted WRP. Funding up to $300,000 may be awarded for projects. All funding has a 40% cost share requirement, and projects must be administered through a governmental entity, such as a conservation district or county, or a nonprofit organization. For information about past grant awards and how to apply, please visit http://deq.mt.gov/Water/SurfaceWater/319Projects.

7.0 Public Participation and Public Comments

Stakeholder and public involvement is a component of total maximum daily load (TMDL) planning required by Montana state law which directs the Department of Environmental Quality (DEQ) to consult with a watershed advisory group and local conservation districts during the TMDL development process. Technical advisors, stakeholders, state and federal agencies, interest groups, and the public were solicited to participate in differing capacities throughout the TMDL development process for this project in the Beaverhead TMDL Planning Area.

7.1 Participants and Their Roles

Throughout completion of the sediment and temperature TMDLs in this document, DEQ worked to keep stakeholders apprised of project status and solicited input from a TMDL watershed advisory group. A description of the participants and their roles in the development of the TMDLs in this document is contained below.

Montana Department of Environmental Quality

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

United States Environmental Protection Agency

EPA is the federal agency responsible for administering and coordinating requirements of the Clean Water Act. Section 303(d) of the Clean Water Act directs states to develop TMDLs (see **Section 1.1**), and EPA has developed guidance and programs to assist states in that regard. EPA has provided funding and technical assistance to Montana's overall TMDL program and is responsible for reviewing and evaluating TMDLs to see that they meet all federal requirements.

Local Conservation Districts

DEQ consulted with the Beaverhead and Gallatin conservation districts during development of the TMDLs in this document, which included opportunities to provide comment during the various stages of TMDL development and an opportunity for participation in the watershed advisory group described below.

Beaverhead TMDL Planning Area Watershed Advisory Group

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

Advisory group involvement was voluntary, and the level of involvement was at the discretion of the individual members. Members had the opportunity to attend meetings organized by DEQ for soliciting feedback on project planning. Communication with advisory group members was conducted through meetings, conference calls, and e-mails. Draft documents, project status updates, and meeting agendas and presentations were made available both via e-mail and through DEQ's wiki for water quality planning projects (http://mtwaterqualityprojects.pbworks.com/). Opportunities for review and comment were provided for participants at varying stages of TMDL development, including a two-week review and comment period for a draft version of this TMDL document prior to the public comment period. Member's comments were incorporated into this version of the document. The draft TMDLs were also presented to and discussed with the group at a virtual meeting in June 2020.

7.2 Response to Public Comments

Upon completion of a draft TMDL document, DEQ issues a press release and enters into a public comment period. During this timeframe, the draft TMDL document is made available for general public comment; DEQ then addresses and responds to all formal public comments. However, no formal, written comments were received.

The public comment period for this document was initiated on July 23, 2020 and closed on August 21, 2020. A virtual public informational meeting was held August 04, 2020 at 5:00 p.m. via Zoom. At the meeting, DEQ provided an overview of the TMDL document, answered questions, and solicited input and comment on the document. The public comment period and public meeting were announced in a July 23, 2020 press release from DEQ which was published on DEQ's website and was distributed to multiple media outlets across Montana. A public notice advertising the public comment period and public meeting was published in The Montana Standard and Dillon Tribune newspapers. Additionally, the announcement was distributed to the project's TMDL watershed advisory group, the Statewide TMDL Advisory Group, and other additional contacts via e-mail.

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Appendix A - Regulatory Framework and Reference Condition Approach

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

Table of Contents

A1.0 TMDL Development Requirements

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

Since 2004, EPA has requested that states combine the 303(d) list with the 305(b) report containing an assessment of Montana's water quality and its water quality programs. EPA refers to this new combined 303(d)/305(b) report as the Integrated Water Quality Report. The 303(d) list also includes identification of the probable cause(s) of the water quality impairment (e.g., pollutants such as metals, nutrients, sediment, pathogens, or temperature), and the suspected source(s) of the pollutants of concern (e.g., various land use activities). State law (75-5-702, MCA) identifies that a sufficient credible data methodology for determining the impairment status of each waterbody is used for consistency. The impairment status determination methodology is identified in DEQ's Water Quality Assessment Process and Methods (Montana Department of Environmental Quality, 2011).

Under Montana state law, an "impaired waterbody" is defined as a waterbody or stream segment for which sufficient credible data show that the waterbody or stream segment is failing to achieve compliance with applicable water quality standards (Section 75-5-103(11), MCA of the Montana Water Quality Act). A "threatened waterbody" is defined as a waterbody or stream segment for which sufficient credible data and calculated increases in loads show that the waterbody or stream segment is fully supporting its designated uses, but threatened for a particular designated use because of either: (a) proposed sources that are not subject to pollution prevention or control actions required by a discharge permit; the nondegradation provisions; or reasonable land, soil, and water conservation practices or (b) documented adverse pollution trends (Section 75-5-103(31), MCA of the Montana Water Quality Act). State law and Section 303(d) of the Clean Water Act require states to develop all necessary TMDLs for impaired or threatened waterbodies. None of the waterbodies being addressed within the scope of this document are listed as threatened.

A TMDL is a pollutant budget for a waterbody identifying the maximum amount of the pollutant that a waterbody can assimilate without causing applicable water quality standards to be exceeded (not met). TMDLs are often expressed in terms of an amount, or load, of a particular pollutant (expressed in units of mass per time such as pounds per day). TMDLs must account for loads/impacts from point and nonpoint sources in addition to natural background sources and must incorporate a margin of safety and consider influences of seasonality on analysis and compliance with water quality standards. **Section 4.0** of the main document provides a description of the components of a TMDL.

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

A2.0 Applicable Water Quality Standards

Water quality standards include the uses designated for a waterbody, the legally enforceable standards that ensure that the uses are supported, and a nondegradation policy that protects the high quality of a waterbody. The ultimate goal of this TMDL document, once implemented, is to ensure that all designated beneficial uses are fully supported and all water quality standards are met. Water quality standards form the basis for the targets described in **Sections 5.0**. The pollutant addressed in this water quality improvement plan is metals. This section provides a summary of the applicable water quality standards for metals.

A2.1 Classification and Beneficial Uses

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

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

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

Descriptions of Montana's surface water classifications and designated beneficial uses are presented in **Table A2-1**. In 2003, Montana added four classes: D, E, F, and G. These classes include ephemeral streams (E-1 and E-2), ditches (D-1 and D-2), seasonal or semi-permanent lakes and ponds (E-3, E-4, E-5) and waters with low or sporadic flow (F-1). All waterbodies within the BeaverheadTMDL Planning Area are classified as B-1, with the exception of Upper Rattlesnake Creek from the headwaters to the Dillon Water Supply, which is classified as A-1.

Table A2-1. Montana Surface Water Classifications and Designated Beneficial Uses

Classification	Designated Uses
A-CLOSED	Waters classified A-Closed are to be maintained suitable for drinking, culinary and food processing purposes after simple disinfection.
A-1	Waters classified A-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment for removal of naturally present impurities.
B-1	Waters classified B-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B-2	Waters classified B-2 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B-3	Waters classified B-3 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-1	Waters classified C-1 are to be maintained suitable for bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-2	Waters classified C-2 are to be maintained suitable for bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-3	Waters classified C-3 are to be maintained suitable for bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers. The quality of these waters is naturally marginal for drinking, culinary and food processing purposes, agriculture and industrial water supply.
I	The goal of the State of Montana is to have these waters fully support the following uses: drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
D-1	Waters classified D-1 are to be maintained suitable for agricultural purposes and secondary contact recreation.
D-2	Waters classified D-2 are to be maintained suitable for agricultural purposes and secondary contact recreation. Because of conditions resulting from low flow regulations, maintenance of the ditch, or geomorphologic and riparian habitat conditions, quality is marginally suitable for aquatic life.
E-1	Waters classified E-1 are to be maintained suitable for agricultural purposes, secondary contact recreation, and wildlife.
E-2	Waters classified E-2 are to be maintained suitable for agricultural purposes, secondary contact recreation, and wildlife. Because of habitat, low flow, hydro-geomorphic, and other physical conditions, waters are marginally suitable for aquatic life.
E-3	Waters classified E-3 are to be maintained suitable for agricultural purposes, secondary contact recreation, and wildlife.
E-4	Waters classified E-4 are to be maintained suitable for aquatic life, agricultural purposes, secondary contact recreation, and wildlife.

Table A2-1. Montana Surface Water Classifications and Designated Beneficial Uses

Classification	Designated Uses
E-5	Waters classified E-5 are to be maintained suitable for agricultural purposes, secondary contact recreation, saline-tolerant aquatic life, and wildlife.
F-1	Waters classified F-1 are to be maintained suitable for secondary contact recreation, wildlife, and aquatic life, not including fish.
G-1	Waters classified G-1 are to be maintained suitable for watering wildlife and livestock; aquatic life, not including fish; secondary contact recreation; marginally suitable for irrigation after treatment or with mitigation measures.

A2.2 STANDARDS

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

Numeric surface water quality standards have been developed for many parameters to protect human health and aquatic life. These standards are in the Department Circular DEQ-7 (Montana Department of Environmental Quality, 2019) and Circular DEQ-12A (DEQ, 2019). The numeric human health standards have been developed for parameters determined to be toxic, carcinogenic, or harmful, and have been established at levels to be protective of long-term (i.e., lifelong) exposures, as well as through direct contact such as swimming.

The numeric aquatic life standards in Circular DEQ-7 include chronic and acute values that are based on extensive laboratory studies including a wide variety of potentially affected species, a variety of life stages, and durations of exposure. Chronic aquatic life standards are protective of long-term exposure to a parameter. The protection afforded by the chronic standards includes detrimental effects to reproduction, early life stage survival, and growth rates. In most cases the chronic standard is more stringent than the corresponding acute standard. Acute aquatic life standards are protective of short-term exposures to a parameter and are not to be exceeded.

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

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

A2.2.1 Metals Standards

Water quality standards that are applicable to metals impairments include both numeric water quality criteria given in DEQ-7 (**Table A2-2**) and general prohibitions (narrative criteria) given in **Table A2-3.** As water quality criteria for many metals are dependent upon water hardness, **Table A2-2** presents acute and chronic metals numeric water quality criteria at water hardness values of 25, 100, and 400 mg/L for metals of concern in the [project area name]. Also presented in **Table A2-2** is the Human Health Criteria (HHC): note that for mercury and arsenic, the HHC is lower than applicable chronic criteria.

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

It should be noted that recent studies have indicated in some streams that metals concentrations may vary throughout the day because of diel pH and alkalinity changes. In some cases, the variation can cross the standard threshold (both above and below) for a metal. Montana water quality standards are not time of day dependent.
Ensure all the applicable metals for your project are included in this table.

Table A2-2. Metals Numeric Water Quality Criteria

	Aquatic life criteria (µg/L) at 25 mg/L hardness		Aquatic life criteria (µg/L) at 100 mg/L hardness		Aquatic life criteria (µg/L) at 400 mg/L hardness		
Metal of concern	**Acute**	**Chronic**	**Acute**	**Chronic**	**Acute**	**Chronic**	**HHS (µg/L)**
Aluminum, dissolved	750	87	750	87	750	87	---
Antimony, TR	---	---	---	---	---	---	5.6
Arsenic, TR	340	150	340	150	340	150	10
Cadmium, TR	0.49	0.25	1.90	0.79	8.7	2.38	5
Copper, TR	3.79	2.85	14	9.33	51.7	30.5	1,300
Cyanide, Total	22	5.2	22	5.2	22	5.2	140
Iron, TR	---	1,000	---	1,000	---	1,000	300*
Lead, TR	13.98	0.545	81.6	3.18	476.8	18.58	15
Mercury, Total	1.7	0.91	1.7	0.91	1.7	0.91	0.05
Zinc, TR	37	37	119.8	119.8	387.8	387.8	2,000

*HHC for iron is a secondary maximum contaminant level based on aesthetic properties
TR = total recoverable

In addition to numeric criteria given in **Table A2-2**, narrative criteria also provide protection of beneficial uses. Toxic levels of metals in stream sediment are prohibited via ARM 17.30.637(1)(d). Metals concentrations in stream sediment are addressed via the suite of narrative criteria presented in **Table A2-3**. The relevant narrative criteria do not allow for 'concentrations or combinations of materials that are toxic or harmful to human, animal, plant, or aquatic life.' This is interpreted to mean that water quality goals should strive toward a condition in which any increases in metals concentration in sediment above naturally occurring levels are not harmful, detrimental, or injurious to beneficial uses (see definitions in **Table A-1**). Evaluation of numeric and narrative criteria for specific metals impairments for each stream segment is given in **Section 5.4.3**.

Table A2-3. Applicable Rules for Metals Concentrations in Sediment

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

A3.0 Reference Conditions

A3.1 Reference Conditions as Defined in DEQ's Standard Operating Procedure for Water Quality Assessment

DEQ uses the reference condition to evaluate compliance with many of the narrative water quality standards (Montana Department of Environmental Quality, 2011). The term “reference condition” is defined as the condition of a waterbody capable of supporting its present and future beneficial uses when all reasonable land, soil, and water conservation practices have been applied. In other words, reference condition reflects a waterbody’s greatest potential for water quality, given historic land use activities.

DEQ applies the reference condition approach for making beneficial use-support determinations for certain pollutants (such as sediment) that have specific narrative standards. All classes of waters are subject to the provision that there can be no increase above naturally occurring concentrations of sediment and settleable solids, oils, or floating solids sufficient to create a nuisance or render the water harmful, detrimental, or injurious. These levels depend on site-specific factors, so the reference conditions approach is used.

Also, Montana water quality standards do not contain specific provisions addressing detrimental modifications of habitat or flow. However, these factors are known to adversely affect beneficial uses under certain conditions or combination of conditions. The reference conditions approach is used to determine if beneficial uses are supported when flow or habitat modifications are present.

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

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

The following methods may be used to determine reference conditions:

Primary Approach

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

Secondary Approach

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

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

A3.2 Use of Statistics for Developing Reference Values or Ranges

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

Figure A3-1 is an example boxplot-type presentation of the median, 25th and 75th percentiles, and minimum and maximum values of a reference data set. In this example, the reference stream results are stratified by two different stream types. Typical stratifications for reference stream data may include Rosgen stream types, stream size ranges, or geology. If the parameter being measured is one where low values are undesirable and can cause harm to aquatic life, then measured values in the potentially impaired stream that fall below the 25th percentile of reference data are not desirable and can be used to indicate impairment. If the parameter being measured is one where high values are undesirable, then measured values above the 75th percentile can be used to indicate impairment.

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

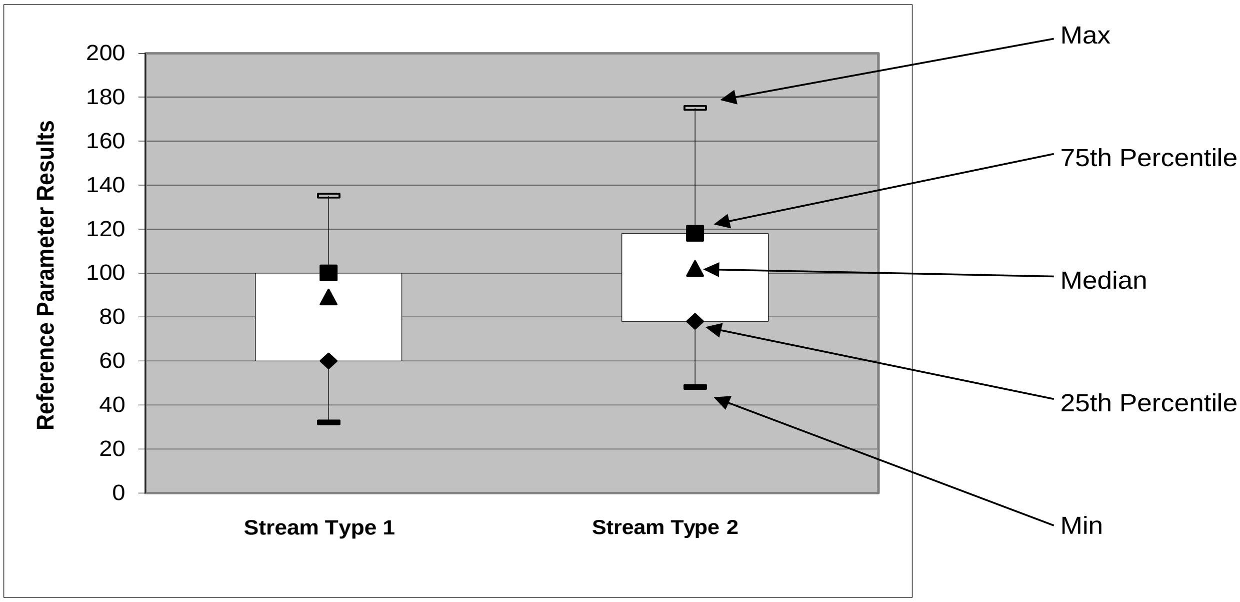

Figure A3-1. Boxplot Example for Reference Data

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

1. It is a simple approach that is easy to apply and understand.
2. About 25% of all streams would naturally fall into the impairment range. Thus, it should not be applied unless there is some linkage to human activities that could lead to the observed conditions. Where applied, it must be noted that the stream's potential may prevent it from achieving the reference range as part of an adaptive management plan.
3. About 25% of all streams would naturally have a greater water quality potential than the minimum water quality bar represented by the 25th to 75th percentile range. This may represent a condition where the stream's potential has been significantly underestimated. Adaptive management can also account for these considerations.
4. Obtaining reference data that represents a naturally occurring condition can be difficult, particularly for larger waterbodies with multiple land uses within the drainage. This is because all reasonable land, soil, and water conservation practices may not be in place in many larger waterbodies across the region. Even if these practices are in place, the proposed reference stream may not have fully recovered from past activities, such as riparian harvest, where reasonable land, soil, and water conservation practices were not applied.
5. A stream should not be considered impaired unless there is a relationship between the parameter of concern and the beneficial use such that not meeting the reference range is likely to cause harm or other negative impacts to the beneficial use as described by the water quality standards in **Table A2-2**. In other words, if not meeting the reference range is not expected to negatively impact aquatic life, coldwater fish, or other beneficial uses, then an impairment determination should not be made based on the particular parameter being evaluated. Relationships that show an impact to the beneficial use can be used to justify impairment based on the above statistical approach.

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

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

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

Another approach would be to develop statistics for a given parameter from all streams within a watershed or region of interest (Buck et al., 2000). The boxplot distribution of all the data for a given parameter can still be used to help determine potential target values knowing that most or all of the streams being evaluated are either impaired or otherwise have a reasonable probability of having significant water quality impacts. Under these conditions you would still use the median and the 25th or 75th percentiles as potential target values, but you would use the 25th and 75th percentiles in a way that is opposite from how you use the results from a regional reference distribution. This is because you are assuming that, for the parameter being evaluated, as many as 50% to 75% of the results from the whole data distribution represent questionable water quality. **Figure A3-2** is an example statistical distribution of an entire dataset where lower values represent better water quality (and reference data are limited).

In **Figure A3-2**, the median and 25th percentiles of all data represent potential target values versus the median and 75th percentiles discussed above for regional reference distribution. Whether you use the median, the 25th percentile, or both should be based on an assessment of how impacted all the measured streams are in the watershed. Additional consideration of target achievability is important when using this approach. Also, there may be a need to also rely on secondary reference development methods to modify how you apply the target and/or to modify the final target value(s). Your certainty regarding indications of impairment may be lower using this approach, and you may need to rely more on adaptive management as part of TMDL implementation.

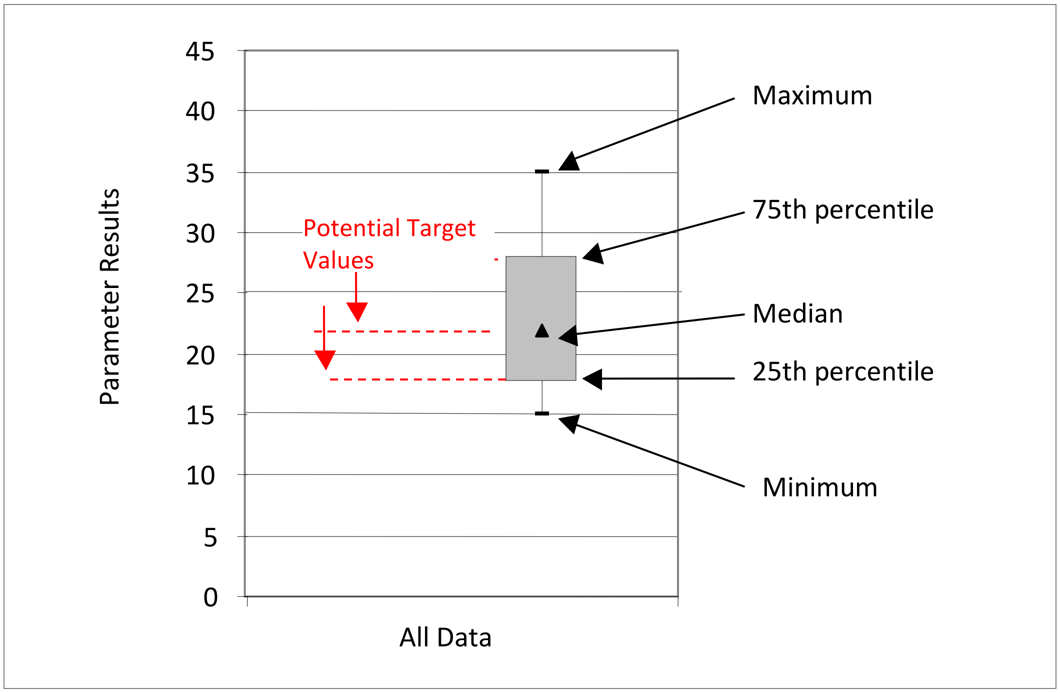

Figure B3-2. Boxplot example for the use of all data to set targets

A4.0 References

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APPENDIX B – WATER QUALITY DATA

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B.0 Data Used in Development of TMDLs

B.1 Reference Data

Table B-1. Water Quality Data at Reference Sites (see Section 5.6.1)

Monitoring Location	Activity Date	Aluminum	Arsenic	Cadmium	Copper	Iron	Lead	Zinc	Latitude	Longitude
MDEQ_WQ_WQX-M01CABNC03	6/14/2016	26	2	NA	NA	290	NA	NA	44.633	-112.9758
MDEQ_WQ_WQX-M01CABNC03	7/21/2016	NA	2	NA	NA	260	NA	NA	44.633	-112.9758
MDEQ_WQ_WQX-M01CABNC03	8/12/2016	NA	2	NA	NA	240	NA	NA	44.633	-112.9758
MDEQ_WQ_WQX-M01CABNC03	6/5/2017	23	2	0.11	1	180	0.074	1.9	44.633	-112.9758
MDEQ_WQ_WQX-M01CABNC03	7/13/2017	12	2	NA	0.69	425	0.0945	2.25	44.633	-112.9758
MDEQ_WQ_WQX-M01CABNC03	8/15/2017	104	2	0.02	0.78	530	0.12	1.4	44.633	-112.9758
MDEQ_WQ_WQX-M01CABNC03	9/12/2017	NA	3	NA	0.83	520	NA	2.6	44.633	-112.9758
MDEQ_WQ_WQX-M01FISHC01	9/28/2016	23	1	NA	NA	230	0.6	NA	44.70028	-111.91
MDEQ_WQ_WQX-M01FISHC01	6/6/2017	21	2	0.05	2	970	1.4	5.7	44.70028	-111.91
MDEQ_WQ_WQX-M01FISHC01	7/18/2017	15	2	0.02	0.78	170	0.26	2.2	44.70028	-111.91
MDEQ_WQ_WQX-M01FISHC01	7/28/2017	182	1.5	0.025	0.935	430	0.65	2.6	44.70028	-111.91
MDEQ_WQ_WQX-M01FISHC01	8/16/2017	179	2	0.02	0.72	230	0.4	1.6	44.70028	-111.91
MDEQ_WQ_WQX-M01FISHC01	8/24/2017	142.5	1	0.02	0.68	160	0.1	2	44.70028	-111.91
MDEQ_WQ_WQX-M01FISHC01	9/7/2017	246.5	2	0.12	0.9	230	0.6	3.2	44.70028	-111.91
MDEQ_WQ_WQX-M01FISHC01	9/28/2017	228.5	0.79	0.03	0.98	240	0.4	2.4	44.70028	-111.91
MDEQ_WQ_WQX-M01FISHC01	6/6/2018	596	2	0.04	2	860	1.1	5	44.70028	-111.91
MDEQ_WQ_WQX-M01FISHC20	6/6/2017	16	2	0.05	1	920	1.2	4.8	44.70303	-111.9325
MDEQ_WQ_WQX-M01FISHC20	7/18/2017	14	2	0.02	0.8	190	0.3	2.9	44.70303	-111.9325
MDEQ_WQ_WQX-M01FISHC20	7/28/2017	120	1	0.02	0.76	350	0.5	2.4	44.70303	-111.9325
MDEQ_WQ_WQX-M01FISHC20	8/16/2017	181.5	2	0.02	2	250	0.4	2.7	44.70303	-111.9325
MDEQ_WQ_WQX-M01FISHC20	8/24/2017	141	1	0.04	0.69	180	0.098	2.4	44.70303	-111.9325
MDEQ_WQ_WQX-M01FISHC20	9/7/2017	168.5	2	0.12	1	200	0.5	2.7	44.70303	-111.9325
MDEQ_WQ_WQX-M01FISHC20	9/28/2017	195	0.77	0.02	0.84	220	0.3	3	44.70303	-111.9325
MDEQ_WQ_WQX-M01LONGC04	6/6/2017	15	1	0.05	1	530	0.5	3.1	44.71361	-112.077

B.1 Reference Data

Table B-1. Water Quality Data at Reference Sites (see Section 5.6.1)

Monitoring Location	Activity Date	Aluminum	Arsenic	Cadmium	Copper	Iron	Lead	Zinc	Latitude	Longitude
MDEQ_WQ_WQX-M01LONGC04	7/18/2017	NA	0.84	0.02	0.39	90	0.086	1.9	44.71361	-112.077
MDEQ_WQ_WQX-M01LONGC04	7/27/2017	27	0.76	0.02	0.43	19	0.036	1.5	44.71361	-112.077
MDEQ_WQ_WQX-M01LONGC04	8/16/2017	NA	0.8	0.02	0.5	70	0.039	0.6	44.71361	-112.077
MDEQ_WQ_WQX-M01LONGC04	8/23/2017	36	0.85	0.02	0.55	80	0.11	1	44.71361	-112.077
MDEQ_WQ_WQX-M01LONGC04	9/5/2017	22.7	0.91	0.02	0.5	80	0.1	3.9	44.71361	-112.077
MDEQ_WQ_WQX-M01LONGC04	9/27/2017	39.5	0.55	0.03	2	80	0.18	3.4	44.71361	-112.077
MDEQ_WQ_WQX-M01LONGC04	6/6/2018	191.5	0.83	0.03	0.8	350	0.3	3	44.71361	-112.077
MDEQ_WQ_WQX-M01LONGC30	7/27/2017	10	0.84	0.02	0.47	110	0.11	0.7	44.70042	-112.0937
MDEQ_WQ_WQX-M01LONGC30	8/23/2017	47	1	0.02	0.67	100	0.28	2.8	44.70042	-112.0937
MDEQ_WQ_WQX-M01LONGC30	9/27/2017	27.95	0.64	0.02	0.6	80	0.1	1	44.70042	-112.0937
MDEQ_WQ_WQX-M01PRICC01	6/23/2012	15	2	NA	NA	245	NA	NA	44.57417	-112.125
MDEQ_WQ_WQX-M01PRICC01	7/12/2012	15	2	NA	NA	210	NA	NA	44.57417	-112.125
MDEQ_WQ_WQX-M01PRICC01	7/9/2013	NA	3	0.04	1	630	0.6	NA	44.57417	-112.125
MDEQ_WQ_WQX-M01PRICC01	8/28/2017	7.8	1.25	NA	NA	322.5	NA	NA	44.57417	-112.125
MDEQ_WQ_WQX-M01RDRKC60	7/28/2017	42	0.83	0.01	0.64	260	0.16	0.9	44.61847	-111.6066
MDEQ_WQ_WQX-M01RDRKC60	8/24/2017	43	0.64	NA	0.37	90	0.066	1	44.61847	-111.6066
MDEQ_WQ_WQX-M01RDRKC60	9/28/2017	59.5	0.61	NA	0.64	120	0.11	1.1	44.61847	-111.6066
MDEQ_WQ_WQX-M06BLNSC03	6/12/2013	NA	4	NA	NA	NA	NA	6	45.21528	-111.7917
MDEQ_WQ_WQX-M06BLNSC03	7/11/2013	NA	4.5	NA	NA	NA	NA	NA	45.21528	-111.7917
MDEQ_WQ_WQX-M06BLNSC03	8/16/2013	NA	4	NA	NA	NA	NA	7	45.21528	-111.7917
MDEQ_WQ_WQX-M06BLNSC03	9/18/2013	NA	4	NA	NA	NA	NA	7.85	45.21528	-111.7917
MDEQ_WQ_WQX-M06MDWFR04	7/31/2012	NA	NA	NA	NA	390	NA	NA	44.76842	-111.9043
MDEQ_WQ_WQX-M06ODLSC03	6/19/2012	NA	20.5	NA	NA	NA	NA	NA	45.26034	-111.7314
MDEQ_WQ_WQX-M06ODLSC03	7/26/2012	NA	20	NA	NA	NA	NA	NA	45.26034	-111.7314
MDEQ_WQ_WQX-M06ODLSC03	8/27/2012	NA	19.5	NA	NA	NA	NA	NA	45.26034	-111.7314
MDEQ_WQ_WQX-M06ODLSC03	9/17/2013	NA	22	NA	NA	NA	NA	NA	45.26034	-111.7314

B.1 Reference Data

Table B-1. Water Quality Data at Reference Sites (see Section 5.6.1)

Monitoring Location	Activity Date	Aluminum	Arsenic	Cadmium	Copper	Iron	Lead	Zinc	Latitude	Longitude
MTVOLWQM_WQX-OD-RST	7/28/2012	NA	34	NA	NA	60	NA	NA	45.26057	-111.7324
MTVOLWQM_WQX-OD-RST	8/26/2012	NA	34	NA	NA	40	NA	NA	45.26057	-111.7324
MTVOLWQM_WQX-OD-RST	9/23/2012	NA	38	NA	NA	50	NA	NA	45.26057	-111.7324
MTVOLWQM_WQX-OD-RST	7/14/2013	NA	36	NA	NA	NA	NA	NA	45.26057	-111.7324
MTVOLWQM_WQX-OD-RST	8/23/2013	NA	37	NA	NA	NA	NA	NA	45.26057	-111.7324
MTVOLWQM_WQX-OD-RST	9/22/2013	NA	34	NA	NA	NA	NA	NA	45.26057	-111.7324

B.2 TMDL Allocations-Data

Table B-2. Water Quality Data used in Assessment and Development of TMDLs

Monitoring LocationIdent-ifier	Subwatershed	Date	Latitude	Longitude	Stream Flow (cfs)	Hard-ness (mg/L)	TSS (mg/L)	Alumi-num (µg/L)	Arse-nic (µg/L)	Cad-mium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Zinc (µg/L)
MDEQ_WQ_WQX-M02GHPRC02	Grasshopper	7/28/2014	45.493	-113.106	0.37	19	4	NA	1	0.05	4	620	0.9	0.018
MDEQ_WQ_WQX-M02GHPRC03	Grasshopper	7/30/2014	45.426	-113.115	5.1	21	<4	11	1	NA	2	170	<.3	0.008
MDEQ_WQ_WQX-M02GHPRC04	Grasshopper	7/31/2014	45.139	-112.959	41.09	91	7	NA	3	NA	NA	310	<.3	NA
MDEQ_WQ_WQX-M02GHPRC06	Grasshopper	9/9/2014	45.11	-112.802	56.45	118	6	NA	4	NA	1	310	0.4	NA
MDEQ_WQ_WQX-M02GHPRC07	Grasshopper	9/8/2014	45.216	-113.04	18.61	88	<4	NA	4	NA	NA	150	<.3	NA
MTWTRSHD_WQX-BVD-GHC-1	Grasshopper	6/3/2009	45.374	-113.122	160.37	18.7	6	NA	NA	NA	2.1	360	0.4	NA
MTWTRSHD_WQX-BVD-GHC-2	Grasshopper	6/3/2009	45.283	-113.119	182.51	28.2	6	NA	NA	NA	1.7	320	0.3	NA
MTWTRSHD_WQX-BVD-GHC-3	Grasshopper	6/2/2009	45.167	-113.012	1121.23	63.6	24	NA	NA	NA	2.1	800	0.5	NA
MTWTRSHD_WQX-BVD-GHC-4	Grasshopper	6/2/2009	45.145	-112.968	7.18	66.8	35	NA	NA	NA	2.8	1000	1.1	0.006
MTWTRSHD_WQX-BVD-GHC-5	Grasshopper	6/3/2009	45.103	-112.78	332.72	93.4	87.9	NA	NA	0.1	5.4	2100	4.2	0.012
MDEQ_WQ_WQX-M02RATSC04	Lower Rattlesnake	5/27/2015	45.233	-112.782	26.32	54	17	NA	2	0.27	3	560	12.2	0.022
MDEQ_WQ_WQX-M02RATSC04	Lower Rattlesnake	8/24/2015	45.233	-112.782	18.55	13	5	NA	2	0.06	52	190	1.5	0.077
MDEQ_WQ_WQX-M02RATSC08	Lower Rattlesnake	8/21/2014	45.198	-112.751	2.24	89	4	NA	3	0.09	2	240	3.7	0.009
MDEQ_WQ_WQX-M02RATSC08	Lower Rattlesnake	5/27/2015	45.198	-112.751	14.86	53	30	NA	3	0.29	5	830	14.8	0.029

B.2 TMDL Allocations-Data

Table B-2. Water Quality Data used in Assessment and Development of TMDLs

Monitoring LocationIdent-ifier	Subwatershed	Date	Latitude	Longitude	Stream Flow (cfs)	Hard-ness (mg/L)	TSS (mg/L)	Alumi-num (µg/L)	Arse-nic (µg/L)	Cad-mium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Zinc (µg/L)
MDEQ_WQ_WQX -M02RATSC08	Lower Rattlesnake	7/8/2015	45.198	-112.751	3.62	64	17	NA	3	0.29	2	390	7.6	0.018
MDEQ_WQ_WQX -M02RATSC08	Lower Rattlesnake	8/24/2015	45.198	-112.751	1.61	82	<4	NA	2	0.04	1	150	1.4	NA
MDEQ_WQ_WQX -M02RATSC09	Lower Rattlesnake	9/9/2014	45.182	-112.701	0.04	179	23	NA	3	NA	NA	150	0.4	NA
MDEQ_WQ_WQX -M02RATSC09	Lower Rattlesnake	5/27/2015	45.182	-112.701	0.6	102	12	21	5	0.04	3	590	2.1	0.012
MTWTRSHD_WQ X-BVD-RSC-3	Lower Rattlesnake	6/2/2009	45.196	-112.75	20.94	51.2	22	NA	NA	0.2	2.9	390	10	0.016
MDEQ_WQ_WQX -M02STONC01	Lower Stone	9/10/2014	45.322	-112.527	5.64	379	<4	NA	3	NA	1	30	NA	NA
MDEQ_WQ_WQX -M02STONC01	Lower Stone	5/27/2015	45.322	-112.527	2.96	369	6	NA	3	NA	1	160	NA	NA
MDEQ_WQ_WQX -M02STONC01	Lower Stone	7/23/2015	45.322	-112.527	3.97	378	8	NA	3	NA	1	140	NA	NA
MDEQ_WQ_WQX -M02STONC01	Lower Stone	8/26/2015	45.322	-112.527	3.21	364	<4	NA	3	NA	<1	20	NA	NA
MDEQ_WQ_WQX -M02STONC01	Lower Stone	4/20/2017	45.322	-112.527	4.45	344	45	NA	2	0.03	8	300	0.4	0.007
MDEQ_WQ_WQX -M02STONC06	Lower Stone	8/6/2014	45.274	-112.446	0.1	211	<5	16	2	0.03	2	110	NA	NA
MDEQ_WQ_WQX -M02STONC06	Lower Stone	7/14/2015	45.274	-112.446	0.03	199	<4	NA	2	NA	2	90	NA	NA
MDEQ_WQ_WQX -M02STONC06	Lower Stone	4/20/2017	45.274	-112.446	0.96	244	290	183	4	0.2	20	9960	5	0.03
MDEQ_WQ_WQX -M02SPRGC03	Spring	8/19/2014	45.26	-112.357	0.38	171	8	NA	NA	NA	2	290	NA	NA
MDEQ_WQ_WQX -M02SPRGC04	Spring	8/19/2014	45.291	-112.405	1.08	189	<2	NA	2	NA	1	40	NA	NA

B.2 TMDL Allocations-Data

Table B-2. Water Quality Data used in Assessment and Development of TMDLs

Monitoring LocationIdent-ifier	Subwatershed	Date	Latitude	Longitude	Stream Flow (cfs)	Hard-ness (mg/L)	TSS (mg/L)	Alumi-num (µg/L)	Arse-nic (µg/L)	Cad-mium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Zinc (µg/L)
MDEQ_WQ_WQX -M02SPRGC04	Spring	5/28/2015	45.291	-112.405	1.12	208	30	NA	1	NA	2	690	0.6	NA
MDEQ_WQ_WQX -M02SPRGC05	Spring	8/21/2014	45.38	-112.449	0.58	553	<4	NA	10	NA	2	60	NA	NA
MDEQ_WQ_WQX -M02SPRGC05	Spring	5/28/2015	45.38	-112.449	0.06	526	<4	NA	9	NA	2	30	NA	NA
MDEQ_WQ_WQX -M02SPRGC05	Spring	7/6/2015	45.38	-112.449	0.91	427	18	NA	7	NA	1	340	NA	NA
MDEQ_WQ_WQX -M02SPRGC06	Spring	8/21/2014	45.335	-112.449	2.99	328	<4	NA	4	NA	1	50	NA	NA
MDEQ_WQ_WQX -M02SPRGC06	Spring	5/28/2015	45.335	-112.449	3.56	329	64	NA	3	0.03	3	1460	1.1	0.008
MDEQ_WQ_WQX -M02STELC01	Steel	7/13/2004	45.334	-113.1	0.05	230	3820	NA	22	0.5	15	3568 0	3.8	0.1
MTWTRSHD_WQ X-BVD-STL-1	Steel	6/4/2009	45.334	-113.106	NA	NA	38.2	NA	1.6	NA	NA	NA	NA	NA
MDEQ_WQ_WQX -M02RATSC05	Upper Rattlesnake	7/31/2014	45.278	-112.85	33.06	59	26	NA	3	0.24	4	360	19.8	0.035
MDEQ_WQ_WQX -M02RATSC06	Upper Rattlesnake	8/20/2014	45.249	-112.801	13.53	82	4	NA	2	0.12	2	140	4.1	0.011
MDEQ_WQ_WQX -M02RATSC06	Upper Rattlesnake	8/24/2015	45.249	-112.801	15.51	68	<4	NA	2	0.1	1	130	2.9	0.008
MDEQ_WQ_WQX -M02RATSC07	Upper Rattlesnake	8/20/2014	45.347	-112.945	10.34	25	<4	NA	NA	NA	NA	70	<.3	NA
MDEQ_WQ_WQX -M02RATSC11	Upper Rattlesnake	8/24/2015	45.322	-112.942	14.59	24	<4	NA	NA	NA	NA	100	<.3	NA
MTWTRSHD_WQ X-BVD-RSC-1	Upper Rattlesnake	6/3/2009	45.321	-112.941	63.48	12.1	2.8	NA	NA	NA	0.7	190	0.1	NA
MTWTRSHD_WQ X-BVD-RSC-2	Upper Rattlesnake	6/22/2009	45.284	-112.871	134.1 7	37.2	7	NA	NA	NA	0.8	310	2.8	NA

B.2 TMDL Allocations-Data

Table B-2. Water Quality Data used in Assessment and Development of TMDLs

Monitoring LocationIdent-ifier	Subwatershed	Date	Latitude	Longitude	Stream Flow (cfs)	Hard-ness (mg/L)	TSS (mg/L)	Alumi-num (µg/L)	Arse-nic (µg/L)	Cad-mium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Zinc (µg/L)
MDEQ_WQ_WQX -M02STONC03	Upper Stone	8/6/2014	45.257	-112.416	0.65	230	8	NA	2	NA	1	420	NA	NA
MDEQ_WQ_WQX -M02STONC03	Upper Stone	5/27/2015	45.257	-112.416	1.71	226	101	NA	2	0.05	8	4080	1.8	0.014
MDEQ_WQ_WQX -M02STONC03	Upper Stone	7/22/2015	45.257	-112.416	0.27	245	11	NA	2	0.03	1	320	NA	NA
MDEQ_WQ_WQX -M02STONC03	Upper Stone	8/25/2015	45.257	-112.416	0.21	231	6	NA	2	NA	1	220	NA	NA
MDEQ_WQ_WQX -M02STONC04	Upper Stone	8/6/2014	45.217	-112.369	1.42	213	20	NA	1	NA	2	860	NA	NA
MDEQ_WQ_WQX -M02STONC04	Upper Stone	5/27/2015	45.217	-112.369	2.04	191	31	NA	2	NA	3	1730	0.5	NA
MDEQ_WQ_WQX -M02STONC04	Upper Stone	7/22/2015	45.217	-112.369	2.04	222	10	NA	1	0.03	1	350	NA	NA
MDEQ_WQ_WQX -M02STONC04	Upper Stone	8/25/2015	45.217	-112.369	0.71	227	36	NA	2	NA	2	1280	0.4	NA
MDEQ_WQ_WQX -M02STONC05	Upper Stone	8/6/2014	45.242	-112.398	1.77	230	26	NA	2	0.03	2	1030	0.4	NA
MDEQ_WQ_WQX -M02STONC05	Upper Stone	7/16/2015	45.242	-112.398	0.95	225	20	NA	2	NA	4	780	0.4	NA
MDEQ_WQ_WQX -M02STONC05	Upper Stone	8/25/2015	45.242	-112.398	0.58	237	6	NA	2	NA	NA	250	NA	NA
MDEQ_WQ_WQX -M02WLMNC01	Wellman	7/29/2014	45.451	-113.08	1	97	14	35	1	0.12	3	120	0.8	0.047
MDEQ_WQ_WQX -M02WLMNC01	Wellman	5/27/2015	45.451	-113.08	0.2	72	4	NA	1	0.12	4	150	0.9	0.041
MDEQ_WQ_WQX -M02WLMNC02	Wellman	7/29/2014	45.444	-113.086	0.02	80	<4	34	2	0.23	13	70	NA	0.126
MDEQ_WQ_WQX -M02WLMNC02	Wellman	5/27/2015	45.444	-113.086	0.3	62	<4	166	6	0.58	48	740	3.3	0.219

B.2 TMDL Allocations-Data

Table B-2. Water Quality Data used in Assessment and Development of TMDLs

Monitoring LocationIdent-ifier	Subwatershed	Date	Latitude	Longitude	Stream Flow (cfs)	Hard-ness (mg/L)	TSS (mg/L)	Alumi-num (µg/L)	Arse-nic (µg/L)	Cad-mium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Zinc (µg/L)
MDEQ_WQ_WQX -M02WLMNC02	Wellman	7/6/2015	45.444	-113.086	0.8	85	<4	50	2	0.28	16	130	0.4	0.132
MDEQ_WQ_WQX -M02WLMNC03	Wellman	7/29/2014	45.436	-113.094	1	72	<4	NA	3	0.21	10	60	0.4	0.082
MDEQ_WQ_WQX -M02WLMNC03	Wellman	5/27/2015	45.436	-113.094	0.21	60	11	67	2	0.29	22	320	1.9	0.121
MDEQ_WQ_WQX -M02WLMNC03	Wellman	7/6/2015	45.436	-113.094	0.1	83	<4	NA	3	0.26	13	60	NA	0.091
MTWTRSHD_WQ X-BVD-WFBTDC-1	West Fork Blacktail	6/1/2009	44.7811	-112.307	23.6	NA	51	NA	1.3	NA	NA	NA	NA	NA
MTWTRSHD_WQ X-BVD-WFBTDC-2	West Fork Blacktail	6/1/2009	44.8653	-112.351	41.15	280	88.5	NA	12	0.2	1.5	NA	1.2	0.013
MDEQ_WQ_WQX -M02BDWFC02	West Fork Blacktail	8/5/2014	44.86533	-112.351	8.59	383	NA	NA	16	NA	NA	80	NA	NA
MDEQ_WQ_WQX -M02BDWFC04	West Fork Blacktail	8/5/2014	44.79064	-112.315	7.34	264	NA	NA	2	0.04	4	60	0.3	NA
MDEQ_WQ_WQX -M02BDWFC05	West Fork Blacktail	8/5/2014	44.83523	-112.333	10.89	369	NA	NA	16	NA	NA	70	NA	NA

APPENDIX C – TMDL EXAMPLES AND CALCULATIONS

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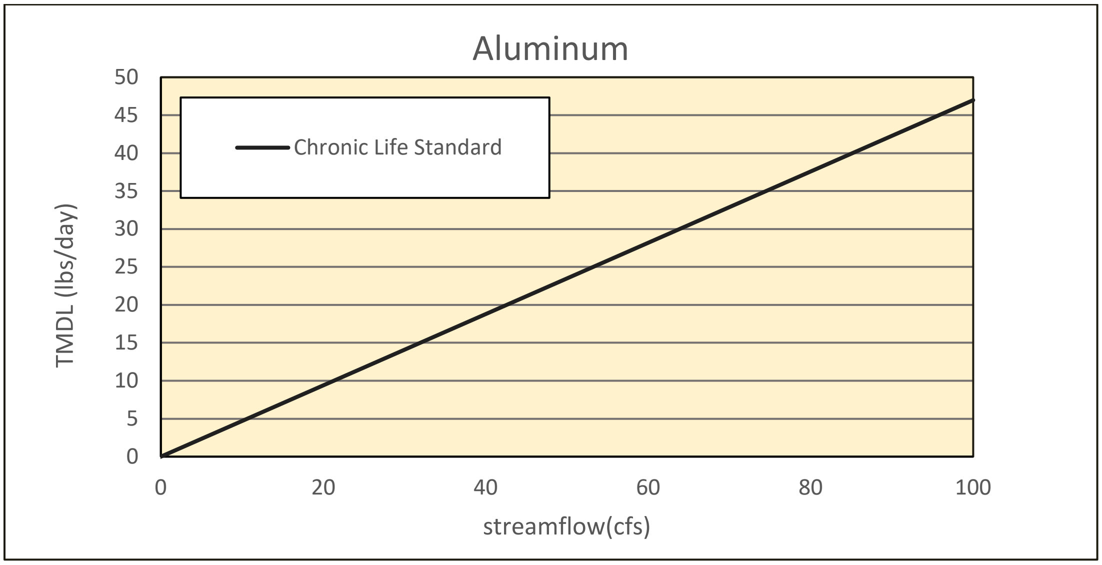
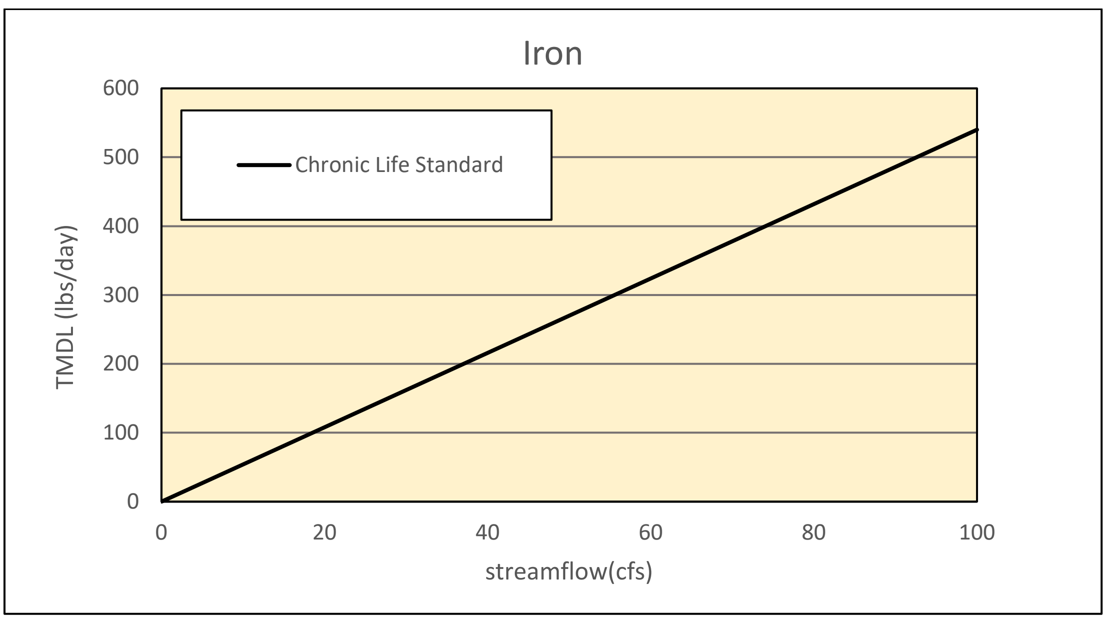
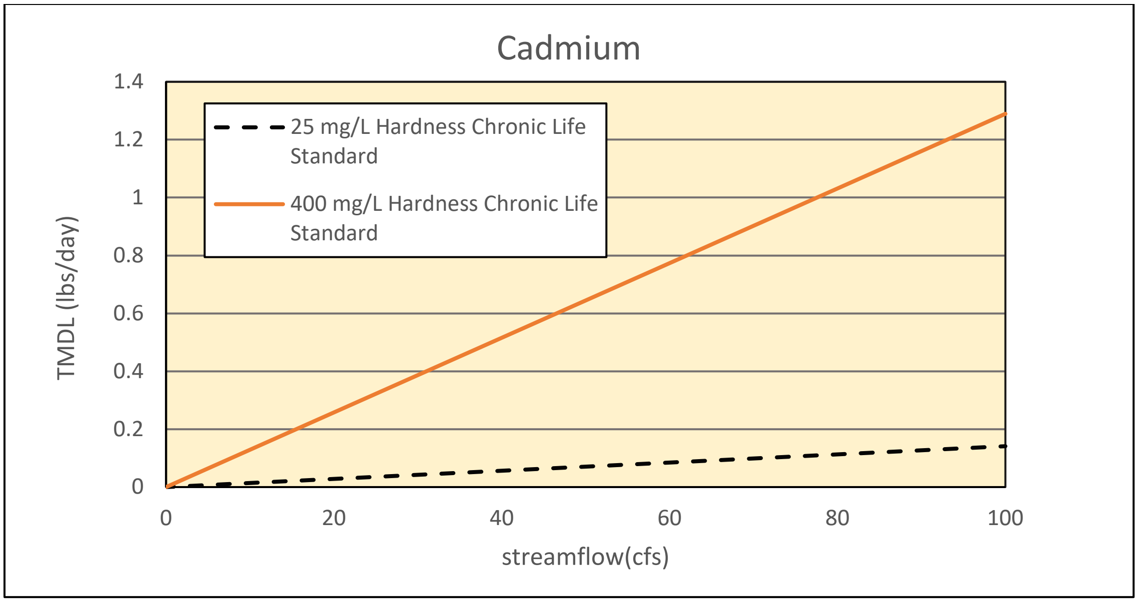
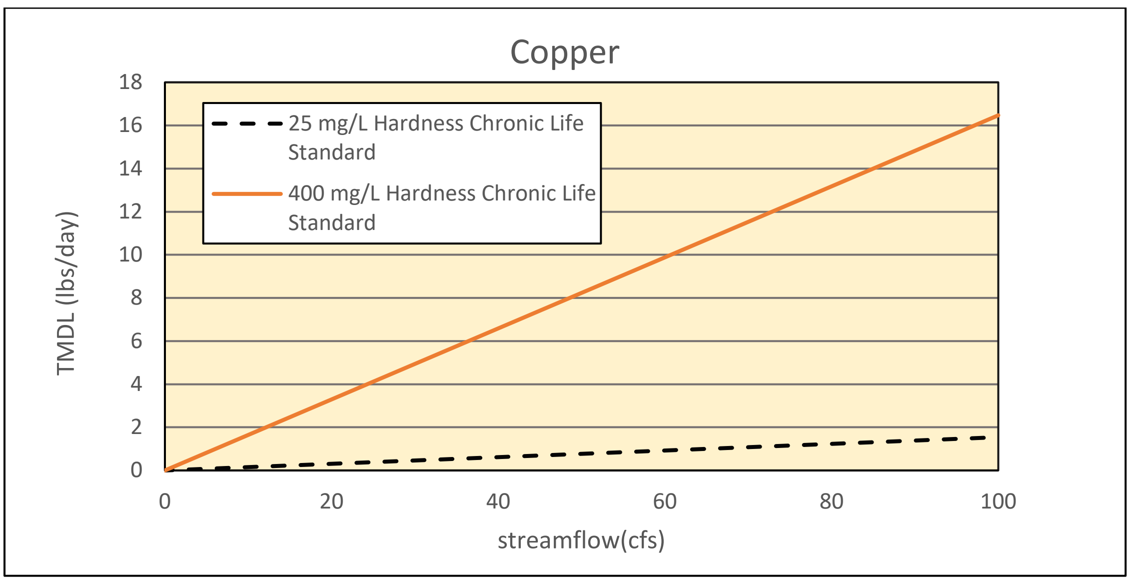
C.0 TMDL Examples and Calculations

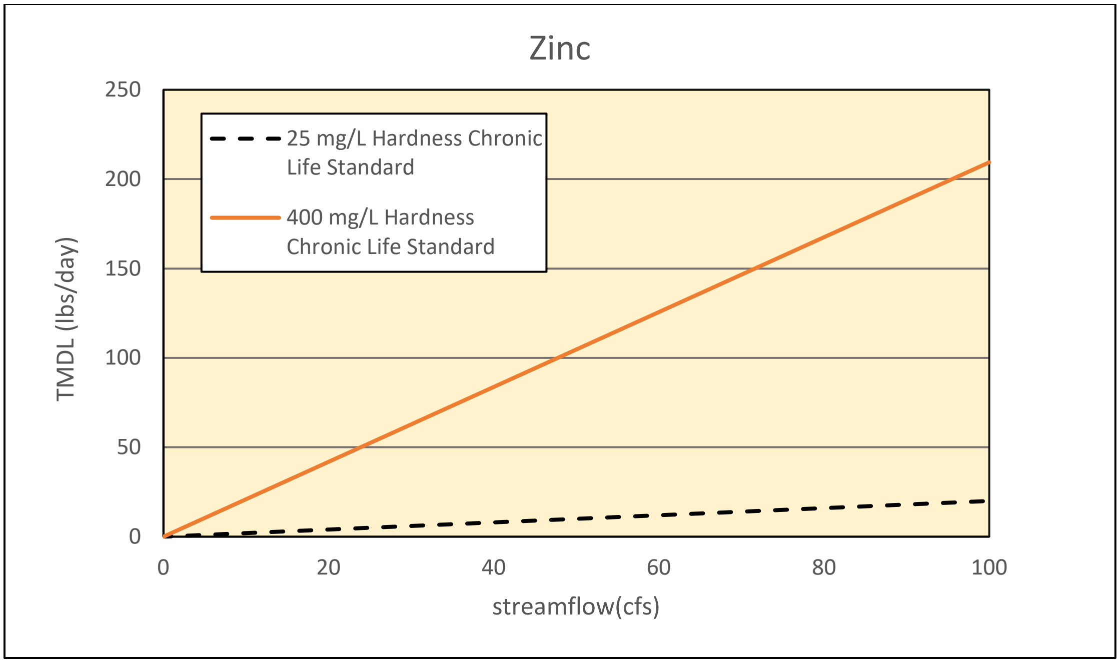
C.1. Graphs Illustrating TMDLs for Each Pollutant at Different Example Flows

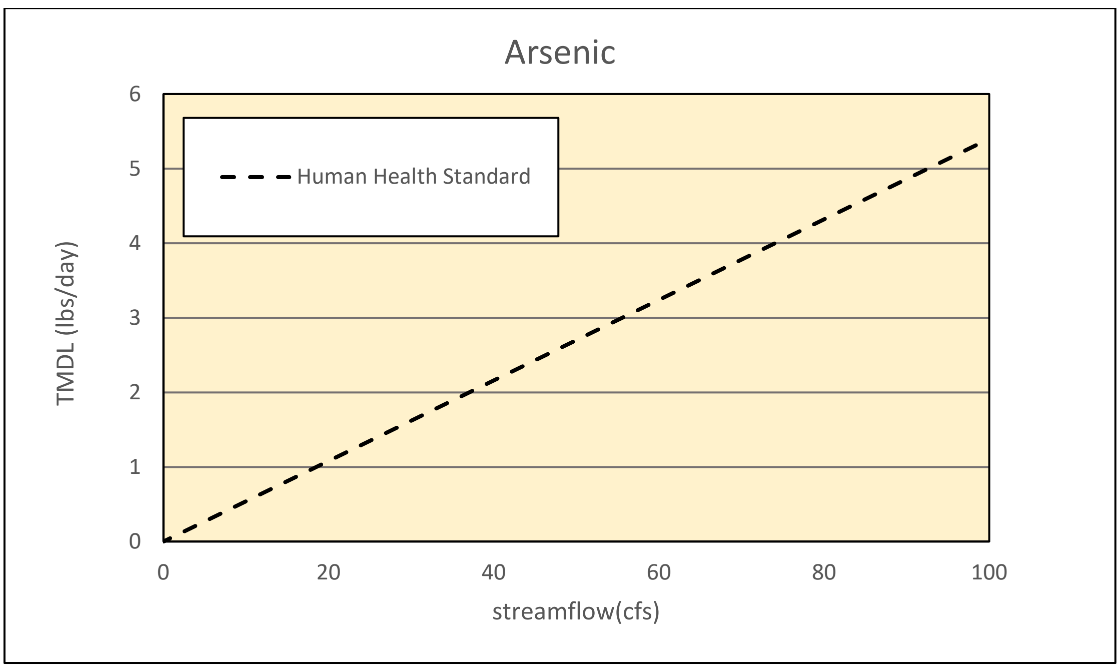


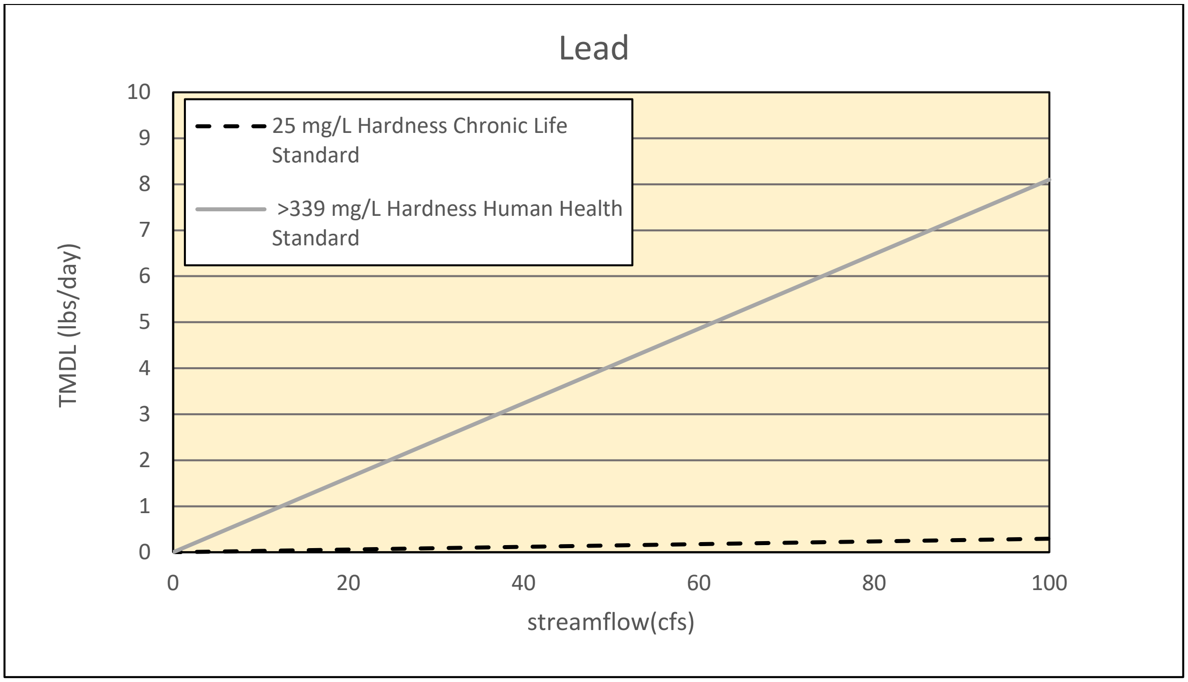



Cadmium
TMDL (lbs/day)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
25 mg/L Hardness Chronic Life Standard
400 mg/L Hardness Chronic Life Standard
0
20
40
60
80
100
streamflow(cfs)


Copper
TMDL (lbs/day)
18
16
14
12
10
8
6
4
2
0
25 mg/L Hardness Chronic Life Standard
400 mg/L Hardness Chronic Life Standard
0
20
40
60
80
100
streamflow(cfs)


Zinc
25 mg/L Hardness Chronic Life Standard
400 mg/L Hardness Chronic Life Standard
TMDL (lbs/day)
250
200
150
100
50
0
0
20
40
60
80
100
streamflow(cfs)


Arsenic
Human Health Standard
TMDL (lbs/day)
6
5
4
3
2
1
0
0
20
40
60
80
100
streamflow(cfs)


Lead
10
9
8
7
6
5
4
3
2
1
0
TMDL (lbs/day)
0
20
40
60
80
100
streamflow(cfs)
25 mg/L Hardness Chronic Life Standard
>339 mg/L Hardness Human Health Standard

C.2. Calculations Used in Development of TMDLs

Table C-1 Calculations Used in Development of Example Lead TMDLs

	Grasshopper		Lower Rattlesnake		Upper Rattlesnake		Wellman	
	Low Flow	High Flow	Low Flow	High Flow	Low Flow	High Flow	Low Flow	High Flow
Flow (cfs)	0.370	332.72	3.62	26.32	33.06	134.17	0.30	0.80
Hardness	19.000	64	64.00	25.00	59.00	37.00	62.00	62.00
Target Concentration (ug/L) (*EXP(1.273*(LN(hardness))-4.705)*	0.380	1.8	1.80	0.55	1.62	0.89	1.66	1.66
Measured Concentration (µg/L)	0.900	4.2	7.60	12.20	19.80	19.80	3.30	3.30
Reference Concentration (µg/L)	0.500	0.5	0.50	0.50	0.50	0.50	0.50	0.50
Existing Load (µg/L) *(Measured µg/L* Flow * 0.0054)*	0.00180	7.55	0.149	1.734	3.535	14.345	0.005	0.014
TMDL Load (lbs/day) *(Target µg/L* Flow * 0.0054)*	0.00076	3.36	0.035	0.077	0.289	0.645	0.003	0.007
Natural Load (lbs day) *(Reference µg/L* Flow*0.0054)*	0.00100	0.898	0.010	0.071	0.089	0.362	0.001	0.002
WLA_{ACTIVE}(lbs/day) *(Outfall Flow cfs *Concentration µg/L * 0.0054)*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
*LAup (lbs/day) (Upstream Flow cfs*Target Concentration µg/L * 0.0054 – Upstream Natural Load)*	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000
WLAComp (lbs/day) (TMDL Load-Natural Load-LAup-WLA_{ACTIVE})	0.000	2.336	0.025	0.002	0.200	0.280	0.002	0.005
% Reduction *((Existing Load-TMDL Load/Existing Load)*100*	44.44	55.49	76.32	95.5	91.82	95.51	49.50	49.50

Table C-2 Calculations Used in Development of Example Iron TMDLs

	Spring Creek		Upper Stone Creek		Lower Stone Creek	
	Low Flow	High Flow	Low Flow	High Flow	Low Flow	High Flow
Flow (cfs)	1.12	3.56	0.95	2.04	0.10	0.96
Hardness	NA	NA	NA	NA	NA	NA
Target Concentration (ug/L) *(1000 µg/L)*	1000	1000	1000.00	1000.00	1000.00	1000.00
Measured Concentration (µg/L)	690	1460	1280.00	4080.00	110.00	9960.00
Reference Concentration (µg/L)	240	240	240.00	240.00	240.00	240.00
Existing Load (µg/L) *(Measured µg/L* Flow * 0.0054)*	4.173	28.067	6.566	44.945	0.059	51.633
TMDL Load (lbs/day) *(Target µg/L* Flow * 0.0054)*	6.048	19.224	5.130	11.016	0.540	5.184
Natural Load (lbs day) *(Reference µg/L* Flow*0.0054)*	1.452	4.614	0.285	0.635	0.130	1.244
WLA_{ACTIVE}(lbs/day) *(Outfall Flow cfs *Concentration µg/L * 0.0054)*	0.000	0.000	3.940	8.370	0.000	0.000
*LAup(lbs/day) (Upstream Flow cfs*Concentration µg/L * 0.0054)*	0.000	0.000	0.000	0.000	0.000	0.000
WLAComp (lbs/day) (TMDL Load-Natural Load-LAup-WLAACTIVE)	4.596	14.61	0.905	2.010	0.410	3.940
% Reduction *((Existing Load-TMDL Load/Existing Load)*100*	0.00	31.51	21.88	75.49	0.00	52.46

Table C-3. Calculations Used in Development of Example Copper TMDLs

	Lower Rattlesnake Creek		Lower Stone Creek		Wellman Creek	
	Low Flow	High Flow	Low Flow	High Flow	Low Flow	High Flow
Flow (cfs)	3.62	26.32	0.1	0.96	0.30	0.80
Hardness	64.00	13.00	199	199	62	62
Target Concentration (ug/L) *EXP(0.8545*(LN(hardness))-1.702)*	6.37	2.85	16.79	16.79	6.20	6.20
Measured Concentration (µg/L)	2.00	52.00	2	20	48.00	48.00
Reference Concentration (µg/L)	1.00	1.00	1	1	1.00	1.00
Existing Load (µg/L) *(Measured µg/L* Flow * 0.0054)*	0.039	7.391	0.0011	0.1037	0.078	0.207
TMDL Load (lbs/day) *(Target µg/L* Flow * 0.0054)*	0.125	0.403	0.0091	0.0870	0.010	0.027
Natural Load (lbs day) *(Reference µg/L* Flow *0.0054)*	0.020	0.140	0.0005	0.0052	0.002	0.004
WLA_{ACTIVE}(lbs/day) *(Outfall Flow cfs *Concentration µg/L * 0.0054)*	0.000	0.000	0.000	0.000	0.000	0.000
*LAup (lbs/day) (Upstream Flow cfs*Target Concentration µg/L * 0.0054 – Upstream Natural Load)*	0.000	0.155	0.0000	0.0000	0.000	0.000
WLAComp (lbs/day) (TMDL Load-Natural Load-LAup-WLA_{ACTIVE})	0.105	0.108	0.0085	0.0820	0.008	0.022
% Reduction *((Existing Load-TMDL Load/Existing Load)*100*	0.00	94.52	0.00	16.05	87.08	87.08

Table C-4. Calculations Used in Development of Zinc TMDL's

	Wellman Creek	
	Low Flow	High Flow
Flow (cfs)	0.30	0.80
Hardness	62.00	62.00
Target Concentration (ug/L) *EXP(0.8473*(LN(hardness))-0.884)*	79.90	79.90
Measured Concentration (µg/L)	219.00	219.00
Reference Concentration (µg/L)	2.75	2.75
Existing Load (µg/L) *(Measured µg/L* Flow * 0.0054)*	0.35	0.95
TMDL Load (lbs/day) *(Target µg/L* Flow * 0.0054)*	0.13	0.35
Natural Load (lbs day) *(Reference µg/L* Flow *0.0054)*	0.004	0.012
WLA_{ACTIVE}(lbs/day) *(Outfall Flow cfs *Concentration µg/L * 0.0054)*	0.000	0.000

Table C-4. Calculations Used in Development of Zinc TMDL's

	Wellman Creek	
	Low Flow	High Flow
*LAup(lbs/day) (Upstream Flow cfs*Concentration µg/L * 0.0054)*	0.000	0.000
Natural Load (lbs day) *(Reference µg/L* Flow *0.0054)*	0.12	0.33
% Reduction *((Existing Load-TMDL Load/Existing Load)*100*	63.52	63.52

Table C-5. Calculations Used in Development of Example Cadmium TMDLs

	Wellman Creek	
	Low Flow	High Flow
Flow (cfs)	0.3	0.8
Hardness	62	62
Target Concentration (ug/L) *EXP(0.7977*(LN(hardness))-3.909)*	0.185	0.185
Measured Concentration (µg/L)	0.58	0.58
Reference Concentration (µg/L)	0.03	0.03
Existing Load (µg/L) *(Measured µg/L* Flow * 0.0054)*	0.001	0.003
TMDL Load (lbs/day) *(Target µg/L* Flow * 0.0054)*	0.0003	0.0008
Natural Load (lbs day) *(Reference µg/L* Flow *0.0054)*	0.0000	0.0001
WLA_{ACTIVE}(lbs/day) *(Outfall Flow cfs *Concentration µg/L * 0.0054)*	0.000	0.000
*LAup(lbs/day) (Upstream Flow cfs*Concentration µg/L * 0.0054)*	0.000	0.000
Natural Load (lbs day) *(Reference µg/L* Flow*0.0054)*	0.000	0.001
% Reduction *((Existing Load-TMDL Load/Existing Load)*100*	68.10	68.10

Table C-7. Calculations Used in Development of Example Aluminum TMDLs

	Lower Stone Creek		Wellman Creek	
	Low Flow	High Flow	Low Flow	High Flow
Flow (cfs)	0.1	0.96	0.30	0.80
Hardness	NA	NA	NA	NA
Target Concentration (ug/L)	87	87	87.00	87.00
Measured Concentration (ug/L)	16	183	166.00	166.00
Reference Concentration (ug/L)	50	50	50.00	50.00
Existing Load (µg/L) *(Measured µg/L* Flow * 0.0054)*	0.009	0.949	0.269	0.717
TMDL Load (lbs/day) *(Target µg/L* Flow * 0.0054)*	0.047	0.451	0.141	0.376
Natural Load (lbs day) *(Reference µg/L* Flow*0.0054)*	0.027	0.259	0.081	0.216
WLA_{ACTIVE}(lbs/day) *(Outfall Flow cfs *Concentration µg/L * 0.0054)*	0.000	0.000	0.000	0.000
*LAup(lbs/day) (Upstream Flow cfs*Concentration µg/L * 0.0054)*	0.000	0.000	0.000	0.000
WLAComp (lbs/day) (TMDL Load-Natural Load-LAup-WLA_{ACTIVE})	0.020	0.192	0.060	0.160
% Reduction *((Existing Load-TMDL Load/Existing Load)*100*	0.00	52.46	47.59	47.59

Table C-8. Calculations Used in Example Arsenic TMDL

	Steel Creek	West Fork Blacktail Deer Creek	
	Low/High Flow	Low Flow	High Flow
Flow (cfs)	0.05	8.59	41.5
Hardness	NA	383	280
Target Concentration (10 ug/L)	10	10	10
Measured Concentration (ug/L)	22	16	16
Reference Concentration (ug/L)	3.5	3.5	3.5
Existing Load (µg/L) (Measured µg/L* Flow * 0.0054)	0.0059	0.742	3.586
TMDL Load (lbs/day) (Target µg/L* Flow * 0.0054)	0.0027	0.464	2.241
Natural Load (lbs day) *(Reference µg/L* Flow *0.0054)*	0.0009	0.162	0.784
WLA_{ACTIVE}(lbs/day) *(Outfall Flow cfs *Concentration µg/L * 0.0054)*	0.000	0.000	0.000
*LAup(lbs/day) (Upstream Flow cfs*Concentration µg/L * 0.0054)*	0.000	0.000	0.000
WLAComp (lbs/day) (TMDL Load-Natural Load-LAup-WLA_{ACTIVE})	0.0018	0.302	1.457
% Reduction *((Existing Load-TMDL Load/Existing Load)*100*	54.55	37.5	37.5