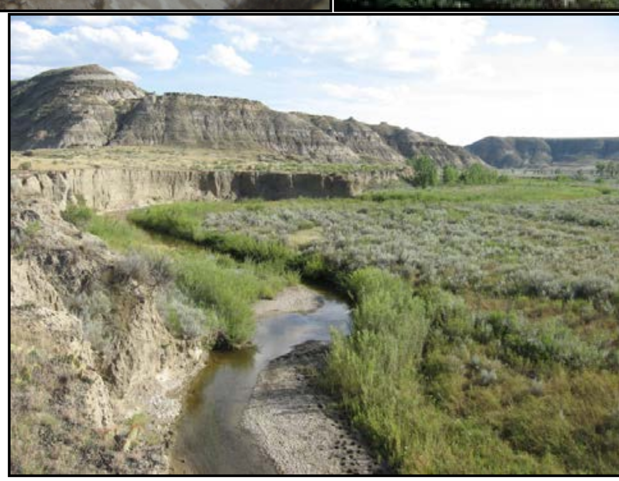
Judith Mountains Project Area TMDLs and Framework Water Quality Improvement Plan



June 2013

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M31-TMDL-02a-F

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ERRATA SHEET FOR THE "JUDITH MOUNTAINS PROJECT AREA TMDLS AND FRAMEWORK WATER QUALITY IMPROVEMENT PLAN"

The Judith Mountains TMDL package was approved by EPA on June 13, 2013. The published document contained two minor table errors. In Armells Creek, mercury is causing an impairment to Drinking Water, not to Aquatic Life as originally written in Table DS-1 and Table 1-1. The corrections to these tables are identified below.

Several copies of the original document were printed and bound for distribution, or sent electronically on compact disks. If you have a bound copy of the TMDL document, please print this errata sheet and place it with your copy of the document. If you have a compact disk, please add this errata sheet to your disk or download the updated version from our website. The corrections identified in this errata sheet have been made in the downloadable version of the TMDL located on our website at:
http://deq.mt.gov/wqinfo/TMDL/finalReports.mcpx

TABLE EDITS

Changes are noted in the shaded cells.

EDIT 1

Document Location:
Page 3, Document Summary, Table DS-1

Original Table:

Table DS-1. List of Impaired Waterbodies and their Impaired Uses in the Judith Mountains Project Area with Completed Sediment, Nutrient and Metals TMDLs Contained in this Document

Waterbody & Location Description	Waterbody ID	TMDL Prepared	TMDL Pollutant Category	Impaired Use(s)**
Armells Creek, headwaters to Deer Creek	MT40E002_022	Aluminum	Metals	Aquatic Life
		Cadmium	Metals	Aquatic Life
		Copper	Metals	Aquatic Life
		Iron	Metals	Aquatic Life
		Mercury	Metals	Aquatic Life
		Zinc	Metals	Aquatic Life

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

Corrected Table:

Table DS-1. List of Impaired Waterbodies and their Impaired Uses in the Judith Mountains Project Area with Completed Sediment, Nutrient and Metals TMDLs Contained in this Document

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		Copper	Metals	Aquatic Life
		Iron	Metals	Aquatic Life
		Mercury	Metals	Drinking Water
		Zinc	Metals	Aquatic Life

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

EDIT 2

Document Location:

Page 1-3, Section 1.2, Table 1-1

Original Table:

Table 1-1. Water Quality Impairment Causes for the Judith Mountains Project Area Addressed within this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)**	Impairment Cause Status	Included in 2012 IR***
Armells Creek, headwaters to Deer Creek	MT40E002_022	Aluminum	Metals	Aquatic Life	Aluminum TMDL contained in this document	No
		Cadmium	Metals	Aquatic Life	Cadmium TMDL contained in this document	Yes
		Copper	Metals	Aquatic Life	Copper TMDL contained in this document	Yes
		Iron	Metals	Aquatic Life	Iron TMDL contained in this document	No
		Mercury	Metals	Aquatic Life	Mercury TMDL contained in this document	Yes
		Zinc	Metals	Aquatic Life	Zinc TMDL contained in this document	Yes
		pH	Metals	Aquatic Life	Addressed by copper TMDL as a surrogate	Yes

** Only the uses impaired by each pollutant are identified; information is based on updated impairment and use support determinations presented within this document.
***Impairment causes not in the "2012 Water Quality Integrated Report" were recently identified and will be included in the 2014 Integrated Report.

Corrected Table:

Table 1-1. Water Quality Impairment Causes for the Judith Mountains Project Area Addressed within this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)**	Impairment Cause Status	Included in 2012 IR***
Armells Creek, headwaters to Deer Creek	MT40E002_022	Aluminum	Metals	Aquatic Life	Aluminum TMDL contained in this document	No
		Cadmium	Metals	Aquatic Life	Cadmium TMDL contained in this document	Yes
		Copper	Metals	Aquatic Life	Copper TMDL contained in this document	Yes
		Iron	Metals	Aquatic Life	Iron TMDL contained in this document	No
		Mercury	Metals	Drinking Water	Mercury TMDL contained in this document	Yes
		Zinc	Metals	Aquatic Life	Zinc TMDL contained in this document	Yes
		pH	Metals	Aquatic Life	Addressed by copper TMDL as a surrogate	Yes

** Only the uses impaired by each pollutant are identified; information is based on updated impairment and use support determinations presented within this document.
***Impairment causes not in the "2012 Water Quality Integrated Report" were recently identified and will be included in the 2014 Integrated Report.

ACKNOWLEDGEMENTS

DEQ and EPA would like to thank the landowners who graciously provided permission to access water quality sampling sites via their land. Additionally, Chad Krause of the BLM; Anne Tews of the Montana Department of Fish, Wildlife, and Parks; Chris Gammons, George Williams, and Steve Parker of Montana Tech; and the Montana Bureau of Mines and Geology all shared data and/or knowledge of the project area. We would also like to thank the Fergus and Blaine Conservation Districts.

Various versions of sections of this document were sent to stakeholders for review and input. The involvement of all reviewers led to improvements in this document and is greatly appreciated.

Peter Brumm, a hydrologist with EPA, prepared the Watershed Characterization and assisted with document compilation. We would like to thank Carrie Greeley, an administrative assistant for the Watershed Management Section of DEQ, for her time and efforts formatting this document.

Multiple consultants provided significant contributions in the development of the document and appendices. Tetra Tech prepared the majority of the sediment, nutrient, and metals TMDL document sections as well as **Appendix E**, *Sediment Total Maximum Daily Loads*. Atkins conducted water quality sampling in 2010 and 2011 and provided significant contributions in the development of **Appendix C**, *Chippewa Creek Sediment Assessment,* and **Appendix D**, *Judith Mountains Project Area Metals Source Assessment.*

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ACRONYM LIST

Acronym	Definition
ACEC	Area of Critical Concern
AML	Abandoned Mine Lands
ARARS	Applicable or Relevant and Appropriate Requirements and Standards
ARM	Administrative Rules of Montana
BDNF	Beaverhead Deerlodge National Forest
BEHI	Bank Erosion Hazard Index
BLM	Bureau of Land Management (Federal)
BMP	Best Management Practices
CALA	Controlled Allocation of Liability Act
CECRA	[Montana] Comprehensive Environmental Cleanup and Responsibility Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CWA	Clean Water Act
DEQ	Department of Environmental Quality (Montana)
DNRC	Department of Natural Resources & Conservation (Montana)
DO	Dissolved Oxygen
EPA	Environmental Protection Agency (U.S.)
EQIP	Environmental Quality Initiatives Program
FAR	Functional – At Risk
FWP	Fish, Wildlife & Parks (Montana)
GIS	Geographic Information System
GWIC	Groundwater Information Center
HHS	Human Health Standard
HUC	Hydrologic Unit Code
ICIS	Integrated Compliance Information System (EPA)
INFISH	Inland Native Fish Strategy
IR	Integrated Report
LA	Load Allocation
LWD	Large Woody Debris
MBMG	Montana Bureau of Mines and Geology
MCA	Montana Code Annotated
MOS	Margin of Safety
MPDES	Montana Pollutant Discharge Elimination System
MSU	Montana State University
NBS	Near Bank Stress
NLCD	National Land Cover Dataset
NOAA	National Oceanographic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPS	Nonpoint Source
NRCS	National Resources Conservation Service
NRDP	Natural Resource Damage Program (Montana Dept. of Justice)
PEL	Probable Effects Levels
PFC	Proper Functioning Condition

PIBO	PACFISH/INFISH Biological Opinion
RAWS	Remote Automatic Weather Station
RIT/RDG	Resource Indemnity Trust/Reclamation and Development Grants Program
SDR	Sediment Delivery Ratio
SMCRA	Surface Mining Control & Reclamation Act
SMZ	Streamside Management Zone
SSURGO	Soil Survey Geographic database
STORET	EPA STOrage and RETrieval database
SWPPP	Storm Water Pollution Prevention Plan
TIE	TMDL Implementation Evaluation
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TPA	TMDL Planning Area
TSS	Total Suspended Solids
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFWS	US Fish and Wildlife Service
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation
VCRA	Voluntary Cleanup and Redevelopment Act
WEPP	Water Erosion Prediction Project
WLA	Wasteload Allocation
WQ	Water Quality
WRP	Watershed Restoration Plan

DOCUMENT SUMMARY

This document presents a total maximum daily load (TMDL) and framework water quality improvement plan for six impaired streams in the Judith Mountains TMDL Project Area including Armells Creek, Chicago Gulch, Chippewa Creek, Collar Gulch Creek, Cow Creek and Fargo Coulee (**Figure A-7** in **Appendix A**). The 31 TMDLs in this document address impairment from sediment, nutrients and metals (**Table DS-1**).

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 Judith Mountains Project Area is located within Fergus, Blaine and Phillips Counties and covers 920,561 acres, or approximately 1,438 square miles. The Project Area is located in the Lower Missouri River Basin of central Montana as shown in **Appendix A**, **Figure A-1**. It is bounded by Fort Belknap Reservation to the northeast and drainage divides to the east and west. The Project Area extends south, capturing three listed streams (Chicago Gulch, Chippewa Creek and Collar Gulch Creek) that originate in the Judith Mountains and drain east into the Mussellshell River, whereas other streams in the Project Area flow to the Missouri River.

Sediment - One sediment TMDL is provided for one waterbody segment (Chippewa Creek) in the Judith Mountains Project Area (**Table DS-1**). Sediment is affecting designated uses in this stream by altering aquatic insect communities, reducing fish spawning success, and increasing turbidity. Water quality restoration goals for sediment were established on the basis of fine sediment levels in trout spawning areas and aquatic insect habitat, stream morphology and available in-stream habitat as it relates to the effects of sediment, and the stability of streambanks. DEQ believes that once these water quality goals are met, all beneficial uses currently affected by sediment will be restored.

Sediment loads are quantified for natural background conditions and for the following sources: bank erosion, hillslope erosion, roads and mill tailings. The most significant sources include: bank erosion and hillslope erosion. The Chippewa Creek sediment TMDL indicates that an overall sediment load reduction of 39% will satisfy the water quality restoration goals. Recommended strategies for achieving the sediment reduction goals are also presented in this plan. They include best management practices (BMPs) for building and maintaining roads and improving upland land cover and expanding riparian buffer areas by using land, soil, and water conservation practices that improve stream channel conditions and associated riparian vegetation.

Nutrients – Two nutrient TMDLs (total phosphorus and nitrogen) are provided for one waterbody segment (Fargo Coulee) in the Judith Mountains Project Area (**Table DS-1**). Nutrient data are limited but other variables that respond to excess nutrients indicate that nutrients are affecting beneficial uses in this stream by being present in concentrations that are linked to nuisance algal growth and low levels of dissolved oxygen. Water quality restoration goals for nutrients were established based on concentrations that will prevent nuisance algal growth and harm to aquatic life.

Livestock grazing is the primary human source of nutrients but composite allocations are provided to all nonpoint sources, including natural background. Recommended strategies for achieving the nutrient reduction goals are also presented in this plan. They include BMPs for livestock grazing and irrigation, as well as improving riparian vegetation.

Metals - Twenty eight metals TMDLs are provided for six waterbody segments in the Judith Mountains Project Area (**Table DS-1**). There are also three waterbody segments with pH impairments; metals TMDLs for those streams are surrogates for pH TMDLs because addressing sources of metals impairments will also address sources of pH impairment. The metals of concern include: aluminum, antimony, arsenic, cadmium, copper, cyanide, iron, lead, mercury and zinc. Water quality restoration goals for metals are established based on the numeric water quality criteria as defined in Circular DEQ-7. DEQ believes that once these water quality goals are met, all water uses currently affected by metals will be restored.

Metals loads are quantified for natural background conditions, abandoned mines, and diffuse sources (e.g., land management practices that increase erosion of mineralized soils). The Judith Mountains Project Area metals TMDLs indicate that reductions in metals loads ranging from 3.6% to 100% will satisfy the water quality restoration goals. Achieving the metals reduction goals presented in this plan will mostly rely on abandoned mine reclamation. The state and federal programs as well as potential funding resources to address metals sources are summarized in this plan.

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.

A flexible approach to most nonpoint source TMDL implementation activities may be necessary as more knowledge is gained through implementation and future monitoring. The plan includes a monitoring strategy designed to track progress in meeting TMDL objectives and goals and to help refine the plan during its implementation.

Although most water quality improvement measures 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 were TMDLs have been developed and approved by EPA. As of January 2013, this project area has no permitted dischargers requiring the incorporation of WLAs into permit conditions.

Table DS-1. List of Impaired Waterbodies and their Impaired Uses in the Judith Mountains Project Area with Completed Sediment, Nutrient and Metals TMDLs Contained in this Document

Waterbody & Location Description	Waterbody ID	TMDL Prepared	TMDL Pollutant Category	Impaired Use(s)**
Chicago Gulch, headwaters to mouth (Fords Creek)*	MT40B002_020	Arsenic	Metals	Drinking Water
		Cadmium	Metals	Aquatic Life
		Lead	Metals	Aquatic Life, Drinking Water
		Zinc	Metals	Aquatic Life
Chippewa Creek, headwaters to confluence with Manitoba Gulch	MT40B002_040	Sedimentation/Siltation	Sediment	Aquatic Life
		Antimony	Metals	Drinking Water
		Arsenic	Metals	Drinking Water
		Cyanide	Metals	Aquatic Life
		Iron	Metals	Aquatic Life
		Mercury	Metals	Aquatic Life, Drinking Water
Collar Gulch Creek, headwaters to mouth (Fords Creek)	MT40B002_030	Aluminum	Metals	Aquatic Life
		Arsenic	Metals	Drinking Water
		Cadmium	Metals	Aquatic Life
		Copper	Metals	Aquatic Life
		Lead	Metals	Aquatic Life, Drinking Water
		Zinc	Metals	Aquatic Life
Armells Creek, headwaters to Deer Creek	MT40E002_022	Aluminum	Metals	Aquatic Life
		Cadmium	Metals	Aquatic Life
		Copper	Metals	Aquatic Life
		Iron	Metals	Aquatic Life
		Mercury	Metals	Drinking Water
		Zinc	Metals	Aquatic Life
Cow Creek, Als Creek to mouth (Missouri River)	MT40E002_040	Aluminum	Metals	Aquatic Life
		Arsenic	Metals	Drinking Water
		Copper	Metals	Aquatic Life
		Iron	Metals	Aquatic Life
		Lead	Metals	Aquatic Life, Drinking Water
Fargo Coulee, headwaters to mouth (Armells Creek)	MT40E002_130	Total Nitrogen	Nutrients	Aquatic Life
		Total Phosphorus	Nutrients	Aquatic Life
		Aluminum	Metals	Aquatic Life
		Arsenic	Metals	Drinking Water

*This waterbody segment is actually part of Ford's Creek and its name will be corrected for the 2014 IR to "Fords Creek (headwaters in Chicago Gulch to East Fork Fords Creek)."

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

1.0 INTRODUCTION

This document presents an analysis of water quality information and establishes total maximum daily loads (TMDLs) for sediment, nutrient and metals problems in the Judith Mountains Project Area. This document also presents a general framework for resolving these problems. **Figure A-7** found in **Appendix A**, shows a map of waterbodies in the project area with sediment, nutrient and metals pollutant listings.

1.1 BACKGROUND

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

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 waterbody. Each state must monitor their waters to assess 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.

Montana's biennial IR identifies all the state's impaired waterbody segments. The 303(d) list portion of the IR includes all of those waterbody segments impaired by a pollutant, which require a TMDL, whereas TMDLs are not required for non-pollutant causes of impairments.

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

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

- Determining measurable target values to help evaluate the waterbody's condition in relation to the applicable water quality standards
- Identifying sources of pollutants contributing to impairment and quantifying the magnitude of pollutant contribution from them
- Determining the TMDL for each pollutant based on the allowable loading limits for each waterbody-pollutant combination

- Allocating the total allowable load (TMDL) into individual loads for each source

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

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

1.2 Water Quality Impairments and TMDLs Addressed by this Document

Table 1-1 below lists all of the impairment causes from the "2012 Water Quality Integrated Report" that are addressed in this document (also see **Figure A-1** in **Appendix A**). Each pollutant impairment falls within a TMDL pollutant category (e.g., metals, nutrients or sediment), and this document is organized by those categories.

Because the production of this document started while 2010 was the most current 303(d) list but TMDLs were finalized after the approval of the 2012 303(d) List, one difference should be noted between the lists. The newer 303(d) list replaced Fargo Coulee's total Kjeldahl nitrogen (TKN) listing with a total nitrogen (TN) listing to avoid analytical bias issues with TKN. Because TKN is a component of TN, addressing the TN impairment will address TKN.

New data assessed during this project identified nine new metals impairment causes on four waterbodies. These impairment causes are identified in **Table 1-1** and noted as not being on the 2012 303(d) List (within the integrated report). Instead, these waters will be documented within DEQ assessment files and incorporated into the 2014 IR.

TMDLs are completed for each waterbody – pollutant combination, and this document contains 31 TMDLs in addition to three pH impairments addressed by surrogate metals TMDLs (**Table 1-1**). There are two non-pollutant types of impairment that are also addressed in this document. As noted above, TMDLs are not required for non-pollutants, although in many situations the solution to one or more pollutant problems will be consistent with, or equivalent to, the solution for one or more non-pollutant problems. The overlap between the pollutant TMDLs and non-pollutant impairment causes is discussed in **Section 8.0**. **Section 8.0** also provides some basic water quality solutions to address those non-pollutant causes not specifically addressed by TMDLs in this document.

Table 1-1. Water Quality Impairment Causes for the Judith Mountains Project Area Addressed within this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)**	Impairment Cause Status	Included in 2012 IR***
Chicago Gulch, headwaters to mouth (Fords Creek)*	MT40B002_020	Arsenic	Metals	Drinking Water	Arsenic TMDL contained in this document	No
		Cadmium	Metals	Aquatic Life	Cadmium TMDL contained in this document	No
		Lead	Metals	Aquatic Life, Drinking Water	Lead TMDL contained in this document	Yes
		Zinc	Metals	Aquatic Life	Zinc TMDL contained in this document	Yes
		pH	Metals	Aquatic Life	Addressed by lead TMDL as a surrogate	Yes
Chippewa Creek, headwaters to confluence with Manitoba Gulch	MT40B002_040	Alterations in streamside or littoral vegetation covers	N/A: Non-Pollutant	Primary Contact Recreation, Aquatic Life	Addressed by a sediment TMDL in this document	Yes
		Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in this document	Yes
		Antimony	Metals	Aquatic Life	Antimony TMDL contained in this document	Yes
		Arsenic	Metals	Drinking Water	Arsenic TMDL contained in this document	Yes
		Cyanide	Metals	Aquatic Life	Cyanide TMDL contained in this document	Yes
		Iron	Metals	Aquatic Life	Iron TMDL contained in this document	Yes
		Mercury	Metals	Aquatic Life, Drinking Water	Mercury TMDL contained in this document	Yes
		Zinc	Metals	Aquatic Life	No TMDL based on review of recent data; updated 303(d) listing status pending	Yes
Collar Gulch Creek, headwaters to mouth (Fords Creek)	MT40B002_030	Aluminum	Metals	Aquatic Life	Aluminum TMDL contained in this document	No
		Arsenic	Metals	Drinking Water	Arsenic TMDL contained in this document	No
		Cadmium	Metals	Aquatic Life	Cadmium TMDL contained in this document	No
		Copper	Metals	Aquatic Life	Copper TMDL contained in this document	No
		Lead	Metals	Aquatic Life, Drinking Water	Lead TMDL contained in this document	Yes
		Zinc	Metals	Aquatic Life	Zinc TMDL contained in this document	Yes
		pH	Metals	Aquatic Life	Addressed by lead TMDL as a surrogate	Yes

Table 1-1. Water Quality Impairment Causes for the Judith Mountains Project Area Addressed within this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)**	Impairment Cause Status	Included in 2012 IR***
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		Cadmium	Metals	Aquatic Life	Cadmium TMDL contained in this document	Yes
		Copper	Metals	Aquatic Life	Copper TMDL contained in this document	Yes
		Iron	Metals	Aquatic Life	Iron TMDL contained in this document	No
		Mercury	Metals	Drinking Water	Mercury TMDL contained in this document	Yes
		Zinc	Metals	Aquatic Life	Zinc TMDL contained in this document	Yes
		pH	Metals	Aquatic Life	Addressed by copper TMDL as a surrogate	Yes
Cow Creek, Als Creek to mouth (Missouri River)	MT40E002_040	Aluminum	Metals	Aquatic Life	Aluminum TMDL contained in this document	Yes
		Arsenic	Metals	Drinking Water	Arsenic TMDL contained in this document	No
		Copper	Metals	Aquatic Life	Copper TMDL contained in this document	Yes
		Iron	Metals	Aquatic Life	Iron TMDL contained in this document	Yes
		Lead	Metals	Aquatic Life, Drinking Water	Lead TMDL contained in this document	Yes
Fargo Coulee, headwaters to mouth (Armells Creek)	MT40E002_130	Alterations in streamside or littoral vegetation covers	N/A: Non-Pollutant	Aquatic Life	Addressed by a nutrient TMDL in this document	Yes
		Total Nitrogen	Nutrients	Aquatic Life	TN TMDL contained in this document	Yes
		Total Phosphorus	Nutrients	Aquatic Life	TP TMDL contained in this document	Yes
		Aluminum	Metals	Aquatic Life	Aluminum TMDL contained in this document	Yes
		Arsenic	Metals	Drinking Water	Arsenic TMDL contained in this document	No
		Iron	Metals	Aquatic Life	No TMDL based on review of recent data; updated 303(d) listing status pending	Yes
		Lead	Metals	Aquatic Life	No TMDL based on review of recent data; updated 303(d) listing status pending	Yes

*This waterbody segment is actually part of Ford's Creek and its name will be corrected for the 2014 IR to "Fords Creek (headwaters in Chicago Gulch to East Fork Fords Creek)."

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

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

1.3 Document Layout

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

Section 2.0 Judith Mountains Project Area 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 Judith Mountains Project Area.

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

Sections 5.0 – 7.0 Sediment, Nutrients and Metals TMDL Components (sequentially):
Each section includes (a) a discussion of the affected waterbodies and the pollutant's effect on designated beneficial uses, (b) the information sources and assessment methods used to evaluate stream health and pollutant source contributions, (c) water quality targets and existing water quality conditions, (d) the quantified pollutant loading from the identified sources, (e) the determined TMDL for each waterbody, (f) the allocations of the allowable pollutant load to the identified sources.

Section 8.0 Other Identified Issues or Concerns:
Describes other problems that could potentially be contributing to water quality impairment and how the TMDLs in the plan might address some of these concerns. This section also provides recommendations for combating these problems.

Section 9.0 Restoration Objectives and Implementation Plan:
Discusses water quality restoration objectives and presents a framework for implementing a strategy to meet the identified objectives and TMDLs.

Section 10.0 Monitoring Strategy:
Describes a water quality monitoring plan for evaluating the long-term effectiveness of the "Judith Mountains Project Area TMDLs and Framework Water Quality Improvement Plan."

Section 11.0 Public Participation and Comments:
Describes other agencies and stakeholder groups who were involved with the development of the plan and the public participation process used to review the draft document. Addresses comments received during the public review period.

2.0 JUDITH MOUNTAINS PROJECT AREA DESCRIPTION

This section describes the general physical, ecological, and cultural characteristics of the Judith Mountains Project Area and is intended to provide background information to support total maximum daily load (TMDL) development. The area described is known as the Judith Mountains TMDL Project Area.

The Montana Department of Environmental Quality (DEQ) has identified six impaired (category 5) waterbodies within the Judith Mountains Project Area: Armells Creek, Chicago Gulch, Chippewa Creek, Collar Gulch Creek, Cow Creek, and Fargo Coulee. The impairments are detailed in DEQ's Integrated 305(b)/303(d) Water Quality Report (Montana Department of Environmental Quality, 2012b). A total of 87.7 miles of streams in the project area are listed as impaired. The maps referenced in the following discussion are contained in **Appendix A**.

2.1 PHYSICAL PARAMETERS

The following information describes the physical characteristics of the Judith Mountains Project Area.

2.1.1 Location

The Judith Mountains Project Area is located within Fergus, Blaine and Phillips Counties and covers 920,561 acres, or approximately 1,438 square miles. The project area is located in the Lower Missouri River Basin of central Montana as shown in **Figure A-1**. It is bounded by Fort Belknap Reservation to the northeast and drainage divides to the east and west. The project area extends south, capturing three listed streams (Chicago Gulch, Chippewa Creek and Collar Gulch Creek) that originate in the Judith Mountains and drain east into the Mussellshell River, opposed to most streams in the project area which contribute flow to the Missouri River within project area boundaries.

2.1.2 Topography

Elevations in the Judith Mountains Project Area range from approximately 2,245 to 6,430 feet above sea level as shown in **Figure A-3**. The lowest point is where the Missouri River exits the project area flowing east and the highest point is Judith Peak, located on the southwestern boundary line. The diverse landscape is characterized by mountains, plains, plateaus and rugged badlands known as the Missouri Breaks.

2.1.3 Geology

Figure A-4 provides an overview of the generalized geology based on a 1:500,000 scale geologic map of the state (Raines and Johnson, 1995).

Bedrock

The oldest bedrock in the Judith Mountains Project Area is sedimentary rock dating back to the Precambrian. Bedrock from the Precambrian through the Jurassic period is comprised of unconsolidated shale, sandstone, and limestone, and can be found in areas affected by mountain uplift; though which process older layers appear on the surface. More recent Cretaceous sedimentary deposits are by far the most widespread geologic unit in the project area. These sediments were created by the Western Interior Seaway that divided present day North American from the Arctic to the Gulf of Mexico during the Cretaceous period. Because the seaway waxed and waned, rocks are of marine, freshwater and brackish origin (U.S. Bureau of Mines, 1979). The Cretaceous geologic units contain abundant fine textured shale and in some places, a sandstone cap. Calcium carbonate and iron oxide concretions are sometimes present throughout the sandstone formations. The prominent series of northeast-trending, parallel faults and folds were formed due to gravity sliding of Cretaceous strata blocks during igneous intrusion and mountain uplift. A nonconforming, northwest-trending fault along Cow Creek is a boundary between two groups of gravity slide blocks. Areas with igneous intrusive bedrock are less common than sedimentary bedrock but can be found in the Bearpaw, Little Rocky and Judith Mountains. Igneous extrusive rock is reserved to a portion of the project area containing the Bearpaw Mountains and is dominated by fine-grained latite and andesite. Early reports investigating the mineral resources of the area indicated contact deposits commonly occurred in limestone near the borders of igneous masses (Weed and Pirsson, 1898) which helps explain the clustered locations of abandoned mines seen today.

Basin Sediments
Quaternary terrace deposits that formed from receding Quaternary ice sheets are present in localized areas. The most recent sediments are alluvial deposits located within modern stream channels that incised into the Cretaceous sedimentary rocks.

2.1.4 Soil Erodibility and Slope

The USGS Water Resources Division (Raines and Johnson, 1995; Schwarz and Alexander, 1995) created a dataset of hydrology-relevant soil attributes, based on the USDA Natural Resources Conservation Service (NRCS) STATSGO soil database. The STATSGO data are intended for small-scale (watershed or larger) mapping, and is too general to be used at scales larger than 1:250,000; for reference, the maps found in **Appendix A** of this document are scaled at approximately 1:700,000. It should be noted that each soil unit in STATSGO may include up to 21 soil components. Soil analysis at a larger scale, 1:24,000 for example, should use the NRCS Soil Survey Geographic (SSURGO) database.

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 A-5**, 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. The majority of the project area is mapped with moderate-low susceptibility soils (61%), followed by moderate-high susceptibility soils (30%), and the remaining area is listed as low susceptibility soils (9%). Areas with higher erodibility values in the project area correspond with herbaceous, savannah-type land cover.

Over 95% of the land is gently sloped (<20°); more abrupt gradients are reserved to the Judith Mountains in the southern portion of the project area, the Bearpaw Mountains to the northwest and the cliffs and coulees of the Missouri River Breaks. Soil slope is mapped on **Figure A-6.**

2.1.5 Surface Water

Ninety-four percent of the Judith Mountains Project Area is located within the Fort Peck Reservoir fourth-code hydrologic unit (HUC 10040104) that drains directly into the Missouri River. The project area also extends south to include a small portion of the Box Elder Creek hydrologic unit (10040204), which flows into the Musselshell River and eventually the Missouri River, and a section of the Peoples Creek hydrologic unit (10050009) to the north as shown on **Figure A-7**.

Although not the subject of comprehensive analysis, the surface water in portions of the project area has been studied in various reports. The BLM collected flow and water quality data in 2002 on Collar Gulch Creek, Chicago Gulch and Armells Creek while developing a resource management plan. The United States Geologic Survey (USGS) has maintained four gaging stations within the project area with varying periods of record, as detailed in **Table 2-1** below. Stream mapping at the 1:100,000 scale includes 762 miles of named streams, with a total of 1,575 miles of streams mapped in the project area. Hydrography and the locations of gaging stations are shown in **Figure A-7**.

Table 2-1. USGS stream gages within the Judith Mountains Project Area.

Site Name	Site Number	Period of Record
Armells Creek near Landusky MT	6115270	2/2000-9/2004
Duval Creek near Landusky MT	6115300	2/2000-9/2004
Missouri River near Landusky MT	6115200	3/1934-present
Missouri R Power Plant Ferry near Zortman MT	6115000	2/1934-11/1968

2.1.6 Groundwater

No comprehensive hydrogeology study is available for the project area; however, the Judith Mountains-were included in a study conducted by Levings et al. (1983) characterizing the hydrogeology and water flow in the Kootenai Aquifer. The effort was initiated to assess the aquifer’s ability to support future economic and population growth. Results of the investigation indicate natural recharge occurs from infiltration of precipitation and upward leakage from adjacent bedrock aquifers; interaction between deeper aquifers and the Kootenai Aquifer across sandstone and shale formations is common. Hydrologic conductivity is estimated between 1.33×10^{-4} to 2.15×10^{-2} feet per day and modeled transmissivity values ranged from 137 to 364 feet squared per day. Since physical characteristics are comparable and proximity is close, groundwater in the broader project area likely behaves similarly to that seen in the Kootenai Aquifer Basin.

Briar et al. (1993) examined the southern portion of the Fort Belknap Reservation, which abuts the project area, and found Quaternary glacial deposits of till and glaciolacustrine clay to be relatively impermeable, thus typically forming a confining unit overlying valley-fill aquifers. Findings show both the dominant ion of the groundwater changes and the overall dissolved solids increase markedly (from 233 mg/l to 11,500 mg/l) as wells get father away from mountain ranges.

The Montana Bureau of Mines and Geology (MBMG) Groundwater Information Center (GWIC) program monitors and samples a statewide network of wells. As of July 2011, the GWIC database reports 307 wells within the project area, and water quality data are available for 23 of the wells (**Figure A-8**). The water quality data include general physical parameters: temperature, pH and specific conductance, in addition to inorganic chemistry (common ions, metals and trace elements).

2.1.7 Climate

Climate in the area is typical of mountains and plains in north-central Montana. Precipitation is most abundant in May and June. Annual precipitation ranges from 12-26 inches. The mountains receive most of the moisture, and the amount received decreases with elevation, with the least falling at Cow Creek’s confluence with the Missouri River. Precipitation data mapped by Oregon State University’s PRISM Group and weather stations are mapped in **Figure A-9.**

One climate station, a BLM Remote Automatic Weather Station (RAWS), is located within the project area. The Armells Creek station (ARMM8) has been collecting temperature, dew point, relative humidity and wind speed data since October 6th, 1998 for the chief purpose of monitoring fire danger. Another RAWS stations, Little Bullwhacker, is just outside the project area boundary to the West. The nearest SNOTEL site operated by NRCS is the Rocky Boy station, eight miles northwest of the project area. A monthly climate summary of National Weather Service data is presented in **Table 2-2** for Lewistown, which is the nearest climate station with monthly data available for a sufficient period of record.

Table 2-2. Monthly Climate Summary for Lewistown, MT (1981-2010).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr
Avg Max Temp (°F)	34.3	36.3	43.8	53.5	62.5	71.0	80.6	80.7	69.1	56.5	43.2	34.2	55.5
Avg Min Temp (°F)	13.4	15.3	22.1	29.4	37.8	45.3	50.5	49.6	41.0	31.1	21.8	12.9	30.9
Avg Total Precip (in)	0.58	0.45	0.97	1.41	2.85	3.08	1.93	1.72	1.35	1.12	0.69	0.60	16.74
Avg Snowfall (in)	9.1	4.7	9.6	7.6	3.7	0.0	0.0	0.0	1.5	3.3	6.9	8.0	54.4
Avg Snow Depth (in)	3.4	2.5	1.6	0.7	0.2	0.0	0.0	0.0	0.0	0.2	1.1	2.9	1.0

2.2 Ecological Parameters

The following information describes the ecological characteristics of the Judith Mountains Project Area.

2.2.1 Aquatic Life

Native fish species present in the project area include: burbot, channel catfish, mottled sculpin, mountain whitefish, paddlefish, pallid sturgeon and westslope cutthroat trout. Pallid sturgeon is listed as federally endangered by the U.S. Fish and Wildlife Service (USFWS). Paddlefish and westslope cutthroat trout are designated “Species of Concern” by Montana Department of Fish, Wildlife and Parks (FWP). Of further significance, the Westslope population in Collar Gulch Creek is the eastern-most known occurrence of the species – a fact that BLM took into consideration when designating Collar Gulch Creek an area of critical environmental concern (ACEC) (Flentie, 2008). Introduced species are also present in streams including: brook, rainbow and brown trout. Data on fish species distribution (**Figure A-11**) are collected, maintained and provided by FWP (2010).

2.2.2 Ecoregion

The project area spans the Northwestern Great Plains, Northwestern Glaciated Plains and Middle Rockies Level III Ecoregions. Further classification of level IV ecoregions within the project area are mapped on **Figure A-2**. These include: Foothill Grassland (42r), Non-calcareous Foothill Grassland (43s), Glaciated Northern Grasslands (42j), Montana Central Grasslands (43n), Missouri Breaks Woodland-Scrubland (43I) and Scattered Eastern Igneous-Core Mountains (17r).

2.2.3 Fires

Fire location data from 2000-2011 provided by the Geospatial Multi-Agency Coordination Group (GeoMAC) indicate one wildfire burnt within the project area during 2010 and two burnt in 2011 totaling 270 acres (< 0.05%) for the two years. Records dating back 150 years from the USFS Region 1 Remote Sensing Applications Center show no fires mapped prior to 2010. However, based on the climate and the availability of herbaceous fuels, low severity grassfires are likely more common than a 150-year fire interval would suggest.

2.3 Social Parameters

The following information describes the social profile of the Judith Mountains Project Area.

2.3.1 Population

There are no incorporated cities or towns within the project area. The nearest major town, Lewistown, has a population near 6,000 and lies approximately 9 miles southwest of the project area. Based on density data from the 2010 census, an estimated 249 people live within the project area. Population density is shown on **Figure A-12.** The mining boom, which peaked in the late 1880s, temporarily increased the number of people living in the area. Giltedge, one such ghost town located along Chippewa Creek, was home to some 50 miners and their families for a few decades in the late 1800s. Evidence of subsequent attempts at homesteading can also be observed across the landscape.

2.3.2 Transportation Networks

US Highway 191 crosses the project area twice en route from Lewistown to Malta. Montana Highway 66 diverges from US 191 at DY Junction on the border of the project area. The network of unpaved roads on public and private lands will be further characterized as part of the sediment source assessment (**Section 5.5** and **Appendix C**). An abandoned Milwaukee Railroad line transects the southern arm of the project area and follows Armells Creek for 3.5 miles. No active rail lines exist.

2.3.3 Land Ownership and Special Management Areas

Land ownership data from 2011 are provided by the Montana Natural Heritage Program. Land ownership is shown on **Figure A-13**. Slightly more than one-half of the project area is under private ownership, as shown in **Table 2-3**. The dominant landholder is the BLM, which administers 33% of the project area, followed by the Montana State Trust and USFWS both administering 8%. The non-profit organization American Prairie Foundation owns and manages a 3,000 acre prairie-based wildlife reserve.

Table 2-3. Land ownership in the Judith Mountains Project Area.

Owner	Acres	Square Miles	% of Total
Private	470,120	7345	51%
BLM	305,709	478	33%
USFWS	71,141	111	8%
Montana State Trust Land	70,296	110	8%
American Prairie Foundation	3,000	4.7	0.33%
Total	**920,561**	**1438**	**100%**

The Judith Mountains Project Area has numerous federally owned areas designated "special management" shown in **Figure A-14**. BLM manages wilderness study areas, areas of critical environmental concern (ACEC) and a national monument. Three adjacent wilderness study areas, Woodhawk, Antelope Creek and Cow Creek, are shown in **Figure A-14** under the same symbol because they are similarly managed to exclude surface disturbance activities and permanent structures. Wilderness study areas can be designated full wilderness protection in the future by an act of Congress. ACECs are established to protect and prevent damage to important cultural and ecological resources or to protect human safety from natural hazards. The Cow Creek ACEC was created in 1988 in part for its scenic qualities and the cultural significance of numerous Native American trails (personal communication with Chad Krause, BLM Hydrologist, March 2012). Collar Gulch Creek ACEC received protection because the stream harbors the eastern-most population of genetically pure westslope cutthroat trout in the nation (Flentie, 2008; Montana Fish, Wildlife and Parks, 2010; Personal communication with Chad Krause, BLM Hydrologist, March 2012). Because the rationale for designating ACECs varies, each ACEC has a unique management plan.

BLM also manages the Upper Missouri National Monument, which was signed into law by President Clinton nationally recognizing the value of biologic, geologic and historic interests in the area. All motorized and mechanical vehicle use is prohibited off road and future land sales and mineral lease are banned (United States Bureau of Land Management, 2001). The monument extends along the Missouri River west of the project area an additional 60 miles. The eastern side of the project area includes a portion of Charles M. Russell National Wildlife Refuge managed by the U.S. Fish and Wildlife Service since 1936 (U.S. Fish and Wildlife Service, 2011). The refuge, name after the prominent Montana artist, is managed to sustain healthy wildlife and habitat.

2.3.4 Land Cover and Use

Land cover within the project area is dominated by herbaceous grasslands as indicated in **Table 2-4**. Scrubland is the second most common land cover followed by evergreen forests, which appear in areas with higher precipitation or near water. The conifer forests are dominated by Lodgepole Pine, transitioning to Pondersoa Pine at lower elevations. Sagebrush is widespread in the shrub/scrub land cover unit. The most urbanized classification in the project area is low intensity development. Information on land cover is based off the most recent National Land Cover Database mapping at a 30-meter spatial resolution (United States Geological Survey, 2011). Land cover is displayed in **Figure A-10**. Agricultural activity in the project area is rare due to mediocre growing conditions and the extent of federally owned land. According to property valuation by the Department of Revenue (2011), less than 0.05% (450 acres) of the land is irrigated and only 6% (58,500 acres) is classified as non-irrigated hay or arid/semi-arid farming. Forested lands capable of producing commercial quality lumber cover 17% (155,600 acres) of the project area.

Table 2-4. Land Cover in the Judith Mountains Project Area.

Land Cover	Acres	Square Miles	% of Total
Open Water	3,258	5.1	0.35%
Developed, Open Space	1,847	2.9	0.20%
Developed, Low Intensity	368	0.6	0.04%
Barren Land (Rock/Sand/Clay)	284	0.4	0.03%
Deciduous Forest	1,230	1.9	0.13%
Evergreen Forest	129,203	201.9	14.02%
Shrub/Scrub	259,982	406.2	28.21%
Grassland/Herbaceous	465,928	728.0	50.56%
Pasture/Hay	3,195	5.0	0.35%
Cultivated Crops	39,602	61.9	4.30%
Woody Wetlands	14,495	22.6	1.57%
Emergent Herbaceous Wetlands	2,125	3.3	0.23%

2.3.5 Mining

There are no active mining permits in the Judith Mountains Project Area; however MBMG and DEQ estimate there to be 75 abandoned and inactive mines. Starting in the 1880s and continuing through the middle of the next century, hardrock mining in the area experienced numerous boom and bust cycles. Most mines are clustered in the southern portion of the project area near the Judith Mountains in what is the Warm Springs Mining District. Based on public health risks, DEQ has identified four priority abandoned mines in the Judith Mountains Project Area, although only three of these are located in impaired watersheds which are the focus of this TMDL document. Extensive mining also occurred to the northeast in the Little Rocky Mountains, but most fall outside the project area. The majority of mining in the area followed underground lodes of precious metals such as silver and gold. Milling is known to have occured in places where mill tailings are present. Evidence of placer mining exists also exists, however hardrock mining is was more prevalent. Clay, specifically bentonite, is another commodity mined historically at three known sites. Additionally, 20 coal mines or “coal inventory” sites are mapped within the project area.

2.3.6 Point Sources

According to EPA’s Integrated Compliance Information System (ICIS) database, there are three active point sources permitted under the Montana Pollution Discharge Elimination System (MPDES) within the project area. All three are general stormwater construction activity permits for gravel excavation and/or highway and street construction. Two of these permits are located in the lower Armells Creek (MT40E002_021) watershed and the receiving water for the third permit is Whisky Creek, a tributary to the lower segment of Chippewa Creek, thus none of the permitted point sources in the project area affect listed stream segments.

2.3.7 Wastewater

There are no sewered areas within the Judith Mountains Project Area; wastewater treatment is provided by on-site septic tanks and drainfields. Roughly one hundred septic systems are estimated in the project area – a number based on the assumption of one septic tank for each 2.5 persons using 2010 census block data. Because most of the project area is uninhabited, septic system densities are much lower than other parts of the state.

3.0 Montana Water Quality Standards

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

Montana's water quality standards include four main parts:

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

Those components that apply to this document are reviewed briefly below. More detailed descriptions of Montana's water quality standards that apply to the Judith Mountains Project Area streams can be found **Appendix B**.

3.1 Judith Mountains Project Area Stream Classifications and Designated Beneficial Uses

Waterbodies are classified based on their designated uses. All Montana waters are classified for multiple uses. All streams within the Judith Mountains Project Area are classified as C-3 which specifies that the water must be maintained suitable to support all the following uses (1) bathing, swimming and recreation, (2) growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl, and furbearers. While some of the waterbodies might not actually be used for a designated use (e.g., swimming), their water quality still must be maintained suitable for that designated use. Because C-3 waters often contain naturally high total dissolved solids (salinity), their quality is marginal for drinking water and agricultural and industrial uses. More detailed descriptions of Montana's surface water classifications and designated uses are provided in **Appendix B**. Fish species distribution provided by Montana Fish, Wildlife and Parks (**Figure A-11**) indicate the presence of trout species in Collar Gulch Creek and Chicago Gulch, suggesting these C-3 streams may need to be reclassified to incorporate coldwater fishery designated uses.

Six waterbody segments in the Judith Mountains Project Area are listed in the "2012 Water Quality Integrated Report" as not supporting or partially supporting one or more designated uses (**Table 3-1**). Waterbodies that are "not supporting" or "partially supporting" a designated use are impaired and require a TMDL. TMDLs are written to protect all designated uses for a waterbody and not just those identified as being not or partially supported. DEQ describes impairment as either partially supporting or not supporting based on assessment results. Not supporting is applied to conditions where the assessment results indicate a severe level of impairment of the beneficial use. A non-supporting level of impairment does not equate to complete elimination of the use. Detailed information about Montana's use support categories can be found in DEQ's "Water Quality Assessment Methods" (Montana Department of Environmental Quality, 2011b).

Table 3-1. Impaired Waterbodies and their Designated Use Support Status on the "2012 Water Quality Integrated Report" in the Judith Mountains Project Area.

Waterbody & Location Description	Waterbody ID	Use Class	Aquatic Life	Primary Contact Recreation
Chicago Gulch, headwaters to mouth (Fords Creek)	MT40B002_020	C-3	P	X
Chippewa Creek, headwaters to confluence with Manitoba Gulch	MT40B002_040	C-3	N	N
Collar Gulch Creek, headwaters to mouth (Fords Creek)	MT40B002_030	C-3	P	X
Armells Creek, headwaters to Deer Creek	MT40E002_022	C-3	N	X
Cow Creek, Als Creek to mouth (Missouri River)	MT40E002_040	C-3	N	F
Fargo Coulee, headwaters to mouth (Armells Creek)	MT40E002_130	C-3	N	F

F = Fully Supporting, P = Partially Supporting, N= Not Supporting, T = Threatened, X = Not Assessed

3.2 Water Quality Standards

In addition to the use classifications described above, Montana's water quality standards include numeric and narrative criteria that protect the designated uses. Numeric criteria define the allowable concentrations of specific pollutants so as not to impair designated uses. Narrative criteria are "free from" descriptions, or statements of unacceptable conditions. **Appendix B** defines both the numeric and narrative water quality criteria. For the sediment TMDL development in the Judith Mountains Project Area, only the narrative standards are applicable.

Numeric standards apply to pollutants that are known to have adverse effects on human health or aquatic life (e.g., metals, organic chemicals, and other toxic constituents). Human health standards are set at levels that protect against long-term (lifelong) exposure, as well as short-term exposure through direct contact such as swimming. Numeric standards for aquatic life include chronic and acute values. Chronic aquatic life standards prevent long-term, low level exposure to pollutants. Acute aquatic life standards protect from short-term exposure to pollutants. Chronic standards are usually more stringent (i.e., lower) than acute standards.

Narrative standards are developed when there is insufficient information to develop specific numeric standards. Narrative standards describe either the allowable condition or an allowable increase of a pollutant above "naturally occurring" conditions. DEQ uses the naturally occurring condition, called a "reference condition," to determine whether or not narrative standards are being met (see **Appendix B**).

Reference defines the condition a waterbody could attain if all reasonable land, soil, and water conservation practices were put in place. Reasonable land, soil, and water conservation practices usually include, but are not limited to, best management practices (BMPs).

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.

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

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

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

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

TMDL development must include a margin of safety (MOS), which can be explicitly incorporated into the above equation. Alternatively, the MOS can be implicit in the TMDL. 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., pollutant loading or use protection).

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.

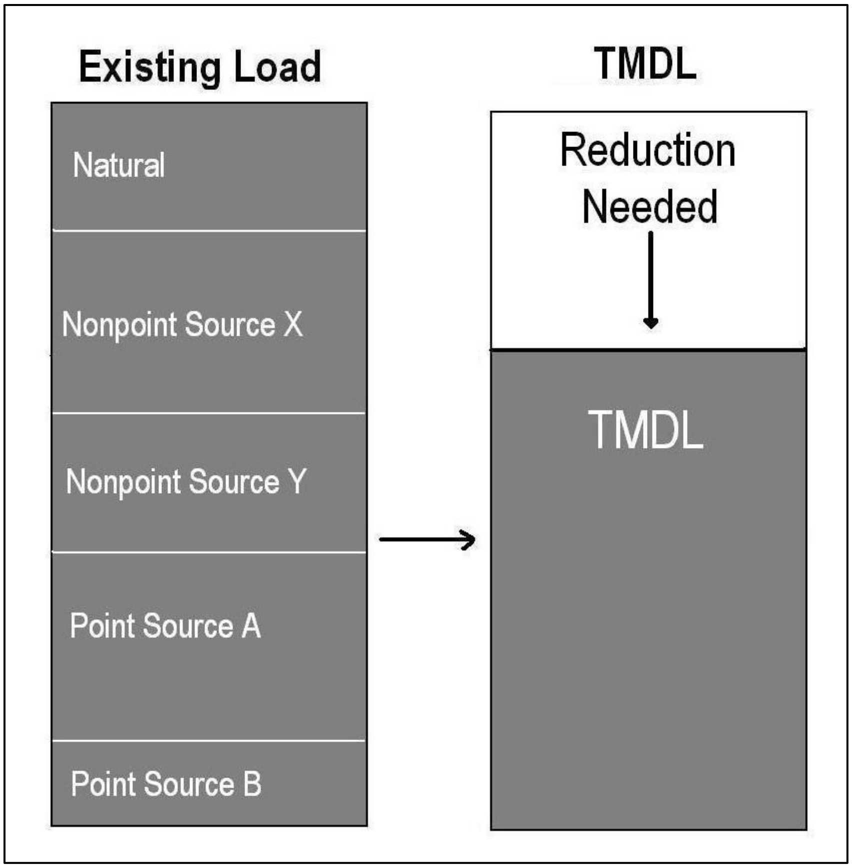

Figure 4-1. Schematic Example of TMDL Development.

4.1 Developing Water Quality Targets

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

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

4.2 Quantifying Pollutant Sources

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

A pollutant load is usually quantified for each point source permitted under the Montana Pollutant Discharge Elimination System (MPDES) program. Nonpoint sources are quantified by source categories (e.g., upland erosion) 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, pollutant sources in a sub-watershed or source area can be combined for quantification purposes.

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

4.3 Establishing the Total Allowable Load

Identifying the TMDL requires a determination of the total allowable load over the appropriate time period necessary to comply with the applicable water quality standard(s). Although "TMDL" implies "daily load," determining a daily loading may not be consistent with the applicable water quality standard(s), or may not be practical from a water quality management perspective. Therefore, the TMDL will ultimately be defined as the total allowable loading during a time period that is appropriate for applying the water quality standard(s) and which 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.

If 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 criteria. This same approach can be applied when a numeric target is developed to interpret a narrative standard.

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. The allocations are often determined by quantifying feasible and achievable load reductions through application of a variety of best management practices and other reasonable conservation practices.

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

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

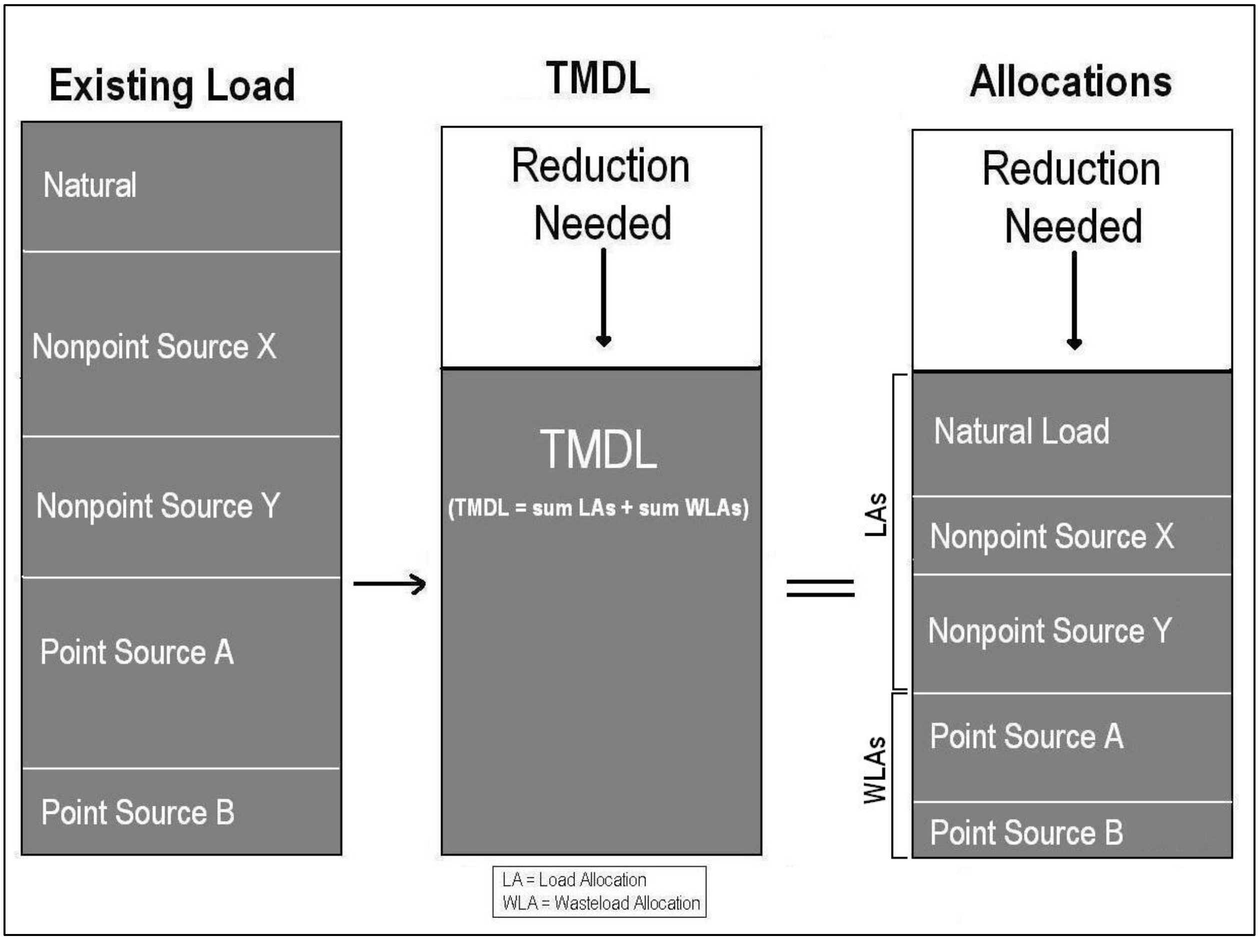

Figure 4-2. Schematic Diagram of a TMDL and its Allocations.

Incorporating an MOS is required when developing TMDLs. The MOS accounts for the uncertainty between pollutant loading and water quality and is intended to ensure that load reductions and allocations are sufficient to support beneficial uses. The MOS may be applied implicitly by using conservative assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading (U.S. Environmental Protection Agency, 1999a).

5.0 SEDIMENT TMDL COMPONENTS

This portion of the document focuses on sediment as an identified cause of water quality impairments in the Chippewa Creek watershed. It describes: 1) the mechanisms by which sediment can impair beneficial uses, 2) the specific stream segment of concern, 3) the available data pertaining to sediment impairment characterization in the watershed, 4) the various contributing sources of sediment based on recent studies, and 5) the sediment TMDLs and allocations.

The term sediment is used in this document to refer collectively to several closely-related pollutant categories, including suspended sediment, stream channel geometry that can affect sediment delivery and transport, and sediment deposition on the stream bottom.

5.1 EFFECTS OF EXCESS SEDIMENT ON BENEFICIAL USES

Sediment is a naturally occurring component of healthy and stable stream and lake ecosystems. Regular flooding allows sediment deposition to build floodplain soils and point bars, and it prevents excess scour of the stream channel. Riparian vegetation and natural in-stream barriers such as large woody debris, beaver dams, or overhanging vegetation help trap sediment and build channel and floodplain features. When these barriers are absent or excessive sediment loading enters the system from increased bank erosion or other sources, it may alter channel form and function and affect fish and other aquatic life by increasing turbidity and causing excess sediment to accumulate in critical aquatic habitat areas not naturally characterized by high levels of fine sediment.

More specifically, sediment may block light and cause a decline in primary production, and it may also interfere with fish and macroinvertebrate survival and reproduction. Fine sediment deposition reduces availability of suitable spawning habitat for salmonid fishes and can smother eggs or hatchlings. Effects from excess sediment are not limited to suspended or fine sediment; an accumulation of larger sediment (e.g. cobbles) can fill pools, reduce the percentage of desirable particle sizes for fish spawning, and cause channel overwidening (which may lead to additional sediment loading and/or increased temperatures). Although fish and aquatic life are typically the most sensitive beneficial uses regarding sediment, excess sediment may also affect other uses. For instance, high concentrations of suspended sediment in streams can also cause water to appear murky and discolored, negatively impacting recreational use, and excessive sediment can increase filtration costs for water treatment facilities that provide safe drinking water.

5.2 STREAM SEGMENT OF CONCERN

Chippewa Creek is a tributary to McDonald Creek and is located within the Box Elder HUC8 (10040204). The 3.8 mile reach of Chippewa Creek from its headwaters to the confluence with Manitoba Gulch is listed as impaired due to sedimentation/siltation and alterations in streamside or littoral vegetative covers. Much of the upper portion of the creek is a dry gulch without perennial flow (Atkins North America, Inc., 2011a).

5.3 INFORMATION SOURCES AND ASSESSMENT METHODS

For TMDL development, information sources and assessment methods fall within two general categories. The first category, discussed within **Section 5.4**, is focused on characterizing overall stream health with regards to sediment and related water quality conditions. The second category, discussed in **Section 5.5**, is focused on quantifying sources of sediment loading within the watershed.

The primary source of data used to evaluate overall stream health is sediment and habitat data collected in 2010 to assist with TMDL development (**Appendix C**). Data were collected along two low-gradient, 500-foot long reaches on Chippewa Creek. The types of data collected include:

Channel form and stability
- Channel cross-sections
- Flood prone width measurements
- Water surface slope

Fine sediment
- Riffle pebble count
- Riffle grid toss

In-stream habitat
- Channel bed morphology
- Residual pool depth
- Pool habitat quality
- Large woody debris quantification

Riparian health
- Riparian greenline assessment
- Proper functioning condition assessment

In addition, field observations and habitat assessment data collected by Watershed Consulting in 2004 and 2005 were used to further substantiate the source assessment.

5.4 Water Quality Targets

This section provides the rationale for each sediment-related target parameter, discusses the basis of the target values, and then presents a comparison of those values to available data for Chippewa Creek.

In developing targets, natural variation within a stream must be considered. DEQ uses the reference condition to gage natural variability and assess the effects of pollutants with narrative standards, such as sediment. The preferred approach to establishing the reference condition is using reference site data, but modeling, professional judgment, and literature values may also be used. The DEQ defines "reference" 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 and current land use activities. Waterbodies used to determine reference conditions are not necessarily pristine. The reference condition approach is intended to accommodate natural variations due to climate, bedrock, soils, hydrology and other natural physiochemical differences yet allow differentiation between natural conditions and widespread or significant alterations of biology, chemistry or hydrogeomorphology due to human activity.

The basis for the value for each water quality target and supplemental indicator varies depending on the availability of reference data. There are several statistical approaches the DEQ uses for target development; they include using percentiles of reference data or of the entire sample dataset, if reference data are limited. For example, if low values are desired, the sampled streams are assumed to be severely degraded, and there is a high degree of confidence in the reference data, the 75th percentile of the reference dataset or the 25th percentile of the sample dataset (if reference data are not available) is typically used. However, percentiles may be used differently depending on whether a high or low value is desirable, the representativeness and range of variability of the data, the severity of human disturbance to streams within the watershed, and size of the dataset. Additionally, the target value for some parameters may apply to all streams, whereas others may be stratified by reach type characteristics (i.e. ecoregion, gradient, stream order, and/or confinement) or by Rosgen stream type.

Although the basis for target values may differ by parameter, the goal is to develop values that incorporate an implicit MOS and are achievable.

The sediment water quality targets and supplemental indicators for the Chippewa Creek watershed are summarized in **Table 5-1** and described in detail in the sections that follow. For sediment, a combination of measurements of instream siltation, channel form and habitat characteristics that contribute to loading, storage, and transport of sediment or that demonstrate those effects are typically used to assess the current condition of a stream. Generally, targets most closely linked to sediment accumulation or sediment-related effects to aquatic life habitat are given the most weight. Values are based on the current best available information but will be assessed during future TMDL reviews for their validity and may be modified if new information provides a better understanding of reference conditions.

Table 5-1. Sediment targets for Chippewa Creek.

Parameter Type	Targets	Criteria
Fine sediment	Percentage of fine surface sediment <6 mm in riffles based the reach average of riffle pebble counts	≤30% for an E4 stream type*
	Percentage of fine surface sediment <2 mm based on the reach average of riffle pebble counts	≤10-15%
	Percentage of fine surface sediment <6 mm based on the reach average of grid tosses in riffles and pool tails	20%
Channel form and stability	Bankfull width/depth ratio, based on median of the channel cross-section measurements	≤7 for an E4 stream type*
	Entrenchment ratio, based on median of the channel cross-section measurements	≥3.7 for an E stream type
Riparian health	Proper Functioning Condition (PFC) riparian assessment	*Proper functioning condition* or *Functional at risk* with an upward trend and intent of reaching *Proper functioning condition*
Parameter Type	**Supplemental Indicators**	**Criteria**
Instream habitat	Large Woody Debris (LWD) per mile	≥188 LWD/mile
	Pools per mile	≥39pools/mile
	Reach average residual pool depth	≥0.9 feet
Riparian health	Percent of streambank with understory shrub cover, expressed as the average of the greenline measurements	≥40% understory shrub cover in reaches with potential for dense shrub cover
Human Caused Sediment Sources	Human caused sediment sources	No significant sources based on field and aerial surveys

*Values are only summarized for an E4 stream because the potential for Chippewa Creek is E4

5.4.1 Target Development and Rationale

Regional reference data were the primary basis for target development. As discussed in **Section 2.2.2**, the project area is comprised of three level 3 ecoregions: Northwestern Great Plains, Northwestern Glaciated Plains and Middle Rockies. Chippewa Creek originates in the Middle Rockies and then transitions to the Northwestern Great Plains ecoregion in the middle of the listed waterbody segment. Because sediment TMDLs have been completed recently in both ecoregions that span the Chippewa Creek watershed, reference-based water quality targets from those TMDL documents were selected for Chippewa Creek. Water quality targets for the Chippewa Creek watershed were selected from the TMDL documents for the Shields River watershed (Montana Department of Environmental Quality, 2009), the

West Fork Gallatin River watershed (Montana Department of Environmental Quality, 2010), and the Little Blackfoot River watershed (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, 2011). The Shields watershed is the closest with recently completed sediment TMDLs, it is largely in the Northwestern Great Plains ecoregion, and it contains several streams that originate in the foothills and are similar to Chippewa Creek. The West Fork Gallatin River watershed is less similar, but is one of the most recent documents containing water quality targets based on reference data from the Middle Rockies ecoregion. The Little Blackfoot watershed also has recently completed sediment TMDLs with water quality targets based on reference data from the Middle Rockies ecoregion, and it contains small streams in transitional areas similar to Chippewa Creek.

The water quality targets in the Shields, West Fork Gallatin, and Little Blackfoot TMDL documents were derived from a combination of reference data from the Greater Yellowstone Area and Beaverhead Deerlodge National Forest (BDNF), PACFISH/INFISH Biological Opinion (PIBO) Effectiveness Monitoring Program, Rosgen (Rosgen, 1996), and DEQ field-collected data, as well as literature values. Both the BDNF data and the PIBO data were collected within the Middle Rockies ecoregion. There are no PIBO reference sites in the Northwestern Great Plains. However, because the impaired segment of Chippewa Creek originates in the Middle Rockies and is a foothills stream, DEQ determined that water quality targets derived from these sources are applicable to Chippewa Creek. Some water quality targets for Chippewa Creek are based on percentiles of the BDNF dataset, whereas others are based on percentiles of reference data as used for target setting for other recent TMDL documents. For targets and supplemental indicator values based on recent TMDLs, additional rationale regarding the percentiles and values chosen is contained within those documents (Montana Department of Environmental Quality, 2010; 2011; 2009).

The upper half of Chippewa Creek that flows through the Middle Rockies ecoregion is part of the Scattered Eastern Igneous-Core Mountains level 4 ecoregion (which is more fine-scale than level 3 and contained within the Middle Rockies). No PIBO reference sites are contained within that level 4 ecoregion, but it does have three managed (i.e., non-reference) PIBO sites. Values from those sites were not used directly for target development but were used to check the appropriateness of target values.

For all water quality targets, future surveys should document stable (if meeting criterion) or improving trends. The exceedance of one or more target values does not definitively equate to a state of impairment; the degree to which one or more targets are exceeded are taken into account (as well as the current 303(d) listing status), and the combination of target analysis, qualitative observations, and sound, scientific professional judgment is crucial when assessing stream condition. Site-specific conditions such as recent wildfires, natural conditions, and flow alterations within a watershed may warrant the selection of unique indicator values that differ slightly from those presented below, or special interpretation of the data relative to the sediment target values. Additional discussion on sediment standards and targets can be found in **Appendix B**.

5.4.1.1 Fine Sediment

The percent of surface fines less than 6 mm and percent of fines less than 2 mm are measurements of the fine sediment on the surface of a streambed and is directly linked to the support of the coldwater fish and aquatic life beneficial uses. Increasing concentrations of surficial fine sediment can negatively affect salmonid growth and survival, clog spawning redds, and smother fish eggs by limiting oxygen availability (Irving and Bjorn, 1984; Weaver and Fraley, 1991; Shepard et al., 1984; Suttle et al., 2004). Excess fine sediment can also decrease macroinvertebrate abundance and taxa richness (Mebane, 2001; Zweig and Rabeni, 2001). Because similar concentrations of sediment can cause different degrees of impairment to different species, and even age classes within a species, and because the particle size defined as “fine” is variable and some assessment methods measure surficial sediment while others measure also include subsurface fine sediment, literature values for harmful fine sediment thresholds are highly variable. Some studies of salmonid and macroinvertebrate survival found an inverse relationship between fine sediment and survival (Suttle et al., 2004) whereas other studies have concluded the most harmful percentage falls within 10 and 40% fine sediment (Bjorn and Reiser, 1991; Mebane, 2001; Relyea et al., 2000). Therefore, literature values are taken into consideration during fine sediment target development, but because increasing concentrations of fine sediment are known to be harmful to aquatic life, targets are developed using a conservative statistical approach.

Riffle Substrate Percent Fine Sediment <6 mm and <2 mm via Pebble Count

Surface fine sediment measured in riffles by the modified Wolman (1954) pebble count indicates the particle size distribution across the channel width and is an indicator of aquatic habitat condition that can point to excessive sediment loading. Pebble counts in 2010 were performed in three riffles per sampling reach for a total of at least 300 particles.

The target for riffle substrate percent fine sediment <6 mm is set at less than or equal to the median of the reference value based on the BDNF reference dataset (**Table 5-2**). The median was chosen instead of the 75th percentile because pebble counts in the BDNF reference dataset were performed using the “zigzag” method, which includes both riffles and pools, and likely results in a higher percentage of fines than a riffle pebble count. This reference data was used as the target basis for the Shields, West Fork Gallatin, and Little Blackfoot sediment TMDLs.

Table 5-2. Median percent fine sediment <6 mm by stream type from the BDNF reference sites.

Parameter	Stream type			
	E3	E4	Ea	E
Sample size (n)	12	64	23	115
Percent surface fines <6 mm	17%	30%	28%	30%

Source: DEQ (Montana Department of Environmental Quality, 2010, Table 5-4); mm = millimeter

There are no regional reference data available for fine sediment less than 2 mm. A study by Bryce et al. (2010) found the macroinvertebrate minimum effect level for sediment less than 2mm to be 10%. Based on regional sample data, E channel targets in the Little Blackfoot and Shields TMDLs ranged from 10 to 15% fine sediment less than 2mm. Therefore, based on the literature value and target values for E streams in the Little Blackfoot and Shields watersheds, the target for fine sediment less than 2mm will be set as less than 10 to 15% for Chippewa Creek.

Percent Fine Sediment <6mm in Riffle and Pool Tails via Grid Toss

Grid toss measurements in riffles and pool tails are an alternative measure to pebble counts that assess the level of fine sediment accumulation in macroinvertebrate habitat and potential fish spawning sites. A 49-point grid toss (Kramer et al., 1991) was used to estimate the percent surface fine sediment < 6mm in riffles and pool tails in Chippewa Creek.

Based on regional reference data from numerous TMDL watersheds (e.g., Blackfoot Headwaters, Middle Blackfoot, Lolo, Nevada Creek), 20% was used as the grid toss pool tail target for fine sediment less than 6mm in the Shields TMDL document. For the Little Blackfoot TMDL document, 21% was selected as the target based on field data from all E sites. The target for fine sediment less than 6mm in riffles and pools via grid toss for Chippewa Creek will be 20% based on the target from the Shields TMDL document (Montana Department of Environmental Quality, 2009).

5.4.1.2 Channel Form and Stability

Width/Depth Ratio and Entrenchment Ratio

The width/depth ratio and the entrenchment ratio are fundamental aspects of channel morphology and each provides a measure of channel stability, as well as an indication of the ability of a stream to transport and naturally sort sediment into a heterogeneous composition of fish habitat features (i.e. riffles, pools, and near bank zones). Although they are not direct measurements of in-stream sediment, as indicators of channel stability, they integrate alterations to streamflow and sediment supply at the reach and watershed scale and influence habitat availability. Factors that can alter channel morphology include stream channelization, dams, clearcutting, riparian vegetation removal, and over-grazing in the riparian zone.

Width/depth and entrenchment ratios are variable, but minimally disturbed streams in similar landscape settings tend to exhibit similar characteristics. Therefore, if a channel has a width/depth ratio greater than the expected range, this suggests channel overwidening and aggradation, which is frequently linked to excess sediment loading from bank erosion or other acute or chronic upstream sources, excess levels of fine and/or coarse sediment within the channel, and a reduction in habitat for fish and other aquatic life. Whereas channel overwidening is typically associated with aggradation, channel incision (i.e., entrenchment) is typically related to channel downcutting and degradation. Streams are often incised due to detrimental land management or may be naturally incised due to landscape characteristics. As a channel becomes incised (i.e. the entrenchment ratio decreases), the stream loses its ability to dissipate energy onto the floodplain during high flow and that energy becomes concentrated within the channel, resulting in increased sediment loading to the channel from bank erosion. If the stream is not actively downcutting, the sources of human caused incisement are historic in nature and may not currently be present; however, because of the altered channel form, increased bank erosion may be continuing and limiting aquatic life habitat. To summarize, accelerated bank erosion, an increased sediment supply, and a reduction in aquatic life habitat often accompany an increase in the width/depth ratio and/or a decrease in the entrenchment ratio (Knighton, 1998; Rosgen, 1996; Rowe et al., 2003). Therefore, due to the long-lasting impacts of changes to channel morphology and the large potential for sediment loading in altered channels, width/depth ratio and entrenchment ratio are important measures of channel condition as it relates to sediment loading and habitat condition.

The target values for width/depth ratio and entrenchment ratio are based on the BDNF reference dataset, which is stratified by Rosgen channel type. This reference data was used as the target basis for the Shields, West Fork Gallatin, and Little Blackfoot sediment TMDLs. As shown in **Table 5-3**, the 75th percentile of the entrenchment ratios for E stream types range from 3.7 to 15.9 and are greater than the Rosgen delineative criteria (Rosgen, 1996; E>2.2), and additional stability (or reductions in sediment loading) will not necessarily be gained by increasing the entrenchment ratio in a channel adequately accessing its floodplain. Therefore, the target for entrenchment ratio is set at the lowest BDNF reference value for the entrenchment category, which is **bolded** in **Table 5-3**: E ≥ 3.7. When comparing assessment results to target values, more weight will be given to those values that fail to satisfy both the identified target and fail to meet the minimum value associated with literature values for Rosgen stream type.

Table 5-3. Width/depth and entrenchment ratios from the BDNF reference sites.

Parameter	Stream Type			
	E3	E4	Ea	E
Sample size (n)	12	64	23	115
Width/depth ratio	10	7	7	7
Entrenchment ratio	14	15.9	8.7	**3.7**

Source: (Montana Department of Environmental Quality, 2010; Table 5-5)

5.4.1.3 Instream Habitat Measures

There were no targets set for instream habitat measures in the Shields TMDL document (as field measurements and target parameters have changed some since field work for that watershed), but both the Little Blackfoot and West Fork Gallatin TMDL documents had targets for large woody debris frequency, residual pool depth, and pool frequency based on PIBO reference data. Because the PIBO data are not stratified by Rosgen stream type, targets were developed within those documents by grouping data based on reach type characteristics like gradient and bankfull width because streams that share those characteristics tend to respond similarly to flow and sediment inputs (Bauer and Ralph, 1999). Because Chippewa Creek is a small, low gradient stream (i.e., bankfull width <10 feet and gradient <2%), only target values for those stream types were considered. Based on the transitional nature of Chippewa Creek, the target for each instream habitat measure was selected as the least stringent value between the West Fork Gallatin River sediment TMDL (Montana Department of Environmental Quality, 2010) and the Little Blackfoot TMDL (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, 2011). The target values were then compared to the managed PIBO sites to assess achievability. All instream habitat measures were used as supplemental indicators, which means they are used as supporting evidence of a sediment supply or transport imbalance but carry less weight than the targets.

Large Woody Debris Frequency

Large woody debris (LWD) is a critical component of stream ecosystems, providing habitat complexity, quality pool habitat, cover, and long-term nutrient inputs. LWD also constitutes a primary influence on stream function, including sediment and organic material transport, channel form, bar formation and stabilization, and flow dynamics (Bilby and Ward, 1989). LWD frequency is sensitive to land management activities, particularly over the long-term, and its frequency tends to be greater in smaller streams (Bauer and Ralph, 1999). Large woody debris per mile should be calculated based the LWD number per reach and then scaled up to give a frequency per mile.

Based on the 25th percentile of PIBO reference data, the LWD frequency target for streams with a bankfull width less than 15 feet in the Little Blackfoot TMDL document was 222 pieces of LWD per mile, and the target for streams with a gradient less than 2% in the West Fork Gallatin TMDL document was 188 (i.e., the less stringent value). LWD counts from the three managed PIBO sites in the same level 4 ecoregion ranged from 29 to 451 LWD per mile, indicating 188 is a feasible value. Therefore, the LWD supplemental indicator value for Chippewa Creek will be 188 or more pieces LWD per mile.

Residual Pool Depth

Residual pool depth, defined as the difference between the maximum depth and the tail crest depth, is a discharge-independent measure of pool depth and an indicator of the quality of pool habitat. Deep pools are important resting and hiding habitat for fish, and provide refugia during temperature extremes and high flow periods. Similar to channel morphology measurements, residual pool depth integrates the effects of several stressors; pool depth can be decreased as a result of filling with excess sediment, a reduction in channel obstructions (such as large woody debris), and changes in channel form and stability (Bauer and Ralph, 1999). Residual pool depth is typically greater in larger systems.

Based on the median of PIBO reference data, the target from the West Fork Gallatin TMDL document was 1.4 feet for streams with a gradient less than 2%, and the target in the Little Blackfoot was 0.9 feet for streams with a bankfull width of less than 15 feet (i.e., the less stringent value). PIBO data from the three managed sites within the same level 4 ecoregion had residual pool depths ranging from 0.79 to 1.02 feet. Therefore, a residual pool depth of at least 0.9 feet should be achievable and will be applied as the supplemental indicator value for Chippewa Creek.

Pool Frequency

Pool frequency is another indicator of sediment loading that relates to changes in channel geometry and is an important component of a stream's ability to support the fishery beneficial use. Excess fine sediment may limit pool habitat by filling in pools. Alternatively, aggradation of larger particles may exceed the stream's capacity to scour pools, thereby reducing the prevalence of this critical habitat feature. Pool frequency generally decreases as stream size (i.e., watershed area) increases and gradient decreases.

Based on the 25th percentile of PIBO reference data, the pool frequency target for streams with a bankfull width less than 15 feet in the Little Blackfoot TMDL document was 90 pools per mile, and the target for streams with a gradient less than 4% in the West Fork Gallatin TMDL document was 39 (i.e., the less stringent value). PIBO data from the three managed sites within the same level 4 ecoregion ranged from 37 to 126 pools per mile. Therefore, a pool frequency of at least 39 pools per mile should be achievable and will be applied as the supplemental indicator value for Chippewa Creek.

5.4.1.4 Riparian Health

Greenline Understory Shrub Cover

Interactions between the stream channel and the riparian vegetation along the streambanks are a vital component in the support of the beneficial uses of coldwater fish and aquatic life. Riparian vegetation provides organic material used as food by aquatic organisms and supplies large woody debris that influences sediment storage and channel morphology. Riparian vegetation also helps stabilize streambanks and can provide shading, cover, and habitat for fish. The percent of understory shrub cover is of particular interest in valley bottom streams historically dominated by willows and other riparian shrubs.

A greenline understory shrub cover target was not set in the Shields TMDL (Montana Department of Environmental Quality, 2009). The target set for the West Fork Gallatin River sediment TMDL was 53% (Montana Department of Environmental Quality, 2010) based on sample data and reference data from nearby watersheds. The target for the Little Blackfoot watershed was 40% (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, 2011) based on reference data within that watershed. Based on healthier portions of the riparian zone along Chippewa Creek and similarities to valley streams in the Little Blackfoot watershed, an understory shrub cover of at least 40% will be applied as a supplemental indicator for Chippewa Creek. The understory shrub cover will be applied in situations where riparian shrubs are a significant component of the streamside vegetation, such as in meadow areas.

Proper Functioning Conditions Assessments
The Proper Functioning Condition (PFC) method is a qualitative method for assessing the physical functioning of riparian-wetland areas (Prichard, 1998). The hydrologic processes, riparian vegetation characteristics, and erosion/deposition capacities of streams were evaluated using the PFC method for both stream reaches assessed in 2010 and 2011. Each reach was rated as being in "proper functioning condition" (PFC), "functional – at risk" (FAR), or "non-functioning" (NF). Based on these assessments, a supplemental indicator of either "proper functioning condition" or "functional – at risk" with an upward trend with the intent of attaining "proper functioning condition" is established for Chippewa Creek.

5.4.1.5 Human Caused Sediment Sources
The presence of human sediment sources does not always result in sediment impairment of a beneficial use. If there are no significant identified human sources of sediment within the Chippewa Creek watershed , no TMDL will be prepared since Montana's narrative criteria for sediment cannot be exceeded in the absence of human causes. There are no specific target values associated with sediment sources, but the overall extent of human sources will be used to supplement any characterization of impairment conditions. This includes evaluation of human induced and natural sediment sources, along with field observations and watershed scale source assessment information obtained using aerial imagery and GIS data layers. The analyses of human sediment sources are presented in **Appendix C**.

5.4.2 Existing Condition and Comparison to Targets
This section includes a comparison of existing data to water quality targets and a TMDL development determination for the 303(d) listed waterbody.

5.4.2.1 Physical Condition and Sediment Sources
Habitat has been degraded primarily by historic mining activities and currently by livestock grazing (Montana Department of Environmental Quality, 2011a). DEQ identified the loss of riparian vegetation and the overwidening of the stream channel in photos and habitat assessments performed in 2005 (Montana Department of Environmental Quality, 2011a). A summary of the physical conditions and sediment sources is presented in the source assessment in **Appendix C**. The human sources of sediment include unpaved road crossings, mill tailings, and livestock grazing.

An evaluation of 18 eroding streambanks along Chippewa Creek showed that historic mining activities were the primary source of streambank erosion in the dry portion of the creek and livestock grazing (e.g., hoof shear) was the primary source in the portion of the creek with perennial flow. The upper 0.9 miles of Chippewa Creek was not evaluated; streambank erosion along this historically mined area was likely limited by dense riparian vegetation.

5.4.2.2 Existing Data and Comparison to Water Quality Targets
The existing sediment and habitat data for Chippewa Creek are summarized in **Table 5-4**. All available data were collected at two sites in 2010 (**Figure 5-1**). CHIP-01 was located just upstream of the Maiden Road crossing, while CHIP-02 was located between the Maiden Road crossing and the Black Butte Road crossing. At CHIP-01, there was a mill tailings pile adjacent to the river right streambank (**Figure 5-1**) with clear evidence that sediment from the mill tailings pile was eroding into the stream channel. A ground level view of the tailings is contained in **Figure 5-2**. CHIP-01 was also used for livestock grazing, which resulted in some localized channel widening. The CHIP-02 monitoring site was also utilized by livestock and the channel was overwidened at cattle access points. Both monitoring sites along

Chippewa Creek were slightly entrenched, with one small headcut observed within the CHIP-02 monitoring site.

As shown in **Table 5-4**, neither of the sites met water quality targets for fine sediment or channel form. Additionally, both sites did not meet the supplemental indicator values for residual pool depth or LWD. The pool frequency supplemental indicator value was met at both sites, and the riparian vegetation was in better condition at the downstream site (CHIP-02), where both supplemental indicators for riparian health were met. The primary human sediment sources are unpaved road crossings, mill tailings, and agricultural activities that impact habitat and streamside vegetation (Atkins North America, Inc., 2011a). This information supports the 303(d) listing and a TMDL for sediment will be developed for Chippewa Creek (MT40B002_040).

Table 5-4. Chippewa Creek data from 2010 compared to targets and supplemental indicators.

Monitoring site	Existing Rosgen stream type	Potential Rosgen stream type	Channel form (median)		Fine sediment (mean)			Instream habitat			Riparian health	
			W/D ratio	Entrenchment ratio	Riffle pebble count		Grid toss % <6mm	Residual pool depth (ft) (mean)	Frequency (#/mile)		% Greenline shrubs (mean)	PFC assessment
					%<6mm	%<2mm	Riffle		Pools	LWD		
CHIP-01	B4c	E4	**8.6**	**1.7**	**35**	**24**	**25**	**0.4**	42	**21**	**22**	**NF**
CHIP-02	B4c	E4	**8.9**	**2.5**	**31**	**28**	**29**	**0.4**	74	**74**	46	FAR

PFC – Proper Functioning Condition; FAR – Functional – At Risk; NF – Nonfunctional
Bold values did not meet the targets

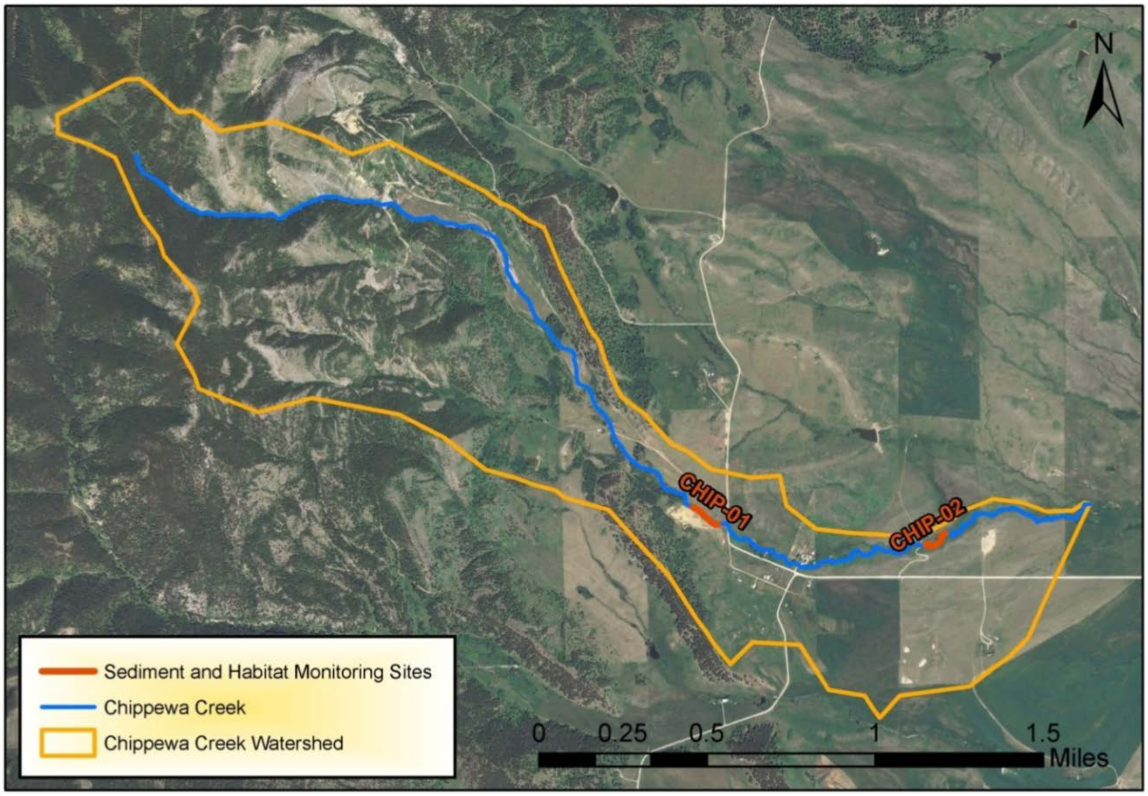

Figure 5-1. 2010 Habitat Monitoring Sites on Chippewa Creek.

Figure 5-2. Looking across from the left streambank of Chippewa Creek at the mill tailings.

5.5 Source Assessment and Quantification

This section presents a summary of the assessment approach, current sediment load estimates, and rationale for load reductions from human sources within four main source categories: road crossings, mill tailings, bank erosion, and upland erosion. The sources are more fully discussed in **Appendix C**.

EPA sediment TMDL development guidance for source assessments states that an inventory of sediment sources should be compiled using one or more methods to determine the relative magnitude of source loading, focusing on the primary and controllable sources of loading (U.S. Environmental Protection Agency, 1999b). Additionally, regulations allow that loadings may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading (Water Quality Planning and Management, 40 CFR § 130.2[G]).

The source assessment evaluated loading from the primary sediment sources using standard DEQ methods, but the sediment loads presented herein represent relative loading estimates within each source category, and, as no calibration has been conducted, should not be considered as actual loading values. Rather, relative estimates provide the basis for percent reductions in loads that can be accomplished via improved land management practices for each source category. Until better information is available, and the linkage between loading and in-stream conditions becomes clearer, the loading estimates presented here should be considered as an evaluation of the relative contribution from sources and areas that can be further refined in the future through adaptive management.

5.5.1 Road Crossings

The roads assessment used a combination of GIS analysis, field data collection, the Water Erosion Prediction Project (WEPP) model, and data analysis to estimate sediment loading to streams at or near road crossings. Five unpaved road crossings were identified in GIS as potential sediment sources; all crossings were evaluated in the field in October 2010 and but only three were determined to be sources of sediment to Chippewa Creek. At those three crossings, measurements were taken to estimate sediment loading potential and included the length, gradient, and width of road contributing sediment from each side of a stream crossing. Additional information was collected describing road design, road surface type, soil type, rock content, traffic level, and the presence of any Best Management Practices (BMPs).

Information collected at each assessed unpaved road crossing was used to estimate sediment loading with the WEPP:Road model. The model was used to approximate the sediment load associated with existing road crossings (and current BMP usage, including a grass filter strip) and the achievable sediment loading reductions associated with additional BMP implementation. The modeled existing sediment load for the three road crossings is 0.016 tons per year. The modeling of BMP implementation (including the installation of slash filters, vegetated buffers, and fabric raps) resulted in a potential future load of 0.006 tons per year. The modeled BMPs were based on field observations and vary by road crossing (**Appendix C**), but the necessary load reductions may be achieved by alternate BMPs.

5.5.2 Mill Tailings

The evaluation of sediment loading from the mill tailings pile (**Figure 5-3**) included a field assessment in 2010, field photographs, GIS analysis, and WEPP Hillslope modeling. GIS tools and color aerial photographs from 2009 were used to estimate the extent of the mill tailings for use in WEPP Hillslope modeling. The inner perimeter of the mill tailings pile was 0.66 acres and the outer perimeter was 2.67

acres. Model input parameters and assumptions are presented in **Appendix C** and the estimated annual loading from the mill tailings was 1.98 tons. The BMP scenario assumes that the mill tailings are remediated and a vegetated riparian buffer is installed such that the mill tailings are will no longer contribute sediment to Chippewa Creek.

5.5.3 Bank Erosion

In 2010, approximately 60% of the impaired segment (2.2 miles) was walked and eroding streambanks were evaluated. Sections that were not walked are the uppermost 0.9 miles of the stream, which is above an impoundment and likely has minimal erosion because of dense riparian vegetation, and a 0.7 mile section downstream of the Maiden Road crossing due to access constraints.

Based on observations during the field assessment, loading from natural streambank erosion along Chippewa Creek is very low; naturally eroding streambanks were not further evaluated as part of the source assessment. Eighteen locations where erosion was caused by human sources were further evaluated. The Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) were estimated at each of the eroding streambanks that was impacted by human activities. The BEHI rates erosion severity from very low to very high based on a combination of six factors: bank height, bankfull height, root depth, root density, bank angle, and surface protection. NBS is also estimated using a rating scale from very low to very high but it is based on the shape of the channel at the toe of the eroding streambank and the force of the water against that streambank. The annual streambank retreat rate was then estimated based on research conducted in the Lamar River watershed in Yellowstone National Park (Rosgen, 1996) that provides retreat rates for each combination of NBS and BEHI ratings (e.g., low NBS and moderate BEHI). The average annual sediment load for each eroding streambank was then calculating by multiplying the length of the eroding bank by the average height and retreat rate. Additionally, the human source of streambank instability was noted for each eroding streambank. For Chippewa Creek, the only human sources identified were mining and agriculture.

The NBS was estimated to be low at all 18 eroding streambanks caused by human sources. The BEHI was estimated to be moderate at 13 eroding banks, high at four eroding banks, and very high at one eroding bank. Grazing was the primary source of instability (due to hoof shear) at all moderate BEHI eroding banks and one high BEHI eroding bank. Mining was the primary source of instability at the very high BEHI site and the other three high BEHI eroding banks.

A segment of approximately 0.7 miles was not assessed in the field due to limited property access. The streambank erosion for this segment was extrapolated using data collected from the assessed segments. Thus, the ratios of length of human-caused and natural streambank erosion to total assessed length were applied to the un-assessed segment.

Naturally eroded streambanks, which were not quantitatively evaluated, were estimated to have a BEHI score of very low. These streambanks were identified during field investigations and include all streambanks that were not actively eroding. A corresponding natural background sediment load was calculated.

The total estimated sediment load from bank erosion was 51.56 tons per year (45.78 tons/year human-caused and 5.78 tons/year natural). The estimated potential future load, after BMP implementation, was 24.64 tons per year. This scenario was estimated by improving the very high and high estimated BEHI eroding banks to moderate BEHI eroding banks (i.e., the very high and high BEHI retreat rates were altered in the calculations to the retreat rate for medium BEHI). The moderate score was assumed to be achievable based upon Bengeyfield (2004), which found that a moderate score can be expected for reference streams in the BDNF. Specific practices were not modeled to achieve a moderate score but would likely include re-vegetating denuded banks and limiting cattle access to Chippewa Creek.

5.5.4 Upland Erosion

Upland erosion was modeled using the Universal Soil Loss Equation (USLE) combined with a sediment delivery ratio (SDR). The USLE model requires five landscape factors which are combined to predict upland soil: loss, including a rainfall factor (R), soil erodibility factor (K), length and slope factors (LS), a cropping factor (C), and a management practices factor (P). The general form of the USLE equation has been widely used for upland sediment erosion modeling and is presented as (Brooks et al., 1997):

$$A = RK(LS)CP \text{ (in tons per acre per year)}$$

GIS data were obtained to estimate these factors; for example, Natural Resources Conservation Service Soil Survey Geographic database was downloaded and used to estimate the soil erodibility (K) factor. A full discussion of each factor, the GIS data, and estimation assumptions are presented in **Appendix C**.

USLE model results were combined with a SDR to predict sediment delivery to streams. The SDR was calculated in GIS based upon the distance of each grid cell from Chippewa Creek. The SDR for various distances from streams is presented in **Appendix C**. The USLE results were modified by the SDR and a summary is presented in **Table 5-5**. The BMP scenario assumes that the sediment loads from agriculture (i.e. livestock grazing and crops, as represented by grassland/herbaceous and cultivated crops, respectively) can be reduced while all natural land covers continue to contribute their natural sediment loads.

Table 5-5. Upland Erosion Assessment Results by Land Use Category.

Land Use Type	Area (acres)	Percent of Watershed	Existing Condition Load (Tons/Year)	Desired Conditions Load (Tons/Year)
41 - Deciduous Forest	50	5%	0.40	0.40
42 - Evergreen Forest	269	25%	6.05	6.05
52 - Shrub/Scrub	279	26%	11.75	11.75
71 - Grassland/Herbaceous	439	41%	23.86	15.40
82 - Cultivated Crops	15	1%	0.10	0.06
90 - Woody Wetlands	9	1%	0.45	0.45
95 - Emergent Herbaceous Wetland	0.2	0%	0.00	0.00
Total Human-caused	**454**	**43%**	**24.0**	**15.5**
Total Natural	**608**	**57%**	**18.6**	**18.6**
Total Watershed	**1062**	**100%**	**42.6**	**34.1**

5.6 TMDL and Allocations

The sediment TMDL for Chippewa Creek will use a percent reduction approach whereas an annual reduction in loading is allocated among sources. An implicit MOS will be applied as further discussed in **Section 5.6.3.2**. Cover et al. (2008) observed a correlation between sediment supply and in-stream measurements of fine sediment in riffles and pools; it is assumed that a decrease in sediment supply will correspond to a decrease in fine sediment and result in attainment of water quality standards. A percent reduction approach is used because there is no numeric standard for sediment to calculate the allowable load with and because of the uncertainty associated with the loads derived from the source assessment. Additionally, the percent reduction TMDL approach is more applicable for restoration planning and sediment TMDL implementation because it shifts the focus from a set number to loading reductions associated with improvements in land management practices. Within this section, the existing load and allocations to the sources will be discussed and then the TMDL will be provided.

Because sediment generally has a cumulative effect on beneficial uses, and all sources in the Chippewa Creek watershed are associated with periodic loading, an annual expression of the TMDLs was determined as the most appropriate timescale to facilitate TMDL implementation. Although EPA encourages TMDLs to be expressed in the most applicable timescale, TMDLs are also required to be presented as daily loads (Grumbles, Benjamin, personal communication 2006). Daily loads are presented in **Appendix E**.

5.6.1 Allocation Approach and Assumptions

The percent reduction allocations are based on the modeled BMP scenarios for each major source type (e.g., upland erosion) and reflect reasonable reductions as determined from literature, agency and industry documentation of BMP effectiveness, and field assessments. Sediment loading reductions are expected to be achieved through a combination of BMPs, and the most appropriate BMPs will vary by site.

Because of the scale of the source assessments, reductions are estimated by making assumptions at the watershed scale about the level of existing BMP implementation and level of additional BMP implementation and associated effectiveness that will meet the intent of the relevant water quality standards. However, it is acknowledged that conditions are variable throughout a watershed, and even within a 303(d) stream segment, and this affects the actual level of BMPs needed in different areas, the practicality of changes in some areas (e.g. considering factors such as public safety and cost-effectiveness), and the potential for significant reductions in loading in some areas. Also, note that BMPs typically correspond to all reasonable land, soil, and water conservation practices, but additional conservation practices above and beyond BMPs may be required to achieve compliance with water quality standards and restore beneficial uses.

Sediment loading values and the resulting TMDL and allocations are acknowledged to be coarse estimates. Progress towards TMDL achievement will be gauged by BMP implementation for nonpoint sources, and improvement in or attainment of water quality targets. Any effort to calculate loads and percent reductions for purposes of comparison to the TMDL and allocations in this document should be accomplished via the same methodology and/or models used to develop the loads and percent reductions presented within this document.

5.6.2 Annual Loading Capacity

The current annual sediment load for Chippewa Creek (MT40B002_040) is estimated at 96 tons/year (**Table 5-6**). By applying BMPs, the sediment load to the Chippewa Creek watershed could be reduced to 59 tons/year. To achieve this reduction, a 63% sediment load reduction is allocated to roads sources. Additionally, a 100% reduction is allocated to mill tailings, which can be achieved with remediation of that tailing pile and improvement of riparian buffers (refer to **Appendix C** for a discussion of the mill tailings pile). A reduction of 59% is allocated to bank erosion that is primarily caused by grazing and mining, and a reduction of 20% is allocated to upland sources. No permitted point sources are present along the impaired segment of Chippewa Creek; therefore, no wasteload allocations for point sources are included in **Table 5-6**. The total maximum daily sediment load for Chippewa Creek is expressed as a 39% reduction in the total average annual sediment load.

Table 5-6. Sediment TMDL and allocations for Chippewa Creek (MT40B002_040).

Sediment sources		Current estimated load (tons/year)	Total allowable load (tons/year)	Sediment load allocation (% reduction)[b]
Road crossings		0.016	0.006	63%
Mill tailings		1.98	0	100%
Bank Erosion	Grazing & mining	46	18.9	59%
	Natural	5.8	5.8	--
Upland Erosion	Forest & wetland [a]	6.9	6.9	--
	Shrub/scrub	11.8	11.8	--
	Grassland/herbaceous	23.9	15.4	35%
	Cultivated crops	0.1	0.06	38%
	Upland erosion total	*43*	*34*	*20%*
Total sediment load		**96**	**59**	**39%**

[a.] Summation of: deciduous forest, mixed forest, woody wetland, and emergent herbaceous wetland; [b.] Percentages might differ slightly from the loads shown due to rounding

5.6.3 Seasonality and Margin of Safety

All TMDL documents must consider the seasonal variability, or seasonality, on water quality impairment conditions, maximum allowable pollutant loads in a stream, and load allocations. TMDL development must also incorporate a MOS to account for uncertainties between pollutant sources and the quality of the receiving waterbody, and to ensure (to the degree practicable) that the TMDL components and requirements are sufficiently protective of water quality and beneficial uses. This section describes seasonality and MOS in the Chippewa Creek sediment TMDL development process.

5.6.3.1 Seasonality

The seasonality of sediment impact to aquatic life is taken into consideration in the analysis within this document. Sediment loading varies considerably with season. For example, sediment delivery increases during spring when snowmelt delivers sediment from upland sources and the resulting higher flows scour streambanks. However, these higher flows also scour fines from streambeds and sort sediment sizes, resulting in a temporary decrease in the proportion of deposited fines in critical areas for fish spawning and insect growth. While fish are most susceptible to fine sediment deposition seasonally during spawning, fine sediment may affect aquatic insects throughout the year. Because both fall and spring spawning occur in Chippewa Creek, streambed conditions need to support spawning through all seasons. Additionally, reduction in pool habitat, by either fine or coarse sediment, alters the quantity and quality of adult fish habitat and can, therefore, affect the adult fish population throughout the year. Thus, sediment targets are not set for a particular season, and source characterization is geared toward identifying average annual loads. Annual loads are appropriate because the impacts of delivered sediment are a long-term impact once sediment enters the stream network, it may take years for sediment loads to move through a watershed. Although an annual expression of the TMDLs was determined as the most appropriate timescale to facilitate TMDL implementation, to meet EPA requirements daily loads are provided in **Appendix E**.

5.6.3.2 Margin of Safety

Incorporating a MOS is a required component of TMDL development. The MOS accounts for the uncertainty between pollutant loading and water quality and is intended to ensure that load reductions and allocations are sufficient to sustain conditions that will support beneficial uses. MOS may be applied implicitly by using conservative assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading (U.S. Environmental Protection Agency, 1999b). The sediment TMDL incorporates an implicit MOS in a variety of ways:

- By using multiple targets to help verify beneficial-use support determinations and assess standards attainment after TMDL implementation. Conservative assumptions were used during target development (i.e., target values were selected to be realistic but as protective as possible).
- By using targets and TMDLs that address both coarse and fine sediment delivery.
- Conservative assumptions were used for the source assessment process, including erosion rates, sediment delivery ratio, and BMP effectiveness (see **Appendix C**).
- By considering seasonality (discussed above) and yearly variability in sediment loading.
- By using an adaptive management approach to evaluate target attainment and allow for refinement of load allocation, targets, modeling assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development (discussed below in **Section 5.6.4** and in **Sections 9.0** and **10.0**).
- By using naturally occurring sediment loads as described in ARM 17.30.602(17) (see **Appendix B**) to establish the TMDLs and allocations based on reasonably achievable load reductions for each source category. This includes an allocation process that addresses all known human sediment causing activities, not just the significant sources.
- TMDLs are developed at the watershed scale so that human sources are addressed beyond just the listed waterbody segment scale, which should also improve conditions within and reduce loading to other waterbodies within the watershed.

5.6.4 Uncertainty and Adaptive Management

A degree of uncertainty is inherent in any study of watershed processes related to sediment. Because sediment has narrative water quality standards, the impairment characterization is based on a suite of water quality targets and the TMDL is based on loads derived from the source assessment; the relationship between sources and the instream condition is not straightforward and is variable among watersheds. Additionally, the assessment methods and targets used in this study to characterize impairment and measure future restoration are each associated with a degree of uncertainty.

Based on the evaluation of existing conditions, the TMDL for Chippewa Creek is expressed as a percent reduction from the existing load. Although each TMDL expression is associated with some uncertainty, the goal of the margin of safety is to mitigate as much uncertainty as possible to ensure that the TMDLs result in attainment of water quality standards. Another component to TMDL development that addresses uncertainty is an adaptive management plan to account for uncertainties in the field methods and water quality targets.

For the purpose of this document, adaptive management relies on continued monitoring of water quality and stream habitat conditions, continued assessment of impacts from human activities and natural conditions, and continued assessment of how aquatic life respond to changes in water quality and stream habitat conditions. Adaptive management addresses important considerations, such as feasibility and uncertainty in establishing targets. For example, despite implementation of all restoration activities, the attainment of targets may not be feasible due to natural disturbances, such as forest fires, flood events, or landslides.

The targets established in the document are meant to apply under median conditions of natural background and natural disturbance. The goal is to ensure that management activities achieve loading approximate to the TMDLs within a reasonable timeframe and prevent significant excess loading during recovery from significant natural events. Additionally, the natural potential of Chippewa Creek could preclude achievement of some targets. For instance, natural geologic and other conditions may contribute sediment at levels that cause a deviation from numeric targets associated with sediment. Conversely, some targets may be underestimates of the stream's potential and it may be appropriate to apply more protective targets upon further evaluations. In these circumstances, it is important to recognize that the adaptive management approach provides the flexibility to refine targets as necessary to ensure protection of the resource and to adapt to new information concerning target achievability.

Some of the target parameters can be indicators of excess coarse sediment (e.g. pool frequency and residual pool depth), but most of the direct sediment measures used as targets to assess stream condition focus on the fine sediment fraction found on the stream bottom, while the source assessments included all sediment sizes. Additionally, none of the source assessment techniques were calibrated, so potential instream measurements of suspended solids/bedload and associated loads will likely not correlate to modeled loads. Therefore, because sediment source modeling may under- or over-estimate natural inputs due to selection of sediment monitoring sections and the extrapolation methods used, model results should not be taken as an absolutely accurate account of sediment production within each watershed. Instead, source assessment model results should be considered as a tool to estimate sediment loads and make general comparisons of sediment loads from various sources.

Cumulatively, the source assessment methodologies address average sediment source conditions over long timeframes. Sediment production from both natural and human sources is driven by storm events. Pulses of sediment are produced periodically, not uniformly, through time. Separately, each source assessments methodology introduces different levels of uncertainty. For example, the road erosion method focuses on sediment production and sediment delivery locations from yearly precipitation events. The WEPP hillslope erosion model focuses primarily on sediment production across the landscape during typical rainfall years. Sediment delivery is a function of distance to the stream channel; however, upland loads are likely overestimated because the model does not account for upland or instream sediment routing. The significant filtering role of near-stream vegetated buffers (riparian areas) was incorporated into the hillslope analysis, resulting in proportionally reduced modeled sediment loads from hillslope erosion relative to the average health of the vegetated riparian buffer throughout the watershed. Additional discussion regarding uncertainty for each source assessment is provided in **Appendix C**.

Because the sediment standards relate to a waterbody's greatest potential for water quality given current and historic land use activities where all reasonable land, soil, and water conservation practices have been applied and resulting conditions are not harmful, detrimental, or injurious to beneficial uses, the percent-reduction allocations are based on the modeled upland and riparian BMP scenarios for each major source type. The allocations reflect reasonable reductions as determined from literature, agency and industry documentation of BMP effectiveness, and field assessments. However, if new information becomes available regarding the feasibility or effectiveness of BMPs, adaptive management allows for the refinement of TMDLs and allocations.

Additionally, as part of this adaptive management approach, shifts in the amount or intensity of land use activities should be tracked and incorporated into the source assessment to determine if allocations need to be revised. Cumulative impacts from multiple projects must also be considered. This approach will help track the recovery of the system and the impacts, or lack of impacts, from ongoing management activities in the watershed. Under these circumstances, additional targets and other types of water quality goals may need to be developed to address new stressors to the system, depending on the nature of the activity.

6.0 Nutrient TMDL Components

This portion of the document focuses on nutrients (nitrogen and phosphorus forms) as a cause of water quality impairments in the Judith Mountains TMDL Project Area. It includes: 1) the mechanisms by which nutrients can impair beneficial uses, 2) the specific stream segments of concern, 3) the presently available data pertaining to nutrients impairment characterization in the watershed, including target development and a comparison of existing water quality to targets, 4) quantification of the various contributing sources of nutrients based on recent studies, and 5) identification of and justification for the nutrients TMDLs and the TMDL allocations.

6.1 Effects of Excess Nutrients on Beneficial Uses

Nutrients (nitrogen and phosphorus forms) are needed for primary production to occur and produce food for aquatic insects and eventually the fishery. However, excessive concentrations of nutrients can affect a waterbody's ability to support its aquatic life, coldwater fisheries, drinking water, and recreation beneficial uses. Excess nutrients typically impair beneficial uses by leading to a proliferation of undesirable algae growth in streams, thereby impairing a stream's recreational and aquatic life uses.

Nitrogen and phosphorus are naturally occurring chemical elements required for the healthy and stable functioning of aquatic ecosystems. Streams in particular are dynamic systems that are dependent on a balance between nutrient additions, consumption by autotrophic organisms, cycling of biologically fixed nitrogen and phosphorus into higher trophic levels, and cycling of organically fixed nutrients into inorganic forms with biological decomposition. Nutrient additions to streams from natural landscape erosion, groundwater discharge and in-stream biological decomposition maintain a balance between organic and inorganic nutrient forms. Human influences may alter nutrient cycling pathways causing damage to biological stream function and water quality degradation.

Excess nitrogen in the form of dissolved ammonia (which is typically associated with wastewater) can be toxic to fish and other aquatic life, and elevated nitrate in drinking water can inhibit normal hemoglobin function in infants. The current drinking water nitrate limit is 10 mg/L (Montana Department of Environmental Quality, 2012a). Beside the direct effects of excess nitrogen, elevated inputs of nitrogen and phosphorus from human sources can accelerate aquatic algal growth to nuisance levels. Respiration and decomposition of excessive algal biomass depletes the supply of dissolved oxygen, which can cause mortality of fish and other forms of aquatic life. Nutrient concentrations in surface water are considered controlling factors in formation of blue-green algae blooms (Priscu, 1987), which can produce toxins that can be lethal to aquatic life, wildlife, livestock and humans. Aside from the toxicity effects, nuisance algae tend to be less palatable and can cause shifts in the macroinvertebrate community structure, which may also affect fish, who feed on macroinvertebrates (U.S. Environmental Protection Agency, 2010). Additionally, changes in water clarity, fish community structure, and aesthetics can detract from recreational uses such as fishing, swimming, and boating (Suplee et al., 2009). Nuisance algae can also increase treatment costs of drinking water or pose health risks if ingested in drinking water (World Health Organization, 2003).

6.2 Stream Segments of Concern

One waterbody segment in the Judith Mountains Project Area, Fargo Coulee, is listed as impaired due to nutrient-related (phosphorus and nitrogen) causes on the 2012 Montana 303(d) List (**Table 6-1**).

Table 6-1. Stream segments of concern for nutrients on the 2012 303(d) List.

Waterbody	Segment ID	2012 303(d) nutrient impairment
FARGO COULEE, headwaters to mouth at Armells Creek	MT40E002_130	Phosphorus (total) Nitrogen (total)

6.3 Water Quality Data and Information Sources

Although nutrient water quality data have been collected over several years, water quality data are limited for Fargo Coulee because much of the channel goes dry during the summer growing season when beneficial uses are most likely to be impaired. Additionally, some data that were previously part of DEQ's assessment file were excluded from this review because the length of the stream segment was shortened during the 2010 303(d) listing cycle as a result of higher resolution hydrography information from USGS's National Hydrography Dataset.

In total, six samples have been collected and analyzed for nutrients from Fargo Coulee during the growing season between 2004 and 2012. DEQ conducted water quality sampling at two sites in June 2004 (M31FRGOC01 and M31FRGOC02, **Figure 6-1**) and three sites during July 2012 (M31FRGOC01, M31FRGOC05, and M31FRGOC04, **Figure 6-1**). In August 2012, DEQ attempted to sample the same three sites as in July but only one had water (M31FRGOC05). EPA visited three sites in August 2010 (FRGC-M1, FRGC-M2, and FRGC-M3, **Figure 6-1**) but no samples were collected because the stream was either not flowing or dry at the sampling locations.

All growing season nutrient data used for the data review and TMDL development are included in this section. Other nutrient data from the watershed is publicly available through EPA's STORET water quality database and the DEQ's EQuIS water quality database.

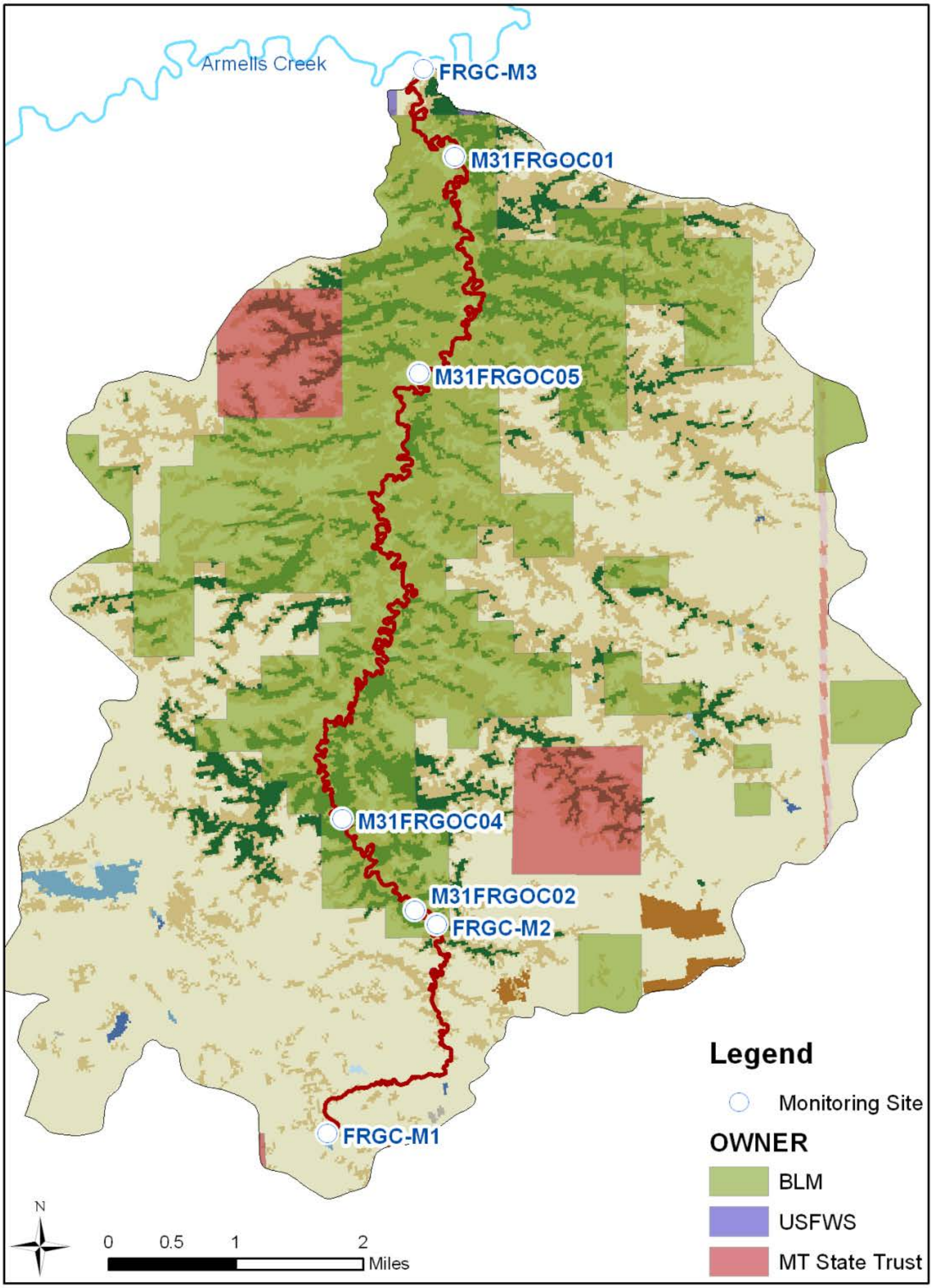

Figure 6-1. Nutrient monitoring sites on Fargo Coulee.

6.4 Water Quality Targets

TMDL water quality targets are numeric indicator values used to evaluate attainment of water quality standards. The following section presents nutrient water quality targets, and compares those target values to recently collected nutrient data in the Fargo Coulee watershed. This section presents the nutrient water quality targets used in the evaluation and nutrient targets attainment evaluations.

6.4.1 Targets

Although Montana's water quality standards for nutrients are currently narrative, draft numeric nutrient criteria have been developed by DEQ, and are the basis of the nutrient water quality targets for Fargo Coulee. The draft nutrient criteria are the result of research initiated by DEQ in 2001 and are based on 1) the results of a public perception survey regarding what level of algae was perceived as 'undesirable' (Suplee et al., 2009); 2) stressor-response studies performed by DEQ to determine the maximum nutrient concentrations that will maintain algal growth below undesirable levels; 3) a literature review of stressor-response studies; and 4) a comparison of nutrient stressor-response thresholds to eco-regionally stratified reference data from Montana (Suplee et al., 2008).

Nutrient targets for total nitrogen (TN) and total phosphorus (TP) are presented in **Table 6-2** and based on the draft nutrient criteria for the Northwestern Great Plains level 3 ecoregion, which encompasses the Fargo Coulee watershed. Both the nutrient criteria and the nutrient targets within this document apply during the summer growing season from July 1st through Sept 30th, when algal growth has the highest potential to affect beneficial uses. Because dissolved oxygen concentrations and the composition of the diatom community (which is a type of algae) can be affected by excess nutrients, the daily dissolved oxygen change (i.e., delta) and an index of diatom community composition are also used as nutrient targets (**Table 6-2**). Additional discussion on nutrient standards and targets can be found in **Appendix B**.

Table 6-2. Nutrient targets for Fargo Coulee

Parameter	Target Value
Total Nitrogen (TN)	≤ 1.4 mg/L
Total Phosphorus (TP)	≤ 0.14 mg/L
Dissolved Oxygen Delta	≤ 5.3 mg/L
Diatom Increaser Taxa – Probability of Impairment	≤ 51%

Ideally, nutrient water quality data will be evaluated following the methodology in the DEQ draft guidance document *2011 Assessment Methodology for Determining Wadeable Stream Impairment due to Excess Nitrogen and Phosphorus Levels (Suplee and Sada de Suplee, 2011)* prior to TMDL development. The assessment methodology evaluates compliance with the draft nutrient criteria (which correspond to the targets in **Table 6-2**) via two statistical tests: an exact binomial test and a student's t-test. The results of those tests are combined with the dissolved oxygen and diatom data into a decision matrix that weighs the results of each factor and determines if they collectively indicate impairment. For the nutrient evaluation, 12-13 samples are preferred, with lesser samples being acceptable if numerous samples exceed the criterion. For the other data, desired sample sizes are three for dissolved oxygen and two for diatom samples, but if a single value for either factor exceeds the target value, it is considered failing (i.e., indicating impairment) for that factor.

6.4.2 Existing Conditions and Comparison to Targets

Due to time limitations of the project and the ephemeral nature of the stream, there are insufficient nutrient, dissolved oxygen, and diatom data to strictly follow the draft assessment methodology. Therefore, existing conditions will be evaluated relative to the water quality targets in **Table 6-2**, with the decision matrix taken into consideration. Also, instantaneous dissolved oxygen values were collected in 2004 and will be used as supporting information and compared to the aquatic life standard of 5.0 mg/L (one-day minimum concentration) for C-3 streams as defined in DEQ-7.

6.4.2.1 Fargo Coulee

Fargo Coulee (MT40E002_130) is a tributary to Armells Creek located in the Fort Peck Reservoir HUC8 (10040104). Fargo Coulee is an ephemeral stream and commonly stops flowing or dries up during the summer months. The 21.1 mile reach of Fargo Coulee from its headwaters to Armells Creek is listed on the 2012 303 (d) List as impaired by total phosphorus and total nitrogen.

<u>Available Water Quality Data</u>

All available growing season nutrient data for Fargo Coulee are summarized in **Table 6-3**. Two water samples were collected in 2004 and four water samples were collected in 2012. Although the samples from 2004 were collected slightly before the growing season dates specified in the assessment methodology, data collected within a ten day window on either end of the season is acceptable (Suplee and Sada de Suplee, 2011). No diatom data are available for 2004 but instantaneous DO measurements were collected. The maximum daily change in DO concentration (i.e., DO delta) could only be measured at one site in 2012 because of the lack of water in the channel at the other sites. As mentioned previously, all data were evaluated relative to the target values but target compliance cannot be fully evaluated because of the limited size of the dataset.

Table 6-3. Fargo Coulee growing season nutrient water quality data summary.

Monitoring Station	Date	Flow (cfs)	TN (mg/L)	TP (mg/L)	Dissolved oxygen (mg/L)	Diatom Impairment Probability (%)
M31FRGCO01	6/27/04	0.02	0.96*	0.021	Instant = 5.0	--
M31FRGCO02	6/29/04	0	**1.48***	0.064	Instant = 5.9	--
M31FRG0C01	7/13/12	0	1.18	0.059	Delta = **12**	**56.40**
M31FRGOC05	7/13/12	0	1.10	0.067	--	21.33
M31FRGOC04	7/12/12	0	0.82	0.040	--	33.52
M31FRGOC05	8/14/12	0	1.24	0.096	--	15.62

Notes: TN = total nitrogen; TP = total phosphorus; -- = No data, * = calculated from TKN and nitrate/nitrite
BOLD exceeds nutrient targets

<u>Data Summary and TMDL Development Determination</u>

All total phosphorus values were below the target and one sample exceeded the target for total nitrogen. High concentrations of algae and/or macrophytes, which tend to take up nutrients and lower measurable concentrations, were not observed in 2012. One of the DO values was equal to the daily aquatic life standard and the DO delta at one site was more than double the target value. Most of the diatom samples did not indicate impairment, but the sample collected at the site with the high DO delta (i.e., M31FRGOC01) did exceed the 51% target, indicating impairment. The DEQ assessment file mentions low intensity grazing at both sites sampled in 2004. The site visit notes from 2012 mention heavy cattle usage but no stream access near site M31FRGOC01, and intensive cattle grazing at site

M31FRGOC05 with crossings and access points common, indicating there may be human sources of excess nutrients.

Using the decision matrix, even if there were additional water quality samples and the data passed both statistical tests (i.e., binomial and t-test), the failure of the DO and diatom target indicate borderline impairment of the aquatic life beneficial use. Concentrations during the growing season and in samples collected in May 2011 suggest nitrogen is more of an issue than phosphorus. To be conservative, since the data indicate borderline impairment, human nutrient sources are present, the DO delta is more than double the target value, and because Fargo Coulee is currently listed, nitrogen and phosphorus TMDLs will be developed for Fargo Coulee. Additional monitoring for all target parameters is recommended to better evaluate nutrient loading and its effects on water quality and beneficial uses.

6.5 Nutrient Source Characterization, TMDLs and Allocations

This section describes the potential nutrient sources, TMDLs and load allocations for Fargo Coulee.

6.5.1 Source Characterization

Given the ephemeral nature of the stream and lack of flowing water during the growing season, the water quality data are of limited use in assessing nutrient sources and loading. There are no permitted point sources in the watershed, so any nutrient inputs are from nonpoint sources on the landscape. Land cover in the watershed is primarily shrub/scrub and grassland/herbaceous, with shrub/scrub being dominant near the stream (**Table 6-4** and **Figure 6-2**). Much of the land is managed by the BLM (**Figure 6-1**) and used for cattle grazing allotments. Some allotments are grazed seasonally whereas other are open throughout the year.

During the two growing season sampling events with samples from multiple sites (**Table 6-3**), Fargo Coulee was not visibly flowing at all sites and there were no spatial trends in nutrient concentrations. Samples were collected during runoff in May 2011 at sites FRGC-M2 and FRGC-M3 (**Figure 6-2**); flow increased from 0.55cfs to 6.78cfs between the sites and nutrient concentrations increased as well. Total nitrogen at the lower site (FRGC-M3) was the only sample that was greater than the target value. Although the nutrient targets apply seasonally, since surface flow rapidly declines in much of the stream during the growing season, loading that occurs during the spring and early summer may be a significant nutrient source during the growing season.

Table 6-4. Fargo Coulee land cover (2006 NLCD).

Land Use	Area (acres)	Area (square miles)	Percentage
Open Water	8.23	0.01	0.03%
Developed Open Space	65.83	0.10	0.26%
Developed Low Intensity	65.61	0.10	0.26%
Bare	6.67	0.01	0.03%
Evergreen Forest	2,818.40	4.40	11.15%
Shrub/Scrub	7,946.36	12.42	31.45%
Grassland/Herbaceous	14,049.07	21.95	55.60%
Pasture/Hay	1.11	0.00	0.00%
Cultivated Crops	144.11	0.23	0.57%
Woody Wetlands	59.16	0.09	0.23%
Emergent Herbaceous Wetlands	102.30	0.16	0.40%
Total	**25,266.84**	**39.48**	**100%**

Figure 6-2. Fargo Coulee land use and monitoring stations.

Several of the BLM grazing allotments that fall within the watershed were noted in the Judith Resource Area Management Plan (U.S. Department of the Interior, Bureau of Land Management, 1994) as not meeting riparian and wetland management objectives. On a rotating basis, the BLM Lewistown Office continues to monitor the health of the allotments within its jurisdiction, and those not meeting management objectives are prioritized for improvements. The Resource Area Management Plan, in conjunction with the Standards for Rangeland Health and Guidelines for Livestock Grazing Management for Montana and the Dakotas (U.S. Department of the Interior, Bureau of Land Management, 1997), outline grazing management practices that focus on establishment and protection of proper functioning conditions and attainment of water quality standards. Using monitoring results as a guide, the BLM evaluates permit/lease conditions with each renewal and works with permit/lease holders to assure its standards and guidelines are met. Based on DEQ assessment file notes, some localized areas of overgrazing were observed during data collection in 2012, but overall riparian conditions were improved from 2004.

6.5.2 Nutrient TMDLs

Phosphorus and nitrogen TMDLs are presented in this section for Fargo Coulee. The TMDL equation for each nutrient form is based on flow and the nutrient targets, and is provided in **Equations 6-1** and **6-2**. The target values are based on the most sensitive uses; therefore, the nutrient TMDLs are protective of all designated beneficial uses. Future conditions will be considered meeting the TMDL if there is less than a 20 percent exceedance rate as long as exceedances are spatially and temporally random during the summer months. This exceedance rate allows for natural variability yet should protect against nutrient conditions that impact any use of the water. The TMDLs are applied only to the summer growing season (July 1st through Sept 30th).

Equation 6-1.

Total Nitrogen TMDL (lbs/day) = CFS*7.56

Where: CFS = Average daily discharge in cubic feet per second

7.56 = Conversion factor (5.4) combined with total nitrogen target of 1.4 mg/L

Equation 6-2.

Total Phosphorus TMDL (lbs/day) = CFS*0.756

Where: CFS = Average daily discharge in cubic feet per second

0.756 = Conversion factor (5.4) combined with total phosphorus target of 0.14 mg/L

TMDL examples are provided for Fargo Coulee using growing season sample data. The TMDL can also be displayed as a line graph of allowable loading with increasing flow. **Figures 6-3** and **6-4** are the graphs of the TN and TP TMDLs for the range of mean daily flows from zero to 30 cfs.

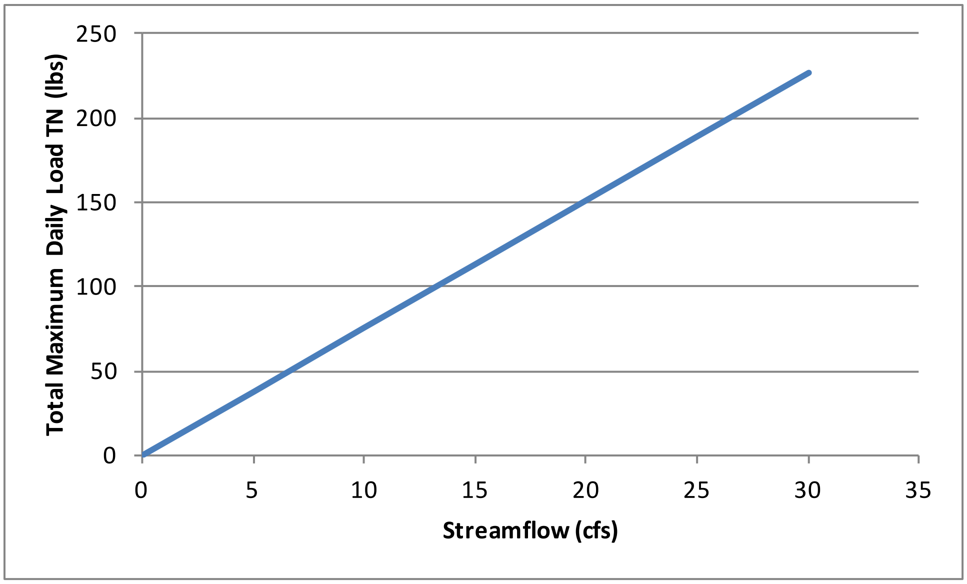

Figure 6-3. TN TMDL for mean daily flows from zero to 30 cfs.

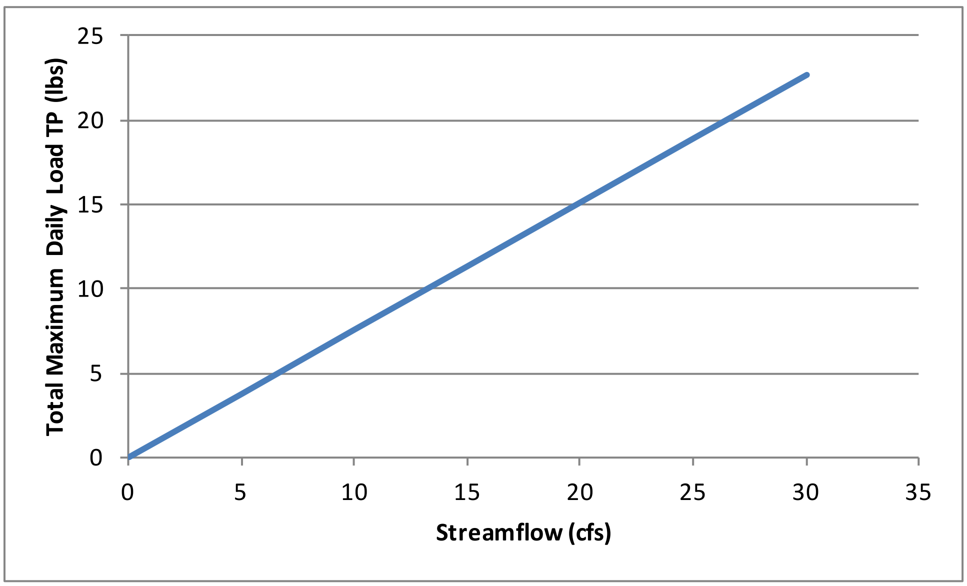

Figure 6-4. TP TMDL for mean daily flows from zero to 30 cfs.

6.5.3 Fargo Coulee TMDLs and Allocations

The TMDL allocations are composited into a single load allocation to all nonpoint sources, which are primarily agriculture and natural background sources. Therefore, the equation for all nutrient TMDLs is as follows: TMDL = LA. Because there are no point sources, the wasteload allocation (WLA) is 0. The MOS is implicit in this allocation scheme, through a variety of conservative assumptions (see **Section 6.6**).

Growing season water quality data from 2004 (**Table 6-3**) are used for the TMDL examples and to calculate the necessary percent load reduction to achieve the TMDL for each nutrient under those sampling conditions (**Table 6-5**). For the sampling site where no measureable flow was occurring, 0.01 cfs is used for the example. As only one nitrogen sample was greater than the target, it is the only example in **Table 6-5** showing a percent reduction. However, with an increased amount of sample data, it is assumed that some level of reduction will be necessary for nitrogen and phosphorus.

Table 6-5. Fargo Coulee: nutrients TMDLs and allocation summary.

Monitoring station	Parameter	Flow condition (cfs)	Observed load (lb/day)	TMDL (lb/day)	Percent reduction (%)
M31FRGOC01	Total Nitrogen	Low (0.02)	0.10	0.15	0
	Total Phosphorus	Low (0.02)	0.002	0.015	0
M31FRGOC02	Total Nitrogen	Low (0.01)[a]	0.080	0.076	5
	Total Phosphorus	Low (0.01)[a]	0.003	0.008	0

[a.] There was no measurable flow during this sampling event and 0.01cfs was used for the example. If flow is 0, the TMDL is 0.

6.5.3.1 Meeting Allocations

It is important to recognize that the first critical step toward meeting the nutrient allocations involves applying and/or maintaining the land management practices or BMPs that will reduce nutrient loading. For many nonpoint source activities, it can take several years to achieve the full load reduction at the location of concern, even though full BMP implementation is in effect. For example, it may take several years for riparian areas to fully recover and decrease nutrient loading after implementing grazing BMPs.

Because the water quality data indicate borderline impairment and DEQ field observations indicated an improvement in riparian conditions since 2004, it is recommended that current management practices be evaluated first to determine if changes are necessary or if changes already implemented need additional time before the full improvement is realized. If it is determined that all reasonable BMPs have been implemented or additional improvements are needed, once these actions have been completed at a given location, the landowner or land manager will have taken action consistent with the intent of the nutrient allocation for that location. It is also important to apply proper BMPs and other water quality protection practices for all new or changing land management activities to limit any potential increased nutrient loading. Progress towards TMDL and individual allocation achievement can be gauged by BMP implementation and improvement in or attainment of water quality targets defined in **Section 6.4.1**.

6.6 Seasonality and Margin of Safety

TMDL documents must consider the seasonal variability, or seasonality, on water quality impairment conditions, maximum allowable pollutant loads in a stream (TMDLs), and load allocations. TMDL development must also incorporate a margin of safety to account for uncertainties between pollutant sources and the quality of the receiving waterbody, and to ensure (to the degree practicable) that the TMDL components and requirements are sufficiently protective of water quality and beneficial uses. This section describes seasonality and margin of safety in the Fargo Coulee watershed nutrient TMDL development process.

Addressing seasonal variations is an important and required component of TMDL development and throughout this plan seasonality is an integral consideration. Water quality and particularly nitrogen concentrations are recognized to have seasonal cycles. Specific examples of how seasonality has been addressed within this document include:

- Water quality targets and subsequent allocations are applicable for the summer-time growing season (July1st – Sept 30th), to coincide with seasonal algal growth targets.

- Nutrient TMDLs incorporate streamflow as part of the TMDL equation.
- Although the targets and TMDLs only apply to the growing season, because all sources are nonpoint, it is anticipated that TMDL implementation will result in reductions in nutrient loading year-round. This will address sources of nutrients that tend to be introduced to during runoff but stored in channel and become available during the summer growing season.

A MOS is a required component of TMDL development. The MOS accounts for the uncertainty about the pollutant loads and the quality of the receiving water and is intended to protect beneficial uses in the face of this uncertainty. The MOS may be applied implicitly by using conservative assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading (U.S. Environmental Protection Agency, 1999a). This plan addresses MOS implicitly in a variety of ways:

- Target values were developed to error on the conservative side of protecting beneficial uses.
- Static nutrient target values were used to calculate allowable phosphorus and nitrogen loads (TMDLs). Allowable exceedances of nutrient targets were not incorporated into the calculation of allowable loads, thereby adding a MOS to established nutrient allocations.
- By considering seasonality and variability in nutrient loading.
- By using an adaptive management approach to evaluate target attainment and allow for refinement of load allocation, assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development.

6.7 Uncertainty and Adaptive Management

Uncertainties in the accuracy of field data, target development, source assessments, loading calculations, and other considerations are inherent when assessing and evaluating environmental variables for TMDL development. While uncertainties are an undeniable fact of TMDL development, mitigation and reduction of uncertainties through adaptive management approaches is a key component of ongoing TMDL implementation and evaluation.

The process of adaptive management is predicated on the premise that TMDL targets, allocations, and the analyses supporting them are not static, but are processes subject to modification and adjustment as new information and relationships are understood. For instance, numeric nutrient targets are based on the best information and analyses available at the time of document production, and represent water quality concentrations believed to limit algal growth below nuisance levels within Fargo Coulee. As numeric nutrient criteria development efforts by the DEQ progress, nutrient water quality targets may be modified or adjusted. Additionally, because of the limited amount of sampling data, there is uncertainty regarding the extent of nutrient impairment and the contribution from human sources. Additional monitoring of nutrients and nutrient related parameters in Fargo Coulee during the growing season is recommended to reduce this uncertainty and refine the source assessment.

As further monitoring of water quality and source loading conditions is conducted, uncertainties associated with these assumptions and considerations may be mitigated and loading estimates may be refined to more accurately portray watershed conditions. As part of this adaptive management approach, land use activities, nutrient management and control should be tracked. Changes in land use or management may change nutrient dynamics and may trigger a need for additional monitoring. The extent of monitoring should be consistent with the extent of potential impacts, and can vary from basic BMP assessments to a complete measure of target parameters above and below the project area before the project and after completion of the project. This approach will help track the recovery of the system and the impacts, or lack of impacts, from ongoing management activities in the watershed.

7.0 Metal TMDL Components

This portion of the document focuses on metals as an identified cause of water quality impairments in the Judith Mountains TMDL Planning Area. It describes: 1) the mechanisms by which metals impair beneficial uses of those streams, 2) the specific stream segments of concern, 3) the presently available data pertaining to metals impairments in the watershed, 4) the various contributing sources of metals based on recent data and studies, and 5) the metals TMDLs and allocations.

7.1 Effects of Excess Metals on Beneficial Uses

Waterbodies with metals concentrations exceeding the aquatic life and/or human health standards can impair support of numerous beneficial uses including aquatic life, coldwater fisheries, drinking water, and agriculture. Within aquatic ecosystems, elevated concentrations of heavy 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.

7.2 Stream Segments of Concern

A total of six waterbody segments are listed as impaired due to metals-related causes on the 2012 Montana 303(d) List (**Table 7-1**). All of the stream segments are classified by DEQ as C-3. Metals-related listings include aluminum, antimony, arsenic, cadmium, copper, cyanide, iron, lead, mercury, zinc, and pH. In most cases altered pH is related to dissolved metals in water samples associated with metals sources, so the pH impairment is addressed in conjunction with the metals impairments.

Table 7-1. Waterbody segments with metals listings on the 2012 303(d) list.

Waterbody	Segment ID	Impairment cause
CHICAGO GULCH, headwaters to the mouth (Fords Creek)*	MT40B002_020	Lead, pH, Zinc
CHIPPEWA CREEK, headwaters to confluence with Manitoba Gulch	MT40B002_040	Antimony, Arsenic, Cyanide, Iron, Mercury, Zinc
COLLAR GULCH CREEK, headwaters to mouth (Fords Creek)	MT40B002_030	Lead, pH, Zinc
ARMELLS CREEK, headwaters to Deer Creek	MT40E002_022	Cadmium, Copper, Mercury, pH, Zinc
COW CREEK, Als Creek to the mouth (Missouri River)	MT40E002_040	Aluminum, Copper, Iron, Lead
FARGO COULEE, headwaters to mouth at Amells Creek	MT40E002_130	Aluminum, Iron, Lead

*This waterbody segment is actually part of Ford's Creek and its name will be corrected for the 2014 IR to "Fords Creek (headwaters in Chicago Gulch to East Fork Fords Creek)."

7.3 Water Quality Data and Information Sources

To determine the location and magnitude of general sources, GIS layers, available water quality data, and aerial photos were used. GIS data 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 permitted point sources (i.e. Montana Pollutant Discharge Elimination System permits). Because geology and soil can influence water quality, geologic data from the USGS General Surficial Geology of Montana 1:500,000 scale map (**Figure A-4** in **Appendix A**) and soils data from the State Soil Geographic (STATSGO) database were also examined (**Figures A-5** and **A-6** in **Appendix A**).

A query of applicable databases showed there are no active hardrock mines and no relevant NPDES permitted point sources in the Judith Mountains Project Area. However, there are approximately 56 abandoned mines within the Judith Mountains Project Area according to the DEQ and MBMG abandoned mining databases. Two have been ranked by DEQ as high priority abandoned mines: the Gilt Edge Tailings on Chippewa Creek and the Tail Holt Mine in the Collar Gulch drainage. Abandoned mine types included in the databases are placer, hard rock/lode, mineral deposits, mill sites, and coal mines. Because of the different mine types in the databases, abandoned mine sites may range from small ground disturbances to areas with adits (which can be dry or discharging) and/or tailings and waste rock piles of different sizes. Waste rock dumps and tailings may be in upland areas, in the floodplain or streamside, or in the stream channel. Depending on the parent geology, stability and level of re-vegetation, and capacity to leach metals and/or generate acid mine drainage, the effects of mining wastes on stream water quality can vary greatly.

Many of the 303(d) listings are based on water column and sediment metals data from either the 1980s or the 1990s. Data collected earlier than 10 years ago (pre- 2001) 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.

Information used for the data review and TMDL development includes DEQ's assessment data collected since 2001 as well as other data available in STORET. To add to the historical dataset and document seasonal variability, EPA conducted metals water quality monitoring in 2010 and 2011 during spring runoff and base flow conditions. An assessment of potential sources of metals loading to 303(d) listed metals impaired streams was also performed in 2011 using the GIS data described above in combination with a field investigation of sources to facilitate TMDL development (**Appendix D**). The field investigation of sources focused on abandoned hardrock mines and did not include Cow Creek and Fargo Coulee watersheds, which primarily contain mineral prospect and former coal mining sites. Field and analytical protocols for the samples collected in 2010 and 2011 are described in the Monitoring for Fort Peck Area Tributaries and Flatwillow-Box Elder TMDL Planning Areas Sampling and Analysis and Quality Assurance Project Plan (Atkins North America, Inc., 2011c). For all data reviewed, samples collected between April 15th and June 30th are assumed to represent high flow and all other samples are low flow (unless otherwise specified in a sampling report).

The effect of runoff on metals concentrations can vary as spring runoff may dilute metals sources that enter the stream through groundwater or may increase erosion and erode soils and tailings containing metals. Mining areas may contribute metals through groundwater discharge, which occurs year-round, but tend to be more apparent during low flow when surface water inputs are minimal. Examining water quality data under various hydrologic conditions is necessary to characterize water chemistry metal conditions.

Table 7-2 provides a summary of available water quality data between 2002 and present. Data summaries for relevant water quality parameters are provided in **Section 7.4.3** for each impaired waterbody segment. Data used to assist in source characterization, target evaluation, loading analysis, and development of load allocations are derived from the aforementioned source assessment.

Table 7-2. Water quality data evaluated for TMDL development.

Data source and data year	Applicable 303(d) listed waterbody segments	Data description
US EPA 2010-2011	All	Metals sampling for TMDL development
Modern STORET 2002-2012	All	Water quality sampling and sediment sampling for metals

As described in **Appendix D**, BLM is conducting water quality sampling in Collar Gulch Creek, Chicago Gulch, and Armells Creek. The goal of the sampling is to identify the metals loading contribution from human and natural sources in those drainages and help prioritize where restoration efforts should be focused. The project was initiated in 2011 but most sampling will be conducted in 2012 and 2013. Because the project is still in-progress and is also part of a graduate research project, the data are not presented or analyzed within this document. However, the project findings will be critical during TMDL implementation and future evaluation of Collar Gulch Creek, Chicago Gulch, and Armells Creek.

7.4 Water Quality Targets

Water quality data described in **Section 7.3** were compiled and evaluated for attainment of water quality standards. This section presents the evaluation framework, water quality targets, and attainment evaluations for each impaired waterbody listed in **Table 7-1**.

7.4.1 Metals Evaluation Framework

Evaluating attainment of water quality standards for metals-related impairments involves three steps:

1. **Evaluation of metals sources.**
   Sources of metals in a watershed can be both natural and human-caused. TMDLs are not developed for waterbodies that are not meeting water standards due solely to "naturally occurring" pollutants. Consequently, metals-impaired streams must demonstrate existence of human 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 (narrative and numeric) or represent a water quality condition that is unimpaired for the pollutant of concern. Metals water quality targets are presented in **Section 7.4.2.**

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 metals water quality targets. TMDL determination is based on the following assumptions:

- Unless background data are available to show otherwise, natural levels of metals are below the water quality standards for aquatic life under all flow conditions.
- Single water quality samples represent a 96-hour average water quality condition.

  Whether or not a TMDL is developed depends on target and supplemental indicator compliance, the presence of human sources, pollutant waterbody listing status, and dataset size as follows.

For a currently listed waterbody-pollutant combination:

- A TMDL will be developed if all water quality targets and sediment supplemental indicator values are met and the sample size is less than eight but the source assessment indicates human sources.
- A TMDL will not be developed if all water quality targets and sediment supplemental indicator values are met and the sample size is at least eight.
- A TMDL will be developed if data are not in compliance with water quality targets and human sources are identified. This also applies if human sources are identified but data indicate natural background conditions may exceed water quality targets under certain flow conditions. Additional monitoring may be recommended in lieu of TMDL development if background conditions exceed water quality targets and human sources are not identified.

For an unlisted waterbody-pollutant combination:

- A TMDL will be developed if there are at least eight recent samples, human sources are identified, and water quality samples are not in compliance with targets.
- If there are at least eight recent water quality samples and data are in compliance with targets but sediment samples exceed supplemental indicator values, TMDL development will be determined on a case by case basis depending on human sources and the severity and extent of elevated sediment metals concentrations.
- Monitoring may be recommended in lieu of TMDL development if water quality targets or sediment supplemental indicators are not met but the sample size is less than eight.

7.4.2 Targets

The metals targets and supplemental indicators are summarized in **Table 7-3** and detailed in the sections that follow. Additional discussion on metals standards and targets can be found in **Appendix B**.

Table 7-3. Targets and supplemental indicators for metals.

Water Quality Targets	Proposed Criterion
Montana's numeric water quality standards	As described in Circular DEQ-7
Supplemental Indicators	**Proposed Criterion**
Sediment metal concentrations (µg/g dry weight)	Not impeding aquatic life use support: Comparable to Probable Effects Levels (PEL) guidance values.
Human metals sources	No significant human sources

7.4.2.1 Water Column Metals Concentrations

For metals with numeric criteria, the most protective established state numeric water quality criteria as defined in DEQ Circular DEQ-7 (Montana Department of Environmental Quality, 2012a) is adopted as the water quality target. Numeric criteria apply to both human health and aquatic life protection. The numeric aquatic life criteria for most metals are dependent upon water hardness values: as the hardness increases, the water quality criteria for a specific metal also increase. Water quality criteria (acute and chronic aquatic life, human health standard [HHS]) for each parameter of concern at a water hardness of 25 mg/L, 100 mg/L, and 400 mg/L are shown in **Table 7-4**. Acute and chronic toxicity aquatic life criteria are designed to protect aquatic life uses, while the HHS is designed to protect drinking water uses. Attainment of *chronic* aquatic life water quality criteria are based on an average water quality metals concentration over a 96 hour period. The 96 hour average concentration of these parameters in surface waters may not exceed the chronic standard more than once in any three year period, on average. *Acute* aquatic life water quality criteria are applied as a one-hour average concentration that cannot be exceeded more than once in a three year period, with the exception of silver, which is applied as a "not-to-exceed" value. *HHS* water quality criteria are applied as a "not-to-exceed" value.

Based on DEQ's draft assessment methodology, a waterbody-pollutant combination will be considered not in compliance with the metals target if any of these circumstances are met:

- The exceedance rate of chronic aquatic life standards is > 10%. Note: the desired minimum sample size for this evaluation is 8; if there are less than 8 samples, at least 2 samples must exceed the chronic aquatic life standard to be considered not meeting the target.
- ≥ 1 sample exceeds twice the acute aquatic life water quality standard.
- ≥ 1 sample exceeds the human health water quality standard.

Table 7-4. Metals numeric water quality targets

Metal of concern	Aquatic life criteria (ug/L) at 25 mg/L hardness		Aquatic life criteria (ug/L) at 100 mg/L hardness		Aquatic life criteria (ug/L) at 400 mg/L hardness		HHS (ug/L)
	Acute	Chronic	Acute	Chronic	Acute	Chronic	
Aluminum, dissolved	750	87	750	87	750	87	---
Antimony, TR	---	---	---	---	---	---	5.6
Arsenic, TR	340	150	340	150	340	150	10
Cadmium, TR	0.52	0.1	2.1	0.27	8.7	0.76	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	---
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

TR = total recoverable

7.4.2.2 pH

Waterbodies impaired by metals are also sometimes impaired by pH. For human health, changes in pH are addressed by the general narrative criteria in ARM 17.30.601 et seq. and ARM 17.30.1001 et seq. For aquatic life, which can be sensitive to small pH changes, criteria are specified for each waterbody use classification. For C-3 waters, ARM 17.30.629 (2)(c) states *"Induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 9.0 must be less than 0.5 pH unit. Natural pH outside this range must be maintained without change. Natural pH above 7.0 must be maintained above 7.0"* The numeric criteria will be applied as the target for pH. For listed waterbodies that either do not meet this target or have a limited amount of recent data and the cause is attributable to metals sources, a metals TMDL will be written as a surrogate for a pH TMDL because acid mine drainage associated with metals sources should be addressed in conjunction with reclamation activities needed to meet metals TMDLs.

7.4.2.3 Sediment Metals Concentrations

Narrative standards found in Montana's general water quality prohibitions apply to metals concentrations that are found in stream bottom sediments. Stream sediment data may also be indicative of beneficial use impairment caused by elevated metals and are used as supplementary indicators 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 during runoff conditions. This can be a particularly important supplemental indicator when high flow data is lacking or limited.

The National Oceanic and Atmospheric Administration (NOAA) has developed Screening Quick Reference Tables that contain metals concentration guidelines for freshwater sediments (Buchman, 2008). Screening criteria concentrations come from a variety of toxicity studies and are expressed in Probable Effects Levels (PELs) (**Table 7-5**). PELs represent the sediment concentration above which toxic effects frequently occur, and are calculated as the geometric mean of the 50th percentile concentration of the toxic effects dataset and the 85th percentile of the no-effect dataset. Although the State of Montana does not currently have criteria that define impairment condition based on sediment quality data, PELs provide a screening tool to evaluate the potential for impacts to aquatic life and will be used as a supplemental indicator to assist in impairment determinations where water chemistry data are limited. Because numeric standards exist for metals in water and sediment standards are narrative, sediment metals information will be used as a supplemental indicator to water column data.

Table 7-5. Screening level criteria for sediment metals concentrations.

Metal of Concern	PEL (ppm dry weight)
Aluminum	--
Antimony	--
Arsenic	17
Cadmium	3.53
Copper	197
Iron	--
Lead	91.3
Mercury	0.486
Zinc	315

7.4.3 Existing Conditions and Comparison to Targets

For each waterbody segment listed on the 2012 303(d) List for metals (**Table 7-1**), the source evaluation is discussed and water quality and sediment data are evaluated relative to the targets to make a TMDL development determination. Data for all existing metals listings are evaluated relative to water quality targets as well as data for other metals with exceedances of water quality targets. Much of the metals source information for each stream is based on a source assessment study completed in 2011 (**Appendix D**).

7.4.3.1 Chicago Gulch (aka Ford's Creek) (MT40B002_020)

Chicago Gulch is a tributary to Ford's Creek and is located in the Box Elder HUC 8 (10040204). The entire 3 mile length of Chicago Gulch is listed as impaired for metals (lead and zinc) and pH. Note, this waterbody segment is actually part of Ford's Creek and its name will be corrected for the 2014 IR: Fords Creek (headwaters in Chicago Gulch to East Fork Fords Creek).

Metals Sources

An assessment of potential sources of metals loading to Chicago Gulch was completed in 2011 (**Appendix D**). This assessment included a review of relevant literature; compilation and review of GIS layers pertaining to land uses, land ownership, and locations of abandoned and inactive mines; and a field reconnaissance inspection of all but the upper headwaters region of the watershed.

The literature review for Chicago Gulch did not identify references to historical mining activities in this drainage. The MBMG and DEQ databases identify three abandoned mines or prospects in the watershed (**Table 7-6** and **Figure 7-1**). The DEQ abandoned mines database shows one exploration prospect or abandoned mine site (D7) in the extreme headwaters of Chicago Gulch. It is not named or described in the database and a field survey was not possible due to deep snow. The MBMG database included two additional abandoned mine sites in, or immediately adjacent to, this watershed: Hamilton Copper Queen Group Prospect (M8), and the Big Chicago Mine (M25). Site M8 appears to be located on the drainage divide between the Chicago Gulch and Armells Creek Watersheds (**Figure 7-1**). It was not visited or specifically evaluated as part of the source assessment and the direction of surface/groundwater flow from this site is not known. According to the MBMG database, this has been identified as an abandoned prospect for copper and gold. MBMG's comments noted the site was dry and no impacts were observed. Site M25 is an underground gold exploration prospect located on private property on the south side of Chicago Gulch. The MBMG site description indicates no impacts associated with the site.

Table 7-6. Abandoned and inactive mines in the Chicago Gulch watershed.

Map label [a]	Name	MBMG comments	Status	Commodities mined
D7	Red Mountain Warm Springs Dist	-	-	-
M8	Hamilton Copper Queen Group	Dry, no impact.	Exploration Prospect	Copper, gold
M25	Big Chicago	Observed from a distance, no impact.	Exploration Prospect	Gold

[a.] An "M" preceding the number indicates that this site was listed in the MBMG abandoned mines database. A "D" preceding the number indicates that the site was listed in DEQ's abandoned mines database.

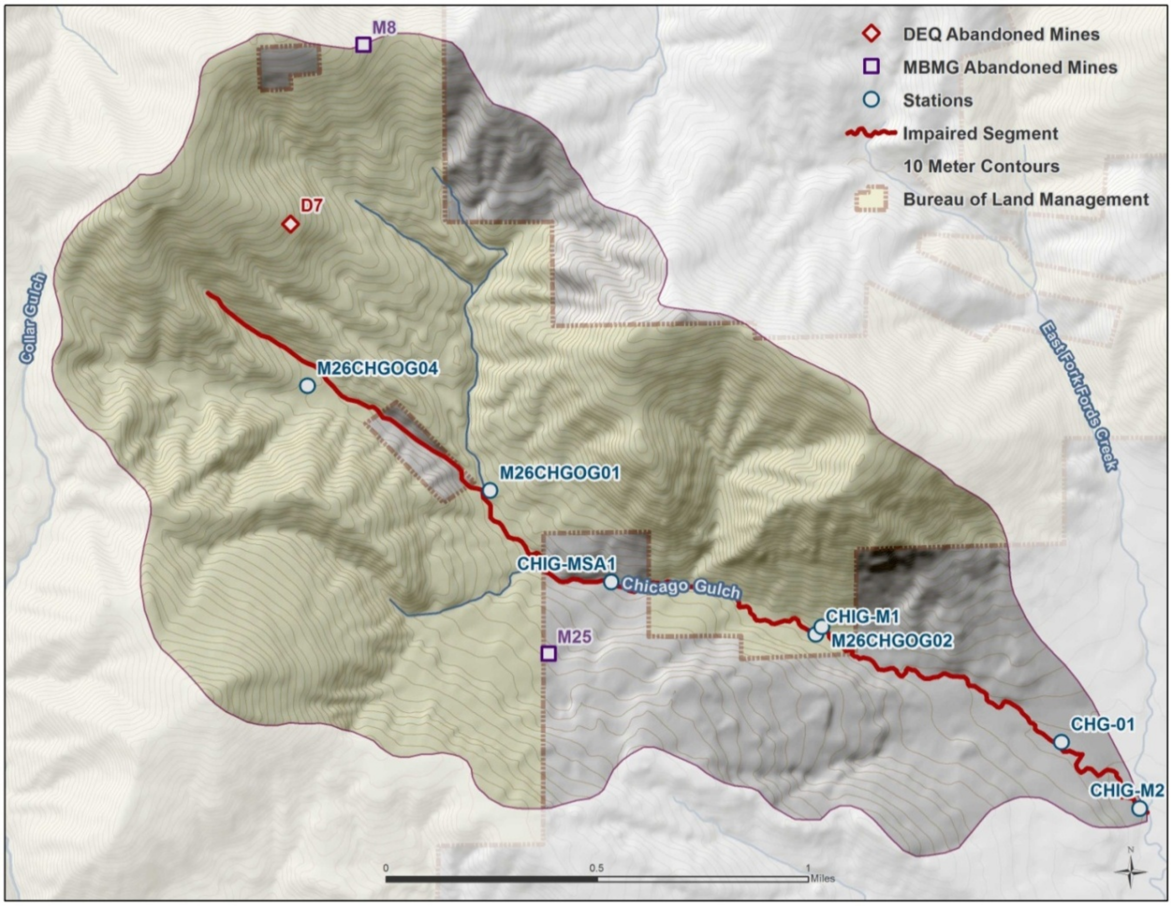

Figure 7-1. Location of Chicago Gulch monitoring stations and abandoned mines.

The field reconnaissance visit was conducted on May 16, 2011. All but the upper headwaters, that were inaccessible due to deep snow, were visually assessed on foot. No obvious sources of metals were observed. Additionally, during the 2011 monitoring, the portion of the listed segment from the BLM boundary downstream to the East Fork of Fords Creek was observed from a trail which parallels the creek. No apparent mining related or other human sources of metals loading were observed in this segment of Chicago Gulch.

Available Water Quality Data

Metals water quality collected during high and low flow between 2003 and 2011 were used to evaluate attainment of water quality targets (**Table 7-7**). Sediment metals sampling was conducted in 2003 and 2004 (**Table 7-8**). One water quality sample collected in 2004 does not have a reported hardness value; the metals concentrations were evaluated using a hardness value of 39 mg/L, which is the 10th percentile of available hardness data for Chicago Gulch. The entire metals suite was evaluated relative to the target values; however metals that did not include any exceedances and were not listed on the 2012 303(d) List are not included in the summary tables or discussion below.

Table 7-7. Chicago Gulch metals and metals-related data.

Monitoring Station	Date	pH	Hardness (mg/L)	Flow (cfs)	Al (µg/L) D	As (µg /L) TR	Cd (µg /L) TR	Pb (µg /L) TR	Zn (µg /L) TR
M26CHGOG01	8/19/03	**3.75**	143	E 0.5	--	**19** [hhs]	< 0.1	< 1	< 1
M26CHGOG02	8/19/03	7.52	119	E 1	--	**18** [hhs]	< 0.1	< 1	8
M26CHGOG04	6/30/04	**3.56**	39[a]	E 0.25	2,680[b]	< 1	**1.2** [ac]	**127** [ac, hhs]	**259** [ac]
CHG-1	10/3/04	7.84	121	0.31	--	< 3	< 0.1	< 0.05	< 10
CHIG-MSA1	5/19/11	7.76	34	12.1	**90** [ch]	< 3	< 0.08	**5.5** [ch]	10
CHIG-M1	5/19/11	7.85	42	15.35	80	< 3	< 0.08	**4.3** [ch]	20
CHIG-M1	8/18/10	7.71	98	0.57	< 30	< 3	< 0.08	1.2	10
CHIG-M2	8/18/10	7.78	121	0.8	< 30	< 3	< 0.08	< 0.5	< 10

[a]. Hardness value was not measured for this sampling event but was approximated based on the 10th percentile of sample data for Chicago Gulch.
[b]. Aquatic life standard exceedance not identified due to pH measurements outside of applicable range
BOLD indicates exceedance of the target.
[ch] = chronic exceedance; [ac] = acute exceedance; [hhs] = human health standard exceedance

Table 7-8. Chicago Gulch metals sediment quality summary.

Monitoring Station	Date	Al[1] (µg/g)	As (µg/g)	Cd (µg/g)	Pb (µg/g)	Zn (µg/g)
M26CHGOG01	8/19/03	11,500	**23.1**	1	61.7	155
M26CHGOG02	8/19/03	39,400	13.9	**12**	**597**	**2,680**
M26CHGOG04	6/30/04	8,980	14.2	< 0.5	**830**	114

BOLD indicates PEL exceedance; [1]There is no PEL for aluminum

Spatial and Seasonal Trends

Under high flow conditions, aluminum and lead concentrations were typically higher than during low flow conditions, indicating pollutant sources associated with watershed runoff or channel erosion. A seasonal pattern was not observed for arsenic, cadmium and zinc. Low pH values were only measured in the upper portion of the creek (i.e., sample sites M26CHGOG01 and M26CHGOG04), indicating an acidic source is present in the headwaters portion of the watershed. The low pH values coincide with several metal target exceedances in the creek.

Although the limited number of sampling sites per sample event makes it difficult to discern much of a spatial pattern, metals concentrations generally decline in a downstream direction and were greatest at the uppermost sampling site (M26CHGOG04), indicating the dominant source of metals loading may also be causing the low pH values. The lead concentration in sediment corresponded to the water quality data and was greatest at the uppermost sampling site (9 times the PEL value) but all other sediment metals values at that site were below the PEL. However, the sediment arsenic concentration was slightly greater than the PEL at the next downstream site and cadmium, lead, and zinc were all multiple times greater than the PEL at the most downstream site (M26CHGOG02). This pattern in sediment concentrations suggests there is also likely an upland or in-channel source of metals loading downstream of the uppermost site. Based on the greatest metals concentrations occurring near the headwaters, there is likely a substantial natural component of metals loading. However, based on the mining history in the watershed, it is also possible that mining or other human disturbances are contributing to metals impairment. **Note**: Chicago Gulch is one of the streams in the ongoing study being conducted by BLM that is investigating the natural versus human contribution to metals loading.

Comparison of Metals Concentrations to Water Quality Targets and TMDL Determination

Aluminum

Chicago Gulch is not listed as impaired for aluminum on the 2012 303(d) List but one sample was slightly greater than the chronic aquatic life standard. However, due to the small sample size (n = 5) and presence of only one exceedance of the chronic aquatic life standard, an aluminum TMDL is not presented. Additional monitoring is recommended to determine if aluminum is a cause of impairment.

Arsenic

Chicago Gulch is not listed as impaired for arsenic on the 2012 303(d) List. Two of the eight samples exceeded the human health standard and one sediment sample exceeded the PEL by 26 percent. Both arsenic water quality samples exceeded the target during high flow conditions. Based on exceedances of the target and supplemental indicator values, an arsenic TMDL is presented.

Cadmium

Chicago Gulch is not listed as impaired for cadmium on the 2012 303(d) List. Of the eight water quality samples collected, there is one exceedance of the acute aquatic life standard and an exceedance of the PEL in the sediments by 71 percent. Based on exceedances of the target and supplemental indicator values, a cadmium TMDL is presented.

Lead

Chicago Gulch is listed as impaired for lead on the 2012 303(d) List. The listing is based primarily on data collected in 1982 that exceeded the human health standard. Evaluation of water quality data collected since the initial listing verifies this impairment. One sample collected in 2004 exceeded both the acute aquatic life standard and the human health standard, and two samples collected in 2011 exceeded the chronic aquatic life standard. In addition, sediment samples collected in 2003 and 2004 exceeded the PEL by 85 and 89 percent. Based on the target and supplemental indicator value exceedances, a lead TMDL is presented.

pH

Chicago Gulch is listed as impaired for pH on the 2012 303(d) List. Although the 2010 and 2011 pH samples are meeting the target, samples collected closer to the headwaters in 2003 and 2004 were much more acidic. Based upon the data collected, a pH impairment resulting from metals sources may still be present. The metals TMDLs will be used as a surrogate for a pH TMDL because reclamation activities needed to meet the metals TMDLs will address sources that cause pH impairment.

Zinc

Chicago Gulch is listed as impaired for zinc on the 2012 303(d) List. The listing is based primarily on data collected in 1982 that exceeded the human health standard. One water quality sample collected in 2004 indicates likely exceedance of the acute aquatic life standard; although there was no hardness value for that sample event, it would have been well over the acute aquatic life standard using the highest measured hardness value in Chicago Gulch (i.e., standard = 162.23 ug/L at hardness of 143 mg/L). Additionally, a sediment sample collected in 2003 exceeds the zinc PEL by 88 percent. Based on exceedances of the target and supplemental indicator values, a zinc TMDL is presented.

7.4.3.2 Chippewa Creek (MT40B002_040)

Chippewa Creek is a tributary to McDonald Creek and is located within the Box Elder HUC8 (10040204). The 3.8 mile reach of Chippewa Creek from its headwaters to the confluence with Manitoba Gulch is listed as impaired for metals (antimony, arsenic, iron, mercury and zinc) and cyanide.

Metals Sources

An assessment of potential sources of metals loading to Chippewa Creek was performed in 2011 (**Appendix D**). This assessment included a review of relevant literature; compilation and review of GIS layers pertaining to land uses, land ownership, and locations of abandoned and inactive mines; and a field reconnaissance inspection of the watershed.

The literature review revealed a considerable amount of mining activity between the 1880s and 1980s in and adjacent to the Chippewa Creek watershed. The DEQ abandoned mine and MBMG databases identified 10 abandoned mines (**Table 7-9** and **Figure 7-2**). The databases do not mention problems associated with any of the mine and mill sites; however, cyanide was used as a leachate at the Giltedge Mine in the late 1800s/early 1900s and then again in the 1980s to reprocess old tailings, and in 1985 the Giltedge Mine was cited for violations including an inadequate leach pad liner and surface discharges from treatment ponds. At that time, elevated cyanide concentrations were documented in groundwater down-gradient from the mine. After the mine was abandoned, DEQ used the bond money to treat and land-apply the contents of the treatment ponds and to bury sediment from the treatment ponds on-site. In 1993, approximately 700 feet of channel was reconstructed and the floodplain was recontoured to minimize erosion. Some of the reprocessed tailings remain along lower Chippewa Creek near Giltedge (M29/D1 in **Figure 7-2**).

The Gilt Edge Tailings site (sites D1 and M29) has been identified as a priority abandoned mine by DEQ (current ranking = 40) (Montana Department of Environmental Quality,2012). The Gilt Edge Tailings were investigated by Pioneer Technical Services, Inc. in 1994 (Pioneer Technical Services, Inc., 1995). At that time, the volume of tailings observed was estimated to be 69,860 cubic yards and the tailings contained elevated concentrations of arsenic, antimony, and mercury. Additionally, two mine openings (adits) were observed in the area.

During site reconnaissance visits conducted in 2010 and 2011, potential sources were evaluated from upstream of the Giltedge Mine to the confluence with Manitoba Gulch. Streamflow was negligible upstream of monitoring site CIPC-MSA1 during both visits (**Figure 7-2**), and no surface discharges were observed from mines or mill sites. Downstream of the reclaimed area associated with Golden Maple's former heap leach operations, groundwater seeps were noted in the floodplain, and streamflow increased from this area downstream to the Maiden Road. The Gilt Edge tailings were observed to be eroding into the stream channel at several locations.

Table 7-9. Abandoned and inactive mines in the Chippewa Creek watershed.

Map label	Name	MBMG comments	Status	Commodities mined
M1/D20	Gilt Edge	Active mine in 1995	Past producer	Gold, silver
M26	Gilt Edge Coal Mines	-	Exploration Prospect	Coal
M29/D1	Gilt Edge Tailings	-	None	-
D9	Upper Ox Frame Gulch	-	-	-
D10	Lower Ox Frame Gulch	-	-	-
D16	Coal Inventory CI1034	-	-	-
D18	Cliff Mine CI1097	-	-	-
D19	Giltedge Mine	-	-	-

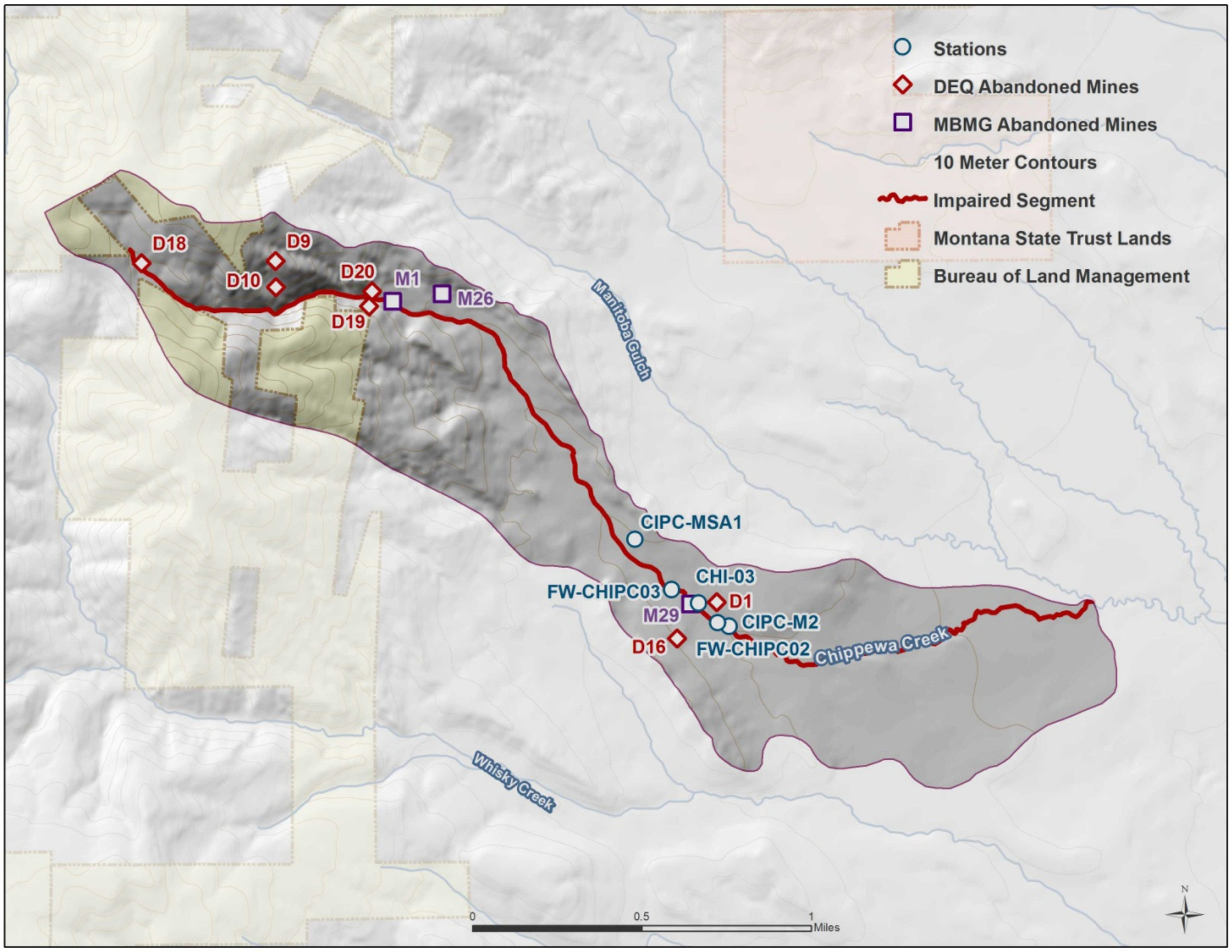

Figure 7-2. Location of Chippewa Creek monitoring stations and abandoned mines.

Available Water Quality Data

Metals water quality and sediment data collected between 2004 and 2011 were used to evaluate attainment of water quality targets (**Table 7-10** and **Table 7-11**). This dataset includes synoptic water quality data collected during 2005, 2010, and 2011 under both low and high flows. The entire metals suite was evaluated relative to the target values; however metals that did not include any exceedances and were not listed on the 2012 303(d) List are not included in the summary tables or discussion below.

Table 7-10.Chippewa Creek metals and metals-related data.

Monitoring station	Date	pH	Hard-ness (mg/L)	Flow (cfs)	Sb (µg /L) TR	As (µg /L) TR	Cyanide (µg /L) T	Fe (µg /L) TR	Hg (µg /L) T	Zn (µg /L) TR
CHI-03	10/3/04	8.1	450	0.02	**11** hhs	**92** hhs	--	**1,960** ch	**0.1** hhs	20
FW-CHIPC03	4/25/05	7.9	377	0.0024	**6** hhs	**13** hhs	--	610	--	10
FW-CHIPC02	4/25/05	7.9	355	0.0024	**6** hhs	**47** hhs	--	970	--	10
FW-CHIPC03	6/6/05	7.9	405	0.021	4	**37** hhs	--	**3,040** ch	--	40
FW-CHIPC02	6/6/05	8.1	419	0.013	**8** hhs	**74** hhs	--	420	--	< 10

Table 7-10.Chippewa Creek metals and metals-related data.

Monitoring station	Date	pH	Hard-ness (mg/L)	Flow (cfs)	Sb (µg /L) TR	As (µg /L) TR	Cyanide (µg /L) T	Fe (µg /L) TR	Hg (µg /L) T	Zn (µg /L) TR
CIPC-M2	8/19/10	8.1	413	0.07	3	**34** [hhs]	**10** [ch]	590	0.0292	< 10
CIPC-MSA1	5/18/11	8.1	345	0.26	3	**16** [hhs]	**12** [ch]	130	0.0215	< 10
CIPC-M2	5/18/11	8.3	353	0.78	4	**26** [hhs]	**11** [ch]	680	**0.0564** [hhs]	< 10

BOLD indicates exceedance of the target.
[ch] = chronic exceedance; [ac] = acute exceedance; [hhs] = human health standard exceedance

Table 7-11. Chippewa Creek sediment quality summary.

Monitoring station	Date	**Sb**[1] (µg/g)	**As** (µg/g)	**Fe**[1] (µg/g)	**Hg** (µg/g)	**Zn** (µg/g)
FW-CHIPC03	4/25/05	2.4	**62.8**	7,720	< 0.5 [a]	68
FW-CHIPC02	4/25/05	20.5	**297**	7,960	**1.6**	93
FW-CHIPC03	6/6/05	2	**75.6**	8,240	--	82.8
FW-CHIPC02	6/6/05	7.2	**102**	11,400	--	70.6

[a.] Detection limit is greater than PEL
BOLD indicates PEL exceedance; [1]No PEL exists for Sb and Fe

Spatial and Seasonal Trends

Water quality target exceedances for antimony, arsenic, cyanide, iron, and mercury occur under both low and high flow conditions. Arsenic levels in the water column increase downstream during each of the synoptic sampling events during both low and high flow conditions, indicating a constant source of arsenic to the creek, such as groundwater, and also potentially an additional source associated with runoff and/or mobilization of sediment within the channel. Based on flow measurements, the Gilt Edge tailings and original cyanide mill site are in a gaining section of stream (i.e., groundwater inputs) that is bracketed upstream by monitoring sites FW-CHIPC03 and CIPC-MSA1 and downstream by sites CIPC-M2 and FW-CHIPC02. Although only one sample was collected at CIPC-MSA1 (where surface flow originates) the cyanide concentration was greatest at that site, indicating historical contamination of the groundwater from mining remains a problem. The only iron water quality target exceedances occurred at sampling sites adjacent to or just upstream of the Gilt Edge tailings, indicating the tailings may be a source of iron but that there is also likely another source upstream; no other spatial patterns were apparent for iron. Both mercury water quality target exceedances occurred at sites adjacent to or downstream of the Gilt Edge tailings (CHI-03 and CIPC-M2), indicating the tailings and/or groundwater inputs in that section are the source. One of the sediment samples collected downstream of the tailings exceeded the mercury PEL, which also indicates the tailings or other sediment inputs between sites FW-CHIPC03 and FW-CHIPC02 are a source of mercury loading.

Comparison of Metals Concentrations to Water Quality Targets and TMDL Determination

Antimony

Chippewa Creek is listed as impaired for antimony on the 2012 303(d) List. Evaluation of water quality data collected since the initial listing verifies this impairment. Four of the eight water quality samples exceed the human health standard. There is no PEL for antimony, however sediment sampling conducted in 1995 and 2005 were found to be elevated above natural background conditions as reported in the assessment record. Based on the exceedances of the water quality target, an antimony TMDL is presented.

Arsenic

Chippewa Creek is listed as impaired for arsenic on the 2012 303(d) List. Evaluation of water quality data collected since the initial listing verifies this impairment. All eight of the water column samples exceeded the human health standard and all of the sediment quality samples exceeded the PEL by 73 to 94 percent. Based on exceedances of the target and supplemental indicator values, an arsenic TMDL is presented.

Cyanide

Chippewa Creek is listed as impaired for cyanide on the 2012 303(d) List, based primarily on 1985 sampling near the historic Giltedge Mine. Evaluation of water quality data collected since the initial listing verifies this impairment. All three of the water quality samples collected in 2010 and 2011 exceeded the chronic aquatic life standard. Based on exceedances of the water quality target, a cyanide TMDL is presented.

Iron

Chippewa Creek is listed as impaired for iron on the 2012 303(d) List. Evaluation of water quality data collected since the initial listing verifies this impairment. Two out of eight water quality samples exceeded the chronic aquatic life standard. Based on exceedances of the water quality target, an iron TMDL is presented.

Mercury

Chippewa Creek is listed as impaired for mercury on the 2012 303(d) List. Evaluation of water quality data collected since the initial listing verifies this impairment. Two of four water quality samples exceed the human health standard and one sediment quality samples exceeds the PEL by 70 percent. Based on exceedances of the target and supplemental indicator values, a mercury TMDL is presented.

Zinc

Chippewa Creek is listed as impaired for zinc on the 2012 303(d) List. Evaluation of data collected since the initial listing does not verify this impairment. None of the samples, including eight water quality samples and four sediment quality samples, exceed the zinc target or supplemental indicator values. Therefore, no zinc TMDL will be developed, and the 303(d) listing status for zinc will be formally reevaluated by DEQ in the future.

7.4.3.3 Collar Gulch Creek (MT40B002_030)

Collar Gulch Creek is a tributary to Ford's Creek and is located in the Box Elder HUC8 (10040204). The entire 6.4 mile length of Collar Gulch Creek is listed as impaired for metals (lead and zinc) and pH. A notable population of genetically pure westslope cutthroat trout is present in this stream (Montana Fish, Wildlife and Parks, 2011). In 2007, FWP and BLM diverted 300 feet of Collar Gulch Creek around a failing wood/rock crib dam from the Collar Mine stamp mill to a newly created stream channel with increased habitat for westslope cutthroat trout (Flentie, 2008). Fish populations increased following the project, but activities were not thought to affect metals loading.

Metals Sources

An assessment of potential sources of metals loading to Collar Gulch Creek was performed in 2011 (**Appendix D**). This assessment included a review of relevant literature; compilation and review of GIS layers pertaining to land uses, land ownership, and locations of abandoned and inactive mines, and; a field reconnaissance inspection of the watershed.

The literature review indicated that mining activities began in the Collar Gulch Creek watershed in the 1880s, with some mining activity potentially as recent as 1995. The GIS analysis of the MBMG and DEQ abandoned mines databases identified eight abandoned mines (**Table 7-12** and **Figure 7-3**). All abandoned mine sites are in the upper half of the drainage.

Table 7-12. Abandoned and inactive mines in the Collar Gulch Creek watershed.

Map label	Name	MBMG comments	Status	Commodities mined
M2/D2	Tail Holt Mine	Adit discharge, active claim in 1995	Past producer	Gold, silver
M12	Collar	Dry open cut, caved workings	Developed deposit	Silver
M18/D3	Silver Bullion	Active mine in 1995	Exploration prospect	Silver, gold
M21	Hardscramble	Dry, no impact	Unknown	Gold
M23	Montago Mine	Same as Collar Mine (fe001347), no impact	Past producer	Gold, silver, copper
M24	Black Diamond	Dry prospect	Raw prospect	Gold

The Tail Holt Mine is on DEQ's list of priority abandoned mines (current ranking = 112). During a site evaluation in 1993, waste rock at Tail Holt was estimated to total 3,800 cubic yards and contained elevated levels of arsenic, mercury, and copper. One adit was observed at the site. Discharge was noted, but seeped into the ground prior to leaving the site (Pioneer Technical Services, Inc., 1995). During TMDL-related sampling in August 2010, the site was examined and no adit discharge was observed.

During site reconnaissance visits conducted in 2010 and 2011, no readily apparent mining related sources of metals loading to Collar Gulch Creek were observed (**Appendix D**). During the 2011 monitoring event, the entire four-mile portion of the listed segment from the private ranch road crossing to the upper-most monitoring site CLRG-MSA1 was observed from a trail which parallels the creek. At the time, two or more feet of snow was present in the floodplain at CLRG-MSA1. The Collar Mine site was examined in August 2010 and again in May 2011. Downstream of the Collar Mine (and site CLRG-M1), Collar Gulch Creek loses flow to groundwater, but during sampling in May 2011, several small tributaries were observed between CLRG-M1 and CLRG-M3. Another more recent mine prospect was examined further downstream in the drainage, consisting of a vertical shaft sunk in a limestone outcrop adjacent to Collar Gulch Creek.

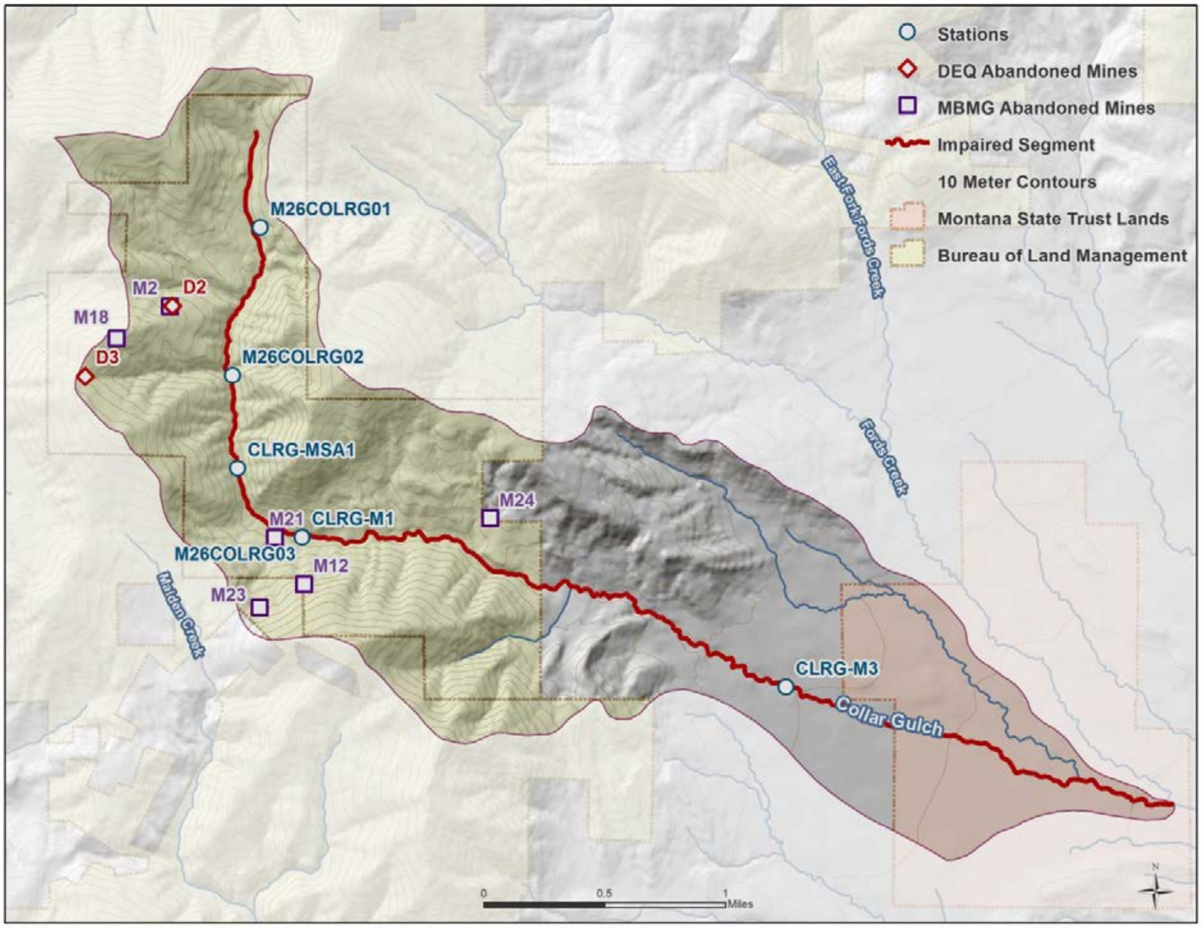

Figure 7-3. Location of Collar Gulch Creek monitoring stations and abandoned mines.

Available Water Quality Data

Metals water quality collected during high and low flow between 2003 and 2011 were used to evaluate attainment of water quality targets (**Table 7-13**). Sediment metals data were collected in 2003 (**Table 7-14**). The entire metals suite was evaluated relative to the target values; however metals that did not include any exceedances and were not listed on the 2012 303(d) List are not included in the summary tables or discussion below.

Table 7-13.Collar Gulch Creek metals and metals-related data.

Monitoring Station	Date	pH	Hard-ness (mg/L)	Flow (cfs)	Al (µg/L) D	As (µg /L) TR	Cd (µg /L) TR	Cu (µg /L) TR	Fe (µg /L) TR	Pb (µg /L) TR	Zn (µg /L) TR
M26COLRG01	8/18/03	**3.6**	22.1	E 0.25	--	4	**4**[ac]	**228**[ac]	**1,080**[ch]	**1,270**[ac, hhs]	**264**[ch]
M26COLRG02	8/18/03	7.39	80.6	E 1	--	**11**[hhs]	**4**[ac]	**23**[ac]	20	**220**[ac, hhs]	**217**[ch]
M26COLRG03	8/20/03	7.38	99.8	E 1.5	--	**15.5**[hhs]	**0.45**[ch]	1	< 10	**4**[ch]	37
CLRG-M1	8/18/10	7.67	85	0.37	50	< 3	**0.42**[ch]	3	< 30	**10.8**[ch]	40
CLRG-M3	8/18/10	Sample site was dry and no data were collected									
CLRG-MSA1	5/19/11	7.8	31	11.28	**100**[ch]	< 3	**0.12**[ch]	**7**[ac]	370	**21.8**[ac, hhs]	10
CLRG-M1	5/19/11	7.82	35	11.52	**90**[ch]	< 3	**0.15**[ch]	**7**[ac]	370	**9.7**[ch]	20
CLRG-M3	5/19/11	7.98	62	11.88	60	< 3	0.12	6	350	**32.1**[ch, hhs]	10

BOLD indicates exceedance of the target.
[ch] = chronic exceedance; [ac] = acute exceedance; [hhs] = human health standard exceedance

Table 7-14. Collar Gulch Creek metals sediment quality summary.

Monitoring Station	Date	Al[1] (µg/g)	As (µg/g)	Cd (µg/g)	Cu (µg/g)	Fe[1] (µg/g)	Pb (µg/g)	Zn (µg/g)
M26COLRG01	8/18/03	5,260	**33.2**	0.35	162	146,000	**1,590**	26.3
M26COLRG02	8/18/03	115,000	11.7	**12.8**	**1,850**	24,900	**23,600**	**2,990**

BOLD indicates PEL exceedance; [1]No PEL exists for Al or Fe

Spatial and Seasonal Trends

The pH value was very low and metals concentrations were highest for cadmium, copper, iron, lead, and zinc at the most upstream monitoring site during low flow in 2003, indicating a discrete source of metals upstream of M26COLRG01. The databases do not indicate any abandoned mines upstream of the upper site. Also during low flow in 2003, arsenic concentrations in the water column increased in a downstream direction, indicating a discrete source of arsenic, which may be associated with the abandoned mines in that portion of the stream (i.e., Tail Holt, Hardscramble, and Silver Bullion). Numerous exceedances of metals water quality targets also occurred during high flow, which suggests a source of loading associated with overland flow or mobilization of in-stream sediment. With the exception of arsenic and iron, sediment metals concentrations were much higher at the lower site sampled in 2003 (i.e., M26COLRG02) which is downstream from the Tail Holt and Silver Bullion mines. Note: both sites from 2003 were upstream of all sites sampled in 2010 and 2011.

The in-stream sediment from the upper watershed and/or the upland source(s) of the in-stream sediment in the upper watershed is likely a source of metals loading during high flow as most of the metals that exceeded the supplemental indicator value in sediment also exceeded the water quality target at CLRG-MSA1 during high flow sampling in 2011. During high flow sampling, most metals concentrations stayed the same or decreased moving downstream from CLRG-MSA1, which may be associated with losses to groundwater and dilution from the tributaries. However, cadmium increased between that site and CLRG-M1, and lead increased between CLRG-M1 and CLRG-M3. Based on the distribution of abandoned mines, the cadmium increase may be associated with the Hardscramble Mine and the lead increase may be associated with the Collar, Montago, or Black Diamond mines. Given the low pH and high metals concentrations during low flow in 2003, there may be a substantial loading contribution from natural sources. However, other water quality target exceedances relative to the distribution of abandoned mines also indicate abandoned mines are contributing to metals impairment. Note, Collar Gulch Creek is one of the streams in the ongoing study being conducted by BLM that is investigating the natural versus human contribution to metals loading.

Comparison of Metals Concentrations to Water Quality Targets and TMDL Determination

Aluminum

Collar Gulch Creek is not listed as impaired for aluminum on the 2012 303(d) List; however, recent data provide evidence of aluminum as a cause of water quality impairment on Collar Gulch Creek. Two out of four samples exceed the chronic aquatic life standard. Based on exceedances of the water quality target, an aluminum TMDL is presented.

Arsenic

Collar Gulch Creek is not listed as impaired for arsenic on the 2012 303(d) List. There are two exceedances of the HHS (2 out of 7) and an exceedance of the PEL in the sediment by 49% in 2003. All arsenic water quality samples exceedances were measured in 2003 and occurred during low flow conditions. Based on exceedances of the target and supplemental indicator values, an arsenic TMDL is presented.

Cadmium
Collar Gulch Creek is not listed as impaired for cadmium on the 2012 303(d) List. Six of seven samples exceed the chronic aquatic life standard and of those, two also exceed the acute aquatic life standard. In addition, there is an exceedance of the PEL in the sediments by 72%. Based on exceedances of the target and supplemental indicator values, a cadmium TMDL is presented.

Copper
Collar Gulch Creek is not listed as impaired for copper on the 2012 303(d) List. Four out of seven water quality samples exceed the acute and chronic aquatic life standards. Exceedances occur during both high and low flow conditions. In addition, there is an exceedance of the copper PEL in the sediment by 89%. Based on exceedances of the target and supplemental indicator values, a copper TMDL is presented.

Iron
Collar Gulch Creek is not listed as impaired for iron on the 2012 303(d) List; however; data provide evidence of iron as a cause of water quality impairment. One out of seven water quality samples exceed the chronic aquatic life standard. Due to the limited sample size (n = 7) and presence of only one exceedance of the target, an iron TMDL is not provided. However, additional monitoring is recommended to determine if iron is a cause of impairment.

Lead
Collar Gulch Creek is listed as impaired for lead on the 2012 303(d) List. Evaluation of water quality data collected since the initial listing verifies this impairment. All of the samples collected exceed the chronic aquatic life standard, three of these also exceed the acute aquatic life standard, and four exceed the HHS. In addition, two sediment quality samples exceed the PEL by 94 and 100%. Based on exceedances of the target and supplemental indicator values, a lead TMDL is presented.

pH
Collar Gulch Creek is listed as impaired for pH on the 2012 303(d) List. One sample collected in the headwaters has a very low pH of 3.6. This sample coincides with several metal target exceedances. The remaining samples are meeting the pH target. Based upon the data collected, a pH impairment resulting from metals sources may still be present. The metals TMDLs will be used as a surrogate for a pH TMDL because reclamation activities needed to meet the metals TMDLs will address sources that cause pH impairment.

Zinc
Collar Gulch Creek is listed as impaired for zinc on the 2012 303(d) List. Evaluation of water quality data collected since the initial listing verifies this impairment. Two out of seven samples exceed the chronic aquatic life standard. Both of these samples were collected in 2003. A sediment quality sample collected in 2003 exceeds the PEL by 89%. Samples collected in 2010 and 2011 along Collar Gulch Creek did not exceed any targets. Based on exceedances of the target and supplemental indicator values, a zinc TMDL is presented.

7.4.3.4 Armells Creek (MT40E002_022)
Armells Creek is a tributary to the Missouri River, and is located in the Fort Peck Reservoir HUC8 (10040104). The 19.3 mile reach of Armells Creek from its headwaters to Deer Creek is listed as impaired for metals (cadmium, copper, mercury and zinc) and pH.

Metals Sources
An assessment of potential sources of metals loading to Armells Creek was performed in 2011 (**Appendix D**). This assessment included a review of relevant literature; compilation and review of GIS layers pertaining to land uses, land ownership, and locations of abandoned and inactive mines; and a field reconnaissance inspection of all but the upper headwaters portion of the watershed.

The literature review for Armells Creek produced limited findings and no detailed information on the mining history of this watershed. According to landowners on Armells Creek (personal communication, August 2010), whose relatives came to this area in 1895, no significant producing mines or mills were ever developed in the Armells Creek drainage (see **Appendix D**).

The GIS analysis of the MBMG and DEQ abandoned mines databases identified 18 mining related sites: nine in the headwaters of the mainstem Armells Creek, eight in the upper reaches of East Fork Armells Creek, and one in the west central region of the Middle Fork Armells Creek watershed (**Table 7-15** and **Figure 7-4**). Of the sites for which the MBMG provided comments (9 of the 18), there was no indication of impact. No information is available for the remaining sites. It should be noted that sites M8 and D6 appear to be located on the Armells Creek drainage divide. As a result, it is not known if these sites are potential contributors of metals.

Table 7-15. Abandoned and inactive mines in the Armells Creek watershed.

Map label [a]	General location	Name	MBMG comments	Status	Commodities mined
ttM22	East Fork Armells Crk.	Armells Creek Placer	No impact on BLM	Exploration prospect	Gold
ttM9	East Fork Armells Crk.	Big Spring	-	Developed deposit	Lead, silver
M13	Upper Armells Crk.	Cave	Dry, no impact	Developed deposit	Silver, lead
ttM8	East Fork Armells Crk.	Golden Armells and Armells Bonanza	No potential for impact on BLM land	Exploration prospect	Gold
M7	Upper Armells Crk.	Hamilton Copper Prospect	Dry, no impact.	Developed deposit	Copper, silver
M8	East Fork Armells Crk.	Hamilton Copper Queen Group	Dry, no impact.	Exploration prospect	Copper, gold
M5	Upper Armells Crk.	Independents Nos. 3 & 4	-	Raw prospect	Iron
M19	Upper Armells Crk.	Iron King	-	Exp prospect	Iron
M4	Upper Armells Crk.	Sutter Mine	Dry, no impact	Past producer	Iron, copper, silver
ttM17	Middle Fork Armells Crk.	Two Lady No. 7	-	Developed deposit	Gold, silver
M30	East Fork Armells Crk.	Voltaire Mine	Reclaimed site, dry	Exploration prospect	Gold, silver
M3	Upper Armells Crk.	West Armells Creek	Dry, no impact	Unknown	Iron, manganese
M16	Upper Armells Crk.	White & Gilpatrick Claims	Dry, no impact	Exploration prospect	Lead, zinc, copper
D5	Upper Armells Crk.	Armell Creek No 1	-	-	-
ttD8	East Fork Armells Crk.	East Fork Armell Creek No 1	-	-	-

Table 7-15. Abandoned and inactive mines in the Armells Creek watershed.

Map label [a]	General location	Name	MBMG comments	Status	Commodities mined
ttD9	East Fork Armells Crk.	East Fork Armell Creek No 2	-	-	-
ttD24	East Fork Armells Crk.	East Fork Armell Creek No 4	-	-	-
D6	Upper Armells Crk.	Verde	-	-	-

[a.] A "tt" preceding the number indicates that this site was not labeled in either the MBMG or DEQ abandoned mines database, and was therefore assigned a new label.

During May 2011, Armells Creek from approximately one half mile upstream of the headwater fork to Highway 236 was observed from adjacent roads or on foot (**Figure 7-4** and **Appendix D**). The lowest half mile of the headwaters tributary was also surveyed. The extreme headwaters of Armells Creek and its headwaters tributary could not be accessed due to remaining deep snow. Extensive flood damage to the road, culverts and stream channel from peak snowmelt runoff the previous week was observed along upper Armells Creek on BLM and privately owned lands. Many of the accessible, previously listed mine prospect sites were examined for discharges or potential metals source areas. The high elevation Iron King and Hamilton Copper Prospect sites were not accessible. No readily apparent mining related or other human sources of metals loading to Armells Creek were observed during the site reconnaissance survey. However, actively eroding streambanks on BLM lands revealed brilliant red soils, which may indicate soils in the watershed have naturally high levels of iron and possibly other metals.

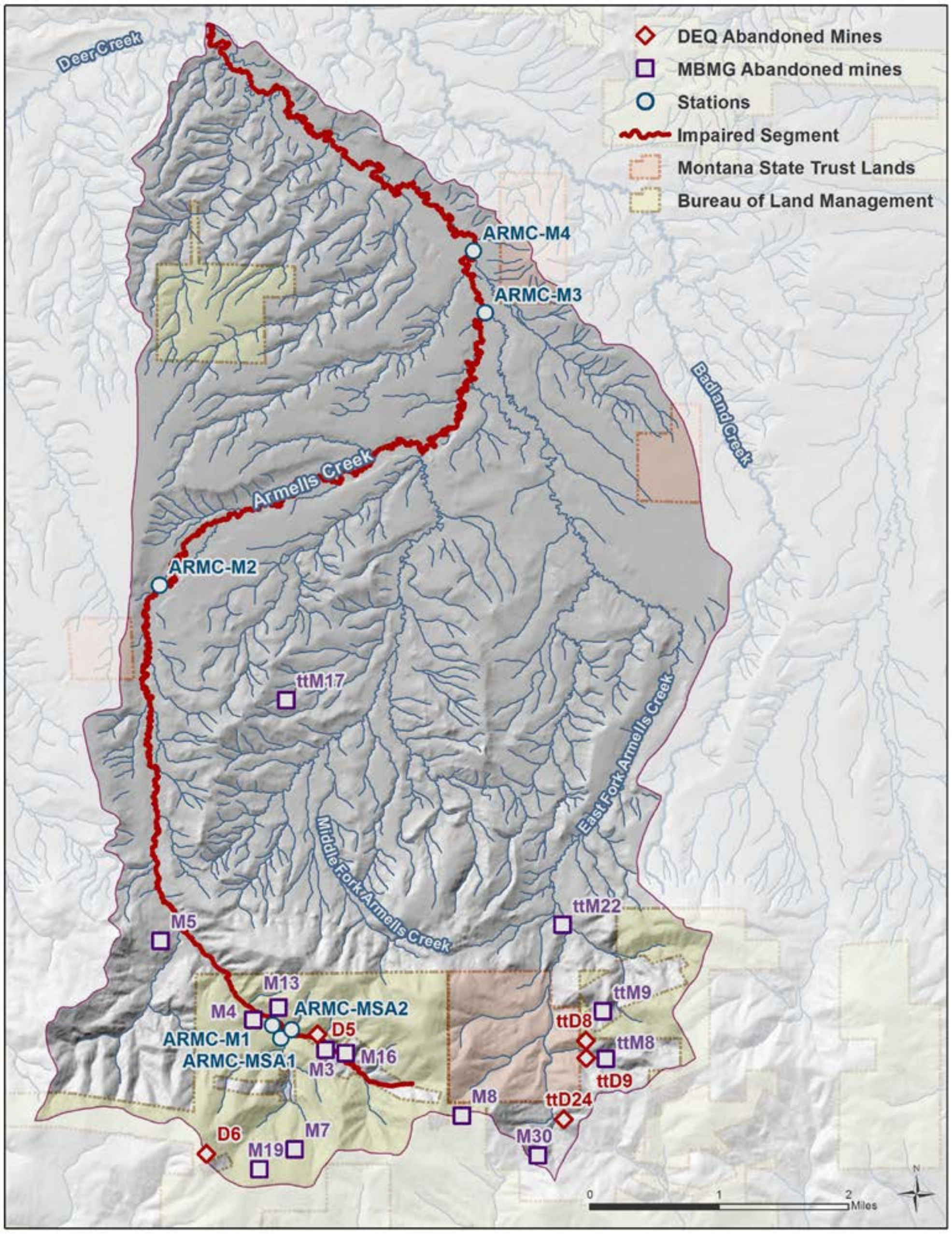

Figure 7-4. Location of Armells Creek monitoring stations and abandoned mines.

Available Water Quality Data

Metals water quality data collected during high and low flow in 2010 and 2011 were used to evaluate attainment of water quality targets (**Table 7-16**). There are a total of six samples along the mainstem used in this evaluation. Because of access issues, no sampling was conducted near the mouth; the most downstream site, ARMC-M4, was approximately three miles upstream from the mouth. To help with the source assessment, two tributary sites were also sampled (ARMC-MSA1 and ARMC-MSA2). The entire metals suite was evaluated relative to the target values; however metals that did not include any exceedances and were not listed on the 2012 303(d) List are not included in the summary tables or discussion below. No sediment metals sampling has been conducted within the metals-impaired portion of Armells Creek.

Table 7-16. Armells Creek metals and metals-related data

Monitoring Station	Date	pH	Hard-ness (mg/L)	Flow (cfs)	**Al** (µg/L) **D**	**Cd** (µg/L) **TR**	**Cu** (µg/L) **TR**	**Fe** (µg/L) **TR**	**Hg** (µg/L) **TR**	**Zn** (µg/L) **TR**
ARMC-M1	8/16/2010	6.79	88	1.12	**540** [ch]	0.18	**10** [ch]	**2,300** [ch]	< 0.005	**150** [ch]
ARMC-M2	8/16/2010	7.9	168	0.54	< 30	< 0.08	< 1	490 [a]	< 0.005	< 10
ARMC-M3	8/16/2010	8.42	357	1.58	< 30	< 0.08	< 1	210	< 0 .005	< 10
ARMC-MSA1[a]	5/18/2011	7.62	31	5.37	**180** [ch]	< 0.08	**18** [ac]	840	0.0057	40
ARMC-MSA2	5/18/2011	7.74	77	4.64	**130** [ch]	< 0.08	4	780	0.0071	20
ARMC-M1	5/18/2011	7.87	54	10.35	**170** [ch]	< 0.08	**12** [ac]	820	0.0059	30
ARMC-M2	5/18/2011	7.99	111	11.37	< 30	< 0.08	2	740	< 0.005	< 10
ARMC-M4	5/17/2011	7.84	239	57.82	< 30	< 0.08	2	**1,120** [ch]	< 0.005	< 10

[a.] Site is on a tributary to Armells Creek
BOLD indicates exceedance of the target.
[ch] = chronic exceedance; [ac] = acute exceedance; [hhs] = human health standard exceedance

Spatial and Seasonal Trends

The majority of metal water quality target exceedances are near the headwaters at or upstream of ARMC-M1. Data were only collected upstream of ARMC-M1 during high flow, and based on that data, there is a source of aluminum near the headwaters of Armells Creek but a more significant source of aluminum and other metals (i.e., copper, iron, and zinc) along the headwaters tributary. The only known potential mining sources in that portion of the watershed are the Iron King and Hamilton Copper prospects and the Verde mine. The greatest copper concentration occurred during high flow sampling, which indicates copper loading is associated with runoff and/or mobilization of in-stream sediment. However, copper was also greater than the water quality target during low flow, and concentrations of other metals with water quality target exceedances were greatest during low flow sampling, which indicates a discrete source of metals loading.

Although high flow sampling indicates much of the metals loading is from the headwaters tributary, the source dynamics may differ during low flow (when groundwater inputs constitute most of the surface flow), and additional sampling is recommended near the headwaters to evaluate background and mining-related loading during low flow. Additionally, sediment metals sampling is recommended to help interpret spatial trends in water quality data. However, DEQ did collect sediment samples at five sites downstream of the metals impaired segment (i.e., between Deer Creek and the mouth); none of the samples exceeded the supplemental indicator values and iron concentrations were similar to that found in other streams in the Judith Mountains TMDL Project Area.

Comparison of Metals Concentrations to Water Quality Targets and TMDL Determination

Aluminum

Armells Creek is not listed as impaired for aluminum on the 2012 303(d) List, however, recent data provide evidence of aluminum as a cause of water quality impairment in Armells Creek. Three out of seven water quality samples along the mainstem of Armells Creek exceed the chronic aquatic life standard; all exceedances were near the headwaters. Target exceedances occur during both high and low flow conditions. Based on exceedances of the water quality target, an aluminum TMDL is presented.

Cadmium

Armells Creek is listed as impaired for cadmium on the 2012 303(d) List, based primarily on data from 1982. None of the samples exceed any of the water quality targets. However, to be conservative given the small sample size (*n*=7) and because human metals sources are present, a cadmium TMDL is presented. Additional monitoring is recommended to further evaluate if cadmium is a cause of metals impairment.

Copper

Armells Creek is listed as impaired for copper on the 2012 303(d) List, based primarily on data from 1982 when copper levels exceeded the chronic aquatic life standards. Evaluation of water quality data collected since the initial listing verifies this impairment. Two out of seven water quality samples collected along the mainstem of Armells Creek exceed the copper target; one water quality sample collected in 2010 exceeds the chronic aquatic life standard and one sample in 2011 exceeds the acute aquatic life standard. Based on exceedances of the water quality target, a copper TMDL is presented.

Iron

Armells Creek is not listed as impaired for iron on the 2012 303(d) List; however, recent data provide evidence of iron as a cause of water quality impairment in Armells Creek. Two of seven water quality samples exceed the chronic aquatic life standard. Iron was the only metal that exceeded its water quality target downstream from the headwaters. Although one of the target exceedances occurred during low flow near the headwaters, indicating a discrete source, the other target exceedance occurred during high flow at the most downstream site (ARMC-M4). Given the lack of known abandoned mines downstream of site ARMC-M2 and red eroding soils observed during sampling, the elevated value during high flow is likely associated with sediment. This is supported by the TSS values during high flow sampling: the TSS concentration was below the detection limit of 4 mg/L at all sites except ARMC-M4, where the concentration was 22 mg/L. Due to exceedances of the water quality target and the presence of human sources, an iron TMDL is presented.

Mercury

Armells Creek is listed as impaired for mercury on the 2012 303(d) List. Out of seven water quality samples along the mainstem of Armells Creek, none exceeded the water quality target. However, to be conservative given the small sample size (*n*=7) on the mainstem and because human metals sources are present, a mercury TMDL is presented. Additional monitoring is recommended to further evaluate if mercury is a cause of metals impairment.

pH

Armells Creek is listed as impaired for pH on the 2012 303(d) List. The recent data do not support this listing, however, the dataset is small and a pH impairment resulting from metals sources may still be present. Therefore, metals TMDLs will be used as a surrogate for a pH TMDL because reclamation activities needed to meet the metals TMDLs will address sources that cause pH impairment.

Zinc

Armells Creek is listed as impaired for zinc on the 2012 303(d) List. Evaluation of water quality data collected since the initial listing verifies this impairment. One out of seven water quality samples exceeds the chronic aquatic life standard. Based on the exceedance of the water quality target, a zinc TMDL is presented.

7.4.3.5 Cow Creek (MT40E002_040)

Cow Creek is a tributary to the Missouri River, and is located in the Fort Peck Reservoir HUC8 (10040104). The 34.2 mile reach of Cow Creek from Als Creek to the Missouri River is listed as impaired for metals (aluminum, copper, iron and lead). There are several 8-digit HUCs tributaries to the impaired segment, although these tributary watersheds were not assessed in detail as part of the source assessment (**Appendix D**).

Metals Sources

The source assessment for Cow Creek was limited to a review of available online information including the MBMG and DEQ abandoned mines databases and the DEQ-MBMG Priority Site List. The analysis of the MBMG and DEQ abandoned mines databases identified 22 mining related sites (**Table 7-17** and **Figure 7-5**). However, unlike in the watersheds draining the Judith Mountains (i.e., Chicago Gulch, Chippewa Creek, Collar Gulch Creek, and Armells Creek), metals do not appear to be the commodity mined. Rather, mining activity at the sites for which information is available appears to focus on coal, abrasives, gemstones, zeolites, and sand and gravel. Many metals are associated with coal, and are either found in the coal directly or in the layers of rock that lie above and between the seams of coal. The heavy metal content of coal varies by coal seam and geographic region. Additionally, zeolites contain aluminum. Therefore, there is potential for activities associated with these abandoned mines to be contributing metals to Cow Creek. Additionally, human-caused erosion could be also be a source of loading if metals concentrations are elevated in the soil. No data or information are currently available, however, to determine the extent to which this is occurring.

Table 7-17. Abandoned and inactive mines in the Cow Creek watershed.

Map label	Name	Status	MBMG comments	Commodities mined
M31	HAL 2, 3	Raw prospect	-	Abrasive, gemstone, zeolites
ttM49	Bryson Mcsharry	Raw prospect	-	Coal
ttM50	HAL 21/22	Raw prospect	-	Abrasive, gemstone, zeolites
M32	HAL 32	Raw prospect	-	Abrasive, gemstone, zeolites
M33	Shellenberger Coal Mine	Past producer	-	Coal
ttM53	Gravel Pit	Past producer	-	Sand & gravel
ttM54	HAL 23124	Raw prospect	-	Abrasive, gemstone, zeolites
ttM55	Dike 1	Unknown	-	Abrasive, gemstone, zeolites
ttM57	Hal 18/19	Raw prospect	-	Abrasive, gemstone, zeolites
M34	Cow Creek Clays	Raw prospect	-	Clay
ttD51	Coal Inventory CI0004	-	-	-
ttD52	Coal Inventory CI0005	-	-	-
ttD53	Coal Inventory CI0006	-	-	-
ttD54	Coal Inventory CI0007	-	-	-
ttD55	Coal Inventory CI0008	-	-	-
ttD56	Cuerth	-	-	-
ttD57	Curtis Moxley	-	-	-
ttD58	Jack Powell et al	-	-	-
ttD59	John Cromley Mine	-	-	-
ttD60	Moxley	-	-	-
ttD61	Roy Reeder et al	-	-	-
D21	Shellenberger	-	-	-

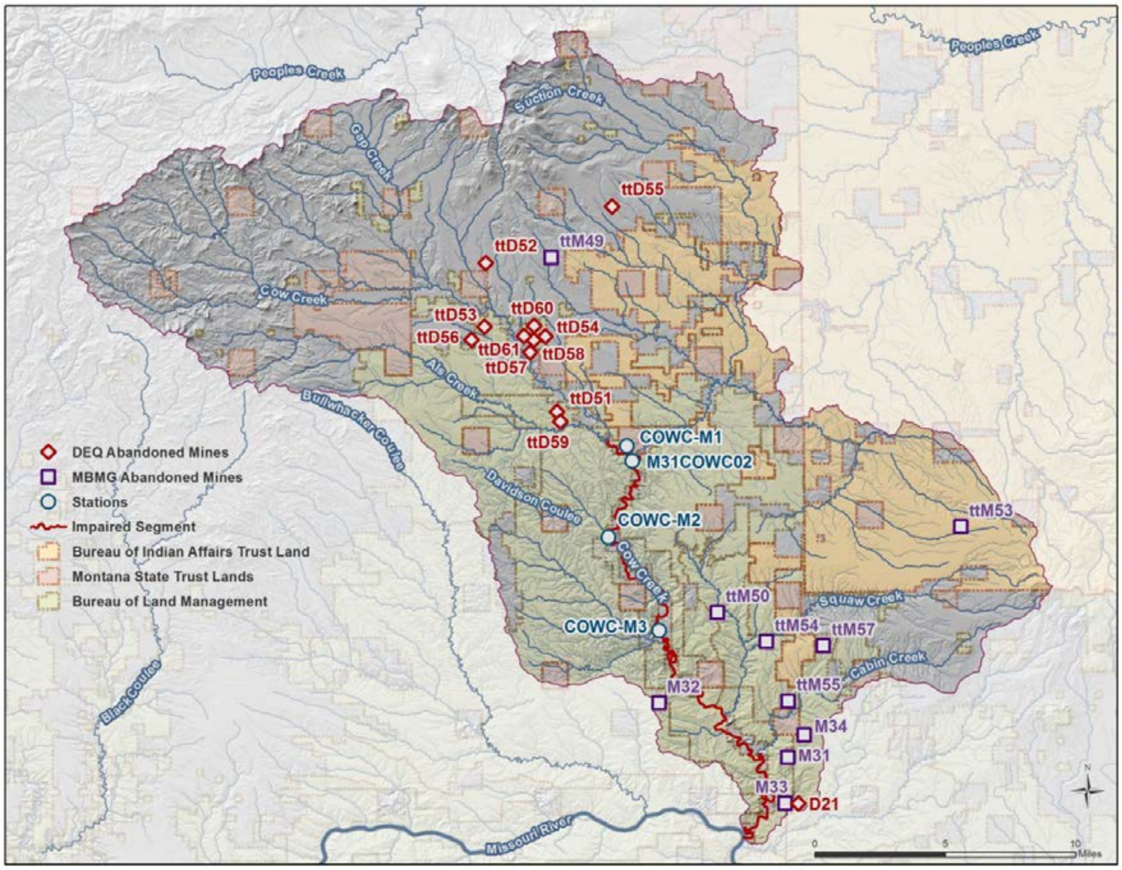

Figure 7-5. Location of Cow Creek monitoring stations and abandoned mines.

Available Water Quality Data

Metals water quality collected during high and low flows between 2004 and 2012 were used to evaluate attainment of water quality targets (**Table 7-18**). Sediment metals data were collected in 2004 (**Table 7-19**). The entire metals suite was evaluated relative to the target values; however metals that did not include any exceedances and were not listed on the 2012 303(d) List are not included in the summary tables or discussion below.

Table 7-18. Cow Creek metals and metals-related data.

Monitoring Station	Date	pH	Hardness (mg/L)	Flow (cfs)	TSS (mg/L)	Al (µg/L) D	As (µg /L) TR	Cu (µg /L) TR	Fe (µg /L) TR	Pb (µg /L) TR
M31COWC02	7/8/04	8.0	125	E 1.75	936	**120** ^{ch}	**13** ^{hhs}	**31** ^{ac}	**29,400** ^{ch}	**18** $^{ch, hhs}$
COWC-M1	8/17/10	8.9	203	1.85	5	< 30	< 3	2	150	< 0.5
COWC-M2	8/17/10	8.8	208	2.04	17	< 30	< 3	3	420	< 0.5
COWC-M3	8/17/10	8.6	276	1.49	13	< 30	< 3	2	300	< 0.5
COWC-M1	5/16/11	8.6	239	50.68	47	< 30	< 3	3	**1,290** ^{ch}	1.1
COWC-M2	5/16/11	8.6	323	51.05	147	< 30	3	5	**3,670** ^{ch}	2.6
COWC-M3	5/16/11	8.6	335	52.3	254	< 30	4	7	**6,650** ^{ch}	4.1
M31COWC01	6/30/12	--	426	1.76	<1	*30	2	<1	27.3	< 0.5

BOLD indicates exceedance of the target
^{ch} = chronic exceedance; ^{ac} = acute exceedance; ^{hhs} = human health standard exceedance
*Because the Al standard has a pH range, Al values with no corresponding pH value were not evaluated for target attainment.

Table 7-19. Cow Creek sediment quality summary.

Monitoring Station	Date	Al[1] (µg/g)	As (µg/g)	Cu (µg/g)	Fe[1] (µg/g)	Pb (µg/g)
M31COWC02	7/8/04	11,700	9.82	19.3	19,400	14.6

BOLD indicates PEL exceedance; [1]No PEL exists for Al or Fe

Spatial and Seasonal Trends

The highest concentrations of all metals occurred during low flow conditions at the most upstream monitoring site (M31COWC02) in 2004. The elevated metals concentrations are likely the result of sediment-bound metals; TSS concentrations were 936 mg/L during the 2004 sampling event. During sampling in 2010 and 2011, metals concentrations also appear to be a factor of the suspended sediment concentration. No water quality targets were exceeded during low flow sampling, when TSS concentrations ranted from 5 – 17 mg/L (**Table 7-18**). During high flow, the iron water quality target was exceeded at all sites, where TSS values ranged from 47 – 254 mg/L (**Table 7-18**). Both TSS and iron concentrations increased moving downstream. Although no other water quality targets were exceeded, concentrations of other metals also increased downstream. All of the abandoned mines identified in the databases are upstream of COWC-M1 or downstream of COWC-M3 (**Figure 7-5**); abandoned mine sources may be contributing to metals loading at COWC-M1 but a significant proportion of the elevated TSS values and associated metals loading is likely nonpoint sources of erosion (e.g., upland, roads, and streambank erosion). The relative contribution of human versus natural sources of loading associated with erosion in unknown.

None of the metals in the sediment sample exceeded supplemental indicator values. Sediment metals concentrations were similar to values in other watersheds in the Judith Mountains TMDL Project Area, which indicates elevated metals values associated with sediment may be more a factor of the amount of suspended sediment in the stream than concentration of metals in the sediment.

Comparison of Metals Concentrations to Water Quality Targets and TMDL Determination

Aluminum

Cow Creek is listed as impaired for aluminum on the 2012 303(d) List. One sample that was below the target value was excluded from evaluation because there was no corresponding pH value. Of the remaining seven samples, one exceeded the chronic aquatic life standard. The target exceedance occurred in 2004 during low flow sampling. Based on the exceedance of the water quality target, an aluminum TMDL is presented.

Arsenic

Cow Creek is not listed as impaired for arsenic. One of the eight samples exceeded the human health standard. The target exceedance occurred in 2004 during low flow sampling. Based on the water quality target exceedance and the presence of human sources, an arsenic TMDL is presented.

Copper

Cow Creek is listed as impaired for copper on the 2012 303(d) List. One of the eight samples exceeded the acute aquatic life standard. The target exceedance occurred in 2004 during low flow sampling. Based on the exceedance of the water quality target, a copper TMDL is presented.

Iron

Cow Creek is listed as impaired for iron on the 2012 303(d) List. Three of eight samples exceeded the chronic aquatic life standard. The target exceedances occurred under low flow conditions in 2004 and under high flow conditions in 2011. Based on the water quality target exceedances, an iron TMDL is presented.

<u>Lead</u>

Cow Creek is listed as impaired for lead on the 2012 303(d) List. One of eight samples exceeded the human health standard and the acute aquatic life standard. The target exceedances occurred in 2004 during low flow sampling. Based on the water quality target exceedances, a lead TMDL is presented.

7.4.3.6 Fargo Coulee (MT40E002_130)

Fargo Coulee is tributary to Armells Creek located in the Fort Peck Reservoir HUC8 (10040104). The 21.1 mile reach of Fargo Coulee from its headwaters to the mouth at Armells Creek is listed as impaired for metals (aluminum, iron and lead).

Metals Sources

The source assessment for Fargo Coulee was limited to a review of available online information including the MBMG and DEQ abandoned mines databases and DEQ's list of priority abandoned mines. No past or present mining activity was identified in the abandoned mines databases and no sites were listed on the DEQ-MBMG Priority Site List.

Although no mining related metals sources were identified during the source assessment, the soils are sensitive to disturbance, particularly in the upper portion of the watershed (see **Figure A-5**, **Appendix A**); therefore, metals loading may be associated with soil erosion that has been accelerated by human influences. The watershed was historically managed more intensively for grazing than it currently is, and although improvements have been made in land management practices, some problem areas still remain as well as head-cuts and other active sources that are legacies of past management practices (personal communication with Chad Krause, BLM Hydrologist, February 2012).

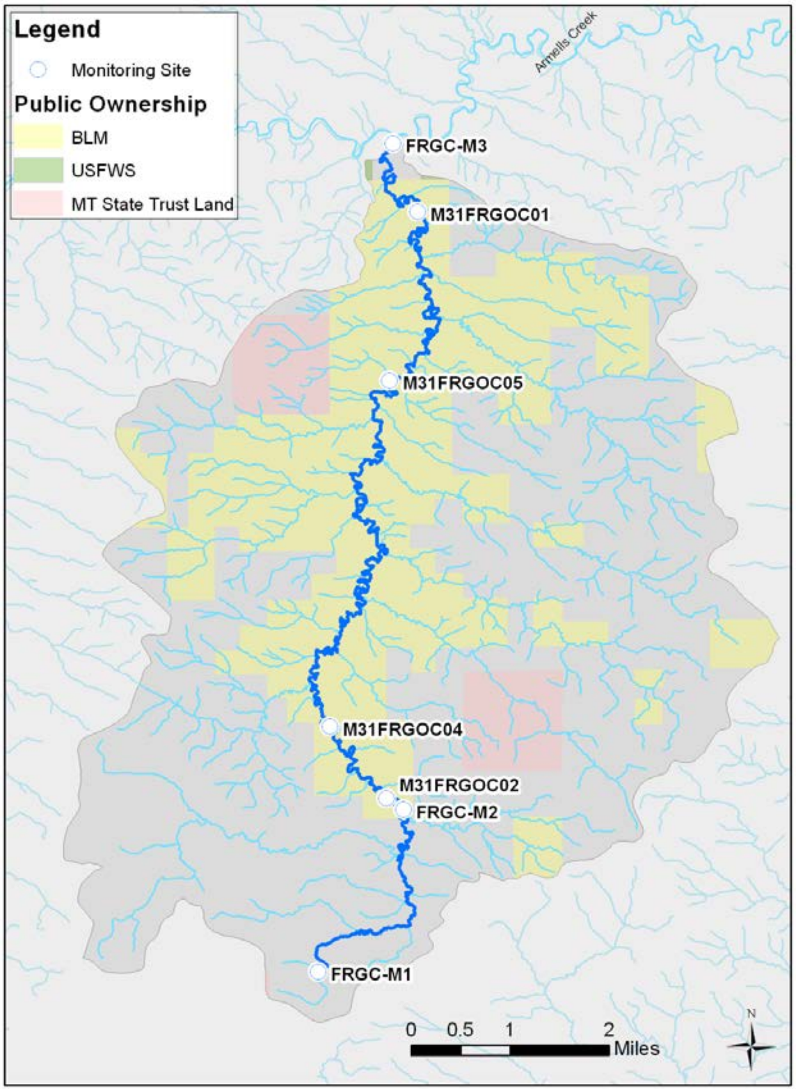

Figure 7-6. Location of Fargo Coulee monitoring stations.

Available Water Quality Data

Metals water quality data collected during high and low flow between 2004 and 2012 were used to evaluate attainment of water quality targets (**Table 7-20** and **Figure 7-6**). The sites sampled in 2011 were also visited in August 2010 but there was no streamflow at any of the sites. There are no sediment metals data available for Fargo Coulee. The entire metals suite was evaluated relative to the target values; however metals that did not include any exceedances and were not listed on the 2012 303(d) List are not included in the summary tables or discussion below.

Table 7-20.Fargo Coulee metals and metals-related data.

Monitoring Station	**Date**	**pH**	**Hardness** (mg/L)	**Flow** (cfs)	**TSS** (mg/L)	**Al** (µg/L) **D**	**As** (µg /L) **TR**	**Fe** (µg /L) **TR**	**Pb** (µg /L) **TR**
M31FRGOC02	6/29/04	9.7	2,810	E 0	53	11*	3	190	1
M31FRGOC01	6/27/04	8.3	2,500	E 0.02	18.6	--	3	130	2
FRGC-M1	5/17/11	Sample site was dry and no data were collected							
FRGC-M2	5/17/11	8.43	2,190	0.55	<4	50	<3	320	< 0.5

Table 7-20.Fargo Coulee metals and metals-related data.

Monitoring Station	Date	pH	Hardness (mg/L)	Flow (cfs)	TSS (mg/L)	Al (µg/L) D	As (µg /L) TR	Fe (µg /L) TR	Pb (µg /L) TR
FRGC-M3	5/17/11	7.74	2,700	6.78	379	< 30	4	**8,360**	6.7
M31FRGOC04	6/23/12	--	3,480	E 0	<1	80*	4	28.3	<0.5
M31FRGOC05	6/23/12	--	2,580	E 0	11.0	70*	4	219	<0.5
M31FRGOC01	6/23/12	--	2,990	E 0	29.5	120*	5	280	<0.5
M31FRGOC04	7/12/12	--	3,480	E 0	3.0	130*	7	160	<0.5
M31FRGOC05	7/13/12	--	2,630	E 0	15.0	110*	6	290	<0.5
M31FRGOC01	7/13/12	--	3,020	E 0	72.0	140*	7	870	<0.5
M31FRGOC05	8/14/12	--	2,800	E 0	16.0	110*	**15**	340	<0.5
M31FRGOC04	8/14/12	Sample site was dry and no data were collected							
M31FRGOC05	8/14/12	Sample site was dry and no data were collected							

BOLD indicates exceedance of the target
[ch] = chronic exceedance; [ac] = acute exceedance; [hhs] = human health standard exceedance
*Because the Al standard has a pH range, Al values with no corresponding pH value or those with a corresponding pH outside of the range of 6.5-9.0 were not evaluated for target attainment.

Spatial and Seasonal Trends

During much of the sampling, there was no measurable flow in the stream. Hardness values are very high in Fargo Coulee, exceeding 2,000 mg/L in all of the samples. Hardness in Fargo Coulee is likely a result of the soils and geologic materials and provides very high buffering capacity for hardness-dependent metals. Similar to Cow Creek, metals concentrations appear to be a factor of the suspended sediment concentration. During the three high flow sampling events, the only water quality target exceedance occurred near the mouth, where the TSS concentration was the highest measured value (379 mg/L) and concentrations are the greatest under all flow conditions. Although no other targets were exceeded during that event, the lead concentration was multiple times greater than all other lead values. This trend during high flow indicates metals loading is associated with a nonpoint sediment source of erosion (e.g., upland, roads, and streambank erosion). There was no trend in arsenic concentrations, which tends to have a larger dissolved component than iron or lead.

Comparison of Metals Concentrations to Water Quality Targets and TMDL Determination

Aluminum

Fargo Coulee is listed as impaired for aluminum on the 2012 303(d) List. Five of the samples were greater than the chronic standard but were not considered a target exceedance because pH was not collected at those sites and it is part of the aquatic life standard for aluminum. Additionally, the aluminum sample collected at M31FRGOC02 is outside of the applicable pH range for the aluminum target (i.e., 6.5-9.0). Therefore, because of exclusions due to no pH data or a pH outside of the applicable range, there are only two samples that could be evaluated. Although both of those samples are below the water quality target, to be conservative given the small sample size and because aluminum is a listed pollutant, an aluminum TMDL is presented. Additional monitoring is recommended to further evaluate if aluminum is a cause of metals impairment and to refine the source assessment.

Arsenic

Fargo Coulee is not listed as impaired for arsenic on the 2012 303(d) List; however, recent data provide evidence of aluminum as a cause of water quality impairment on Fargo Coulee. Although only one out of 11 samples exceeded the human health standard standard, zero exceedances are allowed. Therefore, based on the exceedance of the water quality target, an arsenic TMDL is presented.

<u>Iron</u>

Fargo Coulee is listed as impaired for iron on the 2012 303(d) List. Evaluation of data collected since the initial listing does not verify this impairment. Only one of the 11 water quality samples exceeds the iron target, which is below the allowable 10% exceedance frequency. Therefore, no iron TMDL will be developed, and the 303(d) listing status for iron will be formally reevaluated by DEQ in the future.

<u>Lead</u>

Fargo Coulee is listed as impaired for lead on the 2012 303(d) List. Evaluation of data collected since the initial listing does not verify this impairment. None of the 11 water quality samples exceed the lead target. Therefore, no lead TMDL will be developed, and the 303(d) listing status for lead will be formally reevaluated by DEQ in the future.

7.4.4 Metals TMDL Development Summary

Six individual stream segments are listed as impaired for metals and metals-related pollutants. A review of metals target exceedances verified most metal impairments on the 2012 303(d) List, however, newer zinc data for Chippewa Creek and iron and lead data for Fargo Coulee indicated those metals are not contributing to impairment and no TMDLs will be developed (**Table 7-21**). Additionally, the data review identified elevated concentrations for ten metals not indentified on the 2012 303(d) List that will have TMDLs presented in this document. **Table 7-21** presents a summary of existing metals impairment causes and an overview of which TMDLs were prepared based on observed target exceedances. In total, 28 metals TMDLs are required and will address three pH impairments. The pH impairments on Chicago Gulch, Collar Gulch Creek, and Armells Creek will be addressed via surrogate metals TMDLs because implementation of metals TMDLs is expected to address sources of pH impairment. TMDLs and allocations for these parameters are provided in the following section.

Table 7-21. Summary of metal impairments and TMDLs.

Waterbody	Segment ID	2012 303(d) Listed parameters	TMDLs prepared
CHICAGO GULCH, headwaters to the mouth (Fords Creek)*	MT40B002_020	Lead, pH, Zinc	Arsenic, Cadmium, Lead, pH, Zinc
CHIPPEWA CREEK, headwaters to confluence with Manitoba Gulch	MT40B002_040	Antimony, Arsenic, Cyanide, Iron, Mercury, Zinc	Antimony, Arsenic, Cyanide, Iron, Mercury
COLLAR GULCH CREEK, headwaters to mouth (Fords Creek)	MT40B002_030	Lead, pH, Zinc	Aluminum, Arsenic, Cadmium, Copper, Lead, pH, Zinc
ARMELLS CREEK, headwaters to Deer Creek	MT40E002_022	Cadmium, Copper, Mercury, pH, Zinc	Aluminum, Cadmium, Copper, Iron, Mercury, pH, Zinc
COW CREEK, Als Creek to the mouth (Missouri River)	MT40E002_040	Aluminum, Copper, Iron, Lead	Aluminum, Arsenic, Copper, Iron, Lead
FARGO COULEE, headwaters to mouth at Amells Creek	MT40E002_130	Aluminum, Iron, Lead	Aluminum, Arsenic

*This waterbody segment is actually part of Ford's Creek and its name will be corrected for the 2014 IR to "Fords Creek (headwaters in Chicago Gulch to East Fork Fords Creek)"

7.5 METALS TMDLS AND ALLOCATIONS

7.5.1 Metals TMDLs

As summarized in **Table 7-21**, metals TMDLs are presented herein for impaired waterbodies. A TMDL is a calculation of the maximum pollutant load a waterbody can receive while maintaining water quality standards. The TMDL is based on the most stringent applicable water quality criteria identified in **Section 3.0** and measured streamflow. With most metals, the chronic aquatic life standards are used to calculate the TMDL. In the case of lead (under high water hardness conditions) and antimony, arsenic and mercury (under all conditions), the HHS applies, as it is the most stringent standard. Because streamflow and hardness vary seasonally, the TMDL is expressed as an equation. When flow data are available, the TMDL under a specific flow condition is calculated using the following formula:

TMDL = (X) (Y) (k)
TMDL= Total Maximum Daily Load in lbs/day
X= lowest applicable metals water quality target in µg/L for a specific hardness value
Y= streamflow in cubic feet per second
k = conversion factor of 0.0054

The TMDL equation is applicable to all metals TMDLs within this document and provides a reference for illustrating TMDLs for applicable metals under variable flow and hardness conditions.

7.5.2 Metals Allocations

Metals TMDLs are allocated to point (wasteload) and nonpoint (load) sources. The TMDL is comprised of the sum of all significant point and nonpoint metals sources (natural and human), plus a margin of safety that accounts for uncertainties in loading and receiving water analyses. 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. These elements are combined in the following equation:

TMDL = ΣLA + ΣWLA + MOS
LA = Load allocation or the portion of the TMDL allocated to nonpoint metals sources and natural background
WLA = Wasteload allocation or the portion of the TMDL allocated to metals point sources
MOS = Margin of safety or an accounting of uncertainty about the relationship between metals loads and receiving water quality

Metals allocations are based on metal sources which include the following in the Judith Mountains TPA:

- Natural background loading from mineralized geology
- Abandoned mines, including adit discharge/drainage from abandoned mines and runoff/drainage from abandoned mine tailings
- Upland, in-stream, and floodplain metals deposits from historical mining operations
- Human nonpoint sources, which can include land management practices that accelerate erosion of mineralized soils

7.5.2.1 Natural Background Loading

Natural background loading of metals occurs as a result of geologic conditions. Therefore, the degree of loading can vary considerably among subwatersheds in the planning area, as geologic conditions vary throughout (**Figure A-4** in **Appendix A**). When possible, background loading will be accounted for separately from human-caused sources. The underlying assumption is that natural background sources alone would not result in the exceedance of TMDL target concentrations of metals in the water column, or in sediments. If future monitoring proves this to be incorrect, these TMDLs may need to be revised in accordance with the Adaptive Management strategy provided in **Section 7.7**.

Data collected by DEQ in 2008 from Little Deer Creek (**Table 7-22**) were used to derive natural background metals concentrations for Chicago Gulch, Collar Gulch Creek, Chippewa Creek and Armells Creek. Little Deer Creek is a tributary to Deer Creek, which flows into Armells Creek at the downstream extent of the listed segment discussed in this document (MT40E002_022). The abandoned mines databases do not show any mines in the Little Deer Creek watershed and it has similar geology to the other streams originating in the Judith Mountains. The Cow Creek and Fargo Coulee watersheds vary significantly from the Little Deer Creek watershed, and therefore these data are not appropriate for determining background conditions in those watersheds. There are no other available data to develop background conditions in Cow Creek and Fargo Coulee; allocations for TMDLs in those watersheds are presented as a composite allocation to natural background and human sources. If future monitoring allows for determination of the natural background loading contribution in Cow Creek or Fargo Coulee, or indicates different background concentrations in Chicago Gulch, Collar Gulch Creek, Chippewa Creek and Armells Creek than indicated in **Table 7-22**, the allocations may be changed via the adaptive management process described in **Section 7.7**.

Background conditions for settling the load allocation to natural background sources were determined by taking the 75th percentile of available samples in the Little Deer Creek watershed (**Table 7-22**). For samples that were below the detection limit, half the detection limit was used to represent that sample. Cyanide background conditions were derived by using one-half of the detection limit since cyanide is predominantly a man-made substance. Additional sampling for background conditions in the streams will serve to limit the uncertainty in background loading estimates (see Adaptive Management Strategy in **Section 7.7**).

Table 7-22. Natural background concentrations used in allocations.

Parameter	Chicago Gulch, Collar Gulch Creek, Chippewa Creek, and Armells Creek	
	Sample Count	75th Percentile Concentration
Aluminum (D) (µg /L)	4	5
Antimony, TR (µg/L)	4	0.5
Arsenic (TR) (µg /L)	4	2
Cadmium (TR) (µg /L)	4	0.04
Copper (TR) (µg /L)	4	1
Cyanide, Total (µg/L)	None	2.5
Iron (TR) (µg /L)	4	670
Lead (TR) (µg /L)	4	0.25
Mercury (TR) (µg /L)	2	0.025
Zinc (TR) (µg /L)	4	3

7.5.2.2 Abandoned Mines and Associated Wastes

Waste sources associated with historic mining such as adit discharges, tailings, and waste rock piles are considered non-permitted point sources and subject to a WLA. There is typically not enough data near individual mining sources to allocate a specific percentage of the TMDL to an individual site relative to other abandoned mine sources. Therefore, the contribution from all abandoned mines (e.g. adits, waste rock, tailings) in a contributing area or entire watershed is grouped into a gross WLA from abandoned mines. This approach is based on the assumption that reductions in metals loading can be achieved through the remediation of these abandoned mines and associated waste rock/tailings. The WLA is determined by calculating the difference between the TMDL and the natural background load.

7.5.3 Allocations by Waterbody Segment

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 sample 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. Where possible, TMDL examples are based on high and low flow data from the same sampling site. For any sample data with a value less than the detection limit, one-half the detection limit was used to calculate the observed load.

7.5.3.1 Chicago Gulch (aka Ford's Creek) MT40B002_020

TMDLs for Chicago Gulch (aka Ford's Creek) address impairments that are a result of arsenic, cadmium, lead, pH and zinc. Metals allocations for Chicago Gulch consist of a LA to nonpoint and natural background metals sources and a WLA to abandoned mine sources. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 7.6.2**. Metals TMDLs for Chicago Gulch are described by the following equation:

$\mathbf{TMDL_{Chicago\ Gulch} = LA_{nps} + WLA_{am}}$

LA_{nps} = Load allocation to nonpoint sources in the watershed (unknown sources and natural background)

WLA_{am} = Wasteload allocation to abandoned mining point sources in the watershed

Metals TMDLs and allocations for Chicago Gulch are presented for CHIG-M1 for high and low flow conditions as well as for all sites that require a pollutant load reduction (**Table 7-23**). Load reductions are needed for lead during both high and low flow conditions in order to meet water quality targets. Reductions in arsenic, cadmium and zinc loads are only needed during low flow conditions. The lead TMDL will act as a surrogate for a pH TMDL because setting loads for pH is not practical, lead concentrations are most consistently above targets, and reclamation activities needed to meet the lead TMDL (as well as other metals TMDLs) will address sources of acid mine drainage causing the pH impairment. The allocation scheme in **Table 7-23** assumes that natural loading rates do not cause water quality standards to be exceeded and applying BMPs to mining sources will result in the loading reductions needed to meet the TMDLs and water quality standards.

Table 7-23. Chicago Gulch: metals TMDLs and allocation summary. E = Estimate.

Parameter	Monitoring site	Flow (cfs)/	Hardness (mg/L)	Observed load (lb/day)	TMDL at observed hardness (lb/day)	Reduction (%)	WLA_{am} (lbs/day)	LA_{nps} (lbs/day)
Arsenic	CHIG-M1	0.57	98	0.005	0.031	0	0.025	0.006
	CHIG-M1	15.35	42	0.12	0.83	0	0.66	0.17
	M26CHGOG 01	E 0.5	143	0.051	0.027	47	0.0216	0.0054
	M26CHGOG 02	E 1	119	0.097	0.054	44	0.043	0.011
Cadmium	CHIG-M1	0.57	98	0.0001	0.0008	0	0.0007	0.0001
	CHIG-M1	15.35	42	0.003	0.012	0	0.0087	0.0033
	M26CHGOG 04	E 0.25	39	0.0016	0.00018	89	0.00013	0.00005
Lead	CHIG-M1	0.57	98	0.004	0.0095	0	0.0087	0.0008
	CHIG-M1	15.35	42	0.36	0.087	76	0.066	0.021
	CHIG-MSA1	12.1	34	0.36	0.053	85	0.037	0.016
	M26CHGOG 04	E 0.25	39	0.17	0.0013	99	0.0010	0.0003
Zinc	CHIG-M1	0.57	98	0.03	0.36	0	0.35	0.01
	CHIG-M1	15.35	42	1.7	4.76	0	4.51	0.25
	M26CHGOG 04	E 0.25	39	0.35	0.073	79	0.069	0.004

7.5.3.2 Chippewa Creek MT40B002_040

TMDLs for Chippewa Creek address impairments that are a result of antimony, arsenic, cyanide, iron, and mercury. Metals allocations for Chippewa Creek consist of a LA to nonpoint and natural background metals sources and a WLA to abandoned mine sources. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 7.6.2**. Metals TMDLs for Chippewa Creek are described by the following equation:

$TMDL_{\text{Chippewa Creek}} = LA_{nps} + WLA_{am}$

LA_{nps} = Load allocation to nonpoint sources in the watershed (groundwater and natural background)

WLA_{am} = Wasteload allocation to abandoned mining sources in the watershed

Metals TMDLs and allocations for Chippewa Creek are presented for CIPC-M2 for high and low flow conditions as well as for all sites that require a pollutant load reduction (**Table 7-24**). Load reductions are needed for antimony, arsenic, cyanide, iron, and mercury during both low and high flow conditions in order to meet water quality targets. The allocation scheme in **Table 7-24** assumes that natural loading rates do not cause water quality standards to be exceeded and applying BMPs to mining sources will result in the loading reductions needed to meet the TMDLs and water quality standards.

Table 7-24. Chippewa Creek: metals TMDLs and allocation summary. C = Calculated.

Parameter	Monitoring site	Flow (cfs)	Hardness (mg/L)	Observed load (lb/day)	TMDL at observed hardness (lb/day)	Reduction (%)	WLA_{am} (lbs/day)	LA_{nps} (lbs/day)
Antimony	CIPC-M2	0.07	413	0.0011	0.0021	0	0.0019	0.0002
	CIPC-M2	0.78	353	0.017	0.024	0	0.022	0.002
	CHI-03	0.02	450	0.0012	0.0006	50	0.00055	0.00005
	FW-CHIPC02	C 0.013	419	0.00056	0.00039	30	0.00035	0.00004
	FW-CHIPC03	C 0.0024	377	0.000078	0.000072	8	0.000065	0.000007
Arsenic	CIPC-M2	0.07	413	0.013	0.0038	71	0.0030	0.0008
	CIPC-M2	0.78	353	0.11	0.042	62	0.034	0.008
	CHI-03	0.02	450	0.0099	0.0011	89	0.0009	0.0002
	CIPC-MSA1	0.26	345	0.022	0.014	36	0.011	0.003
	FW-CHIPC02	C 0.0024	355	0.00061	0.00013	79	0.00010	0.00003
	FW-CHIPC02	C 0.013	419	0.0052	0.0007	87	0.0006	0.0001
	FW-CHIPC03	C 0.0024	377	0.00017	0.00013	24	0.00010	0.00003
	FW-CHIPC03	C 0.021	405	0.0042	0.0011	74	0.00087	0.00023
Cyanide	CIPC-M2	0.07	413	0.0038	0.002	47	0.0011	0.0009
	CIPC-M2	0.78	353	0.046	0.022	52	0.011	0.011
	CIPC-MSA1	0.26	345	0.017	0.0073	57	0.0038	0.0035
Iron	CIPC-M2	0.07	413	0.22	0.38	0	0.13	0.25
	CIPC-M2	0.78	353	2.9	4.2	0	1.4	2.8
	CHI-03	0.02	450	0.21	0.11	48	0.04	0.07
	FW-CHIPC03	C 0.021	405	0.34	0.11	68	0.03	0.08
Mercury	CIPC-M2	0.07	413	0.000011	0.000019	0	0.00001	0.000009
	CIPC-M2	0.78	353	0.00024	0.00021	13	0.0001	0.00011
	CHI-03	0.02	450	0.000011	0.0000054	51	0.0000027	0.0000027

7.5.3.3 Collar Gulch Creek MT40B002_030

TMDLs for Collar Gulch Creek address impairment that is a result of aluminum, arsenic, cadmium, copper, lead, pH, and zinc. Metals allocations for Collar Gulch Creek consist of a LA to nonpoint and natural background metals sources and a WLA to abandoned mine sources. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 7.6.2**. Metals TMDLs for Collar Gulch Creek are described by the following equation:

$$\mathbf{TMDL_{Collar\ Gulch\ Creek} = LA_{nps} + WLA_{am}}$$

LA_{nps} = Load allocation to nonpoint sources in the watershed (nonpoint sources, unidentified sources, in-channel sources, natural sources)
WLA_{am} = Wasteload allocation to abandoned mining sources in the watershed

Metals TMDLs and allocations for Collar Gulch Creek are presented for CLRG-M1 for high and low flow conditions as well as for all sites that require a pollutant load reduction (**Table 7-25**). Load reductions are needed for copper, cadmium, and lead during both low and high flow conditions in order to meet water quality targets. Reduction in zinc loads is only needed during low flow conditions and aluminum and arsenic require load reductions during low flow conditions. The lead TMDL will act as a surrogate for a pH TMDL because setting loads for pH is not practical, lead concentrations are most consistently elevated above targets, and reclamation activities needed to meet the lead TMDL (as well as other metals TMDLs) will address sources of acid mine drainage causing the pH impairment. The allocation scheme in **Table 7-25** assumes that natural loading rates do not cause water quality standards to be exceeded and applying BMPs to mining sources will result in the loading reductions needed to meet the TMDLs and water quality standards.

Table 7-25. Collar Gulch Creek: metals TMDLs and allocation summary. E = Estimate.

Parameter	Monitoring site	Flow (cfs)	Hardness (mg/L)	Observed load (lb/day)	TMDL at observed hardness (lb/day)	Reduction (%)	WLA_{am} (lbs/day)	LA_{nps} (lbs/day)
Aluminum	CLRG-M1	0.37	85	0.1	0.17	0	0.16	0.01
	CLRG-M1	11.52	35	5.6	5.4	4	5.1	0.3
	CLRG-MSA1	11.28	31	6.1	5.3	13	5	0.3
Arsenic	CLRG-M1	0.37	85	0.003	0.02	0	0.016	0.004
	CLRG-M1	11.52	35	0.093	0.62	0	0.50	0.12
	M26COLRG02	E 1	81	0.059	0.054	8	0.043	0.011
	M26COLRG03	E 1.5	100	0.13	0.081	38	0.065	0.016
Cadmium	CLRG-M1	0.37	85	0.00084	0.00048	43	0.0004	0.00008
	CLRG-M1	11.52	35	0.0093	0.0077	17	0.0052	0.0025
	CLRG-MSA1	11.28	31	0.0073	0.0069	5	0.0045	0.0024
	M26COLRG01	E 0.25	22	0.0054	0.00012	98	0.00007	0.00005
	M26COLRG02	E 1	81	0.022	0.0012	95	0.00010	0.0002
	M26COLRG03	E 1.5	100	0.0036	0.0022	39	0.0019	0.0003
Copper	CLRG-M1	0.37	85	0.006	0.016	0	0.014	0.002
	CLRG-M1	11.52	35	0.43	0.24	44	0.18	0.06
	CLRG-MSA1	11.28	31	0.43	0.21	51	0.15	0.06
	M26COLRG01	E 0.25	22	0.31	0.0035	99	0.0022	0.0013
	M26COLRG02	E 1	81	0.12	0.042	65	0.037	0.005
Lead	CLRG-M1	0.37	85	0.022	0.0052	76	0.0047	0.0005
	CLRG-M1	11.52	35	0.6	0.052	91	0.036	0.016
	CLRG-M3	11.88	62	2.1	0.11	95	0.094	0.016
	CLRG-MSA1	11.28	31	1.3	0.044	97	0.029	0.015
	M26COLRG01	E 0.25	22	1.7	0.00063	100	0.00029	0.00034
	M26COLRG02	E 1	81	1.2	0.013	99	0.012	0.001
	M26COLRG03	E 1.5	100	0.032	0.026	19	0.024	0.002
Zinc	CLRG-M1	0.37	85	0.08	0.21	0	0.20	0.01
	CLRG-M1	11.52	35	1.2	3.1	0	2.9	0.2
	M26COLRG01	E 0.25	22	0.36	0.045	88	0.041	0.004
	M26COLRG02	E 1	81	1.2	0.54	55	0.52	0.02

7.5.3.4 Armells Creek MT40E002_022

TMDLs for Armells Creek address impairment that is a result of aluminum, cadmium, copper, iron, mercury, pH, and zinc. Metals allocations for Armells Creek consist of a LA to nonpoint and natural background metals sources and a WLA to abandoned mine sources. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 7.6.2**. Metals TMDLs for Armells Creek are described by the following equation:

$$\mathbf{TMDL_{Armells\ Creek} = LA_{nps} + WLA_{am}}$$

LA_{nps} = Load allocation to nonpoint sources in the watershed (natural mineralization, groundwater, localized sources, diffuse sources)
WLA_{am} = Wasteload allocation to abandoned mining point sources in the watershed

Metals TMDLs and allocations for Armells Creek are presented for ARMC-M1 during both low and high flow conditions and for all other sites which require a load reduction (**Table 7-26**). Load reductions are needed for aluminum, copper, and iron during both low and high flow conditions in order to meet water quality targets. Reductions in zinc loading are only needed during low flow conditions. No reduction is shown in the examples for cadmium and mercury because no exceedances were observed during recent sampling, however, reductions may be necessary under certain flow conditions. The copper TMDL will act as a surrogate for a pH TMDL because setting loads for pH is not practical, copper concentrations are most consistently above targets, and reclamation activities needed to meet the copper TMDL (as well as other metals TMDLs) will address sources of acid mine drainage causing the pH impairment. The allocation scheme in **Table 7-26** assumes that natural loading rates do not cause water quality standards to be exceeded and applying BMPs to mining sources will result in the loading reductions needed to meet the TMDLs and water quality standards.

Table 7-26. Armells Creek: metals TMDLs and allocation summary.

Parameter	Monitoring site	Flow (cfs)	Hardness (mg/L)	Observed load (lb/day)	TMDL at observed hardness (lb/day)	Reduction (%)	WLA_{am} (lbs/day)	LA_{nps} (lbs/day)
Aluminum	ARMC-M1	1.12	88	3.3	0.53	84	0.5	0.03
	ARMC-M1	10.35	54	9.5	4.9	48	4.6	0.3
Cadmium	ARMC-M1	1.12	88	0.0011	0.0015	0	0.0013	0.0002
	ARMC-M1	10.35	54	0.0022	0.0096	0	0.0074	0.0022
Copper	ARMC-M1	1.12	88	0.06	0.051	15	0.045	0.006
	ARMC-M1	10.35	54	0.67	0.31	54	0.25	0.06
Iron	ARMC-M1	1.12	88	14	6.0	57	1.9	4.1
	ARMC-M1	10.35	54	46	56	0	19	37
	ARMC-M4	57.82	239	350	310	11	100	210
Mercury	ARMC-M1	1.12	88	0.000015	0.0003	0	0.00015	0.00015
	ARMC-M1	10.35	54	0.00033	0.0028	0	0.0014	0.0014
Zinc	ARMC-M1	1.12	88	0.91	0.65	29	0.63	0.02
	ARMC-M1	10.35	54	1.7	4.0	0	3.83	0.17

7.5.3.5 Cow Creek MT40E002_040

TMDLs for Cow Creek address impairment that is a result of aluminum, arsenic, copper, iron, and lead. Because there are no known permitted or non-permitted point sources of metals, the entire TMDL for Cow Creek is allocated to nonpoint and natural background sources of metals and there is no wasteload allocation. A MOS is implicit in this allocation scheme, based on the conservative assumptions described in **Section 7.6.2**. Metals TMDLs for Cow Creek are described by the following equation:

$\mathbf{TMDL_{Cow\ Creek} = LA_{nps}}$
LA_{nps} = Load allocation to nonpoint sources in the watershed (human and natural sources)

Metals TMDLs and allocations for Cow Creek are presented at COWC-M3 under high and low flow conditions and for all other sites which require a load reduction (**Table 7-27**). Load reductions are needed under low flow conditions to meet aluminum, arsenic, copper, iron, and lead water quality targets. Reductions in iron loading are only needed during high flow conditions.The allocation scheme assumes that natural loading rates do not cause water quality standards to be exceeded and applying BMPs to nonpoint sources will result in the loading reductions needed to meet the TMDLs and water quality standards.

Table 7-27. Cow Creek: metals TMDLs and allocation summary. E = Estimate.

Parameter	Monitoring site	Flow (cfs)	Hardness (mg/L)	Observed load (lb/day)	TMDL/LA_{nps} at observed hardness (lb/day)	Reduction (%)
Aluminum	COWC-M3	1.49	276	0.12	0.7	0
	COWC-M3	52.3	335	4.2	25	0
	M31COWC02	E 1.75	125	1.1	0.82	25
Arsenic	COWC-M3	1.49	276	0.012	0.08	0
	COWC-M3	52.3	335	1.1	2.8	0
	M31COWC02	E 1.75	125	0.12	0.094	22
Copper	COWC-M3	1.49	276	0.016	0.18	0
	COWC-M3	52.3	335	2	7.4	0
	M31COWC02	E 1.75	125	0.29	0.11	62
Iron	COWC-M3	1.49	276	2.4	8	0
	COWC-M3	52.3	335	1900	280	85
	COWC-M2	51.05	323	1000	280	72
	M31COWC02	E 1.75	125	280	9.4	97
Lead	COWC-M3	1.49	276	0.002	0.093	0
	COWC-M3	52.3	335	1.2	4.2	0
	M31COWC02	E 1.75	125	0.17	0.04	76

7.5.3.6 Fargo Coulee MT40E002_130

TMDLs for Fargo Coulee address impairment that is a result of aluminum and arsenic. Because there are no known permitted or non-permitted point sources of metals, the entire TMDL for Fargo Coulee is allocated to nonpoint and natural background sources of metals and there is no wasteload allocation. A MOS is implicit in this allocation scheme, through a variety of conservative assumptions described in **Section 7.6.2**. Metals TMDLs for Fargo Coulee are described by the following equation:

$$\mathbf{TMDL_{Fargo\ Coulee} = LA_{nps}}$$

LA_{nps} = Load allocation to nonpoint sources in the watershed (human and natural sources)

Metals TMDLs and allocations for Fargo Coulee are presented at FRGC-M2 during high flow conditions and at M31FRGOC05 during low flow conditions (**Table 7-28**). There were no paired high and low flow data at any one site. The reduction shown for aluminum is uncertain because pH data were lacking for the sampling event, but based on the aluminum concentrations in numerous samples, reductions will likely be necessary under low flow conditions. The allocation scheme in **Table 7-28** assumes that natural loading rates do not cause water quality standards to be exceeded and applying BMPs to nonpoint sources will result in the loading reductions needed to meet the TMDLs and water quality standards.

Table 7-28. Fargo Coulee: metals TMDLs and allocation summary. E = Estimate.

Parameter	Monitoring site	Flow (cfs)	Hardness (mg/L)	Observed load (lb/day)	$TMDL/LA_{nps}$ at observed hardness (lb/day)	Reduction (%)
Aluminum	FRGC-M2	0.55	2,190	0.15	0.26	0
	M31FRGOC05	E 0[a]	2,800	0.059	0.047	20[b]
Arsenic	FRGC-M2	0.55	2,190	0.004	0.030	0
	M31FRGOC05	E 0[a]	2,800	0.0081	0.0054	33

[a.] There was no measureable flow and 0.1cfs was used for the TMDL example. If flow is zero, the TMDL is zero.
[b.] The reduction shown is based on a measured concentration of 110µg/L but it is not known if a reduction is needed because there was no corresponding pH value to determine if the standard was applicable.

7.6 Seasonality and Margin of Safety

All TMDL documents must consider the seasonal variability, or seasonality, on water quality impairment conditions, maximum allowable pollutant loads in a stream (TMDLs), and LAs. TMDL development must also incorporate a margin of safety into the load allocation process 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 a margin of safety in metal TMDL development process.

7.6.1 Seasonality

Seasonality addresses the need to ensure year round beneficial-use support. Seasonality was considered for assessing loading conditions and for developing water quality targets, TMDLs, and allocation schemes. For metals TMDLs, seasonality is critical due to varying metals loading pathways and varying water hardness during high and low flow conditions. Loading pathways associated with overland flow and erosion of metals-contaminated soils and wastes tend to be the major cause of elevated metals concentrations during high flows, with the highest concentrations and metals loading typically occurring during the rising limb of the hydrograph. Loading pathways associated with groundwater transport and/or adit discharges tend to be the major cause of elevated metals concentrations during low or base flow conditions. Hardness tends to be lower during higher flow conditions, which leads to more stringent water quality standards for hardness-dependent metals during the runoff season. Seasonality is 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 requires 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 seasonal water quality extremes associated with loading and hardness variations.
- A sediment chemistry target is applied as a supplemental indicator to help capture impacts from episodic metals loading events that could be attributed to high flow seasonal runoff conditions.
- Example targets, TMDLs and load reduction needs are developed for high and low flow conditions. The TMDL equation incorporates all potential flow conditions that may occur during any season.

7.6.2 Margin of Safety

The margin of safety 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 can lead 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 curves and captured within the example TMDLs.
- Target attainment, refinement of load 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 a margin of safety for the majority of conditions where the most protective (lowest) target value is linked to the numeric aquatic life 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 conditions in order to consistently achieve the TMDL.
- The monitoring results used to estimate existing water quality conditions are instantaneous measurement used to estimate a daily load, whereas chronic aquatic life standards are based on average conditions over a 96-hour period. This provides a margin of safety 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 a margin of safety necessary for the protection of human health and aquatic life.

7.7 Uncertainty and Adaptive Management

Uncertainties in the accuracy of field data, applicable target values, source assessments, natural conditions, loading calculations, and other considerations are inherent when assessing and evaluating environmental variables for TMDL development. While uncertainties are an undeniable fact of TMDL development, mitigation and reduction of uncertainties through adaptive management approaches is a key component of ongoing TMDL implementation and evaluation. Uncertainties, assumptions, and considerations are addressed throughout this document and point to the need to refine analysis, conduct further monitoring, and address unknowns in order to develop better understanding of impairment conditions and the processes that affect impairment. This process of adaptive management is predicated on the premise that TMDLs, allocations, and the analyses supporting them are not static, but are processes subject to modification and adjustment as new information and relationships are understood.

The adaptive management process allows for continual feedback on the progress of restoration activities and status of beneficial uses. It provides the flexibility to refine targets as necessary to ensure protection of the resource or to adapt to new information concerning target achievability. For instance, as a result of additional monitoring and source refinement new WLAs may be necessary for abandoned mines that are found to be discrete sources and the allocations and margin of safety may be modified. Components may be changed to improve ways of achieving and measuring success.

The water quality targets and associated metals TMDLs developed are based on future attainment of water quality standards. In order to meet water quality standards, all significant sources of metal loading must be addressed via all reasonable land, soil, and water conservation practices. It is recognized however, that in spite of all reasonable efforts, attainment of water quality targets may not be possible due to natural sources or the presence of unalterable human-caused sources. For this reason, an adaptive management approach is adopted for all metals targets described within this document. Under this adaptive management approach, all metals identified in this plan as requiring TMDLs will ultimately fall into one of the categories identified below:

- Implementation of remediation and restoration activities resulting in full attainment of restoration targets for all parameters;
- Implementation of remediation and restoration activities fails to result in target attainment due to underperformance or ineffectiveness of restoration actions. Under this scenario the waterbody remains impaired and will require further restoration efforts associated with the pollutants of concern. The target may or may not be modified based on additional information, but conditions still exist that require additional pollutant load reductions to support beneficial uses and meet applicable water quality standards. This scenario would require some form of additional, refocused restoration work.
- Implementation of restoration activities fails to result in target attainment, but target attainment is deemed unachievable even though all applicable monitoring and restoration activities have been completed. 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 could either reflect the existing conditions at the time or the anticipated future conditions associated with the restoration work that has been performed.
- The water quality targets and TMDL are unattainable due to natural 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.

Determinations on the performance of all aspects of restoration activities, or lack thereof, will be used along with available in-stream data to evaluate the appropriateness of any given target and beneficial-use support. Monitoring and restoration conducted by other parties (e.g. USFS, BLM, the Montana Department of Natural Resources and Conservation’s Trust Lands Management Division, The Nature Conservancy) 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.

It is acknowledged that construction or maintenance activities related to restoration, construction/ maintenance, and future development may result in short term increase in surface water metals concentrations. For any activities that occur within the stream or floodplain, all appropriate permits should be obtained before commencement of the activity. Federal and State permits necessary to conduct work within a stream or stream corridor are intended to protect the resource and reduce, if not completely eliminate, pollutant loading or degradation from the permitted activity. The permit requirements typically have mechanisms that allow for some short term impacts to the resource, as long as all appropriate measures are taken to reduce impact to the least amount possible.

8.0 Other Identified Issues or Concerns

8.1 Pollution Listings

Water quality issues are not limited simply to those streams where TMDLs are developed. In some cases, streams have not yet been reviewed through the assessment process and do not appear on the 303(d) List. In other cases, streams in the Judith Mountains Project Area may appear on the 303(d) List but may not always require TMDL development for a pollutant, but do have pollution listings such as “alteration in streamside or littoral vegetation covers” that could be linked to a pollutant. These habitat related pollution causes are often associated with sediment issues, may be associated with nutrient or temperature issues, or may be having a deleterious effect on a beneficial use without a clearly defined quantitative measurement or direct linkage to a pollutant to describe that impact. Nevertheless, the issues associated with these streams are still important to consider when working to improve water quality conditions in individual streams, and the Judith Mountains Project Area as a whole. In these cases, pollutant and *pollution* causes are listed for waterbody, and the management strategies as incorporated through the TMDL development for the pollutant, inherently address some or all of the pollution listings. **Table 8-1** presents the *pollution* listings in the Judith Mountains Project Area.

Table 8-1. Waterbody Segments with Pollution Listings on the 2012 303(d) List.

Waterbody ID	Stream Segment	2012 Probable Cause of Impairment
MT40B002_040	CHIPPEWA CREEK, headwaters to confluence with Manitoba Gulch	Alterations in streamside or littoral vegetation covers
MT40E002_130	FARGO COULEE, headwaters to mouth (Armells Creek)	Alterations in streamside or littoral vegetation covers

8.1.1 Pollution Cause of Impairment Description

Pollution listings are often used as a probable cause of impairment when available data at the time of assessment does not necessarily provide a direct quantifiable linkage to a specific pollutant, however non-pollutant sources or indicators do indicate impairment. In some cases the pollutant and pollution categories are linked and appear together in the cause listings, however a pollution category may appear independent of a pollutant listing. The following discussion provides some rationale for the application of the identified pollution causes in the Judith Mountains Project Area, and thereby provides additional insight into possible factors in need of additional investigation or remediation.

Alteration in Streamside or Littoral Vegetation Covers

Alteration in streamside or littoral vegetation covers refers to circumstances where practices along the stream channel have altered or removed riparian vegetation and subsequently affected channel geomorphology and/or stream temperature. Such instances may be riparian vegetation removal for a road or utility corridor, or overgrazing by livestock along the stream. As a result of altering the streamside vegetation, destabilized banks from loss of vegetative root mass could lead to overwidened stream channel conditions, elevated sediment and/or nutrient loads, and the resultant lack of canopy cover can lead to increased water temperatures.

8.1.2 Monitoring and BMPs for Pollution Affected Streams

Streams listed for *pollution* as opposed to a pollutant should not be overlooked when developing watershed management plans. Attempts should be made to collect sediment, nutrient, and temperature information where data is minimal and the linkage between probable cause, pollution listing, and effects to the beneficial uses are not well defined. The monitoring and restoration strategies that follow in **Sections 9.0** and **10.0** are presented to address both pollutant and non-pollutant issues for streams in the Judith Mountains Project Area with TMDLs in this document, and they are equally applicable to streams listed for the above pollution categories.

8.2 Potential Pollutant Issues Not Addressed

Although this document addresses all pollutant listings on the 2012 303(d) List, there could be issues where additional investigation may warrant TMDL development in the future. One such case is Armells Creek, where 2011 monitoring by EPA noted extensive flood damage had occurred that spring to the road, stream channel and numerous culverts on BLM and privately owned lands from peak snowmelt runoff. Because Armells Creek was not listed for sediment-related impairment at the time, monitoring related to this TMDL document did not collect sediment parameters on the stream.

9.0 Restoration Objectives and Implementation Strategy

While certain land uses and human activities are identified as sources and causes of water quality impairment during TMDL development, the management of these activities is of more concern than the activities themselves. This document does not advocate for the removal of land and water uses to achieve water quality restoration objectives, but instead for making changes to current and future land management practices that will help improve and maintain water quality. This section describes an overall strategy and specific on-the-ground measures designed to restore beneficial water uses and attain water quality standards in Judith Mountains Project Area streams. The strategy includes general measures for reducing loading from each significant identified pollutant source.

9.1 Water Quality Restoration Objectives

The following are general water quality goals provided in this TMDL document:

- Provide technical guidance for full recovery of aquatic life beneficial uses to all impaired streams within the Judith Mountains Project Area by improving sediment, nutrient, and metal water quality conditions. This technical guidance is provided by the TMDL components in the document which include:
  - water quality targets,
  - pollutant source assessments, and
  - a restoration and TMDL implementation strategy.

A watershed restoration plan (WRP) can provide a framework strategy for water quality restoration and monitoring in the Judith Mountains Project Area, 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. Watershed restoration plans identify considerations that should be addressed during TMDL implementation and should assist stakeholders in developing a more detailed adaptive plan in the future. A locally developed WRP will likely provide more detailed information about restoration goals and spatial considerations but may also encompass more broad goals than this framework includes. A WRP would serve as a locally organized "road map" for watershed activities, sequences of projects, prioritizing of projects, and funding sources for achieving local watershed goals, including water quality improvements. The WRP is intended to be a living document that can be revised based on new information related to restoration effectiveness, monitoring results, and stakeholder priorities. The following are key elements suggested for the WRP:

- Support for implementing restoration projects to protect water conditions so that all streams in the watershed maintain good water quality, with an emphasis on waters with TMDLs completed.
- Detailed cost/benefit analysis and spatial considerations for water quality improvement projects.
- Develop an approach for future BMP installment and efficiency results tracking.
- Provide information and education components to assist with stakeholder outreach about restoration approaches, benefits, and funding assistance.
- Other various watershed health goals, such as weed control initiatives.
- Other local watershed based issues.

9.2 Agency and Stakeholder Coordination

Successful implementation requires collaboration among private landowners, land management agencies, and other stakeholders. The DEQ does not implement TMDL pollutant reduction projects for nonpoint source activities, but can provide technical and financial assistance for stakeholders interested in improving their water quality. The DEQ will work with participants to use the TMDLs as a basis for developing locally-driven WRPs, administer funding specifically to help fund water quality improvement and pollution prevention projects, and can 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 continue to work collaboratively with local and state agencies to achieve water quality restoration which will progress toward meeting water TMDL targets and load reductions. Specific stakeholders and agencies that have been, and will likely continue to be, vital to restoration efforts include Fergus and Blaine County Conservation Districts, USFS, NRCS, DNRC, FWP, NRDP, EPA and DEQ. Other organizations and non-profits that may provide assistance through technical expertise, funding, educational outreach, or other means include Montana Water Trust, Montana Water Center, University of Montana Watershed Health Clinic, and MSU Extension Water Quality Program.

9.3 Restoration Strategy By Pollutant

This section summarizes the primary restoration strategy for each pollutant with TMDLs in this document as well as some general information on restoration of non-pollutant impairments.

9.3.1 Sediment Restoration Strategy

The goal of the sediment restoration strategy is to prevent the availability, transport, and delivery of sediment by a combination of minimizing sediment delivery, reducing the rate of runoff, and intercepting sediment transport. Streamside riparian vegetation restoration and long term riparian area management are vital restoration practices that must be implemented across the watershed to achieve the sediment TMDLs. Vigorous native streamside riparian vegetation filters sediment from upland runoff and improves streambank stability and slows bank erosion. Sediment is also deposited more heavily in healthy riparian zones during flooding because water velocities slow in these areas enough for excess sediment to settle out.

Improved grazing management is another major component of the sediment restoration approach. This may include adjusting the timing and duration of grazing, the development of multi-pasture systems that include riparian pastures, and the development of off-site watering areas. Additionally, grazing management, combined with some additional fencing costs in many riparian areas, would promote natural recovery. Active vegetation planting along with bank sloping may increase costs, but still remains within a reasonable and relatively cost effective restoration approach. When stream channel restoration work is needed because of altered stream channels, costs increase and projects should be assessed on a case by case basis. In general, these are sustainable agricultural practices that promote attainment of conservation objectives while meeting agricultural production goals. The appropriate BMPs will differ by landowner and are recommended to be part of a comprehensive farm/ranch plan.

Although roads may be a small source of sediment at the watershed scale, sediment derived from roads may cause significant localized impact in some stream reaches. Restoration approaches for unpaved roads near streams should be to divert water off of roads and ditches before it enters the stream. The diverted water should be routed through natural healthy vegetation, which will act as filter zones for the sediment laden runoff before it enters streams. Sediment loads from culvert failure and culvert caused scour were not assessed by the TMDL source assessment, but should be considered in road sediment restoration approaches.

Localized sediment-related impacts of tailings from historic milling activities are present in Chippewa Creek. If mining caused sediment sources that can be restored at reasonable costs, they could be prioritized into the WRP. Any other unknown sediment sources could also be incorporated into the WRP while considering cost and sediment reduction benefits.

All of these best management practices are considered reasonable restoration approaches due to their benefit and generally low costs. Riparian restoration and road erosion control are standard best management practices identified by NRCS, and are not overly expensive to our society. Although the appropriate BMP will vary by waterbody and site, controllable sources and BMP types can be prioritized by watershed to reduce sediment loads in individual streams.

9.3.2 Nutrient Restoration Strategy

The goal of the nutrient restoration strategy is to reduce nutrient input to stream channels by increasing the filtering and uptake capacity of riparian vegetation areas, decreasing the amount of bare ground, and limiting the transport of nutrients from rangeland and cropland. Cropland filter strip extension, vegetative restoration, and long-term filter area maintenance are vital BMPs for achieving nutrient TMDLs in predominantly agricultural watersheds. Grazing systems with the explicit goal of increased vegetative post-grazing ground cover are needed to address the same nutrient loading from rangelands. Grazing prescriptions that enhance the filtering capacity of riparian filter areas offer a second tier of controls on the sediment content of upland runoff. Grazing and pasture management adjustments should consider:

1. The timing and duration of near-stream grazing,
2. The spacing and exposure duration of on-stream watering locations,
3. Provision of off-stream site watering areas to minimize near-stream damage and allow impoundment operations that minimize salt accumulations,
4. Active reseeding and rest rotation of locally damaged vegetation stands,
5. Improved management of irrigation systems and fertilizer applications, and
6. Incorporation of streamside vegetation buffer to irrigated croplands and confined feeding areas

Seasonal livestock confinement areas have a historic precedent for placement near or adjacent to flowing streams. Stream channels were the only available livestock water sources prior to the extension of rural electricity. Although limited in size, their repeated use generates high nutrient concentrations in close proximity to surface waters. Episodic runoff with high nutrient concentrations generates large loads that can settle in pools of intermittent streams and remain bio-available through the growing season. Diversion and routing of confinement runoff to harvestable nutrient uptake areas outside of active water courses are effective controls.

In addition to the agricultural related BMPs, a reduction of sediment delivery from roads and eroding streambanks is another component of the nutrient reduction restoration plan. Additional sediment related BMPs are presented in **Section 9.3.1**.

In general, these are sustainable grazing and cropping practices that can reduce nutrient inputs while meeting production goals. The appropriate combination of BMPs will differ according to landowner preferences and equipment but are recommended as components of comprehensive plan for farm and ranch operators. Sound planning combined with effective conservation BMPs should be sought whenever possible and applied to croplands, pastures and livestock handling facilities. Assistance from resource professionals from various local, state, and federal agencies or non-profit groups is widely available in Montana. The local USDA Service Center and county conservation district offices are geared to offer both planning and implementation assistance.

9.3.3 Metals Restoration Strategy

The restoration strategy for metals focuses on regulatory mechanisms and/or programs applicable to the controllable source types present within the watershed; which, for the most part, are associated with historic mining and mining legacy issues. Potential metals loading sources associated with abandoned mines include discharging mine adits and mine waste materials on-site and in-channel. The goal of the metals restoration strategy is to limit the input of metals to stream channels from priority abandoned mine sites and other identified sources of metals impairments. For most of the mining-related sources, additional analysis will likely be required to identify site-specific metals delivery pathways and to develop mitigation plans.

Goals and objectives for future restoration work include the following:

- Prevent soluble metal contaminants or metals contaminated solid materials in the waste rock and tailings materials/sediments from migrating into adjacent surface waters to the extent practicable.

- Reduce or eliminate concentrated runoff and discharges that generate sediment and/or heavy metals contamination to adjacent surface waters and groundwater to the extent practical.

- Identify, prioritize, and select response and restoration actions based on a comprehensive source assessment and streamlined risk analysis of areas affected by historical mining.

9.3.4 Pollution Restoration Strategy

Although TMDL development is not required for pollution listings, they are frequently linked to pollutants, and addressing pollution sources is an important component of TMDL implementation. Pollution listings within the Judith Mountains Project Area include alteration in streamside or littoral vegetative covers. Typically, habitat impairments are addressed during implementation of associated pollutant TMDLs. Therefore, if restoration goals within the Judith Mountains Project Area are not also addressing pollution impairments, additional pollution-related BMP implementation should be considered. Habitat BMPs are discussed below in **Section 9.4**.

9.4 Restoration Approaches by Source Category

For each major source of human-caused pollutant loads in the Judith Mountains Project Area, general management recommendations are outlined below. The effect of different sources can change seasonally and be dependent on the magnitude of storm/high flow events. Therefore, restoration activities within the Judith Mountains Project Area should focus on all major sources for each pollutant category. Yet, restoration should begin with addressing significant sources where large load reductions can be obtained within each source category. For each major source, BMPs will be most effective as part of a management strategy that focuses on critical areas within the watershed, which are those areas contributing the largest pollutant loads or are especially susceptible to disturbance. The source assessment results provided within **Appendices C** and **D** and summarized in **Section 5.5, 6.5, and 7.5** provide information that should be used to help determine priorities for each major source type in the watershed and for each of the general management recommendations discussed.

Applying BMPs for existing activities where they are currently needed is the core of TMDL implementation but only forms a part of the restoration strategy. Also important are efforts to avoid future load increases by ensuring that new activities within the watershed incorporate all appropriate BMPs, and ensuring continued implementation and maintenance of those BMPs currently in place or in practice. Restoration might also address other current pollution-causing uses and management practices. In some cases, efforts beyond implementing new BMPs may be required to address key pollutant sources. In these cases, BMPs are usually identified as a first effort followed by an adaptive management approach to determine if further restoration activities are necessary to achieve water quality standards. Monitoring is also an important part of the restoration process; recommendations are outlined in **Section 10.0**.

9.4.1 Grazing

Development of riparian grazing management plans should be a goal for landowners in the watershed who are not currently using a plan. Private land owners may be assisted by state, county federal, and local conservation groups to establish and implement appropriate grazing management plans. The goal of riparian grazing management is not to eliminate all grazing in these areas. Nevertheless, in some areas, a more restrictive management strategy may be necessary for a period in order to accelerate re-establishment of a riparian community with the most desirable species composition and structure. Grazing should be managed to provide filtering capacity via adequate groundcover, streambank stability via mature riparian vegetation communities, and shading from mature riparian climax communities.

Grazing management includes the timing and duration of grazing, the development of multi-pasture systems, including riparian pastures, and the development of off-site watering areas. The key strategy of the recommended grazing BMPs is to develop and maintain healthy riparian vegetation and minimize disturbance of the streambank and channel. The primary recommended BMPs for the Judith Mountains Project Area are providing off-site watering sources, limiting livestock access to streams, providing “water gaps” where livestock access to a stream is necessary, planting woody vegetation along streambanks, and establishing riparian buffers. Although passive restoration via new grazing plans or limited bank revegetation are a preferred BMPs, in some instances, bank stabilization may be necessary prior to planting vegetation. Other general grazing management recommendations and BMPs to address grazing sources of pollutants and pollution can be obtained in Appendix A of Montana’s NPS Management Plan (Montana Department of Environmental Quality, 2012c).

9.4.2 Riparian Areas and Floodplains

Riparian areas and floodplains are critical for wildlife habitat, groundwater recharge, reducing the severity of floods and upland and streambank erosion, and filtering pollutants from runoff. Therefore, enhancing and protecting riparian areas and floodplains within the watershed should be a priority of TMDL implementation in the Judith Mountains Project Area.

Initiatives to protect riparian areas and floodplains will help protect property, increase channel stability, and buffer waterbodies from pollutants. However, in areas with a much smaller buffer or where historical vegetation removal and development have shifted the riparian vegetation community and limited its functionality, a tiered approach for restoring stream channels and adjacent riparian vegetation should be considered that prioritizes areas for restoration based on the existing condition and potential for improvement. In non-conifer dominated areas, the restoration goals should focus on restoring natural shrub cover on streambanks to riparian vegetation target levels associated with the sediment and nutrient TMDLs. Passive riparian restoration is preferable, but in areas where stream channels are unnaturally stable or streambanks are eroding excessively, active restoration approaches, such as channel design, woody debris and log vanes, bank sloping, seeding, and shrub planting may be needed. Factors influencing appropriate riparian restoration would include the severity of degradation, site-potential for various species, and the availability of local sources as transplant materials. In general, riparian plantings would promote the establishment of functioning stands of native riparian species. Weed management should also be a dynamic component of managing riparian areas.

The use of riprap or other "hard" approaches is not recommended and is not consistent with water quality protection or implementation of this plan. Although they may be absolutely necessary in some instances, these "hard" approaches generally redirect channel energy and exacerbate erosion in other places. Bank armoring should be limited to areas with a demonstrated infrastructure threat. Where deemed necessary, apply bioengineered bank treatments to induce vegetative reinforcement of the upper bank, reduce stream scouring energy, and provide shading and cover habitat.

9.4.3 Unpaved Roads

The road sediment reductions in this document represent an estimation of the sediment load that would remain once appropriate road BMPs were applied at all locations. Achieving this reduction in sediment loading from roads may occur through a variety of methods at the discretion of local land managers and restoration specialists. Road BMPs can be found on the Montana DEQ or DNRC websites and within Montana's Nonpoint Source Management Plan (Montana Department of Environmental Quality, 2012c). Examples include:

- Providing adequate ditch relief up-grade of stream crossings.
- Constructing waterbars, where appropriate, and up-grade of stream crossings.
- Instead of cross pipes, using rolling dips on downhill grades with an embankment on one side to direct flow to the ditch. When installing rolling dips, ensure proper fillslope stability and sediment filtration between the road and nearby streams.
- Insloping roads along steep banks with the use of cross slopes and cross culverts.
- Outsloping low traffic roads on gently sloping terrain with the use of a cross slope.
- Using ditch turnouts and vegetative filter strips to decrease water velocity and sediment carrying capacity in ditches.
- For maintenance, grade materials to the center of the road and avoid removing the toe of the cutslope.
- Preventing disturbance to vulnerable slopes.
- Using topography to filter sediments; flat, vegetated areas are more effective sediment filters.
- Where possible, limit road access during wet periods when drainage features could be damaged.
- Limit new road stream crossings and the length of near-stream parallel segments to the extent practicable.

9.4.4 Stormwater Construction Permitting and BMPs

Construction activities disturb the soil, and if not managed properly, they can be substantial sources of sediment. Construction activity disturbing one acre or greater is required to obtain permit coverage through DEQ under the Stormwater General Permit for Construction Activities. A Stormwater Pollution Prevention Plan (SWPPP) must be developed and submitted to obtain a permit. A SWPPP identifies pollutants of concern, which is most commonly sediment, construction related sources of those pollutants, any nearby waterbodies that could be affected by construction activities, and BMPs that will be implemented to minimize erosion and discharge of pollutants to waterbodies. The SWPPP must be implemented for the duration of the project, including final stabilization of disturbed areas, which is a vegetative cover of at least 70% of the pre-disturbance level or an equivalent permanent stabilization measure. Development and implementation of a thorough SWPPP should ensure WLAs within this document are met.

Land disturbance activities that are smaller than an acre (and exempt from permitting requirements) also have the potential to be substantial pollutant sources, and BMPs should be used to prevent and control erosion consistent with the upland erosion allocations. Potential BMPs for all construction activities include construction sequencing, permanent seeding with the aid of mulches or geotextiles, check dams, retaining walls, drain inlet protection, rock outlet protection, drainage swales, sediment basin/traps, earth dikes, erosion control structures, grassed waterways, infiltration basins, terraced slopes, tree/shrub planting, and vegetative buffer strips. An EPA support document for the construction permits has extensive information about construction related BMPs, including limitations, costs, and effectiveness (EPA 2009).

9.4.5 Forestry and Timber Harvest

Timber harvest activities should be conducted by all landowners according to Forestry BMPs for Montana (Montana State University, Extension Service, 2001) and the Montana Streamside Management Zone (SMZ) Law (77-5-301 through 307 MCA). The Montana Forestry BMPs cover timber harvesting and site preparation, road building including culvert design, harvest design, other harvesting activities, slash treatment and site preparation, winter logging, and hazardous substances. While the SMZ Law is intended to guide commercial timber harvesting activities in streamside areas (i.e., within 50 feet of a waterbody), the riparian protection principles behind the law should be applied to numerous land management activities (i.e., timber harvest for personal use, agriculture, development). Prior to harvesting on private land, landowners or operators are required to notify the Montana DNRC. DNRC is responsible for assisting landowners with BMPs and monitoring their effectiveness. The Montana Logging Association and DNRC offer regular Forestry BMP training sessions for private landowners.

The SMZ Law protects against excessive erosion and therefore is appropriate for helping meet sediment load allocations. USFS INFISH Riparian Habitat Conservation Area guidelines provide significant sediment protection as well as protection from elevated thermal loading (i.e., elevated temperature) by providing adequate shade. This guidance improves upon Montana's SMZ law and includes an undisturbed 300 foot buffer on each side of fish bearing streams and 150 foot buffer on each side of non-fish bearing streams with limited exclusions and BMP guidance for timber harvest, roads, grazing, recreation and other human sources (U.S. Department of Agriculture, Forest Service, 1995).

In addition to the BMPs identified above, effects that timber harvest may have on yearly streamflow levels, such as peak flow, should be considered. Water yield and peak flow increases should be modeled in areas of continued timber harvest and potential effects should be evaluated. Furthermore, noxious weed control should be actively pursued in all harvest areas and along all forest roads.

9.4.6 Mining

Because restoration of metals sources that are not also associated with sediment and nutrients are typically implemented under state and federal programs, this section will discuss general restoration programs and funding mechanisms that may be applicable to the metals sources instead of specific BMPs. The need for further characterization of impairment conditions and loading sources is addressed through the framework monitoring plan in **Section 10.0**. A number of state and federal regulatory programs have been developed to address water quality problems stemming from historic mines, associated disturbances, and metal refining impacts. Some regulatory programs and approaches considered most applicable to the Judith Mountains Project Area watershed include:

- The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA),
- The State of Montana Mine Waste Cleanup Bureau's 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).

A Federal land management agency may pursue cleanup actions outside of any requirements under CERCLA or CECRA where such activities are consistent with overall land management goals and there is funding available.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
CERCLA, which is also common referred to as Superfund, is a Federal law that addresses cleanup on sites, such as historic mining areas, where there has been a hazardous substance release or threat of release. Sites are prioritized on the National Priority List (NPL) using a hazard ranking system with significant focus on human health. Under CERCLA, the potentially responsible party or parties must pay for all remediation efforts based upon a liability approach whereby any existing or historical land owner can be held liable for restoration costs. Where viable landowners are not available to fund cleanup, funding can be provided under Superfund authority. Federal agencies can be delegated Superfund authority, but cannot access funding from Superfund.

Cleanup actions under CERCLA must be based on professionally developed plans and can be categorized as either Removal or Remedial. Removal actions can be used to address the immediate need to stabilize or remove a threat where an emergency exists. Removal actions can also be non-time critical.

Once removal activities are completed, a site can then undergo Remedial Actions or may end up being scored low enough from a risk perspective that it no longer qualifies to be on the NPL for Remedial Action. Under these conditions the site is released back to the state for a "no further action" determination. At this point there may still be a need for additional cleanup since there may still be significant environmental threats or impacts, although the threats or impacts are not significant enough to justify Remedial Action under CERCLA. Any remaining threats or impacts would tend to be associated with wildlife, aquatic life, or aesthetic impacts to the environment or aesthetic impacts to drinking water supplies versus threats or impacts to human health. A site could, therefore, still be a concern from a water quality restoration perspective, even after CERCLA removal activities have been completed.

Remedial actions may or may not be associated with or subsequent to removal activities. A remedial action involves cleanup efforts whereby Applicable or Relevant and Appropriate Requirements and Standards (ARARS), which include state water quality standards, are satisfied. Once ARARS are satisfied, then a site can receive a "no further action" determination.

Additional information about the Federal Superfund program is available on DEQ's website: http://deq.mt.gov/fedsuperfund/default.mcpx.

Abandoned Mine Lands (AML) Reclamation Program

The Abandoned Mines Lands Reclamation Program (AML), which is part of the Mine Waste Cleanup Bureau at DEQ, is responsible for reclamation of historical mining disturbances associated with abandoned mines in Montana. The AML program is funded by fees placed on coal producers through the Surface Mining Control and Reclamation Act of 1977 (SMCRA), and funds are distributed to states by a grant program from the federal government. There are no collections or contributions to the Abandoned Mine Fund from mineral production beyond coal production fees. In order to be eligible for SMCRA funding, a site must have been mined or affected by mining processes, and abandoned or inadequately reclaimed, prior to August 3, 1977 for private lands, August 28, 1974 for Forest Service administered lands, and prior to 1980 for lands administered by the U.S. Bureau of Reclamation. Furthermore, there must be no party (i.e., owner, operator, other) who may be responsible for reclamation requirements, and the site must not be located within an area designated for remedial action under the federal Superfund program or certain other programs.

As part of the approved plan for Montana, abandoned coal mines are required to be prioritized and funded for reclamation ahead of eligible non-coal mine sites (e.g., hard rock mines and gravel pits). Cleanup of any eligible site is prioritized based primarily on human health, which can include health risks such as open shafts, versus risks only associated with hazardous substances, as is the case under CERCLA. Montana's AML Program maintains an inventory of all potential cleanup sites, and also has a list of non-coal priority sites from which to work from. The DEQ reclamation priority number or responsible agency for the priority abandoned mines in the Judith Mountains Project Area are listed in **Table 9-1.** Due to their locations, the Prester John and Cumberland Mines do not contribute to the metals impairments of streams in this document for which TMDLs were written.

Limited scoping and ranking of water pollution from discharging abandoned coal mines has been completed and Montana’s AML program is evaluating how to proceed with funding water treatment and stream quality restoration at the highest priority abandoned coal mine sites. In cases of non-coal cleanups, mitigating impacts associated with discharging adits can be included within the cleanup, although ongoing water treatment is not pursued as a reclamation option to avoid long-term operational commitments, which are outside the scope of the program and funding source. Therefore, even after cleanup, an abandoned non-coal mine site could still represent a source of contaminant loading to a stream, especially if there is a discharging adit associated with the site. Where discharging adits are not of concern, cleanup of either coal or non-coal mines may generally represent efforts to achieve all reasonable land, water, and soil conservation practices for that site.

Additional information about the AML Program is available on DEQ’s website: http://deq.mt.gov/abandonedmines/default.mcpx.

Table 9-1. Priority Abandoned Mine Sites in the Judith Mountains Project Area.

Priority Abandoned Mine	Watershed	DEQ Priority #
Gilt Edge Tailings	Chippewa Creek	40
Tail Holt Mine	Collar Gulch Creek	112
Prester John*	S. Fork Chippewa Creek	45
Cumberland*	Maiden Creek	105

*****Located in unlisted watersheds, not affecting any 2012 303(d) listed streams.

Montana Comprehensive Environmental Cleanup and Responsibility Act (CECRA)
Reclamation of historic mining-related disturbances administered by the State of Montana and not addressed under SMCRA, are typically addressed through the DEQ State Superfund or CECRA program. The CECRA program maintains a list of facilities potentially requiring response actions based on the confirmed release or substantial threat of a release of a hazardous or deleterious substance that may pose an imminent and substantial threat to public health, safety or welfare or the environment (ARM 17.55.108). Listed facilities are prioritized as maximum, high, medium, or low priority or in operation and maintenance status based on the potential threat posed. Currently, there are no active sites on the CECRA priority list in the Judith Mountains Project Area.

CECRA also encourages the implementation of voluntary cleanup activities under the VCRA and CALA. It is possible that any historic mining-related metals loading sources identified in the watershed in the future could be added to the CECRA list and addressed through CECRA, with or without the VCRA and/or CALA process. A site can be added to the CECRA list at DEQ's initiative, or in response to a written request made by any person to the department containing the required information.

CALA and VCRA
CALA is a voluntary process that allows Potentially Responsible Parties to petition for an allocation of liability as an alternative to the strict, joint and several liability scheme included in CECRA. For facilities where a Potentially Responsible Party does not initiate the CALA process, strict, joint and several liability remains. CALA provides a streamlined alternative to litigation that involves negotiations designed to allocate liability among persons involved at facilities requiring cleanup, including bankrupt or defunct persons. Cleanup of these facilities must occur concurrently with the CALA process and CALA provides the funding for the orphan share of the cleanup. DEQ represents the interests of the orphan share throughout the CALA process, as the orphan share is a state special revenue fund.

VCRA formalizes the voluntary cleanup process in the state. The act was developed to permit and encourage voluntary cleanup of facilities where releases or threatened releases of hazardous or deleterious substances exist (regardless of if they are on the CECRA Priority List), by providing interested persons with a method of determining what the cleanup responsibilities will be for reuse or redevelopment of existing facilities. The act offers several incentives to parties voluntarily performing facility cleanup: Any entity can apply and liability protection is provided to entities that would otherwise not be responsible for site cleanup; cleanup can occur on an entire facility or a portion of a facility; and DEQ cannot take enforcement action against any party conducting an approved voluntary cleanup.

Additional information about CECRA, CALA, and VCRA is available on DEQ's website: http://deq.mt.gov/StateSuperfund/default.mcpx.

9.5 Potential Funding Sources

Funding and prioritization of restoration or water quality improvement project is integral to maintaining restoration activity and monitoring successes and failures. Several government agencies fund watershed or water quality improvement projects. Below is a brief summary of potential funding sources to assist with TMDL implementation.

9.5.1 Section 319 Nonpoint Source Grant Program

Section 319 grant funds are typically used to help identify, prioritize, and implement water quality protection projects with focus on TMDL development and implementation of nonpoint source projects.

Individual contracts under the yearly grant typically range from $20,000 to $150,000, with a 25% or more match requirement. 319 projects typically need to be administered through a non-profit or local government such as a conservation district, a watershed planning group, or a county.

9.5.2 Future Fisheries Improvement Program

The Future Fisheries grant program is administered by FWP and offers funding for on-the-ground projects that focus on habitat restoration to benefit wild and native fish. Anyone ranging from a landowner or community-based group to a state or local agency is eligible to apply. Applications are reviewed annually in December and June. Projects that may be applicable to the Judith Mountains Project Area include restoring streambanks, improving riparian vegetation, and restoring/protecting spawning habitats.

9.5.3 Watershed Planning and Assistance Grants

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

Numerous other funding opportunities exist for addressing nonpoint source pollution. Additional information regarding funding opportunities from state agencies is contained in Montana's Nonpoint Source Management Plan (Montana Department of Environmental Quality, 2012c) and information regarding additional funding opportunities can be found at http://www.epa.gov/nps/funding.html.

9.5.4 Environmental Quality Incentives Program

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

9.5.5 Resource Indemnity Trust/Reclamation and Development Grants Program

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

10.0 MONITORING STRATEGY

The monitoring framework discussed in this section is an important component of watershed restoration, a requirement of TMDL development under Montana's TMDL law, and the foundation of the adaptive management approach. While targets and allocations are calculated using the best available data, the data are only an estimate of a complex ecological system. The margin of safety is put in place to reflect some of this uncertainty, but other issues only become apparent when restoration strategies are underway. Having a monitoring strategy in place allows for feedback on the effectiveness of restoration activities (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.

The monitoring framework presented in this section provides a starting point for the development of more detailed and specific planning efforts regarding monitoring needs; it does not assign monitoring responsibility. Monitoring recommendations provided are intended to assist local land managers, stakeholder groups, and federal and state agencies in developing appropriate monitoring plans to meet aforementioned goals. Funding for future monitoring is uncertain and can vary with economic and political changes. Prioritizing monitoring activities depends on stakeholder priorities for restoration and funding opportunities.

The objectives for future monitoring in the Judith Mountains Project Area include: 1) tracking and monitoring restoration activities and evaluating the effectiveness of individual and cumulative restoration activities, 2) baseline and impairment status monitoring to assess attainment of water quality targets and identify long-term trends in water quality and 3) refining the source assessments. Each of these objectives is discussed below.

10.1 ADAPTIVE MANAGEMENT AND UNCERTAINTY

An adaptive management approach is used to manage resource commitments as well as achieve success in meeting the water quality standards and supporting all beneficial uses. This approach works in cooperation with the monitoring strategy and allows for adjustments to the restoration goals or pollutant targets, TMDLs, and/or allocations, as necessary. These adjustments would take into account new information as it arises.

The adaptive management approach is outlined below:

- TMDLs and Allocations: The analysis presented in this document assumes that the load reductions proposed for each of the listed streams will enable the streams to meet target conditions and that meeting target conditions will ensure full support of all beneficial uses. Much of the monitoring proposed in this section of the document is intended to validate this assumption. If it appears greater reductions in loading or improved performance is necessary to meet targets, then updated TMDL and/or allocations will be developed based on achievable reductions via application of reasonable land, soil, and water conservations practices.
- Water Quality Status: As new stressors are added to the watershed and additional data are collected, new water quality targets may need to be developed or existing targets/allocations may need to be modified.

10.2 Tracking and Monitoring Restoration Activities and Effectiveness

Monitoring should be conducted prior to and after project implementation to help evaluate the effectiveness of specific practices or projects. This approach will help track the recovery of the system and the effects, or lack of effects, from ongoing management activities in the watershed. At a minimum, effectiveness monitoring should address the pollutants that are targeted for each project. Information about specific locations, spatial extent, designs, contact information, and any effectiveness evaluation should be compiled about each project. Information about all restoration projects along with tracking overall extent of BMP implementation should be compiled into one location for the entire watershed.

For nutrients and metals, loading reductions and BMP effectiveness can be evaluated with water quality samples and comparing them to the targets. For sediment, which has no numeric standard, loading reductions and BMP effectiveness may be estimated using the approaches used within this document. However, tracking BMP implementation and project-related measurements will likely be most practical for sediment. For instance, for road improvements, it is not anticipated that post-project sediment loads will be measured. Instead, documentation of the BMP, reduced contributing length, and before/after photos documenting the presence and effectiveness of the BMP will be most appropriate. For installation of riparian fencing, before/after photo documentation of riparian vegetation and streambank and a measurement such as greenline that documents the percentage of bare ground and shrub cover may be most appropriate. Evaluating in-stream parameters used for sediment targets will be one of the tools used to gage the success of implementation when DEQ conducts a formal assessment but may not be practical for most projects since the sediment effects within a stream represent cumulative effects from many watershed scale activities and because there is typically a lag time between project implementation and in-stream improvements (Meals et al., 2010).

If sufficient implementation progress is made within a watershed, DEQ will conduct a TMDL Implementation Evaluation (TIE). During this process, recent data are compiled, monitoring is conducted (if necessary), data are compared to water quality targets (typically a subset for sediment), BMP implementation since TMDL development is summarized, and data are evaluated to determine if the TMDL is being achieved or if conditions are trending one way or another. If conditions indicate the TMDL is being achieved, the waterbody will be recommended for reassessment and may be delisted. If conditions indicate the TMDL is not being achieved, according to Montana State Law (75-5-703(9)), the evaluation must determine if:

- The implementation of a new or improved phase of voluntary reasonable land, soil, and water conservation practices is necessary,
- Water quality is improving, but more time is needed for compliance with water quality standards, or
- Revisions to the TMDL are necessary to achieve applicable water quality standards and full support of beneficial uses.

10.3 Baseline and Impairment Status Monitoring

In addition to effectiveness monitoring, watershed scale monitoring should be conducted to expand knowledge of existing conditions and to provide data that can be used during the TIE. Although DEQ is the lead agency for conducting impairment status monitoring, other agencies or entities may collect and provide compatible data. Wherever possible, it is recommended that the type of data and methodologies used to collect and analyze the information be consistent with DEQ methodology so as to allow for comparison to TMDL targets and track progress toward meeting TMDL goals. The information in this section provides general guidance for future impairment status monitoring.

10.3.1 Sediment

Chippewa Creek was stratified into unique reaches based on physical characteristics and human influence. The two assessed sites represent only a percentage of the total number of stratified reaches. Sampling additional monitoring locations could provide additional data to assess existing conditions.

It is acknowledged that various agencies and entities have differing objectives, as well as time and resources available to achieve those objectives. However, when possible, it is recommended that at a minimum the following parameters be collected to allow for comparison to TMDL targets:

- Riffle pebble count (using Wolman Pebble Count methodology and/or 49-point grid tosses)
- Residual pool depth and pool frequency measurements
- Greenline assessment

Additional information will undoubtedly be useful and assist impairment status evaluations in the future and may include total suspended solids, identifying percentage of eroding banks, human sediment sources, areas with a high background sediment load, macroinvertebrate studies, McNeil core sediment samples, and fish population surveys and redd counts.

An important part of impairment determination and adaptive management is determining when a stream has fully recovered from past management practices versus when recovery is still occurring from historical improvements in management but recent BMPs were not applied.

10.3.2 Nutrients

Due to the ephemeral nature of Fargo Coulee, the number of samples available to assist with TMDL development was less than ideal. Additional nutrient monitoring should be conducted in the future, including supporting information such as daily dissolved oxygen, diatoms, and biological oxygen demand.

10.3.3 Metals

Although extensive metals samples were collected to assist with TMDL development, for some metals, insufficient data were collected to fully verify the existing listing. For other metals that are not on the 2012 303(d) List, available data indicate they may be causing impairment but the sample size is too small to make a conclusion. Additional sampling for the metals listed in **Table 10-1** is recommended to characterize watershed conditions during future impairment determinations.

Table 10-1. Waterbody-Pollutant Combinations Where More Sampling is Suggested

Stream Segment	Waterbody ID	Pollutant
Chicago Gulch	MT40B002_020	Aluminum, Selenium
Collar Gulch Creek	MT40B002_030	Iron
Cow Creek	MT40E002_040	Aluminum, Arsenic, Copper, Lead
Armells Creek	MT40E002_022	Cadmium, Mercury, Thallium, Zinc, pH
Fargo Coulee	MT40E002_130	Aluminum, pH

*BLM staff indicated at the public meeting that thallium is exceeding human health standards in the samples recently collected under the BLM source assessment project. Thallium data have not been collected by DEQ and it is recommended this data be evaluated and additional samples collected, if necessary.

10.4 Source Assessment Refinement

In many cases, the level of detail provided by the source assessment only provides broad source categories or areas that need to reduce pollutant loads and additional source inventory and load estimate work may be desirable. Locating more specific sources will also assist in determining where implementation will be most effective. Strategies for strengthening source assessments for each of the pollutants may include more thorough sampling or field surveys of source categories and are described by pollutant in this section. Recommendations for source assessment refinement are described below by pollutant.

10.4.1 Sediment

Sediment-related information that could help strengthen the source assessment includes:

- Refined bank erosion retreat rate for Chippewa Creek.
- A better understanding of bank erosion impacts from historical land management activities.
- Improved modeling for concentrated flow through riparian areas.
- Evaluation of seasonal loading aspects for the major sources and potential implications regarding TMDL target parameters.
- A review of land management practices to determine where the greatest potential for improvement can occur for the major land use categories.

10.4.2 Nutrients

Nutrient-related information that could help strengthen the source assessment includes:

- Additional samples from sites from the middle reach of Fargo Coulee to refine loading patterns and source input locations on this reach.
- Additional samples outside of the growing season when the stream is flowing.
- A better understanding of land management practices to determine where the greatest potential for improvement can occur for the major land use categories.

10.4.3 Metals

Because of the uncertainty regarding the relative contribution from human and natural sources in all watersheds with metals TMDLs, refining this aspect of the source assessment should be a priority. This refinement should focus on defining the contribution from abandoned mines and other discrete mining sources. The study currently being conducted by BLM should be helpful in doing this for Collar Gulch Creek, Chicago Gulch, and Armells Creek. Additionally, there may be discrete abandoned mine sources that are contributing to exceedances of metals targets that are not identified in either of the State databases. As additional information becomes available regarding contributions from abandoned mines, TMDLs may be modified via adaptive management to split composite WLAs into separate WLAs and/or to develop WLAs for discrete mining sources in watersheds dominated by nonpoint source loading that currently have a composite LA.

Several abandoned mines were last assessed by DEQ and/or MBMG years ago, and conditions and source areas at those mines may have changed since then; additional monitoring is recommended to determine the nature of reclamation work required to meet TMDLs.

Metals-related information that could help strengthen source assessments include:

- Investigation of groundwater in the Chippewa Creek watershed to determine the flow path and extent of cyanide migration.

- Site visits to examine environmental impacts of mines in the upper Armells Creek Watershed since deep snow prevented access during the spring 2011 source assessment.
- Further investigations into human metals loading to Cow Creek and the influence on water quality of mining for non-metals (such as coal and zeolites) and other human activities that can result in metals loading through increased erosion.
- Identification of natural background concentrations for Cow Creek and Fargo Coulee.
- Additional monitoring in Fargo Coulee for water samples during low flow conditions and metals concentrations in stream sediments to better understand seasonal loading patterns and specify source areas, especially human sources of metals.

11.0 PUBLIC PARTICIPATION AND COMMENTS

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

11.1 PARTICIPANTS AND ROLES

During completion of the Judith Mountains Project Area TMDLs, DEQ worked with stakeholders to keep them apprised of project status and solicited input from a TMDL advisory group. A description of the participants in the development of the TMDLs in the Judith Mountain Project Area and their roles is contained below.

Montana Department of Environmental Quality
Montana state law (MCA 75-5-703) directs DEQ to develop all necessary TMDLs. DEQ has provided resources toward completion of 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. DEQ has also partnered with watershed organizations to collect data and coordinate local outreach activities for this project.

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

Conservation Districts
DEQ provided both the Fergus County Conservation District and the Blaine County Conservation District with consultation opportunity during development of TMDLs. This included opportunities to provide comment during the various stages of TMDL development, and an opportunity for participation in the advisory group discussed below.

TMDL Advisory Group
The Judith Mountains Project Area Advisory Group consisted of selected resource professionals who possess a familiarity with water quality issues and processes in the Judith Mountains Project Area, and also representatives of applicable interest groups. Advisory group involvement was voluntary and the level of involvement was at the discretion of the individual members. Members had the opportunity to provide comment and review of technical TMDL assessments and reports and to attend meetings organized by DEQ for the purpose of soliciting feedback on project planning. Typically, draft documents were released to the advisory group for review under a limited timeframe, and their comments were then compiled and evaluated. Final technical decisions regarding document modifications resided with DEQ.

Communications with the group members was typically conducted through e-mail and draft documents were made available through DEQ's wiki for TMDL projects (http://montanatmdlflathead.pbworks.com). Opportunities for review and comment were provided for participants at varying stages of TMDL development, including opportunity for review of the draft TMDL document prior to the public comment period.

Area Landowners
Local landowner cooperation in the TMDL process has been critical. Their contribution has included access for stream sampling and field assessments and personal descriptions of seasonal water quality and streamflow characteristics. The DEQ sincerely thanks the planning area landowners for their logistical support and informative participation in impromptu water resource and land management discussions with our field staff and consultants.

11.2 Response to Public Comments

Upon completion of the draft TMDL document, and prior to submittal to EPA, 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, and DEQ addresses and responds to all formal public comments.

The public review period was initiated on April 3, 2013 and ended on May 3, 2013. A public meeting was held in Lewistown, Montana on April 17, 2013. EPA staff provided an overview of the TMDL document, answered questions, and solicited public input and comment on the TMDLs. Notice of the meeting was distributed among the TMDL Advisory Group and posted on the DEQ webpage and at the Fergus Conservation District office. The meeting was and advertised in the following newspapers: The Great Falls Tribune and the Lewistown News. Electronic copies of the draft document were available on the DEQ website, at the Fergus and Blaine Conservation District offices, and at the State Library in Helena, Montana. No public comments were received during the public comment period.

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APPENDIX A – FIGURES AND TABLES

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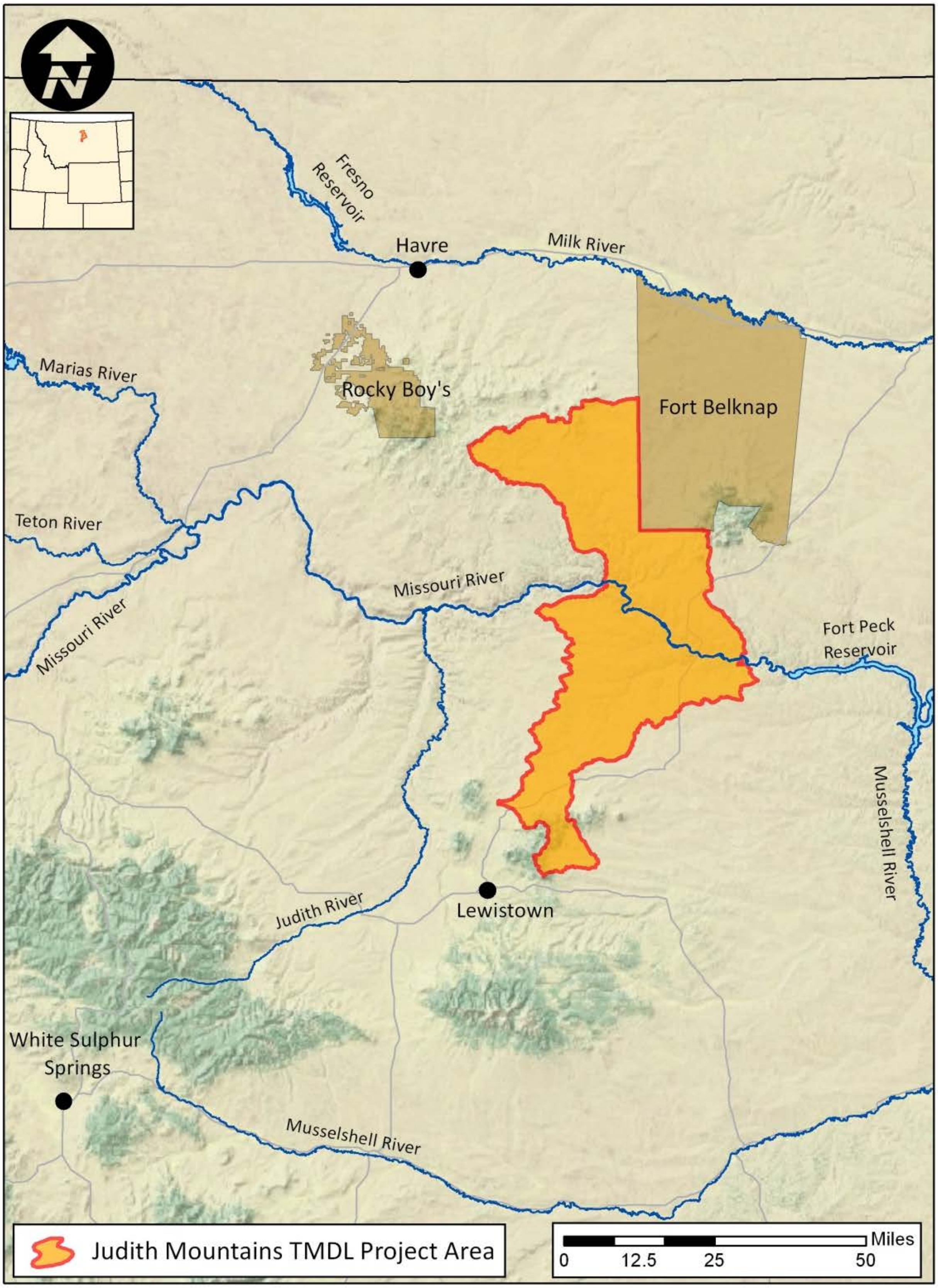

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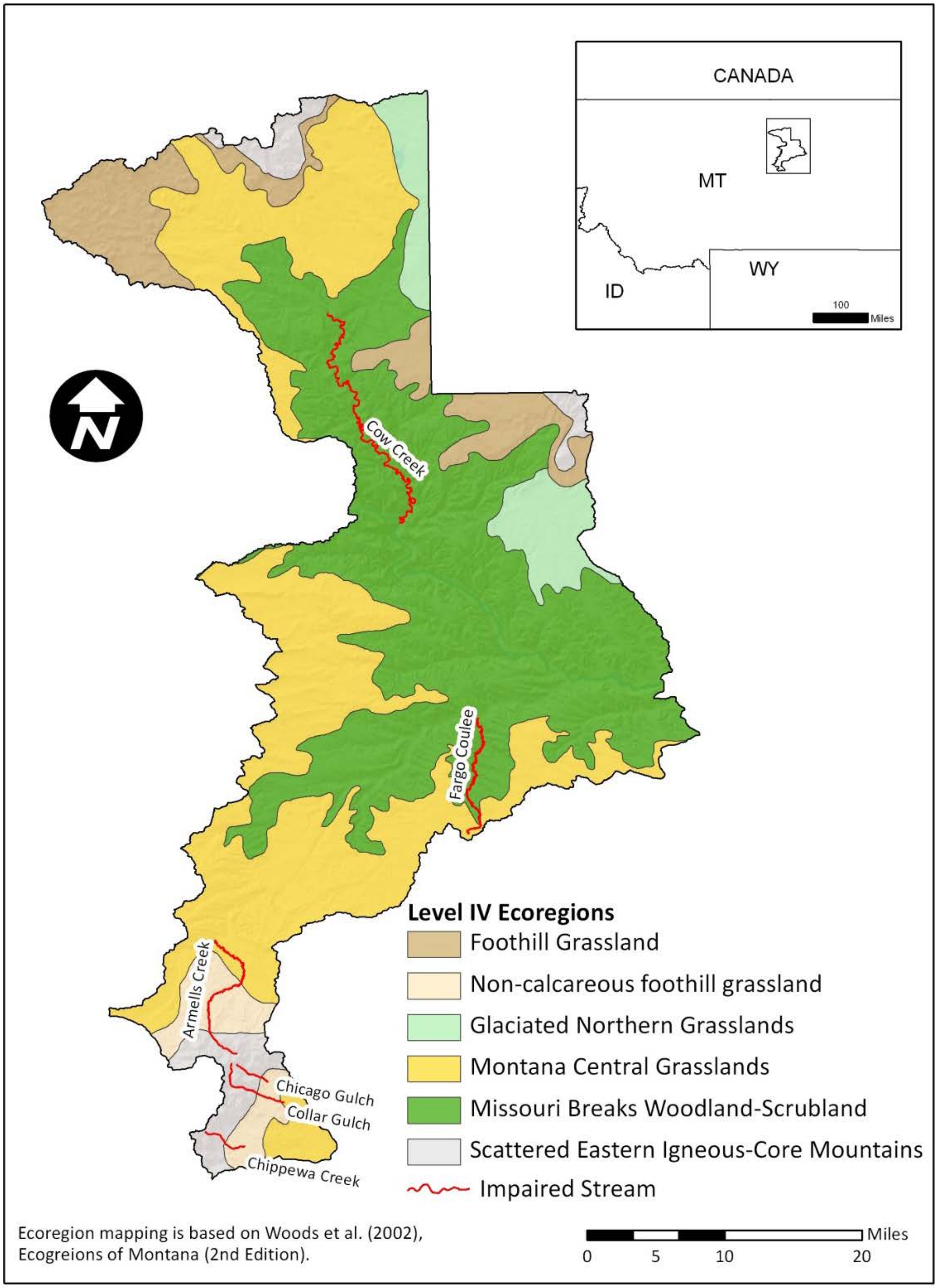

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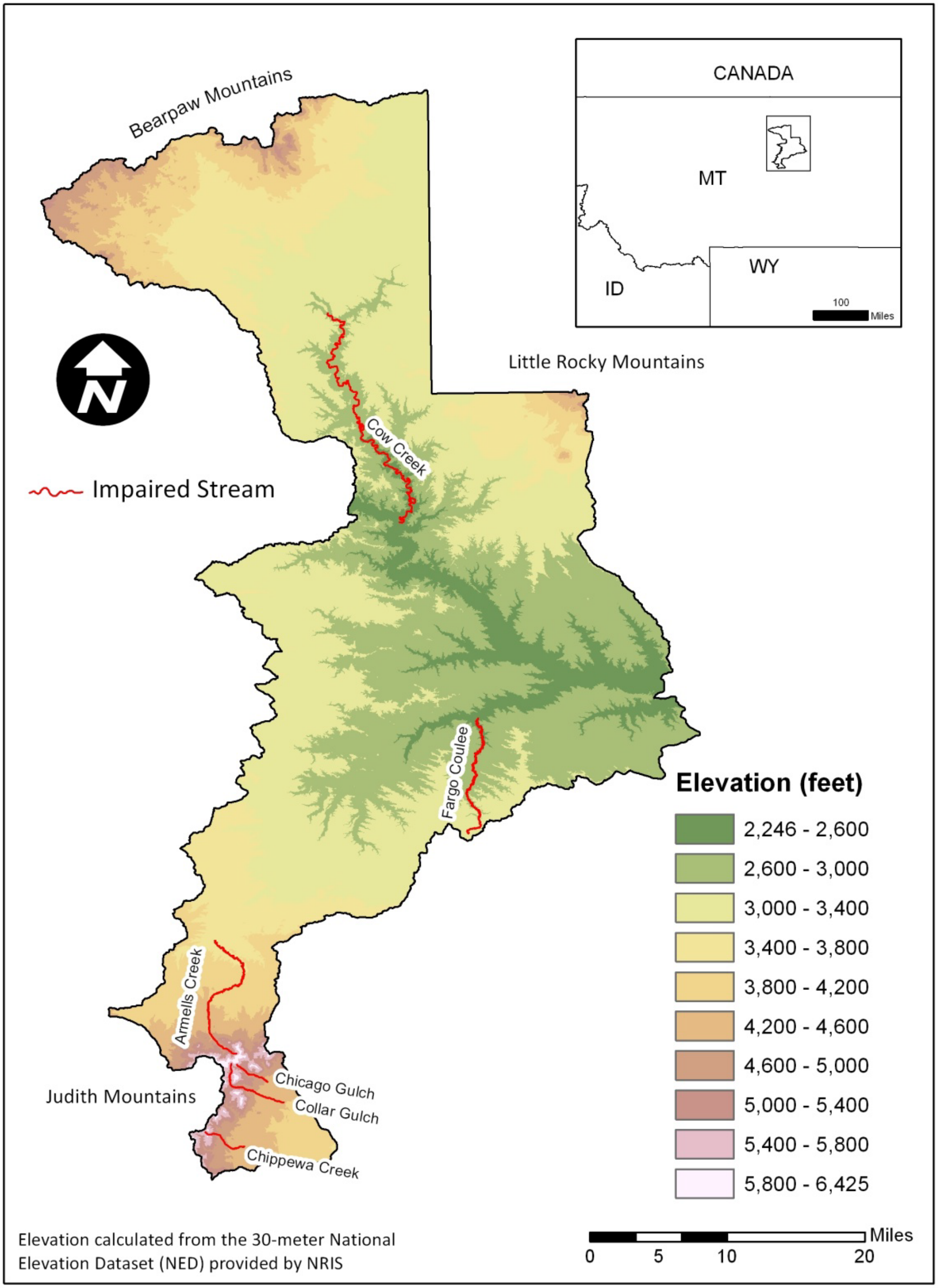

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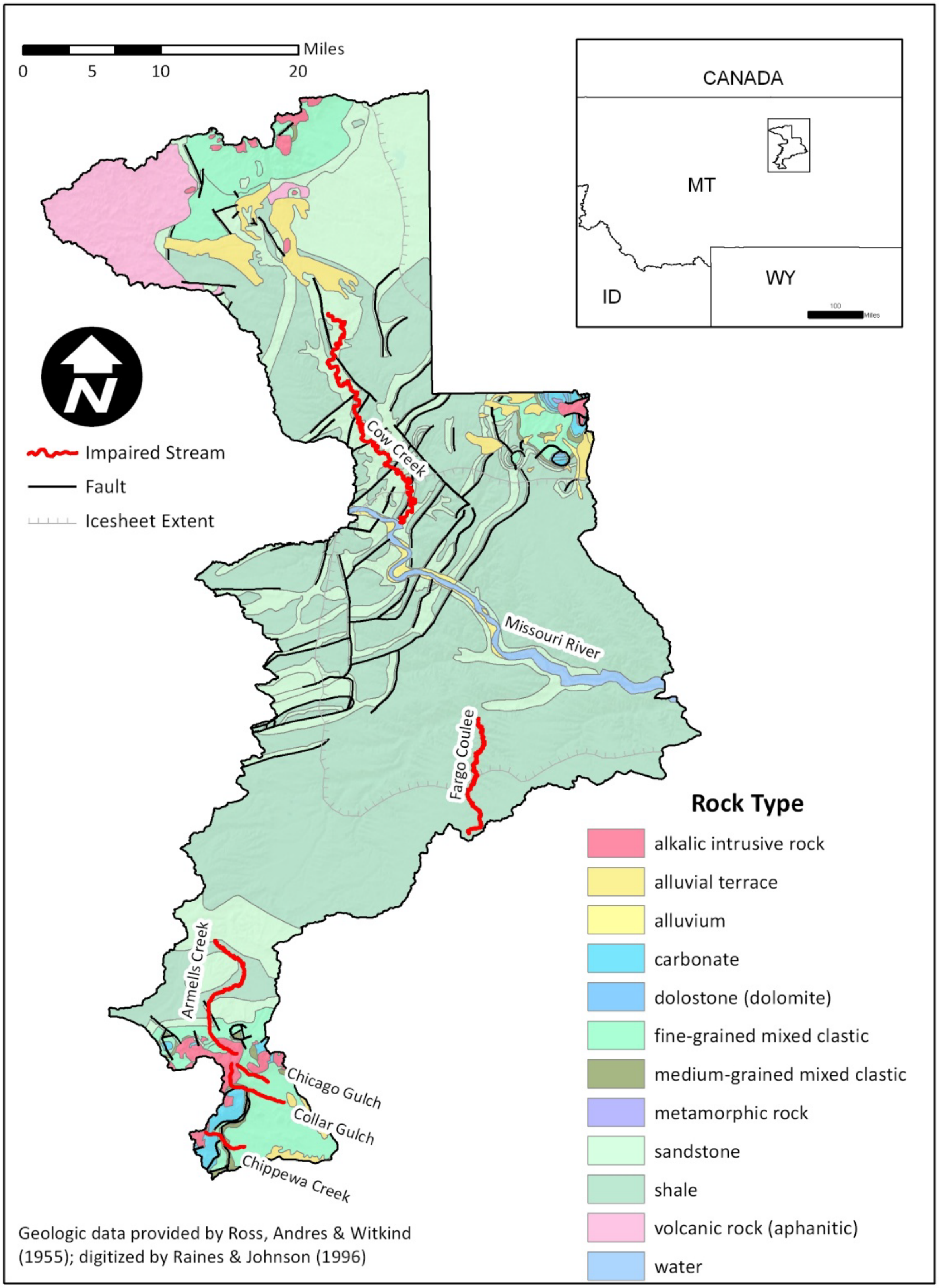

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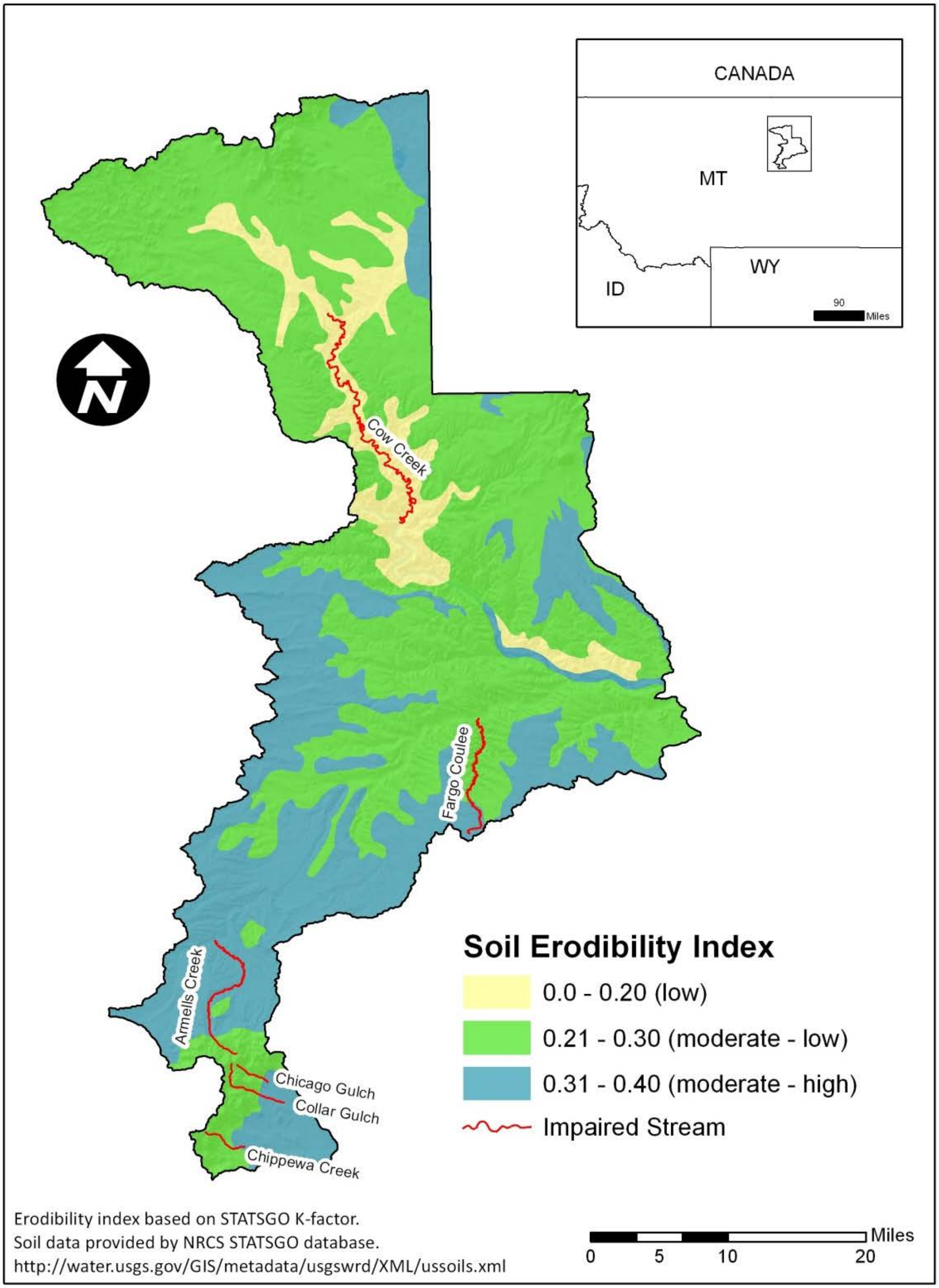

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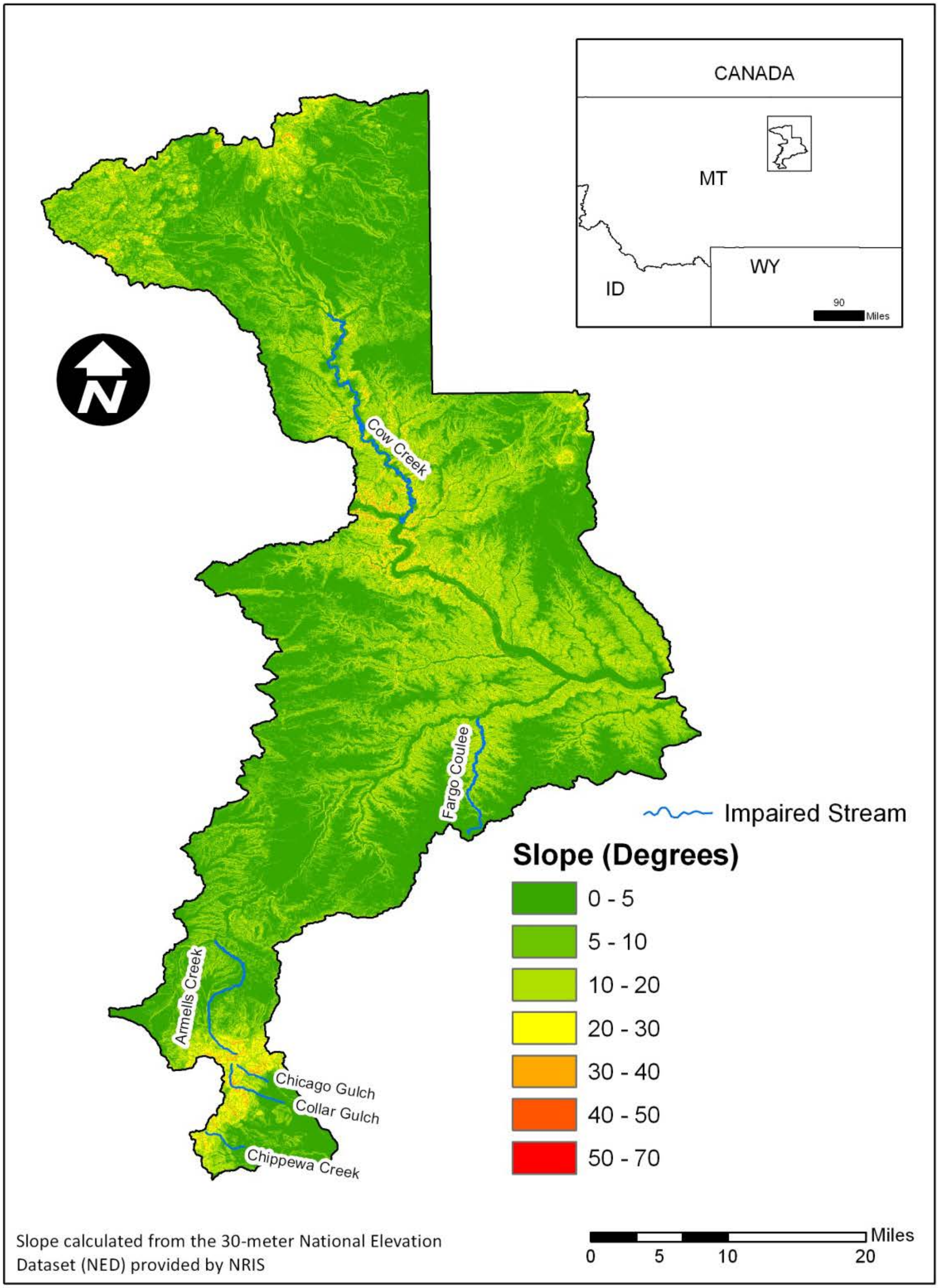

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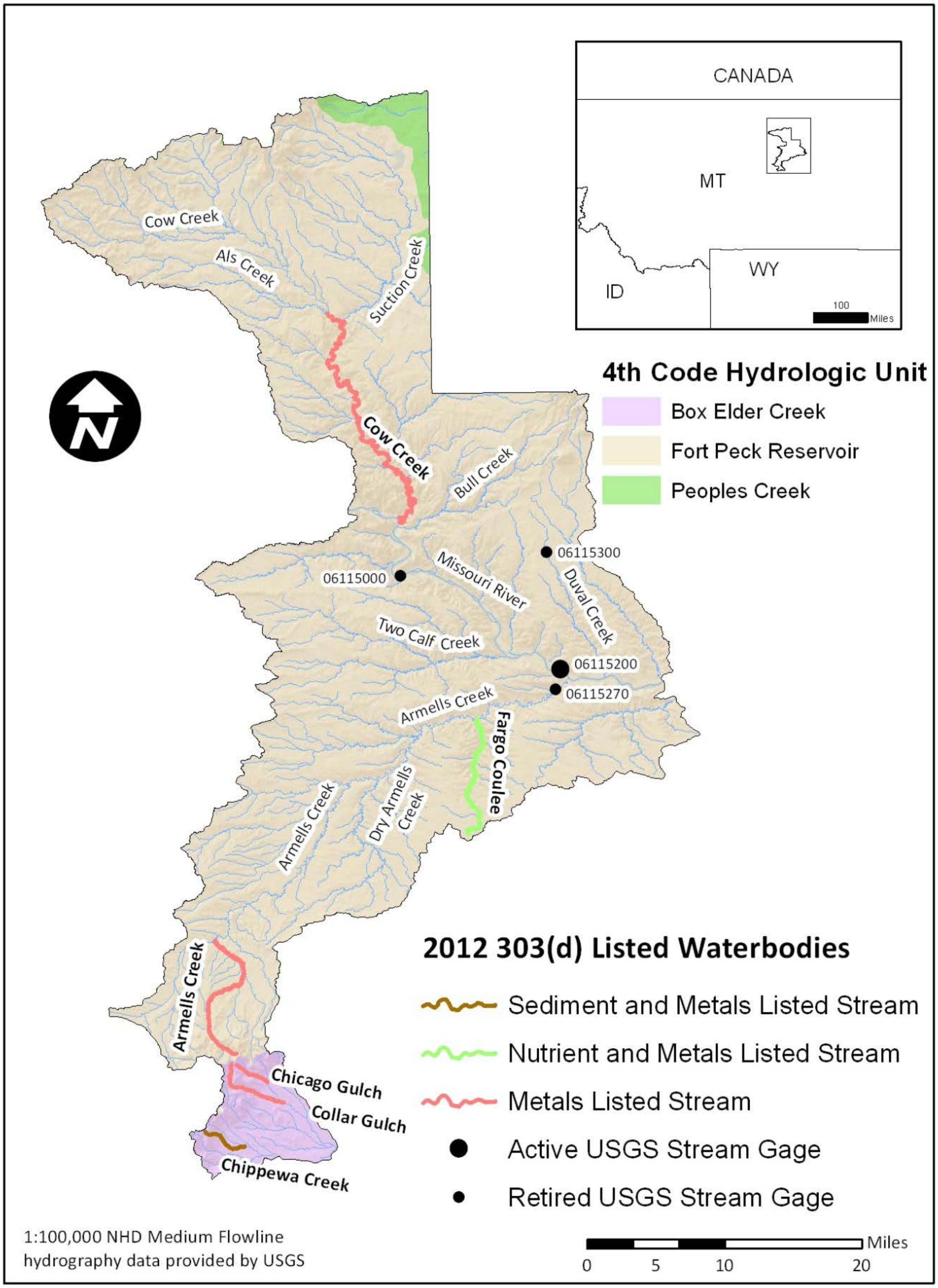

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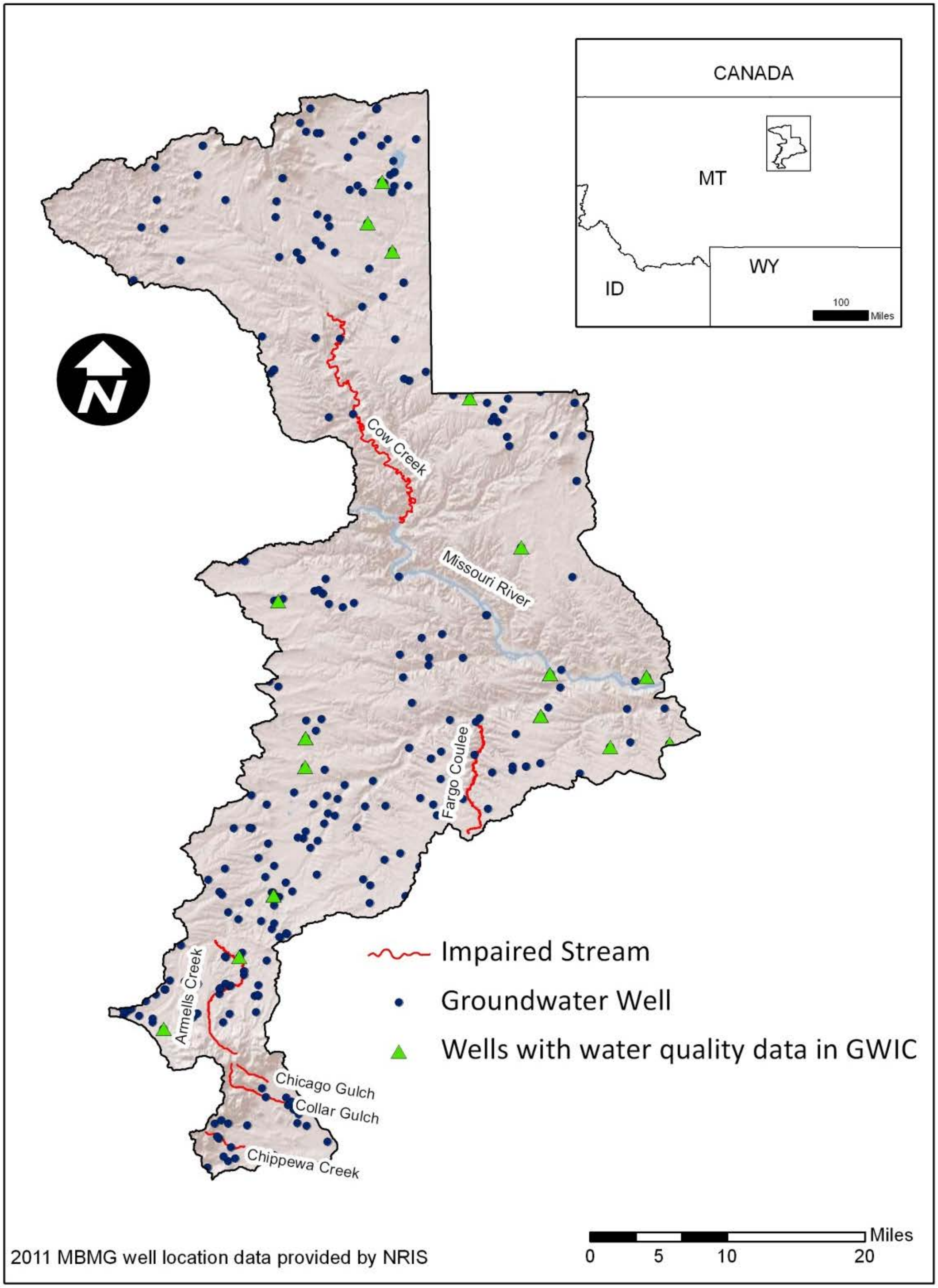

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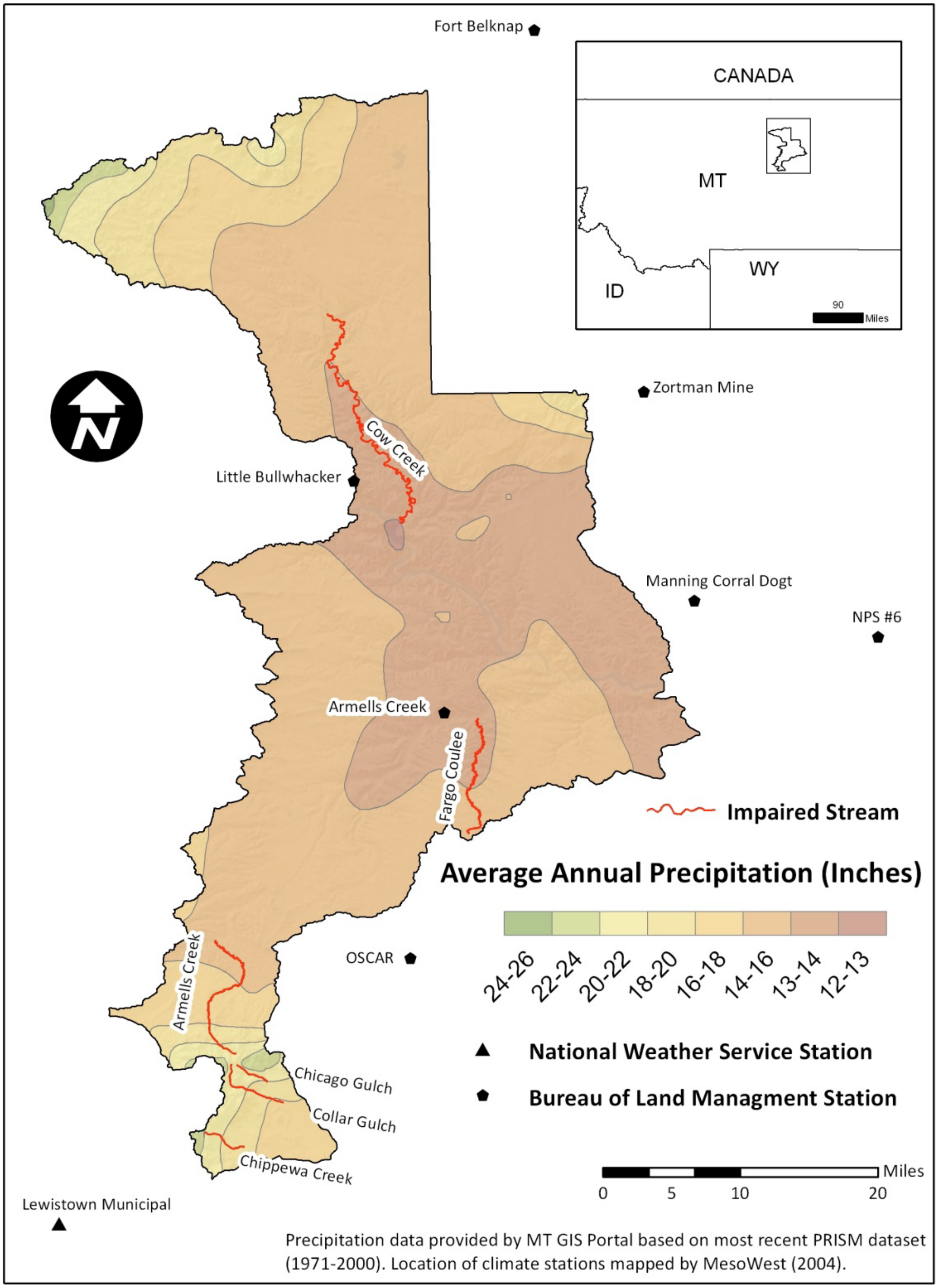

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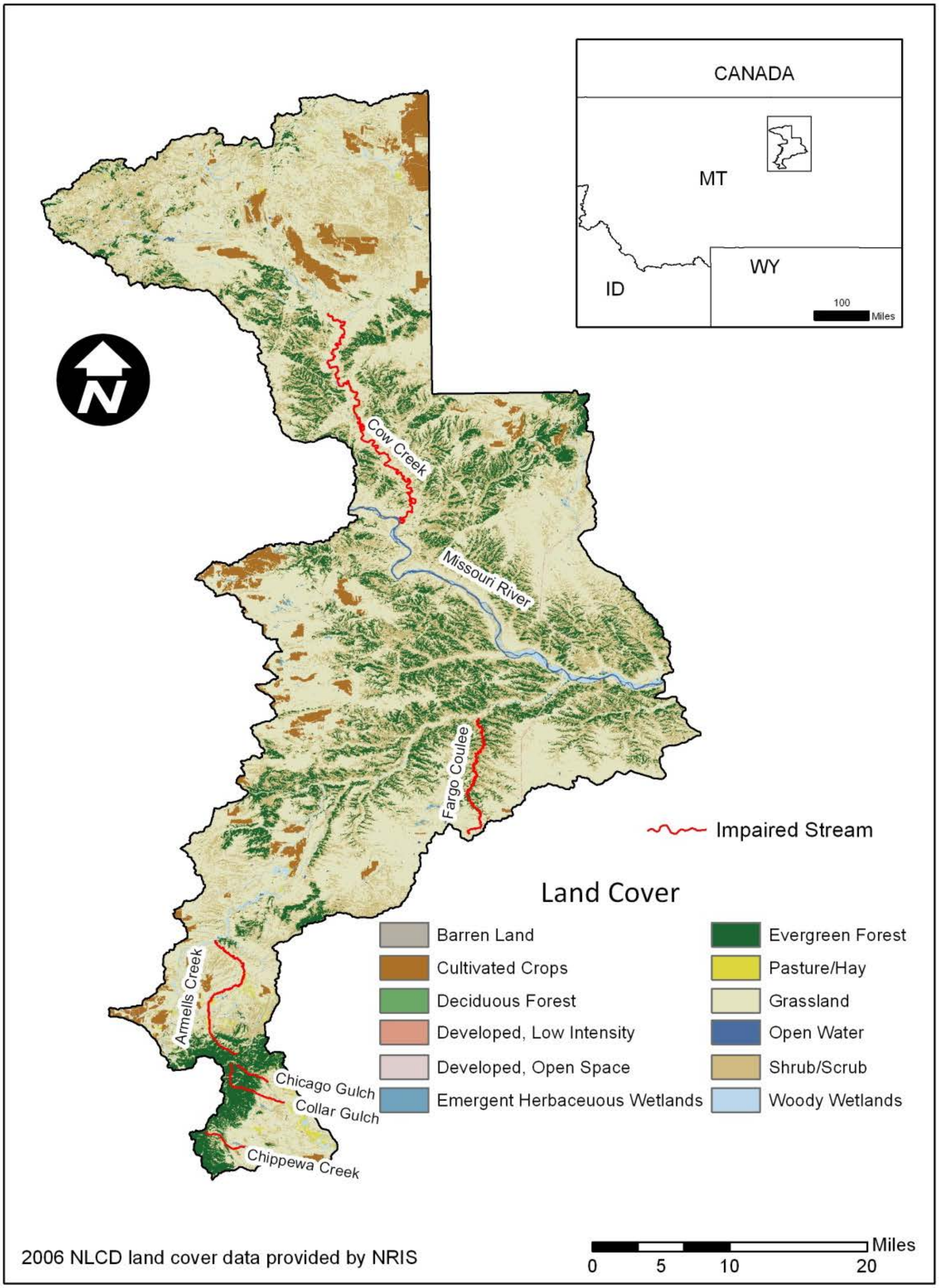

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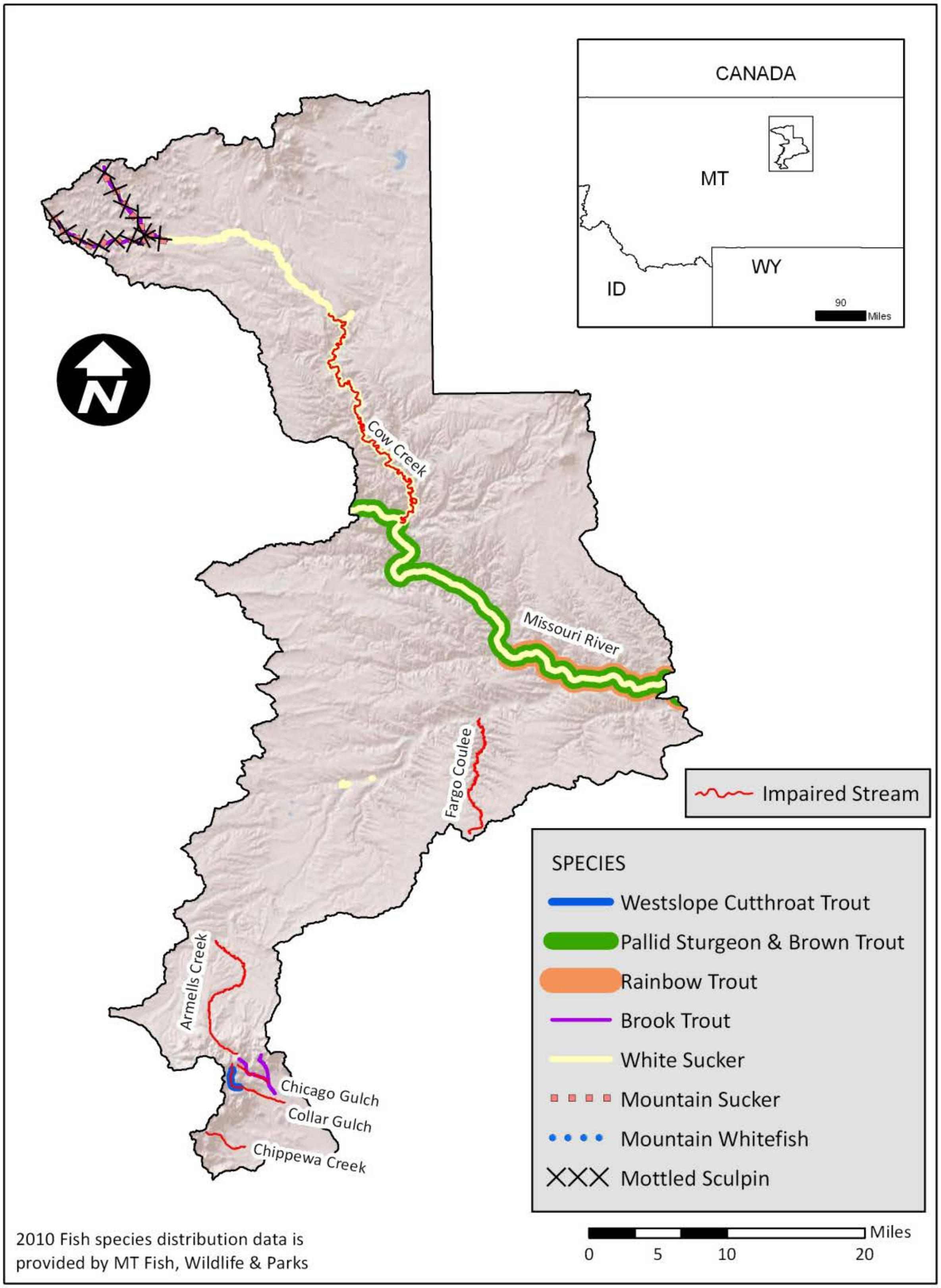

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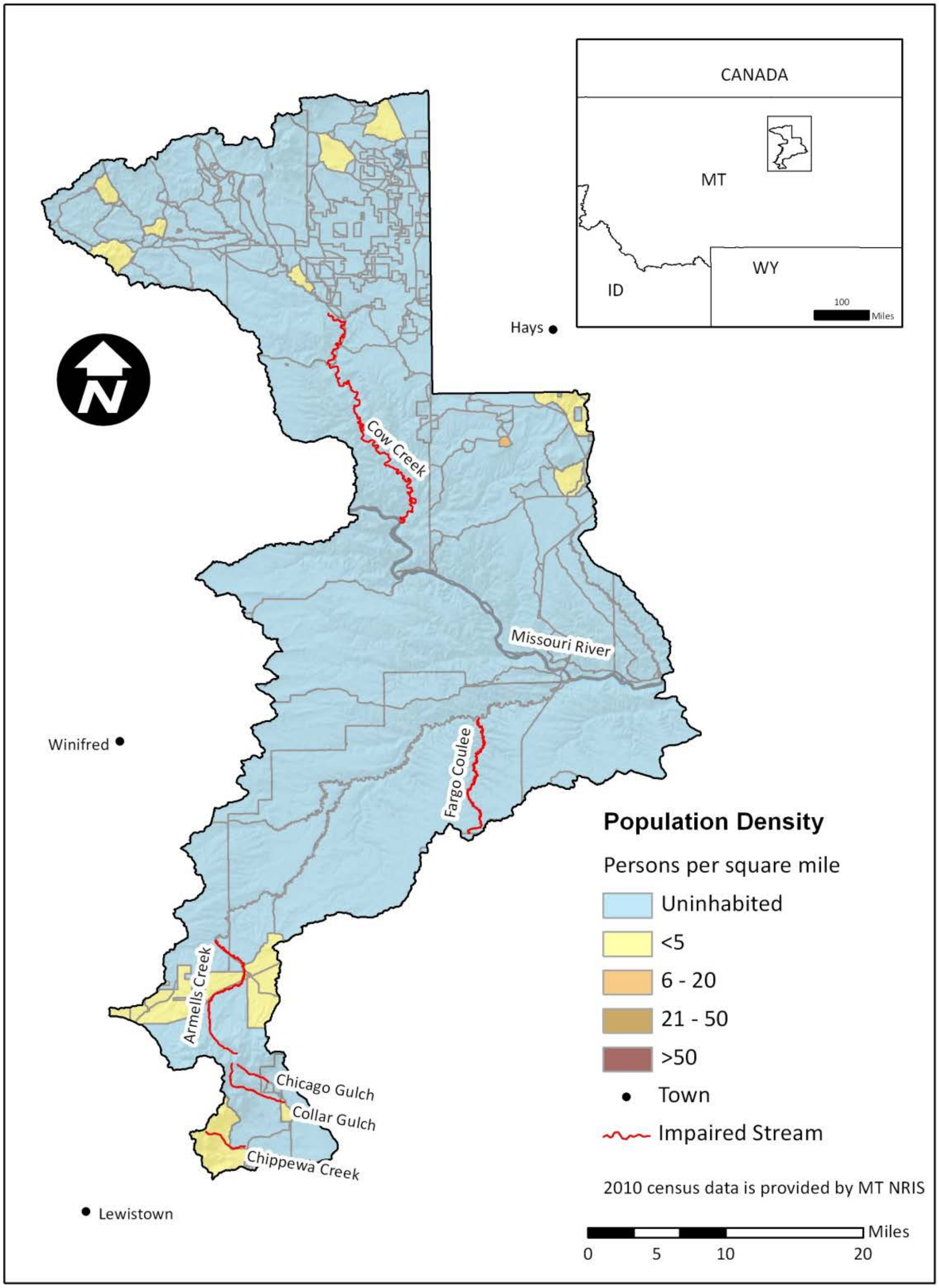

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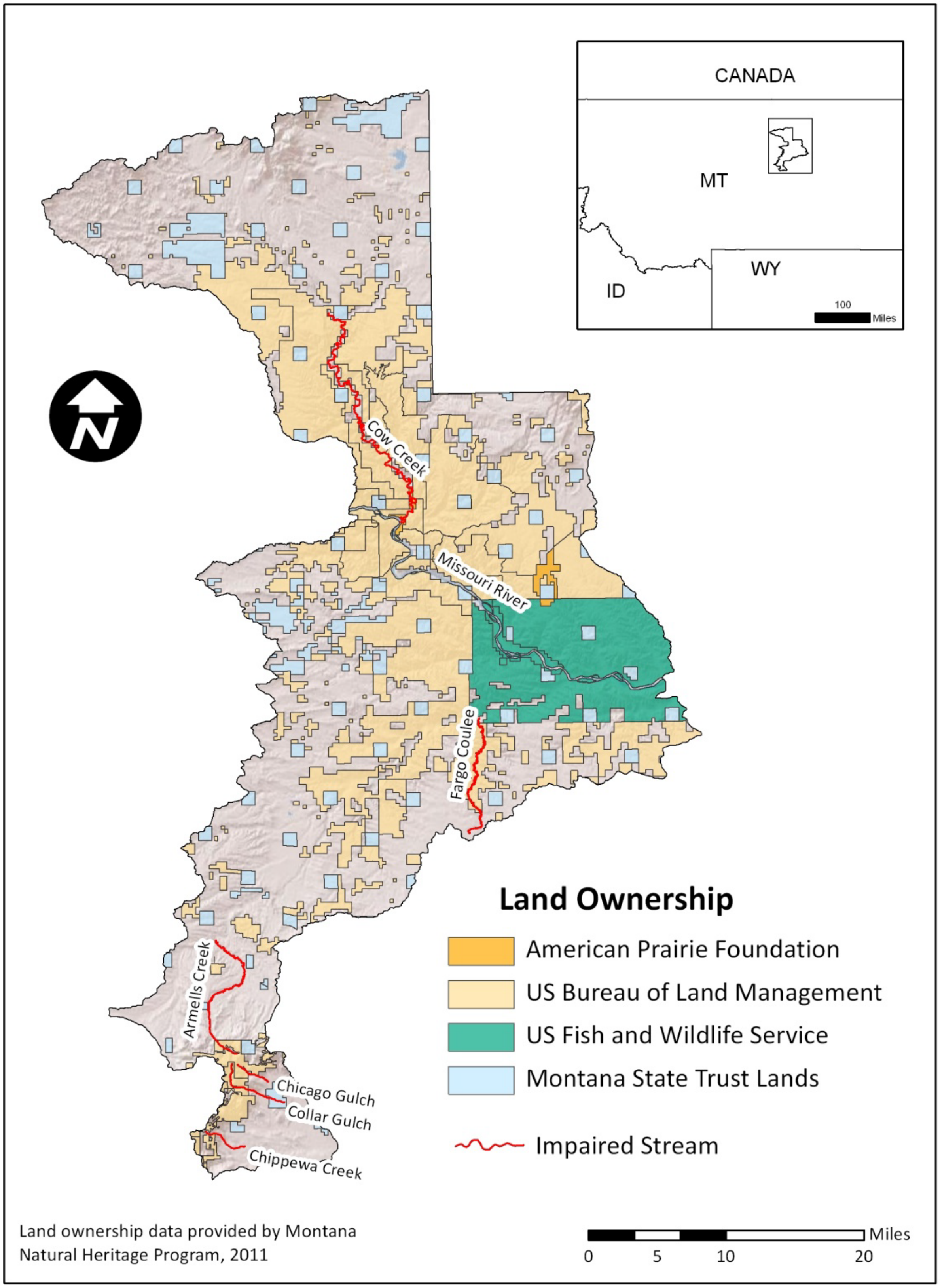

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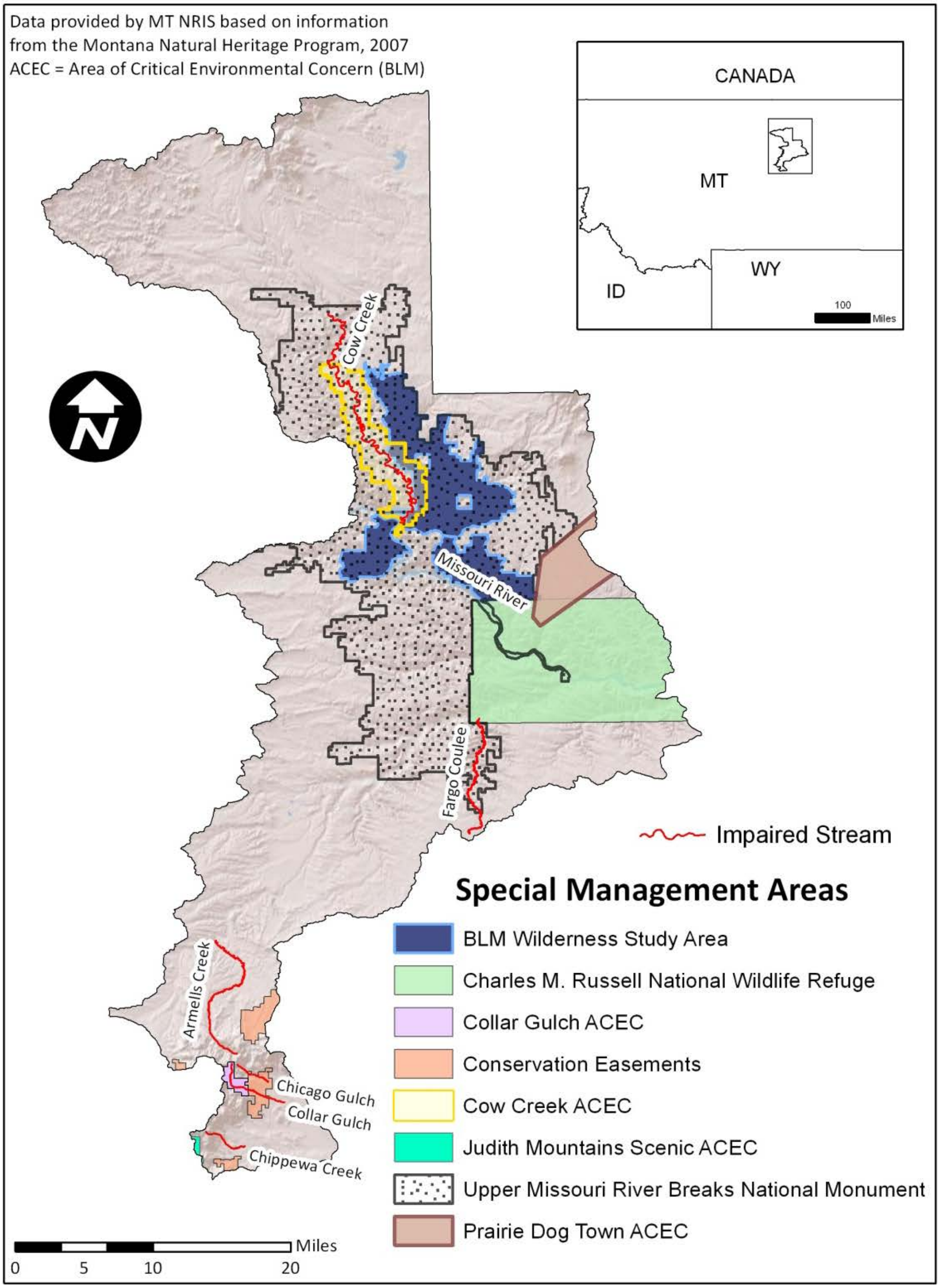

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APPENDIX B - REGULATORY FRAMEWORK AND REFERENCE CONDITION APPROACH

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

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ACRONYMS

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

B1.0 TMDL Development Requirements

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

Since 2004, EPA has requested that states combine the 303(d) list with the 305(b) report containing an assessment of Montana's water quality and its water quality programs. EPA refers to this new combined 303(d)/305(b) report as the Integrated Water Quality Report. The 303(d) list also includes identification of the probable cause(s) of the water quality impairment (e.g. pollutants such as metals, nutrients, sediment, pathogens or temperature), and the suspected source(s) of the pollutants of concern (e.g. various land use activities). State law (MCA 75-5-702) identifies that a sufficient credible data methodology for determining the impairment status of each waterbody is used for consistency. The impairment status determination methodology is identified in DEQ's Water Quality Assessment Process and Methods found in Attachment 1 of Montana's Water Quality Integrated Report (Montana Department of Environmental Quality, 2012b).

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

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

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

B2.0 Applicable Water Quality Standards

WQS include the uses designated for a waterbody, the legally enforceable standards that ensure that the uses are supported, and a nondegradation policy that protects the high quality of a waterbody. The ultimate goal of this TMDL document, once implemented, is to ensure that all designated beneficial uses are fully supported and all water quality standards are met. Water quality standards form the basis for the targets described in **Sections 5.4**, **6.4**, and **7.4**. Pollutants addressed in this framework water quality improvement plan include sediment, nutrients and metals. This section provides a summary of the applicable water quality standards for these pollutants.

B2.1 Classification and Beneficial Uses

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

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

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

Descriptions of Montana's surface water classifications and designated beneficial uses are presented in **Table B2-1**. 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 Judith Mountains Project Area are classified as C-3 (see **Section 3.1** and **Table 3-1** in the main document for individual stream classifications).

Table B2-1. 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 B2-1. 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.

B2.2 Standards

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

Numeric Standards
Numeric surface water quality standards have been developed for many parameters to protect human health and aquatic life. These standards are in the Department Circular DEQ-7 (Montana Department of Environmental Quality, 2012a). The numeric human health standards have been developed for parameters determined to be toxic, carcinogenic, or harmful and have been established at levels to be protective of long-term (i.e., lifelong) exposures as well as through direct contact such as swimming.

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

High quality waters are afforded an additional level of protection by the nondegradation 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 the DEQ. However, under no circumstance may standards be exceeded. It is important to note that waters that meet or are of better quality than a standard are high quality for that parameter, and nondegradation policies apply to new or increased discharges to that the waterbody.

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

The standards applicable to the list of pollutants addressed in the Judith Mountains Project Area TMDLs are summarized below. In addition to the standards below, the beneficial-use support standard for C-3 streams, as defined above, can apply to other conditions, often linked to pollution, limiting aquatic life. These other conditions can include effects from dewatering/flow alterations and effects from habitat modifications.

B.2.2.1 Sediment Standards

Sediment (i.e., coarse and fine bed sediment) and suspended sediment are addressed via the narrative criteria identified in **Table B2-2**. The relevant narrative criteria do not allow for harmful or other undesirable conditions related to increases above naturally occurring levels or from discharges to state surface waters. This is interpreted to mean that water quality goals should strive toward a condition in which any increases in sediment above naturally occurring levels are not harmful, detrimental or injurious to beneficial uses (see definitions in **Table B2-2**).

Table B2-2. Applicable Rules for Sediment Related Pollutants

Rule	Standard
17.30.629(2)	No person may violate the following specific water quality standards for waters classified C-3:
17.30.629(2)(d)	The maximum allowable increase above naturally occurring turbidity is 10 NTU except as permitted in 75-5-318, MCA.
17.30.623(2)(f)	No increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except a 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, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.
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)(a)	Settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines;
17.30.637(1)(d)	Create concentrations or combinations of materials that are toxic or harmful to human, animal, plant, or aquatic life.
17.30.602(19)	"Naturally occurring" means conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil, and water conservation practices have been applied.
17.30.602(25)	"Reasonable land, soil, and water conservation practices" means methods, measures, or practices that protect present and reasonably anticipated beneficial uses. These practices include but are not limited to structural and nonstructural controls and operation and maintenance procedures. Appropriate practices may be applied before, during, or after pollution-producing activities.

B.2.2.2 Nutrient Standards

The narrative standards applicable to nutrients in Montana are contained in the General Prohibitions of the surface water quality standards (ARM 17.30.637 et. Seq.,). The prohibition against the creation of "*conditions which produce undesirable aquatic life*" is generally the most relevant to nutrients. Undesirable aquatic life includes bacteria, fungi, and algae. Montana has recently developed draft nutrient criteria for nitrate+nitrite nitrogen (NO_2+NO_3), total nitrogen (TN), total phosphorus (TP), and chlorophyll-*a* based on the Level III ecoregion in which a stream is located (Suplee et al., 2008). For the Northwestern Glaciated Plains Level III Ecoregion, draft water quality criteria for TN and TP are presented in **Table B2-3**. These criteria are growing season, or summer, values applied from July 1st through September 30th. Additionally, numeric human health standards exist for nitrogen (**Table B2-4**), but the narrative standard is most applicable to nutrients as the concentration in most waterbodies in Montana is well below the human health standard and the nutrients contribute to undesirable aquatic life at much lower concentrations than the human health standard.

Table B2-3. Numeric Nutrient Criteria for the Northwestern Glaciated Plains Ecoregion.

Parameter	Target Value
Total Nitrogen (TN)	≤ 1.4 mg/L
Total Phosphorus (TP)	≤ 0.14 mg/L

Table B2-4. Human Health Standards for Nitrogen for the State of Montana.

Parameter	Human Health Standard (µL)[1]
Nitrate as Nitrogen (NO_3-N)	10,000
Nitrite as Nitrogen (NO_2-N)	1,000
Nitrate plus Nitrite as N	10,000

[1]Maximum Allowable Concentration.

B.2.2.3 Metals Standards

Water quality standards that are applicable to metals impairments include both numeric water quality criteria given in DEQ-7 (**Table B2-5**) and general prohibitions (narrative criteria) given in **Table B2-6.** As water quality criteria for many metals is dependent upon water hardness, **Table B2-5** presents acute and chronic metals numeric water quality criteria at water harnesses of 25, 100 and 400 mg/L for metals of concern in the Judith Mountains Project Area. Also presented in **Table B2-5** is the Human Health Criteria (HHC): note that for mercury and arsenic, the HHC is lower than applicable chronic criteria.

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

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

Table B2-5. Metals Numeric Water Quality Criteria for the Judith Mountains Project Area.

Metal of concern	Aquatic life criteria (ug/L) at 25 mg/L hardness		Aquatic life criteria (ug/L) at 100 mg/L hardness		Aquatic life criteria (ug/L) at 400 mg/L hardness		HHS (ug/L)
	Acute	Chronic	Acute	Chronic	Acute	Chronic	
Aluminum, dissolved	750	87	750	87	750	87	---
Antimony, TR	---	---	---	---	---	---	5.6
Arsenic, TR	340	150	340	150	340	150	10
Cadmium, TR	0.52	0.1	2.1	0.27	8.7	0.76	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

Table B2-5. Metals Numeric Water Quality Criteria for the Judith Mountains Project Area.

Metal of concern	Aquatic life criteria (ug/L) at 25 mg/L hardness		Aquatic life criteria (ug/L) at 100 mg/L hardness		Aquatic life criteria (ug/L) at 400 mg/L hardness		HHS (ug/L)
	Acute	Chronic	Acute	Chronic	Acute	Chronic	
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 B2-5**, narrative criteria also provides 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 B2-6**. 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 B2-6**). Evaluation of numeric and narrative criteria for specific metals impairments by stream segment is given in **Section 7.4.3**.

Table B2-6. Applicable Rules for Metals Concentrations in Sediment

Rule(s)	Criteria
17.30.629 (1)	Waters classified C-3 are to be maintained suitable for bathing, swimming, and recreation, and 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.
17.30.629(2)	No person may violate the following specific water quality standards for waters classified C-3:
17.30.629(2)(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, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.
17.30.629(2)(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.

B.2.2.3.1 pH Standards

Waterbodies impaired by metals are also sometimes impaired by pH as a result of acid mine drainage. For human health, changes in pH are addressed by the general narrative criteria in ARM 17.30.601 et seq. and ARM 17.30.1001 et seq. For aquatic life, which can be sensitive to small pH changes, criteria are specified for each waterbody use classification. For C-3 waters, ARM 17.30.629(2)(c) states "Induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 9.0 must be less than 0.5 pH unit. Natural pH outside this range must be maintained without change. Natural pH above 7.0 must be maintained above 7.0."

B3.0 Reference Conditions

B3.1 Reference Conditions as Defined in DEQ's Standard Operating Procedure for Water Quality Assessment (2006)

DEQ uses the reference condition to evaluate compliance with many of the narrative WQS. 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 waterbodies 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 WQS do not contain specific provisions addressing nutrients (nitrogen and phosphorous), or 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 nutrients, 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.

B3.2 Use of Statistics for Developing Reference Values or Ranges

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

Figure B3-1 is an example boxplot type presentation of the median, 25^{th} and 75^{th} percentiles, and minimum and maximum values of a reference data set. In this example, the reference stream results are stratified by two different stream types. Typical stratifications for reference stream data may include Rosgen stream types, stream size ranges, or geology. If the parameter being measured is one where low values are undesirable and can cause harm to aquatic life, then measured values in the potentially impaired stream that fall below the 25^{th} 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 75^{th} percentile can be used to indicate impairment.

The use of a non-parametric statistical distribution for interpreting narrative WQS or developing numeric criteria is consistent with EPA guidance for determining nutrient criteria (Buck et al., 2000).

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

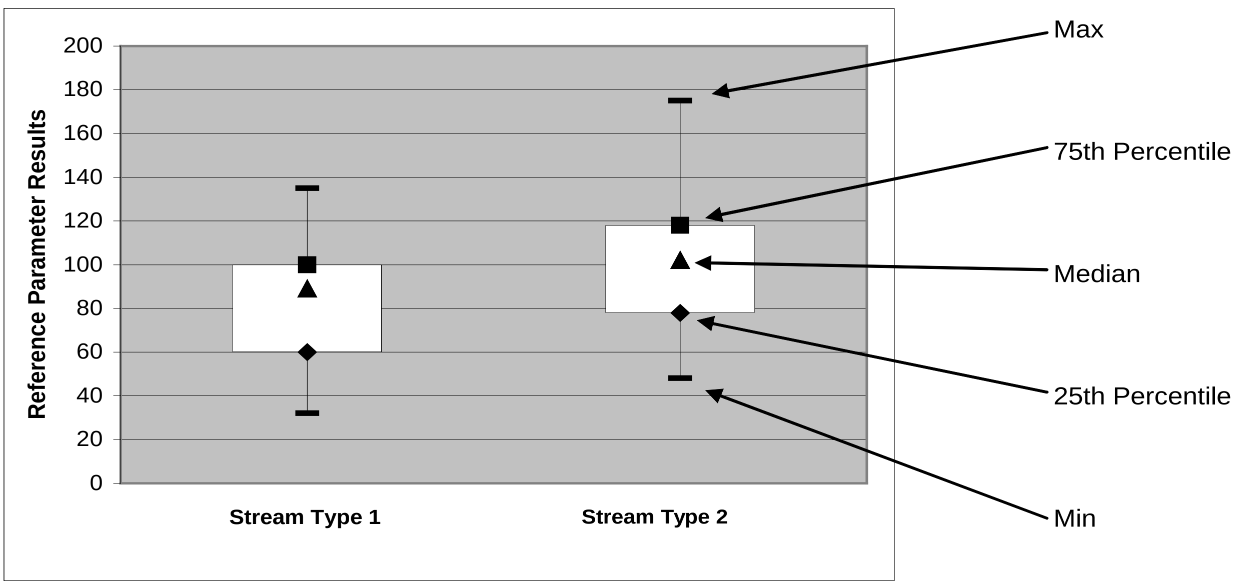

Figure B3-1. Boxplot Example for Reference Data.

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 WQS in **Table B2-2**. In other words, if not meeting the reference range is not expected to negatively impact aquatic life, coldwater fish, or other beneficial uses, then an impairment determination should not be made based on the particular parameter being evaluated. Relationships that show an impact to the beneficial use can be used to justify impairment based on the above statistical approach.

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

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

Options When Regional Reference Data is Limited or Does Not Exist

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

Another approach would be to develop statistics for a given parameter from all streams within a watershed or region of interest (Buck et al., 2000). The boxplot distribution of all the data for a given parameter can still be used to help determine potential target values knowing that most or all of the streams being evaluated are either impaired or otherwise have a reasonable probability of having significant water quality impacts. Under these conditions you would still use the median and the 25th or 75th percentiles as potential target values, but you would use the 25th and 75th percentiles in a way that is opposite from how you use the results from a regional reference distribution. This is because you are assuming that, for the parameter being evaluated, as many as 50% to 75% of the results from the whole data distribution represent questionable water quality. **Figure B3-2** is an example statistical distribution of an entire dataset where lower values represent better water quality (and reference data are limited). In **Figure B3-2**, 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.

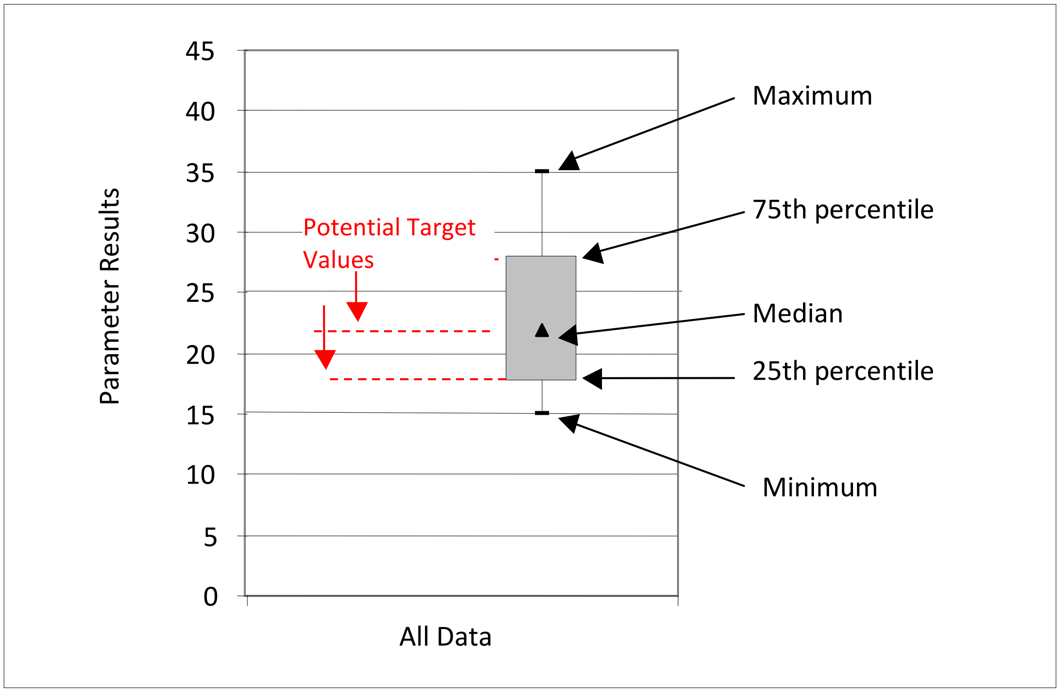

Figure B3-2. Boxplot example for the use of all data to set targets.

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APPENDIX C - CHIPPEWA CREEK SEDIMENT ASSESSMENT

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C1.0 INTRODUCTION

An assessment of sediment loading to Chippewa Creek was performed to facilitate development of sediment TMDLs for this 303(d) listed stream segment in the Judith Mountains TMDL project area. Chippewa Creek is a tributary to McDonald Creek and is located within the Box Elder HUC8 (10040204). The upper 3.8 miles of Chippewa Creek are listed as impaired for sediment and this segment of Chippewa Creek (MT40B002_040) is defined as Chippewa Creek from the headwaters to the confluence with Manitoba Gulch. This assessment included an evaluation of sediment loads associated with unpaved roads, uplands, and a mill tailings pile. A sediment and habitat evaluation of Chippewa Creek was also performed during this assessment to help better characterize existing conditions within the stream. This document describes the assessment approach and results for each source assessment category.

C2.0 METHODS

C2.1 Unpaved Roads Assessment

The road assessment employed GIS analysis, field data collection, and WEPP modeling to assess sediment loading from the unpaved road network to Chippewa Creek.

C2.1.1 GIS Analysis

Prior to field data collection, GIS data layers representing the road network, stream network, land ownership, and ecoregions were used to identify unpaved road crossings throughout the Chippewa Creek watershed. Through GIS analysis, five unpaved road crossings were identified within the Chippewa Creek watershed upstream of Manitoba Gulch.

C2.1.2 Field Data Collection

In October of 2010, a field assessment of unpaved roads was conducted by performing an inspection of sites where unpaved roads cross Chippewa Creek. A total of five unpaved road crossings were identified in the Chippewa Creek watershed, all of which were examined in the field. A complete assessment of potential sediment loading was conducted at three of the unpaved road crossings. At each assessed unpaved road crossing, a series of measurements were performed to define road design, maintenance level, condition, and sediment loading potential. Measurements included the length, gradient, and width of road contributing sediment from each side of a stream crossing. Additional information was collected describing road design, road surface type, soil type, rock content, traffic level, and the presence of any Best Management Practices (BMPs). Information collected at each assessed unpaved road crossing was used to estimate sediment loading with the WEPP:Road model.

C2.1.3 WEPP Modeling

Sediment loading to Chippewa Creek from unpaved road crossings was estimated using the WEPP:Road soil erosion model (http://forest.moscowfsl.wsu.edu/fswepp/). WEPP:Road is an interface to the Water Erosion Prediction Project (WEPP) model developed by the USDA Forest Service and other agencies, and is used to predict runoff, erosion, and sediment delivery from forest roads. The WEPP:Road model predicts sediment yields based on specific soil, climate, ground cover, and topographic conditions. Field data collected from each field assessed unpaved road crossing provided the following input data necessary to run the WEPP:Road model:

- Road design: insloped, bare ditch; insloped, vegetated or rocked ditch; outsloped, rutted; outsloped unrutted
- Road surface: native, graveled, paved
- Traffic level: high, low, none
- Soil texture: clay loam, silt loam, sandy loam, loam
- Rock content
- Gradient, length and width of the road, fill and buffer
- Climate data
- Years to simulate

C2.2 Sediment and Habitat Assessment

The sediment and habitat assessment was performed at two monitoring sites along Chippewa Creek in October of 2010. Sediment and habitat data was collected following the approach described in *Longitudinal Field Methods for the Assessment of TMDL Sediment and Habitat Impairments*(Montana Department of Environmental Quality, 2009). Field monitoring sites were selected in low-gradient portions of Chippewa Creek where sediment deposition is likely to occur. Monitoring sites were assessed progressing upstream and a monitoring site length of 500 feet was utilized since the bankfull width was less than 10 feet (Montana Department of Environmental Quality, 2009). Each monitoring site was divided into five equally sized study cells in which a series of sediment and habitat measurements were performed. Study cells were numbered 1 through 5 progressing in an upstream direction. At each monitoring site, the following measurements were performed:

- Channel form and stability measurements
    - Channel cross-sections
    - Floodprone width measurements
    - Water surface slope

- Fine sediment measurements
    - Riffle pebble count
    - Riffle grid toss

- Instream habitat measurements
    - Channel bed morphology
    - Residual pool depth
    - Pool habitat quality
    - Large woody debris (LWD) quantification

- Riparian health measurements
    - Riparian greenline assessment
    - Proper functioning condition (PFC) assessment

C2.3 Sediment Contributions from Mill Tailings

Sediment loading from the mill tailings pile was assessed based on field observations, GIS analysis and modeling. Field observations were performed during site visits in August and October of 2010 and May of 2011 and included field photographs and notes. GIS analysis using color aerial imagery from 2009 was used to estimate the size of the mill tailings pile. In GIS, the “inner perimeter” of the tailings pile was digitized to represent the main sediment source area for the mill tailings pile, which covers approximately 0.66 acres. The “outer perimeter” was also digitized to document the complete extent of mill tailings at this site, which covers approximately 2.67 acres. For the “inner perimeter”, the width running parallel to Chippewa Creek was estimated at 180 feet, while a length of 160 feet was estimated from aerial imagery in GIS. Sediment loading was then evaluated using WEPP Hillslope with the filter strip application enabled (http://milford.nserl.purdue.edu/wepp/filter.php).

C2.4 USLE Assessment

Upland sediment loading from hillslope erosion was modeled using a Universal Soil Loss Equation (USLE) based model which was combined with a sediment delivery ratio (SDR) to predict the amount of sediment delivered into Chippewa Creek. The USLE based model was implemented as a watershed-scale, raster-based, GIS model using ArcView GIS software. Details and data sources of each factor in the model are described in subsequent sections of this report.

C2.4.1 Modeling Approach

The USLE model requires five landscape factors which are combined to predict upland soil loss, including a rainfall factor (R), soil erodibility factor (K), length and slope factors (LS), a cropping factor (C), and a management practices factor (P). The general form of the USLE equation has been widely used for upland sediment erosion modeling and is presented as (Brooks et al., 1997):

$$A = RK(LS)CP \text{ (in tons per acre per year)}$$

The **R-factor** characterizes the effect of raindrop impact and runoff rates associated with a rainstorm. It is a determined using the kinetic energy of a rainfall event (measured in hundreds of ft-tons per acre per year) and the maximum 30-minute rainfall intensity (inches per hour) for an area. The total kinetic energy of a rain event is obtained by multiplying the kinetic energy per inch of rainfall by the depth of rainfall during each intensity period.

The **K-factor** is a soil erodibility factor that quantifies the susceptibility of soil to erosion. It is a measure of the average soil loss (tons per acre per hundreds of ft-tons per acre of rainfall intensity) from a particular soil in continuous fallow, and has been derived from previous experimental data.

The **LS-factor** is a function of the slope and flow length of the eroding slope or cell. For the purpose of computing the LS-factor, slope is defined as the average land surface gradient per cell. The flow length refers to the distance between where overland flow originates and runoff reaches a defined channel or depositional zone. The equation used for calculating the length and slope factor (LS) was provided by Lim, et al. (2005) using a method developed by Moore and Burch (1986b; 1986a). The equation used to calculate LS is provided below; where A is flow length multiplied by cell size, and Θ is slope angle in degrees.

$$LS = \left(\frac{A}{22.13}\right)^{0.4} * \left(\frac{\sin\Theta}{0.0896}\right)^{1.3}$$

The **C-factor** is a crop management value that represents the ratio of soil erosion from a specific cover type compared to the erosion that would occur on a clean-tilled fallow under identical slope and rainfall. The C-factor integrates a number of variables that influence erosion including vegetative cover, plant litter, soil surface, and land management. The original C-factor of the USLE was experimentally determined for agricultural crops and has since been modified to include rangeland and forested cover.

The **P-factor** or conservation practice factor is a function of the interaction of the supporting land management practice and slope. It incorporates the use of erosion control practices such as strip-cropping, terracing and contouring, and is applicable only to agricultural lands. Values of the P-factor compare straight-row farming practices with that of certain agriculturally based conservation practices. This factor was set to one for this analysis based on existing practices within the watershed.

Results from the USLE equation were combined with a sediment delivery ratio (SDR) to predict the amount of sediment delivered to streams. The sediment delivery ratio was derived within the model for each cell based on the relationship between the distance from the delivery point to the stream and the percent of eroded sediment delivered to the stream.

C2.4.2 Data Sources

The following sections describe the data sources used to obtain the appropriate spatial data required for this model. The results of each specific parameter are shown graphically.

R-Factor

The rainfall and runoff factor grid was prepared by the Spatial Climate Analysis Service (SCAS) of Oregon State University at 4 km grid cell resolution. For the purposes of this analysis, the SCAS R-factor grid was projected to Montana State Plane Coordinates (NAD83, meters), resampled to a 10m analytic cell size and clipped to the extent of the Chippewa Creek watershed to match the project's standard grid definition. The R-Factor for the Chippewa Creek watershed is presented in **Figure C2-1**.

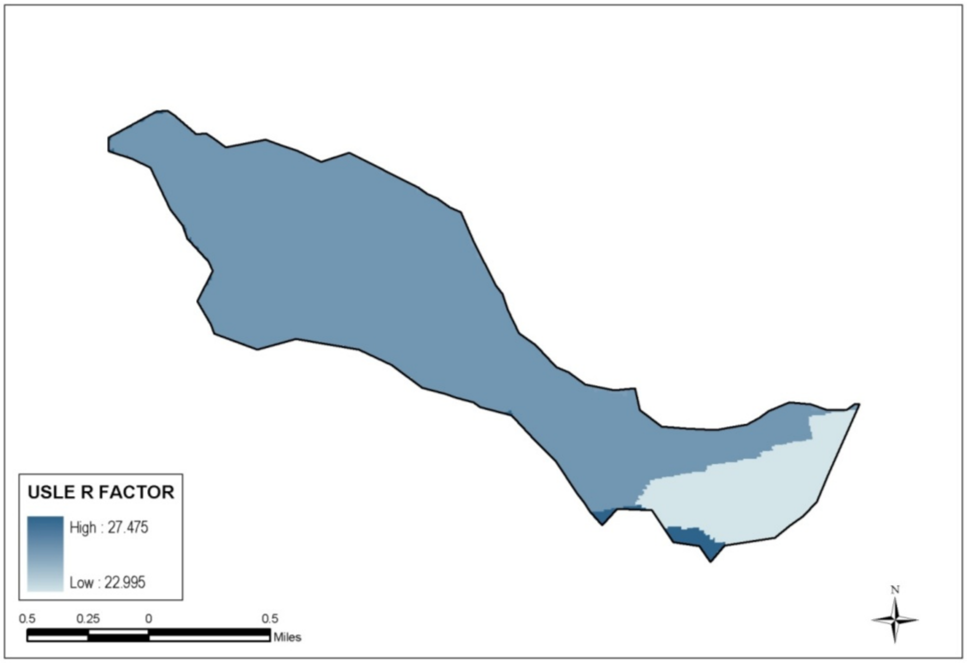

Figure C2-1. USLE R-Factor for the Chippewa Creek Watershed.

K-Factor

Polygon data for the K-factor were obtained from the NRCS Soil Survey Geographic database (SSURGO). The K-factor for the Chippewa Creek watershed is presented in **Figure C2-2.**

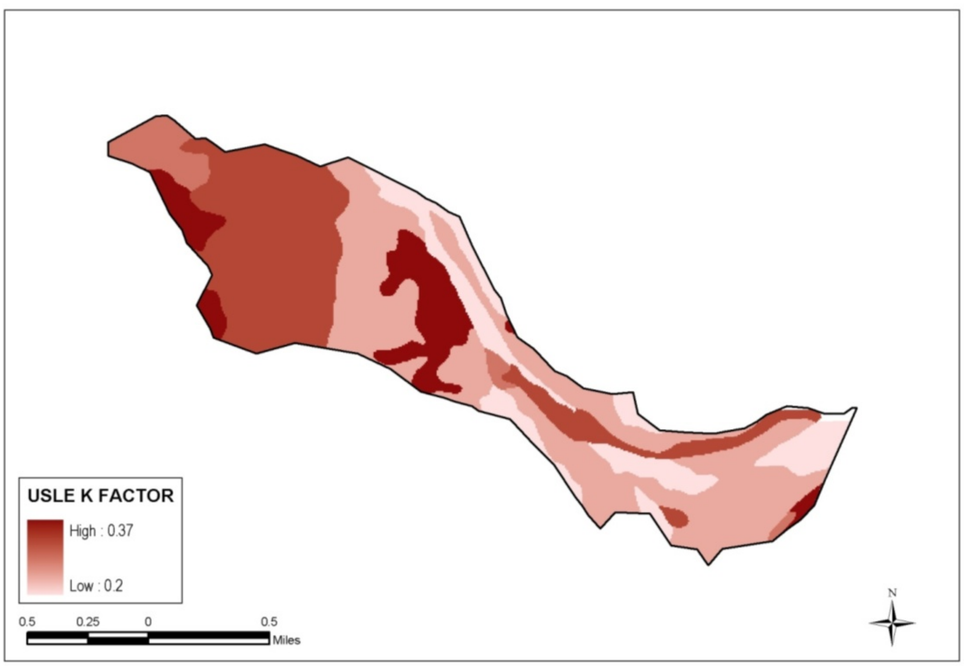

Figure C2-2. USLE K-Factor for the Chippewa Creek Watershed.

Digital Elevation Model (DEM)

The digital elevation model (DEM) of the Chippewa Creek watershed is the base layer used for developing the LS factor. The USGS 30m DEM for the Chippewa Creek watershed was used for this analysis. The DEM was interpolated to a 10m analytic grid cell to render the delineated stream network more representative of the actual size of Chippewa Creek watershed streams and to minimize resolution dependent stream network anomalies. The resulting interpolated 10m DEM was subjected to standard hydrologic preprocessing, including filling of sinks to create a positive drainage condition for all areas of the watershed. Results of the DEM for the Chippewa Creek watershed are presented in **Figure C2-3**.

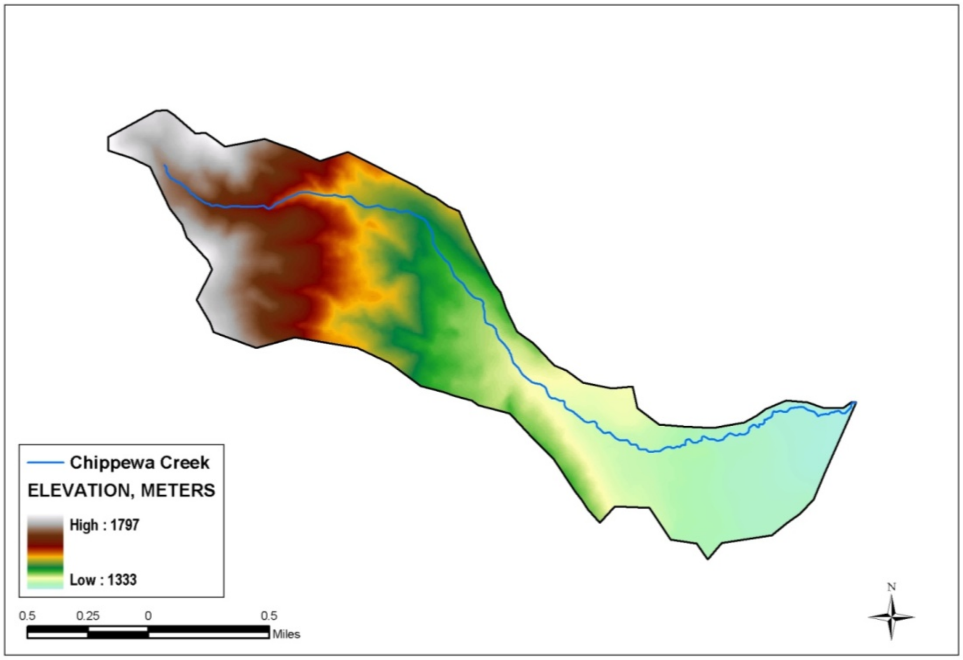

Figure C2-3. DEM for the Chippewa Creek Watershed.

National Land Cover Dataset (NLCD)

The 2006 National Land Cover Dataset (NLCD) was obtained from USGS and is developed through a cooperative project conducted by the Multi-Resolution Land Characteristics (MRLC) Consortium, a partnership of nine federal agencies. This layer is used to establish USLE C-factors for the Chippewa Creek watershed. The NLCD is a categorized 30-meter Landsat Thematic Mapper image from 2006. The NLCD image was reprojected to Montana State plane projection/coordinate system, and resampled to the project standard 10-meter grid size. Results of the NLCD are presented in **Figure C2-4.**

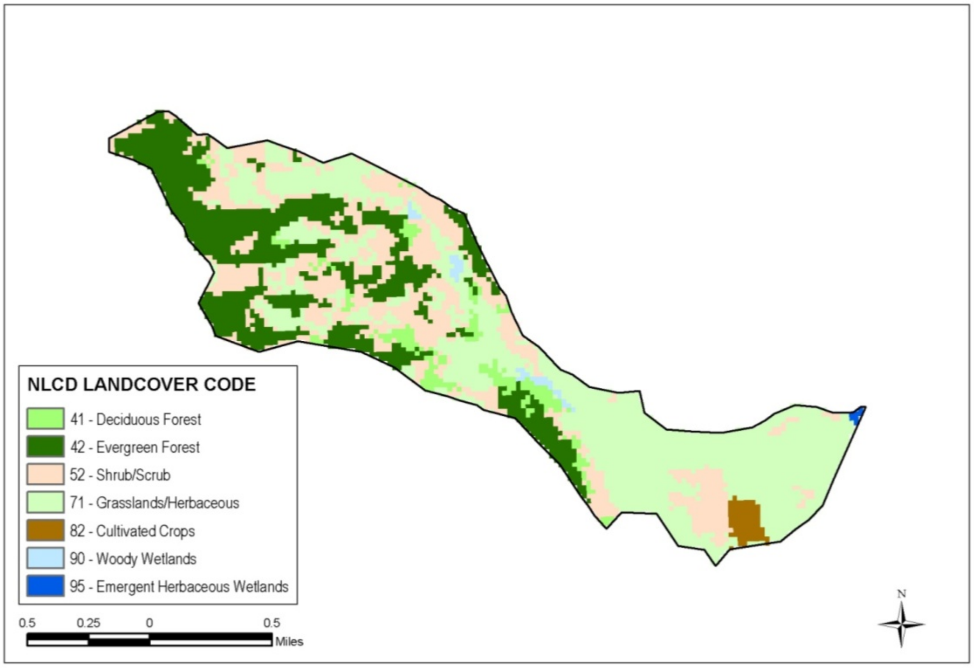

Figure C2-4. NLCD for the Chippewa Creek Watershed.

C-Factor Derivation

A classification scheme was used to assign USLE C-factors to the NLCD land-use types present in the Chippewa Creek watershed (**Table C2-1**) following the approach presented in Lower Clark Fork Tributaries Sediment TMDLs and Framework for Water Quality Restoration (Montana Department of Environmental Quality, 2010). This scheme was initially developed based on ground cover percentages established by the USDA Soil Conservation Service (1977), and has been refined based on present land cover conditions in the Chippewa Creek watershed. In order to estimate the potential sediment reduction that might be accomplished under a best management practices scenario, the model was also run using C-factors assigned to the desired condition. To determine C-factors for the desired conditions, existing condition C-factors for anthropogenic land-use types were changed to reflect the ground cover that best represents an improved land condition in the Chippewa Creek watershed. Land cover types identified as grasslands/ herbaceous and cultivated crops were conservatively changed to reflect a 10 percent and 20 percent increase, respectively, in ground cover over existing conditions, shown below in **Table C2-2**. It is acknowledged that land cover is variable within and across watersheds, and changes seasonally; the C-factors used for the model are intended to represent typical annual conditions at a coarse scale and the percent of improvement achievable via the implementation of BMPs.

Table C2-1. Chippewa Creek C-Factors for Existing and Desired Management Conditions.

NLCD Code	Description	Land Use Category	C-Factor	
			Existing Condition	Desired Condition
41, 42	Deciduous/ Evergreen/Mixed Forest	Natural Source	0.003	0.003
52	Shrub/Scrub	Natural Source	0.008	0.008
71	Grasslands/Herbaceous	Grazing	0.020	0.013
82	Cultivated Crops	Cropland	0.240	0.150
90	Woody Wetlands	Natural Source	0.003	0.003
95	Emergent Herbaceous Wetlands	Natural Source	0.003	0.003

Table C2-2. Percent Ground Cover for Existing and Desired Land Cover Types.

Land Cover	Existing % Ground Cover	Desired % Ground Cover
Grasslands/Herbaceous	75	85
Cultivated Crops	20	40

Sediment Delivery Ratio

USLE model results were combined with a sediment delivery ratio (**SDR**) to predict sediment delivery to streams. The SDR was derived for each grid cell based on the distance from the cell to the nearest stream. This distance-based relationship was established during development of the WARSEM road sediment model by integrating previous studies which evaluated sediment delivery down slope of forest roads (Dube et al., 2004). These studies determined that the percent of sediment delivered to streams decreases with distance from the stream based on the relationship shown in **Table C2-3**. This relationship has been applied in previous USLE models for TMDL development, and is considered to be a conservative estimate of sediment delivery from upland erosion.

Table C2-3. Sediment Delivery vs. Distance from Stream.

Distance from Stream (ft)	Percent of Sediment Delivered to Stream
0	100
35	70
70	50
105	35
140	25
175	18
210	10
245	4
280	3
315	2
350	1

C3.0 RESULTS

C3.1 UNPAVED ROAD ASSESSMENT

Sediment inputs from unpaved road crossings were evaluated using the WEPP:Road model. The potential to reduce sediment loads from unpaved roads through the application of Best Management Practices (BMPs) was also evaluated by reducing contributing road segment lengths to 100 feet. For unpaved road crossings, contributing road segment lengths exceeding 100 feet were reduced to 100 feet on either side of the crossing. Out of the three assessed unpaved road crossings, only CHIP-X2 had a contributing road length of greater than 100 feet, with a measured contributing road length of 426 feet.

C3.1.1 WEPP Model Input Parameters

Road condition data collected in the Chippewa Creek watershed in October of 2010 was input directly into the WEPP:Road model following guidance outlined in *WEPP Interface for Predicting Forest Road Runoff, Erosion and Sediment Delivery Technical Documentation*, which is available on the Internet at http://forest.moscowfsl.wsu.edu/fswepp/docs/wepproaddoc.html. In addition to field collected data, the WEPP:Road model requires the selection of site-specific climate data to provide an estimate of mean annual precipitation. The WEPP:Road model contains 55 custom climate stations for Montana. Out of these 55 custom climate stations, the Roy 8 NE MT was selected. The mean annual precipitation at the Roy NE MT climate station is 13.74 inches. Precipitation data collected from 1971 to 2000 and compiled by the PRISM Group at Oregon State University (http://nris.mt.gov/nsdi/nris/precip71_00.html) indicates the Roy climate station is within the 14-16" precipitation zone, while the assessed unpaved road crossings along Chippewa Creek are in the 18-20" precipitation zone according to the PRISM data. Thus, the Roy 8 NE MT climate station data was modified in the WEPP:Road model to a mean annual precipitation of 18.50 inches by increasing both the mean annual precipitation and the number of wet days by 35%.

C3.1.2 Sediment Loads from Unpaved Roads

A total of three unpaved road crossings were assessed in the field for use in the WEPP:Road model, all of which were located on private lands and within the Non-calcareous Foothill Grasslands Level IV Ecoregion (**Figure C3-1**). The three assessed unpaved road crossings are described as follows:

> **CHIP-1X**: Located on a small ranch access road. Perennial streamflow started just upstream of this site during field evaluations in both August and October of 2010
>
> **CHIP-2X**: Located on the Maiden Road, which is within the city-county road system
>
> **CHIP-3X**: Located on a small ranch access road a short distance upstream of the confluence of Chippewa Creek and Manitoba Gulch

From the three assessed unpaved road crossings, the estimated mean annual sediment load is 0.016 tons (**Table C3-1**). Through the application of BMPs, it is estimated that this load can be reduced to 0.006 tons, which is a 63% reduction in the mean annual sediment load. This reduction is primarily achieved by improving BMPs at CHIP-X2, which is located on the Maiden Road.

Table C3-1. Unpaved Road Crossing Sediment Loads.

Crossing ID	Mean Annual Sediment Load (Tons)	Mean Annual Sediment Load with BMPs (Tons)	Percent Reduction in Sediment Contributions
CHIP-X1	0.002	0.002	0%
CHIP-X2	0.014	0.003	77%
CHIP-X3	0.001	0.001	0%
Chippewa Creek	**0.016**	**0.006**	**63%**

As described below, the remaining two unpaved road crossings identified in GIS using color aerial imagery from 2009 were determined not to be sediment sources and were not included for evaluation in the WEPP:Road model. The uppermost unpaved road crossing in the Chippewa Creek watershed was located near the site of the abandoned mine. Field evaluation indicated there was no flowing water at this site and the road fill over the stream channel lacked a culvert, suggesting streamflow upstream of this site is relatively rare. The other unpaved road crossing not evaluated in the WEPP:Road model was located at a driveway between sites CHIP-X2 and CHIP-X3. At this crossing, Chippewa Creek has been converted to a pond and was not considered a source of sediment since the pond acts as a sediment trap.

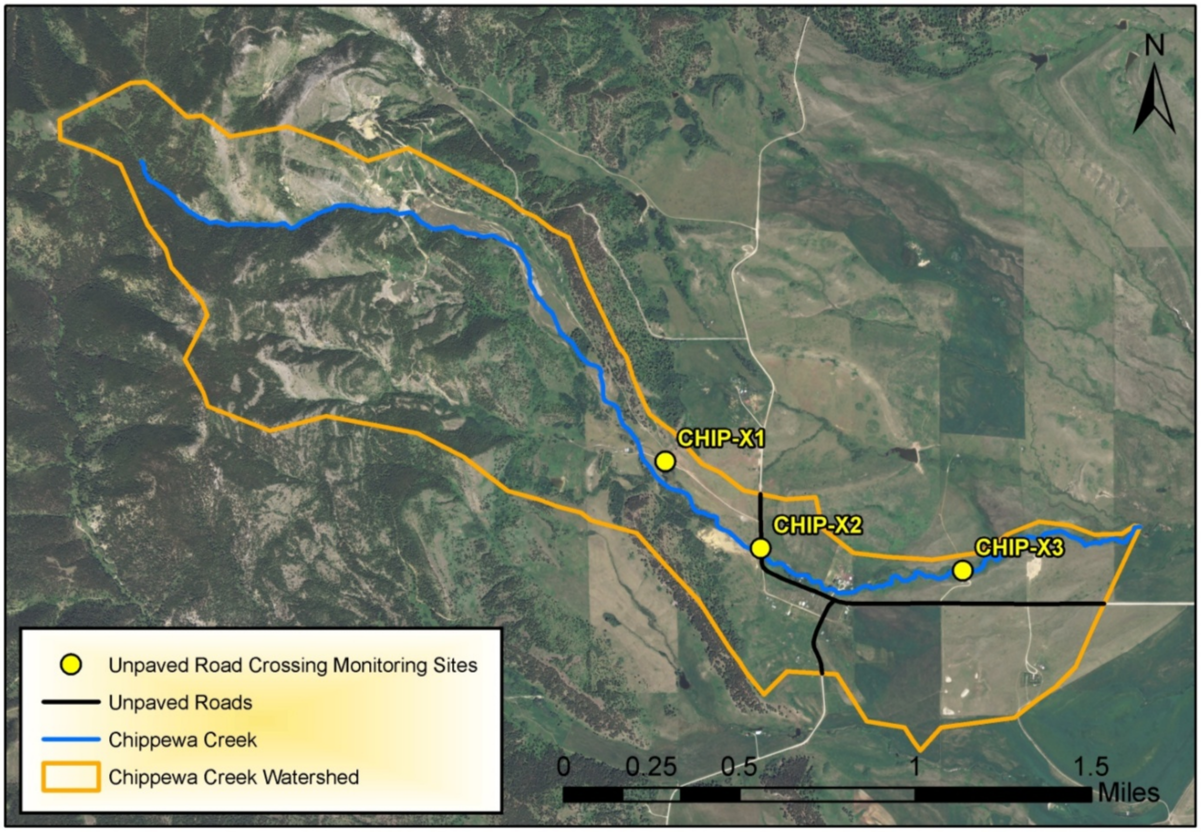

Figure C3-1. Unpaved Road Crossings in the Chippewa Creek Watershed.

C3.2 Sediment and Habitat Assessment

A sediment and habitat assessment was performed at two monitoring sites along Chippewa Creek: CHIP-01 and CHIP-02 (**Figure C3-2**). CHIP-01 was located just upstream of the Maiden Road crossing, while CHIP-02 was located between the Maiden Road crossing and the Black Butte Road crossing. At CHIP-01, there is a mill tailings pile adjacent to the river right streambank with clear evidence that sediment eroding from the mill tailings pile is delivered to the stream channel. In addition, CHIP-01 is also used for livestock grazing, which has led the channel to become overwidened in places. The CHIP-02 monitoring site is also utilized by livestock, which has led the channel to become overwidened at cattle access points. Both monitoring sites along Chippewa Creek are slightly entrenched, with one small headcut observed within the CHIP-02 monitoring site. Pool tail-outs were 100% comprised of fine sediment and lacked spawning potential. The potential stream type for both monitoring sites is E4, though existing conditions more closely resemble a B4c stream type, particularly at the CHIP-01 monitoring site. A summary of the results for the Chippewa Creek sediment and habitat assessment are presented in **Table C3-2**, with the complete dataset presented in **Attachment CB**.

Table C3-2. Summary of Chippewa Creek Sediment and Habitat Assessment Data.

Monitoring Site	Potential Rosgen Stream Type	Channel Form (median)		Fine Sediment (mean)			Instream Habitat			Riparian Health	
		W/D Ratio	Entrenchment Ratio	Riffle Pebble Count		Grid Toss % <6mm	Risidual Pool Depth (feet) (mean)	Frequency #/mile		% Greenline Shrubs (mean)	PFC Assessment
				% <6mm	% <2%	Riffle		Pool	LWD		
CHIP-01	E4	8.6	1.7	35	24	25	0.4	42	21	22	NF
CHIP-02	E4	8.9	2.5	31	28	29	0.4	74	74	46	FAR

PFC = Proper Functioning Condition; FAR = Functional – At Risk; NF = Nonfunctional

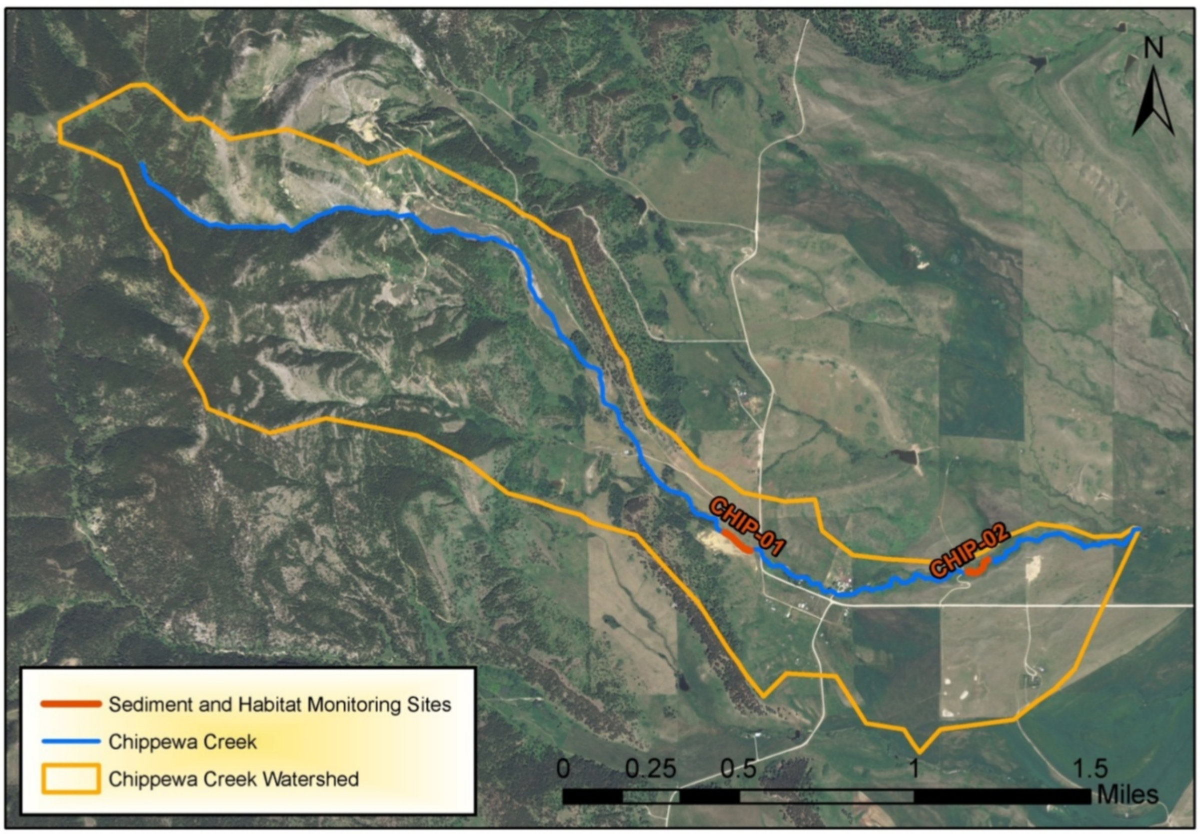

Figure C3-2. Chippewa Creek Sediment and Habitat Monitoring Sites.

C3.3 Sediment Contributions from Mill Tailings

During field assessment activities in 2010, three main sediment delivery points were identified along the mill tailings pile located adjacent to Chippewa Creek (**Figure C3-3**). Sediment loading from this mill tailings pile was assessed using WEPP Hillslope and the following model assumptions:

- Climate Station: ROY 8 NE

- Field Length (ft): 160
- Field Width (ft): 180
- Slope Shape: Convex
- Steepness: 15%
- Soil: FLASHER(LS)
- Management: fallow
- Simulation Years: 30
- Filter Strip Width (ft): 10
- Filter Strip Management: Fescue

The FLASHER(LS) soil was selected following advice from NRCS personnel, while the filter strip width and management parameters were based on field measurements and observations and were applied conservatively in order to provide an additional margin of safety. Based on this approach, it is estimated that 1.98 tons of sediment are delivered to Chippewa Creek annually from the mill tailings pile. Through remediation of this tailings pile and development of a riparian buffer along Chippewa Creek, sediment contributions from the mill tailings pile should be eliminated.

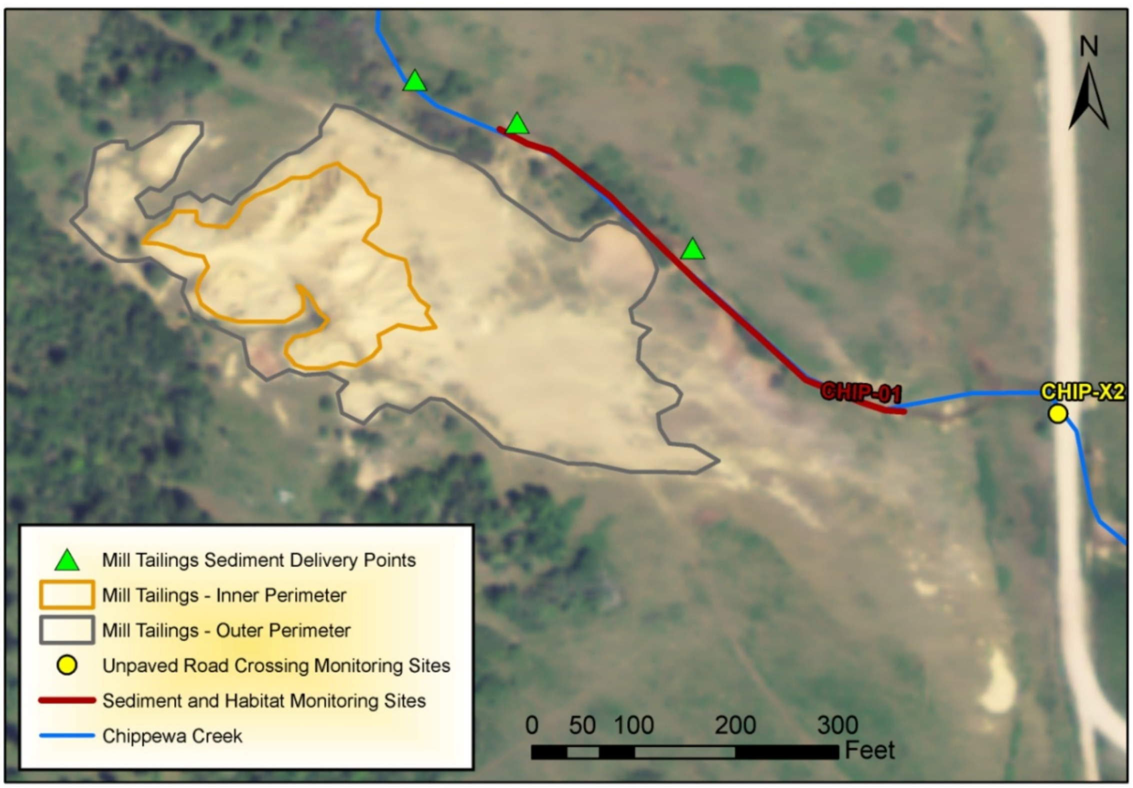

Figure C3-3. Mill Tailings along Chippewa Creek.

C3.4 USLE Assessment

Sediment production results for the existing and desired upland conditions are provided below in **Table C3-3**. Results are presented by land –use type, and are further grouped by anthropogenic and natural sources. The total calculated upland sediment production in the Chippewa Creek watershed is 359.2 tons/year for the existing upland condition. Using the desired upland condition through the application of Best Management Practices, sediment production in the Chippewa Creek watershed was reduced to 288.5 tons/year.

Table C3-3. Results of USLE Model for the Chippewa Creek Watershed.

Land Use Type	Area (acres)	Percent of Watershed	Existing Condition Load (Tons/Year)	Desired Conditions Load (Tons/Year)	Percent Change from Existing
41 - Deciduous Forest	50	5%	5.1	5.1	0%
42 - Evergreen Forest	269	25%	52.0	52.0	0%
52 - Shrub/Scrub	279	26%	98.7	98.7	0%
71 - Grassland/Herbaceous	439	41%	192.4	125.5	35%
82 - Cultivated Crops	15	1%	10.2	6.4	38%
90 - Woody Wetlands	9	1%	0.7	0.7	0%
95 - Emergent Herbaceous Wetland	0.2	0%	0.0	0.0	0%
Total Anthropogenic	**454**	**43%**	**202.7**	**131.9**	**35%**
Total Natural	**608**	**57%**	**156.6**	**156.6**	**0%**
Total Watershed	**1062**	**100%**	**359.2**	**288.5**	**20%**

The USLE model results were combined with a sediment delivery ratio (SDR) to estimate sediment delivery to Chippewa Creek. Total calculated sediment delivered to Chippewa Creek for existing conditions is 42.6 tons/year. Using the desired conditions through the application of Best Management Practices, the sediment delivered to Chippewa Creek was reduced by 20% to 34.1 tons/year.

Table C3-4. Results of SDR Analysis for the Chippewa Creek Watershed.

Land Use Type	Area (acres)	Percent of Watershed	Existing Condition Load (Tons/Year)	Desired Conditions Load (Tons/Year)	Percent Change from Existing
41 - Deciduous Forest	50	5%	0.40	0.40	0%
42 - Evergreen Forest	269	25%	6.05	6.05	0%
52 - Shrub/Scrub	279	26%	11.75	11.75	0%
71 - Grassland/Herbaceous	439	41%	23.86	15.40	35%
82 - Cultivated Crops	15	1%	0.10	0.06	38%
90 - Woody Wetlands	9	1%	0.45	0.45	0%
95 - Emergent Herbaceous Wetland	0.2	0%	0.00	0.00	0%
Total Anthropogenic	**454**	**43%**	**24.0**	**15.5**	**35%**
Total Natural	**608**	**57%**	**18.6**	**18.6**	**0%**
Total Watershed	**1062**	**100%**	**42.6**	**34.1**	**20%**

C4.0 DISCUSSION

This assessment of sediment loading to Chippewa Creek included an evaluation of sediment loads from unpaved roads, uplands and a mill tailings pile, along with a sediment and habitat evaluation. Out of the five identified unpaved road crossings in the Chippewa Creek watershed, a total of three unpaved road crossings were assessed in the field for evaluation in the WEPP:Road model. From the three assessed unpaved road crossings, the estimated mean annual sediment load is 0.016 tons. Through the application of BMPs, it is estimated that this load can be reduced to 0.006 tons, which is a 63% reduction in the mean annual sediment load. An annual sediment load of 1.98 tons is estimated from the mill tailings pile based on the WEPP Hillslope model. Through remediation of this tailings pile and development of a riparian buffer along Chippewa Creek, sediment contributions from the mill tailings pile should be eliminated. The USLE model indicates uplands deliver 42.6 tons/year of sediment to Chippewa Creek under the existing conditions, while sediment delivery from uplands could be reduced by 20% to 34.1 tons/year through the improved application of Best Management Practices.

C5.0 REFERENCES

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ATTACHMENT CA - UNPAVED ROAD CROSSING FIELD DATA AND WEPP MODELED SEDIMENT LOADS

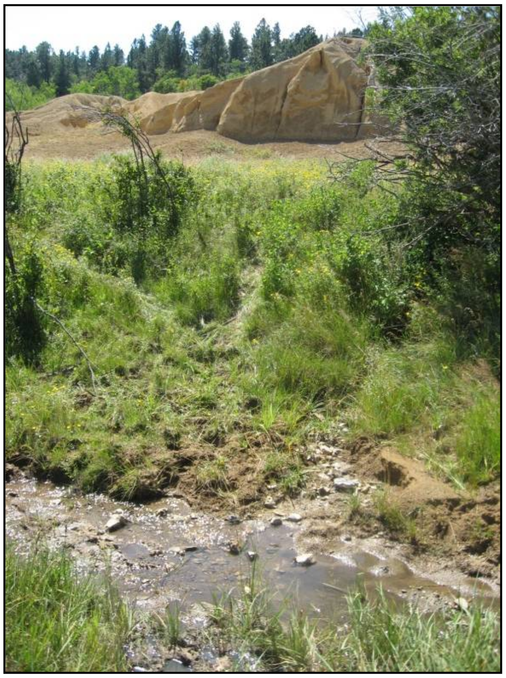
Location ID	Date	Latitude	Longitude	Estimated Mean Annual Precipitation (inches)	Soil Type	% Rock	Insloped/ Outsloped (Modeled Value)	Road Surface	Traffic Level	Years Modeled	Gradient CRL1 (%)	Length CRL1 (Feet)	Width CRL1 (Feet)	Gradient Fill (%)	Length Fill (Feet)	Gradient Buffer (%)	Length Buffer (Feet)	WEPP LOAD (lbs)	Gradient CRL1 (%)	Length CRL1 (Feet)	Width CRL1 (Feet)	Gradient Fill (%)	Length Fill (Feet)	Gradient Buffer (%)	Length Buffer (Feet)	WEPP LOAD (lbs)	MEAN ANNUAL LOAD (lbs)
											L	L	L	L	L	L	L	L	R	R	R	R	R	R	R	R	
CHIP-X1_CRL1	10/18/10	47.13419	-109.21225	18.50	Sand L	10	Outsloped Unrutted	Native	Low	50	2.0	51	13	0	0	12	48	0.00	0.5	12	12	0	0	27	3	0.83	0.83
CHIP-X1_CRL2	10/18/10			18.50			Outsloped Unrutted	Native	Low	50	0.5	33	12	0	0	27	3	2.29									2.29
CHIP-X2	10/18/10	47.13059	-109.20651	18.50	Sand L	30	Outsloped Unrutted	Gravel	Low	50	5.0	426	21	0	0	27	40	27.18									27.18
CHIP-X3	10/18/10	47.12965	-109.19432	18.50	Sand L	5	Outsloped Unrutted	Native	Low	50	0.5	14	12	0	0	173	1	1.30	0.5	7	12	0	0	84	1	0.65	1.95
																model default of 100											
																fill and buffer lower defaults: 0.3% and 1 ft											

Location ID	Segment 1 Installed BMPs		Segment 1 Potential BMPs		Road Crossing and BMP Notes/Comments
	L	R	L	R	
CHIP-X1_CRL1	natural vegetative buffer	none	not required	slash filter	granitic road material
CHIP-X1_CRL2	none		slash filter		granitic road material
CHIP-X2	none		slash filter, fabric wraps		hard gravel road
CHIP-X3	none	none	slash filter, vegetative buffer	slash filter, vegetative buffer	

ATTACHMENT CB - SEDIMENT AND HABITAT DATABASE

Site	Date	Cell	Existing Rosgen Stream Type	Potential Rosgen Stream Type	GIS Calculated Sinuosity	Field Slope (Percent)	Bankfull Channel Width (Feet)	Cross-Sectional Area (Feet²)	Bankfull Mean Depth (Feet)	Width / Depth Ratio	Maximum Depth (Feet)	Floodprone Width (Feet)	Entrenchment Ratio	Riffle Pebble Count D50	Riffle Pebble Count Percent <2mm	Riffle Pebble Count Percent <6mm	Riffle Grid Toss Percent <6mm	Number of Pools per 1000 Feet	Mean Residual Pool Depth	Number of Individual Pieces of LWD per 1000 Feet	Number of LWD Aggregates per 1000 Feet	Total Number of LWD per 1000 Feet	Percent Understory Shrub Cover	Percent Bare/Disturbed Ground	Percent Riprap	Percent Overstory Canopy Cover	Right Bank Mean Riparian Buffer Width	Left Bank Mean Riparian Buffer Width
CHIP-01	10/18/10	1	B4c	E4	1.03	1.0	6.5	4.2	0.65	10.0	1.0	14.0	2.2	8	22	40	37	8	0.4	2	0	4	0	65	0	0	0	0
CHIP-01	10/18/10	2	B4c	E4	1.03	1.0	5.0	3.5	0.70	7.1	1.2	8.0	1.6										35	25	0	0	5	2
CHIP-01	10/18/10	3			1.03	1.0																	0	55	0	0	2	2
CHIP-01	10/18/10	4	B4c	E4	1.03	1.0	4.5	3.8	0.84	5.4	1.1	8.5	1.9	25	21	25	13						75	35	0	0	3	5
CHIP-01	10/18/10	5	B4c	E4	1.03	1.0	6.8	4.3	0.63	10.8	1.3	10.8	1.6	8	28	41	25						0	30	0	0	0	0
CHIP-02	10/18/10	1	B4c	E4	1.36	1.0	4.9	2.6	0.52	9.4	0.8	8.9	1.8	18	26	26	24	14	0.4	0	0	14	65	0	0	0	3	5
CHIP-02	10/18/10	2	B4c	E4	1.36	1.0	5.3	3.8	0.72	7.3	1.0	9.3	1.8										65	25	0	0	5	5
CHIP-02	10/18/10	3			1.36	1.0																	25	0	0	0	5	5
CHIP-02	10/18/10	4	E4	E4	1.36	1.0	4.9	2.9	0.59	8.4	0.8	15.8	3.2	23	18	22	20						55	0	0	0	20	4
CHIP-02	10/18/10	5	E4	E4	1.36	1.0	6.2	3.7	0.60	10.4	0.9	21.2	3.4	7	39	44	44						20	0	0	0	0	5

ATTACHMENT CC - MILL TAILINGS PHOTOS



APPENDIX D - JUDITH MOUNTAINS PROJECT AREA METALS SOURCE ASSESSMENT

TABLE OF CONTENTS

D1.0 INTRODUCTION

This appendix is taken from a an assessment of potential sources of metals loading to 303(d) listed metals impaired stream segments in the Judith Mountains project area was performed in 2011 to facilitate development of metals TMDLs (Atkins North America, Inc., 2011). Stream segments of concern included Chicago Gulch, Chippewa Creek, Collar Gulch, Armells Creek, Cow Creek and Fargo Coulee. Metals impaired stream segments in the project area are shown in **Table D1** and **Figure A-7** (**Appendix A**).

The metals source assessment included: 1) a review of relevant literature sources, 2) compilation and review of GIS layers pertaining to land uses, land ownership, and locations of abandoned and inactive mines, and 3) field data collection activities, including water quality and streamflow monitoring, and field inspections of the subject watersheds. Because water quality data are summarized in the main document, this appendix summarizes the literature review, GIS analysis, and field assessment of metals sources.

It should be noted here that the primary focus of this study was on drainages with abandoned mines in the Judith Mountains: Chicago Gulch, Chippewa Creek, Collar Gulch and Armells Creek. Metals source assessment activities on Cow Creek and Fargo Coulee were limited to water quality monitoring and evaluation and excluded any on-the-ground investigations of former (coal) mining sites or other potential metals sources.

Table D-1. Metals impaired waters in the Judith Mountains TMDL Project Area.

Segment ID	Waterbody Name	303(d) Listing
MT40B002_020	CHICAGO GULCH, headwaters to the mouth (Fords Creek)	Lead, pH, Zinc
MT40B002_040	CHIPPEWA CREEK, headwaters to confluence with Manitoba Gulch	Antimony, Arsenic, Cyanide, Iron, Mercury, Zinc
MT40B002_030	COLLAR GULCH, headwaters to mouth (Fords Creek)	Lead, pH, Zinc
MT40E002_022	ARMELLS CREEK, headwaters to Deer Creek	Cadmium, Copper, Mercury, pH, Zinc
MT40E002_040	COW CREEK, Als Creek to the mouth (Missouri River)	Aluminum, Copper, Iron, Lead
MT40E002_130	FARGO COULEE, headwaters to mouth at Amells Creek	Aluminum, Iron, Lead

D2.0 METHODS

D2.1 METALS SOURCE ASSESSMENT DATA COLLECTION AND ANALYSIS

The metals source assessment employed 1) a review of literature pertaining to historical mining and minerals processing activities in the Judith Mountains, 2) GIS analysis of the watershed settings, including geography, land ownership, hydrography, and locations of impaired stream segments in relation to abandoned and inactive mines, and 3) on-the-ground surveys of the impaired segments and adjacent mine sites. Each of these study elements is described in more detail below.

D2.1.1 Literature Review

Prior to field data collection, an Internet search of relevant documents pertaining to the history of mining in the Judith Mountains was performed, together with topical searches for information pertaining to each of the subject streams. Sites searched included websites and associated information repositories hosted by Montana Department of Environmental Quality (DEQ), the Montana State Library/Natural Resources Information System (NRIS), Montana Bureau of Mines and Geology (MBMG), U.S. Bureau of Land Management (BLM), and various non-governmental locations.

During the Internet search, a 2011 solicitation by the BLM for assessment work in several drainages in the project area to evaluate natural versus human sources of acid mine drainage and metals was found. The streams identified in the solicitation that are within the TMDL project area are Collar Gulch, Chicago Gulch, and Armells Creek. Chad Krause, a BLM hydrologist, was contacted regarding the assessment project and confirmed it is underway; a limited amount of reconnaissance sampling was conducted in 2011 but most sampling will occur in 2012 and 2013 (personal communication, May 2011).

D2.1.2 GIS Analysis

Prior to field data collection, GIS data layers representing road networks, stream hydrography, land ownership, land elevation/topography, and the locations of abandoned and inactive mines catalogued by the Montana DEQ and Montana Bureau of Mines and Geology were assembled and used to create a series of planning maps. The maps were used in the office and in the field to help establish appropriate water quality monitoring locations on the impaired stream segments in relation to abandoned mines, land ownership, land uses and access points, and to catalogue abandoned mine sites for inspection.

D2.1.3 Field Source Assessment

Most of each impaired stream segment for Chicago Gulch, Chippewa Creek, Collar Gulch and Armells Creek was visually surveyed on foot or by vehicle during the week of May 16, 2011. Due to a cool spring and higher than normal mountain snowpack, the extreme headwaters segments of Chicago Gulch, Collar Gulch and Armells Creek could not be accessed during the survey period. In these cases, metals source assessment monitoring locations were established at the upstream limits of access. A number of abandoned mine sites included on the DEQ and MBMG abandoned mines GIS coverages were accessed and visually inspected. In most cases, these sites were located some distance from the active stream courses and, in many cases, in upland areas well away from live drainages. No active seeps or adit discharges were identified in the field, only one adit discharge was described in the abandoned mines inventory data (inaccessible due to deep snow), and none were sampled. However, an attempt was made in each watershed to bracket potential mine related source areas, on the basis of mine or mill location in relation to the stream drainage pattern, closely enough that any increases in loading could be associated with those specific mines or mill sites.

D3.0 RESULTS

D3.1 Chicago Gulch

D3.1.1 Literature Review

The literature review for Chicago Gulch did not identify references to historical mining activities in this drainage, although numerous information sources were identified for adjacent drainages in the Judith Mountains.

D3.1.2 GIS Analysis

Chicago Gulch flows for about 3 miles from its headwaters on the southeast slope of Red Mountain in the Judith Mountains to its confluence with the East Fork of Fords Creek. The upper half of the Chicago Gulch watershed consists of BLM managed public lands and the lower half is private ranch lands. Elevation of the stream varies from about 5400 feet in it headwaters to about 4500 feet at the East Fork confluence. The Montana DEQ abandoned mines database shows one exploration prospect or abandoned mine site in the extreme headwaters of Chicago Gulch (located between the two headwater forks) at an elevation of about 5700 feet. It is not named or described in the database and a field survey was not possible due to deep snow. The site did not appear in the MBMG abandoned mines coverage. The MBMG database includes one additional abandoned mine site in this watershed that is not included in the DEQ inventory. It is called the Big Chicago Mine, and is an underground gold exploration prospect located on private property on the south side of Chicago Gulch at an elevation of about 4880 feet. The MBMG site description indicates no impacts associated with the site, which was observed from a distance.

D3.1.3 Field Source Assessment

Water quality monitoring was conducted at two sites in Chicago Gulch on August 18, 2010, and at three sites on May 19, 2011. The 2010 monitoring locations included one site at about the mid-point of the listed segment (CHIG-M1) and a lower site just above the confluence of the East Fork of Fords Creek (CHIG-M2). Both locations were on privately owned ranch lands. The 2011 monitoring sites included a new upper watershed location near the BLM/private boundary (CHIG-MSA1), the former upstream 2010 site (CHIG-M1), and a site just below the confluence of the East Fork Fords Creek (FORDS-M2) (**Figure 7-1** and **Table 7-7** in TMDL). Note, site FORDS-M2 is not shown on **Figure 7-1** because it is downstream of the listed portion of the stream.

The creek was low, clear and flowing less than 1 cubic foot per second (cfs) in August 2010. In contrast, the stream was slightly turbid with fine suspended sediment particles in May 2011, with elevated flows ranging from 12.1 cfs in the upper reaches, to more than 25 cfs below the East Fork. Snow was present on the trail at the upper monitoring site in May 2011 and snowmelt conditions were well underway.

During the 2011 monitoring, the entire portion of the listed segment from the BLM boundary downstream to the East Fork of Fords Creek was observed from a trail which parallels the creek. No apparent mining related or other anthropogenic sources of metals loading were observed in this segment of Chicago Gulch. Water quality data indicated a metals source in the upper reaches of the watershed upstream of the BLM boundary.

D 3.2 Chippewa Creek

D3.2.1 Literature Review

The literature review for Chippewa Creek and the town of Giltedge revealed a colorful mining history. Placer prospectors worked the area in 1880 and some lode mining began in 1881. Lode deposits associated with the Giltedge Mine were discovered in upper Chippewa Creek in 1884. A crude cyanide mill was built in the drainage near the base of the mountains to process the ore and was operated for a short time. In 1893, the mine ownership changed and new investors rebuilt the cyanide mill allowing 100 tons of $20 ore to be worked each day. About 50 workers and their families established the mining camp of Giltedge near the mill site. Management problems plagued the mill and Giltedge was nearly deserted in the mid-1890's. The property then changed ownership again in 1898 and a new 150 ton cyanide mill was built closer to the mine mouth. The mill was later expanded to 350 tons and included six leaching tanks with capacities of 175 tons each. The mine operated until 1912 and the mill was dismantled before 1916. A cyanide plant was erected at the first mill site in 1918 to rework 8,200 tons of tailings. The series of mines in the Chippewa Creek drainage were said to contain 2.5 miles of underground workings and are credited with production of $1.25 million in gold (Montana DEQ historic narratives available at: http://www.deq.mt.gov/abandonedmines). According to John Koerth at the DEQ Abandoned Mine Cleanup Bureau, Golden Maple Company developed a cyanide heap leach operation in the Chippewa Creek drainage in the 1980's to reprocess old mill tailings from the Giltedge Mine (personal communication July 2011). Prior to the close of the mine in 1985, the operators were cited for violations including an inadequate leach pad liner and surface discharges from treatment ponds, and elevated cyanide concentrations were documented in groundwater down gradient from the mine. After the mine was abandoned, DEQ used the bond money to treat and land apply the contents of the treatment ponds and to bury sediment from the treatment ponds on-site. In 1993, approximately 700 feet of channel was reconstructed and the floodplain was recontoured to minimize erosion. Some of the reprocessed tailings remain along lower Chippewa Creek near Giltedge.

D3.2.2 GIS Analysis

The 303(d) listed segment of Chippewa Creek extends for 3.8 miles from its headwaters to the confluence of Manitoba Gulch about one mile below the former Giltedge town site. Land ownership is BLM managed lands in portions of the upper reaches and private lands scattered over much of the rest of the watershed. Elevation of the stream varies from about 5600 feet in it headwaters to about 4500 feet at the Manitoba Gulch confluence. The Montana DEQ abandoned mines database shows a cluster of abandoned mines in the upper Chippewa Creek drainage, including the Giltedge Mines, the Cliff Mine, and the Upper and Lower Ox Frame Gulch Mines. The DEQ database also includes the Giltedge Tailings near the town of Giltedge, and several coal mines within the drainage. The MBMG database includes the Giltedge Mine, the Giltedge Tailings, and the Giltedge coal mine. The databases do not mention problems associated with any of the mine and mill sites, but do indicate the Giltedge Mine was active in 1995 (presumably the Golden Maple activities).

D3.2.3. Field Source Assessment

Water quality monitoring was conducted at two sites on Chippewa Creek on August 19, 2010, and at three sites on May 18, 2011. The 2010 monitoring locations included one site just upstream of the Maiden Road crossing at Giltedge, within the lower half of the listed segment (CIPC-M2), and a lower site a short distance below the Manitoba Gulch confluence (CIPC-M3) at the county road crossing (**Figure 7-2** and **Table 7-10** in TMDL). Note, site CIPC-M3 is not shown on Figure 7-2 because it is downstream of the listed portion of the stream. Chippewa Creek was dry from its headwaters to a short distance above CIPC-M2 and could not be sampled in August 2010. The 2011 monitoring included a new upper site (CIPC-MSA1) located just downstream from an area of upwelling groundwater and a developed off-channel stock watering tank. Site CIPC-MSA1 was located near the upstream limit of perennial flow in Chippewa Creek based on late-summer 2010 and spring 2011 observations. Former monitoring sites CIPC-M2 and CIPC-M3 were also sampled again on May 18, 2011.

Streamflows in May 2011 increased three-fold from CIPC-MSA1 to CIPC-M2 (0.26 to 0.78 cfs), and increased four-fold from CIPC-M2 to CIPC-M3 (0.78 to 3.14 cfs). Stations CIPC-MSA1 and CIPC-M2 bracket the original Giltedge cyanide mill site and a large nearby pile of reworked mile tailings. There is also a small impoundment on Chippewa Creek at Giltedge which may serve as a temporary sink for sediment associated pollutants such as TR metals and TSS. The stream also gains flows from groundwater discharge through this reach.

During each of the 2010 and 2011 monitoring events, the portion of the listed segment from just upstream of the Giltedge Mine downstream to the Manitoba Gulch confluence was examined. There was no little or no surface flow present in Chippewa Creek from upstream of the Giltedge Mine downstream nearly to the location of monitoring site CIPC-MSA1 during both visits, and no surface discharges were observed from mines or mill sites. However, mill tailings were observed to be eroding into the channel and may be a source of metals loading. Diffuse, very small volume groundwater seeps began appearing across the floodplain downstream of the reclaimed area associated with Golden Maple's former heap leach operations. Flows slowly increased from this area downstream to the Maiden Road, where flows of 0.07 and 0.78 cfs were measured in August 2010 and May 2011, respectively. TSS concentrations were 23 and 26 mg/L at site CIPC-M2 on these two occasions and fine sediment particles were suspended in the water, although the water appeared mostly clear. Snow appeared to be largely gone from the watershed during the mid-May 2011 visit, although the very upper-most reaches of the watershed were not visited (due to no flow present).

D3.3 Collar Gulch

D3.3.1 Literature Review

The literature review for Collar Gulch provided considerable information on the history of minerals exploration and development in this watershed, as well as other resources. The Collar Mine was one of the first mines to be developed in the Maiden area and is the most important mine in the Collar Gulch watershed. The mine is located on the south side of Collar Gulch in the upper half of the stream's 6.4 mile length. This underground lode mine was discovered in August 1880. A 350 foot adit was driven into the mountain and a 190 foot shaft was sunk to meet the adit. Drifts were driven on the 70 foot and 120 foot levels. The mill was operated for only a short time. In 1882, a 20-stamp mill was erected at the mine featuring 850 pound stamps, 12 pans and 6 settlers. In 1884, the mine was sold and resold. The mill was dismantled and moved to another mine. The mine was reopened and expanded in 1906, and cyanide ores were shipped out. By 1906 the mine was reported to have shipped $125,000 in ore (http://www.deq.mt.gov/abandonedmines).

The Tail Holt Mine is located high on a hillside on the west side of the upper Collar Gulch drainage. This mine was discovered in 1911, worked for a short time and then abandoned. In 1927, the mine was actively developed and ore was shipped. A mill and a cyanide plant were erected on-site to work the ore. From 1927-1934, the mine was credited with producing 1,166 ounces of gold and 647 ounces of silver from 2,961 tons of ore (http://www.deq.mt.gov/abandonedmines). The mine continued to be worked intermittently through the 1930's and was an active claim as late as 1995. Other mines or prospects in the Collar Gulch Watershed include the Black Diamond (dry prospect), the Silver Bullion (active in 1995), the Montago (same location as the Collar Mine), and the Hardscramble (dry, no impact).

The literature review also revealed a description of a cooperative fish habitat enhancement project on Collar Gulch in the vicinity of the Collar Mine and mill site. In 2006-2007, BLM, Montana Fish, Wildlife and Parks, and a private contractor routed Collar Gulch around an old log crib dam and enhanced habitat features to protect what is described as the eastern-most known population of genetically pure westslope cutthroat trout (Flentie, 2008). Another publication described the importance of natural caves and abandoned mines in Collar Gulch and other areas in the Judith Mountains as overwintering hibernaculum for several native bat species (Hendricks, 2000).

D3.3.2 GIS Analysis

The 303(d) listed segment of Collar Gulch extends for 6.4 miles from the headwaters to its mouth on Fords Creek. Land ownership is BLM managed lands in the upper half of the watershed drainage area with some scattered private in-holdings likely associated with mining claims, private ranch lands in its central and lower reaches, and state lands (former Fort McGinnis historical site) in the lower 1.5 mile of stream extending to where it meets Fords Creek. Elevation of the stream varies from about 5500 feet in it headwaters to about 4200 feet at the Fords Creek confluence. The MBMG and/or Montana DEQ abandoned mines databases show the previously described abandoned mines and assorted prospects in the Collar Gulch drainage, including the Collar Mine, the Tail Holt, the Silver Bullion, the Montago, and the Hardscramble. All of these mines and prospects are located in the upper half of the watershed. The MBMG database mentions an adit discharge at the Tail Holt Mine, which was not observed during an August 2010 visit to the mine. Problems are not indicated for the other sites within these databases.

D3.3.3 Field Source Assessment

Water quality monitoring was conducted at one site on Collar Gulch on August 18, 2010 (CLRG-M1; a second site was dry and could not be sampled), and at three sites on May 19, 2011 (**Figure 7-3** and **Table 7-13** in TMDL). The 2010 monitoring locations included one site a short distance downstream from the Collar Mine and mill (CLRG-M1), and the lower dry site was at a road crossing on private land (CLRG-M3). The creek channel went dry between CLRG-M1 and CLRG-M3 in August 2010 and sample collection could not be conducted at CLRG-M3 as noted. The May 2011 monitoring included a new upper site (CLRG-MSA1), which was located one-half to three-quarters of a mile upstream of the previously established site CLRG-M1. CLRG-MSA1 was the practical upper limit of access into the Collar Gulch headwaters area during this visit due to deep snow and heavy vegetation. Former monitoring sites CLRG-M1 and CLRG-M3 were also re-sampled on May 19, 2011, during which time the lower site had active streamflow. Station CLRG-M1 is located downstream from the Tail Holt and Silver Bullion Mines, both of which are some distance from the Collar Gulch stream channel. Stations CLRG-MSA1 and CLRG-M1 bracket the Collar Mine and mill site, and the Hardscramble Mine. Monitoring sites CLRG-M1 and CLRG-M3 bracket the Black Diamond dry prospect and the newer vertical exploration shaft adjacent to Collar Gulch near the BLM/private land boundary.

Collar Gulch is known to lose surface flow to groundwater downstream of the Collar Mine, as was observed during August 2010, and this has contributed to the survival and isolation of the population of pure westslope cutthroat trout. In May 2011, several small tributaries were observed discharging to Collar Gulch between sites CLRG-M1 and CLRG-M3. Despite these inflows, the streamflow in Collar Gulch remained a relatively steady 11.28 to 11.88 cfs in this reach, suggesting that any losses to groundwater were offset by tributary surface discharges. TSS concentrations in Collar Gulch were less than detection at all monitoring sites in both August 2010 and May 2011 indicating low levels of suspended sediment despite moderate turbidity levels observed in May 2011. Any sediment present in Collar Gulch in May was obviously in the form of very fine particles that gave a cloudy appearance despite TSS concentrations less than the 4 mg/L detection limit. Most snow was gone from the lower elevation portions of the watershed during the May 19, 2011 visit.

During the 2011 monitoring event, the entire 4 mile portion of the listed segment from the private ranch road crossing to upper-most monitoring site CLRG-MSA1 was observed from a trail which parallels the creek. The Collar Mine site was examined in August 2010 and again in May 2011. Another more recent mine prospect was examined further downstream in the drainage, consisting of a vertical shaft sunk in a limestone outcrop adjacent to Collar Gulch. The Tail Holt Mine was examined in August 2010, as indicated earlier, and no adit discharge was observed at that time. Together, no readily apparent mining related or other anthropogenic sources of metals loading to Collar Gulch were observed during either survey. Snowmelt runoff was observed running down the road below the Collar Mine site during the May 2011 visit and it eventually discharged to Collar Gulch or its immediate floodplain.

D3.4 ARMELLS CREEK

D3.4.1 Literature Review

The literature review for Armells Creek produced limited findings and no detailed information on the mining history of this watershed. From the reference documents located for the other Judith Mountains streams, most of the producing mines were located on the east and west side of the mountains. Mine exploration in the Armells Creek drainage on the north side of the Judith Mountains produced limited success. According to landowners along Armells Creek, whose relatives came to this area in 1895, no significant producing mines or mills were ever developed in the Armells Creek drainage (personal communication with Steve Gilpatrick, Landowner. May 2011).

D3.4.2 GIS Analysis

The 303(d) listed segment of Armells Creek extends for 19.3 miles from the headwaters to the confluence of Deer Creek. Land ownership is BLM managed lands surrounding several miles of the headwaters area, and private ranch lands throughout the remainder of the listed segment. Elevation of the stream varies from about 5200 feet in it headwaters to less than 3800 feet at the Deer Creek confluence. The MBMG and Montana DEQ abandoned mines databases show: 1) the Iron King underground prospect (iron) and the Hamilton Copper Prospect (copper, silver) on the north side of Judith Peak above upper Armells Creek, 2) the White and Gilpatrick exploration prospect (lead, zinc, copper), the West Armells Creek claim (iron, manganese), and the Armells Creek Number 1 claim (unlisted details) adjacent to the headwaters fork of Armells Creek which drains Red Mountain, and 3) the Sutter Mine (iron, copper, silver – past producer), the Cave prospect (silver, lead), and the Independent Numbers 3 and 4 (iron prospect) adjacent to Armells Creek in the area near the BLM/private land boundary. The mines database indicates that most of these sites are dry with no associated environmental impacts, and no specific problems are indicated for any of the sites.

D3.4.3 Field Source Assessment

Water quality monitoring was conducted at three sites on Armells Creek on August 16, 2010, and at five sites on May 17-18, 2011 (**Figure 7-4** and **Table 7-16** in TMDL). The 2010 monitoring locations included one site in the headwaters of Armells Creek on BLM lands downstream from the confluence of the two headwaters tributaries (ARMC-M1), a site on a private ranch at the Gilpatrick Road crossing near Hilger (ARMC-M2), and a site below the confluence of the East Fork Armells Creek at the county road crossing on a privately owned ranch (ARMC-M3). Access permission was not granted to private lands in the lower portion of the listed segment of Armells Creek near the Deer Creek confluence. The May 2011 monitoring included two new upper watershed monitoring locations: ARMC-MSA1 on the headwaters fork of Armells Creek which drains the north side of Judith Peak, and ARMC-MSA2 on the headwaters fork of Armells Creek which drains Red Mountain. During the May 2011 monitoring event, ARMC-M1 and AMC-M2 were also re-sampled. Also during the May monitoring event, the former lower-most site ARMC-M3 was relocated downstream a half mile to a second (abandoned) county bridge crossing on the private ranch and named ARMC-M4. This site was relocated downstream to ensure complete mixing of the East Fork Armells Creek inflow at the very high flow conditions that were encountered on May 18.

The water appeared moderately turbid or turbid at all the monitoring sites in May 2011, but sediment present at the upper sites was obviously in the form of very fine particles that gave a cloudy appearance despite the low TSS measurement values. All snow was gone from the lower elevation portions of the Armells Creek watershed during the May 17-18, 2011 visit.

During the May 2011 monitoring, most of the segment of Armells Creek from its headwater forks downstream to Highway 236, and a half mile or more of each of the two headwater tributaries, was observed from adjacent roads or on foot. The extreme headwaters of the tributaries could not be accessed due to remaining deep snow. Extensive flood damage to the road, culverts and stream channel from peak snowmelt runoff the previous week was observed along upper Armells Creek on BLM and privately owned lands. Many of the accessible, previously listed mine prospect sites were examined for discharges or potential metals source areas. The high elevation Iron King and Hamilton Copper Prospect sites were not accessible. No readily apparent mining related or other anthropogenic sources of metals loading to Armells Creek were observed during the survey. However, actively eroding streambanks on BLM lands revealed brilliant red soils that may have been natural sources of iron and possibly other metals.

D3.5 Cow Creek

D3.5.1 Literature Review
As was noted on page 3 of this report, the primary focus of this study was on Chicago Gulch, Chippewa Creek, Collar Gulch and Armells Creek. Cow Creek was not extensively researched for literature pertaining to former coal or metals mining within its watershed area. No relevant documents were identified.

D3.5.2 GIS Analysis
GIS mapping and analysis for Cow Creek show several abandoned coal and placer mines within the MBMG abandoned mines database in the lower portion of the drainage downstream of the reach monitored as part of this study.

D3.5.3 Field Source Assessment
Water quality monitoring was conducted at three sites on Cow Creek on August 17, 2010, and was repeated at the three same sites on May 16, 2011 (**Figure 7-5** and **Table 7-19** in TMDL). The 2010-2011 monitoring locations included an upper site accessed off the Birdtail Road (COWC-M1), a site at the Cow Island Road Crossing (COWC-M2), and a lower site accessed from the Spencer Ridge Road (COWC-M3). Surface flows present in Cow Creek during the August 2010 visit ranged from 1.85 cfs at COWC-M1 to 1.49 cfs at COWC-M3. In mid-May 2011, snowmelt runoff had likely peaked in the previous week based on evidence of previous over bank flows and flooding. Flows on May 16 ranged from 50.68 cfs at COWC-M1 to 52.31 cfs at COWC-M3 during a (likely) declining hydrograph. Snow was no longer present in the visible watershed during May 2011 sampling and roads were drying out from heavy rainfall that occurred several days earlier. TSS concentrations in Cow Creek in August 2010 were 5 mg/L at COWC-M1, 17 mg/L at COWC-M2, and 13 mg/L at COWC-M3. In May 2011, TSS concentrations ranged from 47 mg/L at COWC-M1 to 254 mg/L at COWC-M3, reflecting the high turbidity and sediment loads carried by

this stream during spring runoff. Turbidity levels at all stations were described as opaque during sampling in May 2011.

No direct sources of metals were identified in the reach of Cow Creek that was examined. Concentrations and loads for most metals increased in a downstream manner in conjunction with increasing TSS concentrations. Concentrations of most metals were higher during runoff conditions in May than during base flow conditions in August, suggesting a diffuse metals source associated with runoff and/or suspension of sediment.

D3.6 Fargo Coulee

D3.6.1 Literature Review

As was noted on page 3 of this report, the primary focus of this study was on Chicago Gulch, Chippewa Creek, Collar Gulch and Armells Creek. Fargo Coulee was not extensively researched for literature pertaining to former mining within its watershed area and no pertinent information was identified that would shed light on that question.

D3.6.2 GIS Analysis

A GIS mapping and analysis exercise was not conducted for Fargo Coulee as a part of this study.
The DEQ and MBMG abandoned and inactive mines database did not reveal any former mines in the Fargo Coulee drainage.

D3.6.3 Field Source Assessment

Water quality monitoring was attempted at each of three sites on Fargo Coulee on August 17, 2010 and again on May 17, 2011 (**Figure 7-6** in TMDL). The monitoring locations included an upper site at the Birdwell Road crossing (FRGC-M1), a middle site accessed from private ranch lands north of Roy (FRGC-M2), and a site at the mouth of Fargo Coulee on Armells Creek (FRGC-M3). All three sites were dry in August 2010, and one of three sites, FRGC-M1, was dry in May 2011.

Surface flows present in Fargo Coulee during the May 2011 monitoring event ranged from 0.55 cfs at FRGC-M2 to 6.78 cfs at site FRGC-M3 at the mouth. During this visit, snowmelt runoff had likely peaked in the previous week based on evidence of previous over bank flows and flooding. Snow was no longer present in the visible watershed and roads were drying out from heavy rainfall that occurred several days earlier. TSS concentrations in Fargo Coulee were less than the analytical detection limit of 4 mg/L at FRGC-M2 and 379 mg/L at FRGC-M3 on May 17, 2011. Turbidity was 3.07 NTU at FRGC-M2 and 434 NTU at FRGC-M3. The water was tannin stained and very clear at FRGC-M2, and opaque with a very heavy sediment load at FRGC-M3. Specific conductance was 7985 µS/cm at FRGC-M2 and 6958 µS/cm at FRGC-M3 indicating very high levels of dissolved solids. Saline seeps were observed entering Fargo Coulee from adjacent coulees just upstream of the FRGC-M2 sampling location and salt crusts were present along the margins of the stream channel.

No mining or other direct human source of metals was identified during the field assessment. Monitoring of Fargo Coulee in May 2011 showed that concentrations and loads for most metals increased in a downstream manner in conjunction with increasing TSS concentrations. This suggests that diffuse sediment associated nonpoint sources in the segment of Fargo Coulee between FRGC-M2 and FRGC-M3 were the largest source of metals in this system.

D5.0 REFERENCES

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APPENDIX E - SEDIMENT TOTAL MAXIMUM DAILY LOADS

E.1 SEDIMENT

E.1.1 OVERVIEW

A percent reduction based on average yearly loading was used as the primary approach for expressing the sediment TMDLs within this document because there is uncertainty associated with the loads derived from the source assessment, and using the estimated sediment loads alone creates a rigid perception that the loads are absolutely conclusive. However, in this appendix the TMDL is expressed using daily loads to satisfy an additional EPA required TMDL element. Daily loads should not be considered absolutely conclusive and may be refined in the future as part of the adaptive management process. It is not expected that daily loads will drive implementation activities.

E.1.2 APPROACH

The preferred approach for calculating daily sediment loads is to use a nearby water quality gage with a long-term dataset for flow and suspended sediment. However, there are no gages in the Chippewa Creek watershed and suspended sediment is not monitored at any of the gages within the Musselshell River watershed. Since sediment loading in the Chippewa Creek watershed is associated with nonpoint sources, the hydrograph is assumed to be a reasonable surrogate for sediment loading to stream (i.e. peak contributions during periods of runoff and high flow). The closest gage to Chippewa Creek with an extensive flow record is the Musselshell River at Mosby (gage 06130500); it has discharge values dating back to 1930. The gage at Mosby is downstream of the confluence with the McDonald Creek, which Chippewa Creek is a tributary to, and likely has similar temporal hydrologic patterns to the Chippewa Creek. Therefore, mean daily discharge values from almost 80 years of record at the gage on the Musselshell River at Mosby were used to calculate daily sediment values for the Chippewa Creek sediment TMDL.

Using the mean of daily mean discharge values from the gage, a daily percentage relative to the mean annual discharge was calculated for each day (**Table E-1**). The daily percentages were multiplied by the total average annual load associated with the TMDL percent reductions in **Section 5.6.2** to calculate the daily load. The daily loads are shown graphically in **Figure E-1** and may be computed by using the daily percentages in **Table E-1** and the annual TMDL of 58.76 tons.

For instance, the total allowable annual sediment load for Chippewa Creek is 58.76 tons. To determine the TMDL for January 1, 58.76 tons is multiplied by 0.06% which provides a daily load for Chippewa Creek on January 1st of 0.03769 tons (78.4 pounds). The daily loads are a composite of the allocations, but as allocations are not feasible on a daily basis, they are not contained within this section. If desired, daily allocations may be obtained by applying allocations provided in **Section 5.6.2** to the daily load.

Table E-1. USGS Stream Gage 06130500 (Musselshell River at Mosby MT) - Percent of mean annual discharge based on mean of daily mean values for each day for 78 - 79 years of record in, cfs (calculation period Oct 1, 1930 through September 30, 2010)

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.06%	0.08%	0.23%	0.41%	0.29%	0.69%	0.64%	0.13%	0.14%	0.09%	0.09%	0.08%
2	0.07%	0.08%	0.33%	0.36%	0.31%	0.67%	0.60%	0.12%	0.12%	0.09%	0.09%	0.08%
3	0.08%	0.08%	0.48%	0.32%	0.32%	0.71%	0.55%	0.14%	0.12%	0.09%	0.09%	0.08%
4	0.07%	0.09%	0.40%	0.30%	0.32%	0.80%	0.58%	0.13%	0.11%	0.08%	0.09%	0.08%
5	0.07%	0.09%	0.37%	0.29%	0.33%	0.73%	0.55%	0.12%	0.11%	0.08%	0.09%	0.08%
6	0.08%	0.10%	0.36%	0.29%	0.38%	0.74%	0.56%	0.13%	0.11%	0.09%	0.09%	0.08%
7	0.08%	0.11%	0.40%	0.30%	0.49%	0.76%	0.52%	0.13%	0.11%	0.08%	0.09%	0.08%
8	0.08%	0.10%	0.40%	0.30%	0.47%	0.82%	0.44%	0.12%	0.14%	0.08%	0.09%	0.07%
9	0.08%	0.10%	0.43%	0.29%	0.47%	0.99%	0.40%	0.12%	0.12%	0.08%	0.09%	0.07%
10	0.08%	0.10%	0.43%	0.29%	0.48%	1.03%	0.38%	0.11%	0.12%	0.08%	0.09%	0.07%
11	0.08%	0.10%	0.44%	0.29%	0.55%	0.96%	0.33%	0.13%	0.11%	0.08%	0.09%	0.07%
12	0.07%	0.11%	0.49%	0.28%	0.52%	1.07%	0.32%	0.11%	0.11%	0.08%	0.08%	0.07%
13	0.07%	0.13%	0.48%	0.27%	0.51%	0.99%	0.33%	0.11%	0.12%	0.08%	0.08%	0.07%
14	0.07%	0.24%	0.46%	0.27%	0.49%	1.04%	0.36%	0.10%	0.11%	0.08%	0.08%	0.07%
15	0.07%	0.28%	0.43%	0.28%	0.48%	1.00%	0.30%	0.12%	0.11%	0.08%	0.08%	0.07%
16	0.08%	0.27%	0.40%	0.29%	0.50%	0.97%	0.28%	0.14%	0.11%	0.08%	0.09%	0.07%
17	0.08%	0.29%	0.40%	0.29%	0.49%	1.14%	0.25%	0.13%	0.11%	0.08%	0.09%	0.07%
18	0.08%	0.26%	0.48%	0.30%	0.52%	1.25%	0.24%	0.12%	0.11%	0.08%	0.09%	0.07%
19	0.08%	0.24%	0.49%	0.28%	0.59%	1.15%	0.23%	0.11%	0.17%	0.08%	0.08%	0.07%
20	0.08%	0.23%	0.48%	0.28%	0.64%	1.08%	0.23%	0.12%	0.13%	0.09%	0.08%	0.07%
21	0.08%	0.21%	0.58%	0.28%	0.69%	1.10%	0.25%	0.12%	0.12%	0.09%	0.08%	0.07%
22	0.08%	0.19%	0.63%	0.27%	0.62%	1.08%	0.20%	0.12%	0.11%	0.09%	0.08%	0.07%
23	0.08%	0.17%	0.59%	0.27%	0.63%	0.95%	0.18%	0.12%	0.10%	0.10%	0.08%	0.07%
24	0.08%	0.17%	0.56%	0.28%	0.69%	0.89%	0.18%	0.11%	0.10%	0.09%	0.08%	0.07%
25	0.08%	0.23%	0.59%	0.27%	0.79%	0.87%	0.17%	0.11%	0.22%	0.09%	0.08%	0.07%
26	0.08%	0.31%	0.57%	0.26%	0.74%	0.82%	0.16%	0.11%	0.18%	0.09%	0.08%	0.07%
27	0.08%	0.27%	0.60%	0.26%	0.73%	0.82%	0.26%	0.11%	0.12%	0.09%	0.08%	0.07%
28	0.08%	0.25%	0.58%	0.26%	0.73%	0.88%	0.22%	0.11%	0.11%	0.09%	0.08%	0.07%
29	0.08%	0.19%	0.53%	0.28%	0.70%	0.79%	0.16%	0.11%	0.10%	0.09%	0.08%	0.07%
30	0.08%	--	0.48%	0.29%	0.73%	0.69%	0.15%	0.11%	0.09%	0.09%	0.08%	0.06%
31	0.08%	--	0.44%	--	0.70%	--	0.14%	0.12%	--	0.09%	--	0.06%

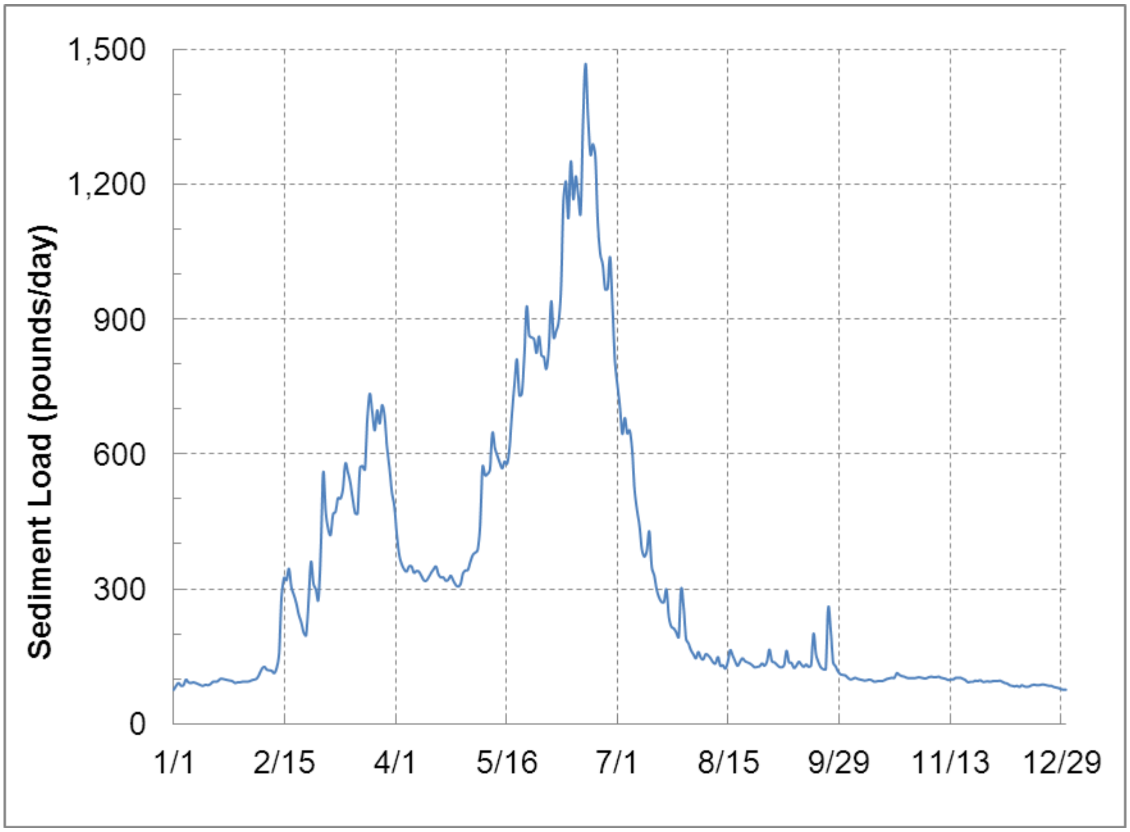

Figure E-1. Average daily sediment load for Chippewa Creek (MT40B002_040).