Final - Upper Clark Fork Phase 2 Sediment and Nutrients TMDLs and Framework Water Quality Improvement Plan

April 2014

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Document Number C01-TMDL-04aF

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Suggested citation: Montana DEQ. 2014. Final - Upper Clark Fork Phase 2 Sediment and Nutrients TMDLs and Framework Water Quality Restoration Plan. Helena, MT: Montana Dept. of Environmental Quality.

ACKNOWLEDGEMENTS

The Montana Department of Environmental Quality (DEQ) would like to acknowledge multiple entities for their contributions in the development of the sediment Total Maximum Daily Loads (TMDLs) contained in this document. The Watershed Restoration Coalition of the Upper Clark Fork watershed provided support throughout the TMDL planning process by providing assistance with the identification of stakeholders and coordinating stakeholder meetings, administering contracts for the completion of sediment source assessments, and via public outreach and education. The WRC will also be involved in implementing many of the water quality improvement recommendations contained in this document.

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. Those instrumental in providing technical review and assistant include Joe Griffin (DEQ), Joel Chavez (DEQ), Brian Bartkowiak (DEQ), Al Nixon (DEQ), David Nimick (United States Geological Survey (USGS), Steve Sando (USGS), Sara Sparks (U.S. Environmental Protection Agency), Tom Mostad (Montana Department of Justice, Natural Resource Damage Program) and Dr. Chris Gammons (Montana Tech). Watershed Consulting, LLC provided contributions for sed/hab work in the development of **Appendix C**.

We would like to thank Janelle Egli, an administrative assistant, from the Watershed Management Section of DEQ, for her time and efforts formatting this document.

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

ACRONYM LIST

Acronym	Definition
AFDM	Ash-Free Dry Mass
AFO	Animal Feeding Operation
AML	Abandoned Mine Lands
ARCO	Atlantic Richfield Company
ARARS	Applicable or Relevant and Appropriate Requirements and Standards
ARM	Administrative Rules of Montana
AU	Assessment Unit
AUM	Animal Unit Months
BDNF	Beaverhead Deerlodge National Forest
BEHI	Bank Erosion Hazard Index
BLM	Bureau of Land Management (Federal)
BMP	Best Management Practices
BNSF	Burlington Northern Santa Fe
BPSOU	Butte Priority Soils Operable Unit
BSB	Butte-Silver Bow
CAFO	Concentrated (or Confined) Animal Feeding Operations
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
CFROU	Clark Fork River Operable Unit
chl-*a*	chlorophyll-*a*
CRDWP	Comprehensive Remedial Design Work Plan
cfs	cubic feet per second
CWA	Clean Water Act
DEQ	Department of Environmental Quality (Montana)
DIC	Decrease in Concentration
DMR	Discharge Monitoring Report
DNRC	Department of Natural Resources & Conservation (Montana)
DQA	Data Quality Analysis
EPA	Environmental Protection Agency (U.S.)
EQIP	Environmental Quality Incentives Program
FWP	Fish, Wildlife & Parks (Montana)
GIS	Geographic Information System
GWIC	Groundwater Information Center
HBI	Hilsenhoff Biotic Metric
HD	Hydrodynamic Device
HIP	Holding and Infiltration/Percolation
HRU	Hydrologic Response Unit
HSB	Horseshoe Bend Water Treatment Plant
HUC	Hydrologic Unit Code
IDDE	Illicit Discharge Detection and Elimination
INFISH	Inland Native Fish Strategy
IR	Integrated Report

Acronym	Definition
LA	Load Allocation
LAO	Lower Area One
MBH	Montana Behavioral Health, Inc.
MBMG	Montana Bureau of Mines and Geology
MCA	Montana Code Annotated
MDHES	Montana Department of Health and Environmental Services
MDT	Montana Department of Transportation
MGD	million gallons per day
MOS	Margin of Safety
MPDES	Montana Pollutant Discharge Elimination System
MPTP	Montana Pole and Treating Plant
MSD	Metro Storm Drain
MSU	Montana State University
MWCB	Mine Waste Cleanup Bureau (DEQ)
NHD	National Hydrography Dataset
NLCD	National Land Cover Dataset
NOAA	National Oceanographic and Atmospheric Administration
NPL	National Priorities List
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NURP	Nationwide Urban Runoff Program
OU	Operable Unit
PCP	PentaChloroPhenol
PIBO	PACFISH/INFISH Biological Opinion
PVC	Poly Vinyl Chloride
RCRA	Resource Conservation and Recovery Act
RDG	Reclamation and Development Grant
REC	Renewable Energy Corporation
RipES	Riparian Evaluation System
RIT	Resource Indemnity Trust
ROD	Record of Decision
SAP	Sampling and Analysis Plan
SCADA	Supervisory Control and Data Acquisition
SMCRA	Surface Mining Control & Reclamation Act
SMZ	Streamside Management Zone
SNOTEL	Snowpack Telemetry
SOP	Standard Operating Procedure
SRP	Soluble Reactive Phosphorus
SSTOU	Streamside Tailings Operable Unit
SWAT	Soil & Water Assessment Tool
SWMP	Storm Water Management Program (DEQ)
SWPPP	Storm Water Pollution Prevention Plan
TC	Total Containment
TIE	TMDL Implementation Evaluation
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen

Acronym	Definition
TNC	The Nature Conservancy
TP	Total Phosphorus
TPA	TMDL Planning Area
TSS	Total Suspended Solids
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation
VCRA	Voluntary Cleanup and Redevelopment Act
VNRP	Voluntary Nutrient Reduction Program
WLA	Wasteload Allocation
WMA	Wildlife Management Area
WRC	Watershed Restoration Coalition
WRCC	Western Regional Climate Center
WRP	Watershed Restoration Plan
WWTP	Wastewater Treatment Plant

DOCUMENT SUMMARY

This document presents a Total Maximum Daily Load (TMDL) and framework water quality improvement plan for eight impaired tributaries to the Clark Fork River including Dempsey Creek, Dunkleberg Creek, Gold Creek, Hoover Creek, Lost Creek, Peterson Creek, Silver Bow Creek and Willow Creek and including the Clark Fork River upstream of the Flint Creek confluence (see **Figures A-2** and **A-3** found in **Appendix A**). The 22 TMDLs in this document address impairment from sediment (*n*=4 TMDLs) and nutrients (*n*=18 TMDLs) and address four sediment impairments and 21 nutrient impairments in the Upper Clark Fork River watershed.

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 project area encompasses Silver Bow Creek and the upper portion of the Clark Fork River watershed, which begins in Silver Bow County at the headwaters near Butte, Montana, and flows 99.7 miles to its confluence with Flint Creek near Drummond, Montana, in Granite County. The project area includes all of 8-digit Hydrologic Unit Code (HUC) 17010201 except the Little Blackfoot Drainage. The Little Blackfoot River drainage is a separate project area and was addressed in a separate TMDL document (2012c).

DEQ determined that eight Clark Fork River tributaries and three segments of the Clark Fork River mainstem do not meet the applicable water quality standards. The scope of the TMDLs in this document addresses problems with sediment and nutrients (see **Table DS-1**). Although DEQ recognizes that there are other pollutant listings for this TMDL Planning Area (TPA), this document addresses only sediment and nutrients.

Sediment was identified as impairing aquatic life in Silver Bow Creek and three segments of the Clark Fork River upstream of the Flint Creek confluence. Sediment is affecting designated uses in these streams 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 instream habitat as it related to the effects of sediment, and the stability of streambanks. DEQ believes that once these water quality goals are met, all water 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, and roads. The most significant sources include: transportation networks, and upland sources in addition to natural sources. The Upper Clark Fork River watershed sediment TMDLs indicate that reductions in sediment loads ranging from 24% to 31% 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, for harvesting timber, and for developing subdivisions. In addition, they includes BMPs for expanding riparian buffer areas and using other land, soil, and water conservation practices that improve stream channel conditions and associated riparian vegetation.

Nutrient TMDLs are provided for 11 waterbody segments in the Upper Clark Fork Phase 2 TPA: Dempsey, lower Dunkleberg, lower Gold, upper Hoover, lower Hoover, Lost, upper Peterson, lower Peterson, Silver Bow Creek, upper Willow, and lower Willow Creeks. Nutrients are affecting beneficial uses in these streams by affecting macroinvertebrate populations and increasing net primary production in the water column impacting habitat. If necessary nutrient reductions are achieved then beneficial uses should be restored. Nutrients are impairing the beneficial uses of aquatic life (including coldwater fishery), primary contact recreation and agricultural uses.

Nutrient loads were quantified for all identified sources such as agricultural practices, residential and developed lands impacts, and nutrient point sources as well as natural background. Several stream segments are currently meeting total nitrogen (TN) TMDLs while the more severely impacted waterbodies require >80% reduction in the existing TN or total phosphorus (TP) load to achieve the TMDL. Major nonpoint nutrient sources include agriculture and residential sources including subsurface wastewater disposal and treatment. The latter becomes more significant in basins with higher septic densities. In Silver Bow Creek, most of the nutrient loading comes from point source discharges and from urban/residential land-use impacts.

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 where TMDLs have been developed and approved by EPA. The Upper Clark Fork Phase 2 TPA has permitted dischargers requiring the incorporation of WLAs into permit conditions on Silver Bow Creek and the Clark Fork River.

Sediment, metals and temperature TMDLs were previously developed in the Upper Clark Fork and are part of a previous document (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2010). This TMDL effort focused on tributaries to the Clark Fork River upstream of the Flint Creek confluence, but did not include Silver Bow Creek.

Table DS-1. List of Impaired Waterbodies and Their Impaired Uses in Upper Clark Fork Phase 2 TPA with Completed Sediment and Nutrient TMDLs Contained in this Document

Waterbody and Location Description	Waterbody ID	Use Class	Impairment Cause[a]	Impaired Use(s)[a]
CLARK FORK RIVER, Cottonwood Creek to Warm Springs	MT76G001_040	C-2	Sedimentation/Siltation	Aquatic Life
CLARK FORK RIVER, the Little Blackfoot River to Cottonwood Creek	MT76G001_030	C-1	Sedimentation/Siltation	Aquatic Life
CLARK FORK RIVER, Flint Creek to Little Blackfoot River	MT76G001_010	B-1	Sedimentation/Siltation	Aquatic Life
DEMPSEY CREEK, the national forest boundary to mouth (Clark Fork River)	MT76G002_100	B-1	Nitrogen (Total)	Aquatic Life, Primary Contact Recreation
			Phosphorus (Total)	Aquatic Life, Primary Contact Recreation
DUNKLEBERG CREEK, T9N R12W S2 to mouth (Un-named Canal), T10N R11W S30	MT76G005_072	B-1	Nitrogen (Total)	Aquatic Life, Primary Contact Recreation
			Phosphorus (Total)	Aquatic Life, Primary Contact Recreation
GOLD CREEK, the forest boundary to mouth (Clark Fork River)	MT76G005_092	B-1	Phosphorus (Total)	Aquatic Life, Primary Contact Recreation
HOOVER CREEK, headwaters to Miller Lake	MT76G005_081	B-1	Phosphorus (Total)	Aquatic Life, Primary Contact Recreation
HOOVER CREEK, Miller Lake to mouth (Clark Fork River)	MT76G005_082	B-1	Nitrogen (Total)	Aquatic Life, Primary Contact Recreation
			Phosphorus (Total)	Aquatic Life, Primary Contact Recreation
LOST CREEK, the south State Park boundary to mouth (Clark Fork River)	MT76G002_072	B-1	Nitrate/Nitrite	Aquatic Life, Primary Contact Recreation
			Nitrogen (Total)	Aquatic Life, Primary Contact Recreation
PETERSON CREEK, headwaters to Jack Creek	MT76G002_131		Phosphorus (Total)	Aquatic Life, Primary Contact Recreation
		B-1	Nitrogen (Total)	Aquatic Life, Primary Contact Recreation
			Total Kjeldahl Nitrogen (TKN)	Aquatic Life, Primary Contact Recreation

Table DS-1. List of Impaired Waterbodies and Their Impaired Uses in Upper Clark Fork Phase 2 TPA with Completed Sediment and Nutrient TMDLs Contained in this Document

Waterbody and Location Description	Waterbody ID	Use Class	Impairment Cause[a]	Impaired Use(s)[a]
PETERSON CREEK, Jack Creek to mouth (Clark Fork River)	MT76G002_132	B-1	Phosphorus (Total)	Aquatic Life, Primary Contact Recreation
			Nitrogen (Total)	Aquatic Life, Primary Contact Recreation
SILVER BOW CREEK, headwaters to mouth (Clark Fork River)	MT76G003_020	I	Nitrates	Aquatic Life, Primary Contact Recreation
			Sedimentation/Siltation	Aquatic Life
			Nitrogen (Total)	Aquatic Life, Primary Contact Recreation
			Phosphorus (Total)	Aquatic Life, Primary Contact Recreation
WILLOW CREEK, headwaters to T4N R10W S30	MT76G002_061	B-1	Phosphorus (Total)	Aquatic Life, Primary Contact Recreation
WILLOW CREEK, T4N R10W S30 to mouth (Mill Creek), T4N R10W S11	MT76G002_062		Phosphorus (Total)	Aquatic Life, Primary Contact Recreation
		B-1	Nitrogen (Total)	Aquatic Life, Primary Contact Recreation

[a] Impaired uses given in this table are based on updated assessment results and may not match the "2012 Water Quality Integrated Report"

1.0 Project Overview

This document presents an analysis of water quality information and establishes Total Maximum Daily Loads (TMDLs) for nutrient and sediment problems in the Upper Clark Fork Phase 2 TMDL Planning Area (TPA). This document also presents a general framework for resolving these problems. **Figures A-2a** and **A-2b**, found in **Appendix A**, show a map of waterbodies in the Upper Clark Fork Phase 2 TPA with sediment and nutrient pollutant listings.

1.1 Why We Write TMDLs

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

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

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

Each waterbody in Montana has a set of designated uses from the list above. Montana has established water quality standards to protect these uses, and a waterbody that does not meet one or more standards is called an impaired water. Each state must monitor their waters to track if they are supporting their designated uses, and every 2 years the Montana Department of Environmental Quality (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. **Table A-1** in **Appendix A** identifies all impaired waters for the Upper Clark Fork TPA from Montana's 2012 303(d) List, and includes non-pollutant impairment causes included in Montana's "2012 Water Quality Integrated Report." **Table A-1** provides the current status of each impairment cause, identifying whether it has been addressed by TMDL development.

Both Montana state law (Section 75-5-701 of the Montana Water Quality Act) and section 303(d) of the federal CWA require the development of 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
- Quantifying the magnitude of pollutant contribution from their sources
- Determining the TMDL for each pollutant based on the allowable loading limits for each waterbody-pollutant combination
- Allocating the total allowable load (TMDL) into individual loads for each source

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

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

1.2 Water Quality Impairments and TMDLs Addressed by this Document

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 **Table A-1** in **Appendix A**). Each pollutant impairment falls within a TMDL pollutant category (nutrients or sediment,) and this document is organized by those categories.

New data assessed during this project identified 13 new nutrient impairment causes for nine stream assessment units on eight waterbodies. These impairment causes are identified in **Table 1-1** and noted as not being on the 2012 303(d) List (within the IR). 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 22 TMDLs that address 25 impairments (**Table 1-1**). There are several 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 7.0**. **Section 7.0** also provides some basic water quality solutions to address those non-pollutant causes not specifically addressed by TMDLs in this document.

Although DEQ recognizes that there are other pollutant listings for the Upper Clark Fork TPA without completed TMDLs (**Table A-1** in **Appendix A**), this document only addresses those identified in **Table 1-1**. This is because DEQ sometimes develops TMDLs in a watershed at varying phases, with a focus on one or a couple of specific pollutant types. Sediment, temperature, and metals TMDLs were previously completed for tributaries in the Upper Clark Fork TPA in 2010 (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2010). In addition the Clark Fork Voluntary Nutrient Reduction Program (VNRP) addressed nutrient impairments in the Clark Fork River (Tri-State Implementation Council, 1998). **Table A-1** in **Appendix A** includes impairment causes with completed TMDLs, well as non-pollutant impairment causes that were addressed by those TMDLs.

Table 1-1. Water Quality Impairment Causes for the Upper Clark Fork Phase 2 TPA Addressed within this Document

Waterbody and Location Description[a]	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status	Included in 2012 IR[b]
CLARK FORK, Cottonwood Creek to Warm Springs	MT76G001_040	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Addressed by sediment TMDL in this document	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document	Yes
CLARK FORK, the Little Blackfoot River to Cottonwood Creek	MT76G001_030	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Addressed by sediment TMDL in this document	Yes
		Physical substrate habitat alterations	Not a Pollutant	Addressed by sediment TMDL in this document	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document	Yes
CLARK FORK, Flint Creek to Little Blackfoot River	MT76G001_010	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Addressed by sediment TMDL in this document	Yes
		Physical substrate habitat alterations	Not a Pollutant	Addressed by sediment TMDL in this document	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document	Yes
DEMPSEY CREEK, the national forest boundary to mouth (Clark Fork River)	MT76G002_100	Nitrate/Nitrite	Nutrients	Not impaired based on 2012 assessment	Yes
		Nitrogen (Total)	Nutrients	TN TMDL contained in this document	No
		Phosphorus (Total)	Nutrients	TP TMDL contained in this document	No
DUNKLEBERG CREEK, T9N R12W S2 to mouth (Un-named Canal), T10N R11W S30	MT76G005_072	Nitrogen (Total)	Nutrients	TN TMDL contained in this document	Yes
		Phosphorus (Total)	Nutrients	TP TMDL contained in this document	No
GOLD CREEK, the forest boundary to mouth (Clark Fork River)	MT76G005_092	Nitrogen (Total)	Nutrients	Not impaired based on 2012 assessment	Yes
		Phosphorus (Total)	Nutrients	TP TMDL contained in this document	No
HOOVER CREEK, headwaters to Miller Lake	MT76G005_081	Phosphorus (Total)	Nutrients	TP TMDL contained in this document	No
HOOVER CREEK, Miller Lake to mouth (Clark Fork River)	MT76G005_082	Nitrogen (Total)	Nutrients	TN TMDL contained in this document	Yes
		Phosphorus (Total)	Nutrients	TP TMDL contained in this document	No
LOST CREEK, the south State Park boundary to mouth (Clark Fork River)	MT76G002_072	Nitrate/Nitrite	Nutrients	Addressed by TN TMDL contained in this document	Yes
		Nitrogen (Total)	Nutrients	TN TMDL contained in this document	No

Table 1-1. Water Quality Impairment Causes for the Upper Clark Fork Phase 2 TPA Addressed within this Document

Waterbody and Location Description[a]	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status	Included in 2012 IR[b]
PETERSON CREEK, headwaters to Jack Creek	MT76G002_131	Phosphorus (Total)	Nutrients	TP TMDL contained in this document	Yes
		Nitrogen (Total)	Nutrients	TN TMDL contained in this document	Yes
		Total Kjeldahl Nitrogen (TKN)	Nutrients	Addressed by TN TMDL contained in this document	Yes
PETERSON CREEK, Jack Creek to mouth (Clark Fork River)	MT76G002_132	Phosphorus (Total)	Nutrients	TP TMDL contained in this document	No
		Nitrogen (Total)	Nutrients	TN TMDL contained in this document	No
SILVER BOW CREEK, headwaters to mouth (Clark Fork River)	MT76G003_020	Physical substrate habitat alterations	Not a Pollutant	Addressed by sediment TMDL in this document	Yes
		Nitrates	Nutrients	Addressed by TN TMDL contained in this document	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document	Yes
		Nitrogen (Total)	Nutrients	TN TMDL contained in this document	No
		Phosphorus (Total)	Nutrients	TP TMDL contained in this document	No
WILLOW CREEK, headwaters to T4N R10W S30	MT76G002_061	Phosphorus (Total)	Nutrients	TP TMDL contained in this document	Yes
WILLOW CREEK, T4N R10W S30 to mouth (Mill Creek), T4N R10W S11	MT76G002_062	Phosphorus (Total)	Nutrients	TP TMDL contained in this document	No
		Nitrogen (Total)	Nutrients	TN TMDL contained in this document	No

[a] All waterbody segments within Montana's Water Quality IR are indexed to the NHD
[b] Impairment causes not in the "2012 Water Quality Integrated Report" were recently identified and will be included in the 2014 IR

1.3 What This Document Contains

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 Upper Clark Fork Watershed Description:
Describes the physical characteristics and social profile of the watershed.

Section 3.0 Montana Water Quality Standards:
Discusses the water quality standards that apply to the Upper Clark Fork watershed.

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

Sections 5.0 – 6.0 Sediment and Nutrients TMDL Components:
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 7.0 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 8.0 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 9.0 Monitoring for Effectiveness:
Describes a water quality monitoring plan for evaluating the long-term effectiveness of the "Upper Clark Fork Phase 2 TMDL" document.

Section 10.0 Public Participation & Public Comments:
Describes other agencies and stakeholder groups who were involved with the development of the plan and the public participation process used to review the draft document. Addresses comments received during the public review period.

2.0 Upper Clark Fork Watershed Description

This report describes the physical, biological, and anthropogenic characteristics of the Upper Clark Fork of the Columbia River (**Figure A-1**), referred to as the Clark Fork River. The characterization establishes a context for impaired waters, as background for TMDL planning.

The Upper Clark Fork Phase 2 project completely overlaps the Upper Clark Fork TPA. In addition to tributaries to the Clark Fork River, the Phase 2 Project includes three segments of the mainstem of the Clark Fork River upstream of the Flint Creek confluence. These segments are separately identified in the Silver Bow Creek – Clark Fork River metals project but for purposes of efficiency have been included in the Phase 2 TMDL project. As the project overlaps the Upper Clark Fork planning area, it is named the Upper Clark Fork Phase 2 TPA.

The project area encompasses Silver Bow Creek and the upper portion of the Clark Fork River watershed, which begins in at the confluence of Warm Springs Creek and Silver Bow Creek and flows 70.6 miles to its confluence with Flint Creek near Drummond, Montana, in Granite County. The project area includes all of 8-digit Hydrologic Unit Code (HUC) 17010201 except the Little Blackfoot Drainage. The Little Blackfoot River drainage is a separate project area and was addressed in a separate TMDL document (Montana Department of Environmental Quality, 2012c).

Per the 2012 303(d) List, DEQ has identified 21 impaired waterbodies within the Upper Clark Fork Phase 2 TPA:

- Antelope Creek
- Beefstraight Creek
- Brock Creek
- Cable Creek
- Clark Fork River
- Dempsey Creek
- Dunkleberg Creek
- German Gulch
- Gold Creek
- Hoover Creek
- Lost Creek
- Mill-Willow Bypass
- Mill Creek
- Modesty Creek
- Peterson Creek
- Silver Bow Creek
- Storm Lake Creek
- Tin Cup Joe Creek
- Warm Springs Creek (near Warm Springs)
- Warm Springs Creek (near Phosphate)
- Willow Creek

The impairment listings are detailed in DEQ's Integrated 305(b)/303(d) Water Quality Report (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012a), and are shown on **Figures A-2a** and **A-2b**. Impairment listings are summarized in **Section 1.0** of this document.

2.1 Physical Characteristics

2.1.1 Location

The Upper Clark Fork Phase 2 TPA is located in the Columbia River Basin (Accounting Unit 170102) of western Montana, as shown on **Figure A-1**. The entire TPA is located within the Middle Rockies (17) Level III Ecoregion. Ten Level IV Ecoregions are mapped within the TPA (**Table 2-1**, **Figure A-3**). The 4 largest of these are: Deer Lodge – Philipsburg – Avon Grassy Intermontane Hills and Valleys (17ak), Upper Clark Fork – Anaconda Mountains (17am), Elkhorn Mountains-Boulder Batholith (17ai), and Dry Intermontane Sagebrush Valleys (17aa).

Table 2-1. Level IV Ecoregions in the Upper Clark Fork Phase 2 TPA

ID	Level IV Ecoregion Name	Area (sq. mi.)
17ak	Deer Lodge-Philipsburg-Avon Grassy Intermontane Hills and Valleys	**561.41**
17am	Flint Creek-Anaconda Mountains	**350.04**
17ai	Elkhorn Mountains-Boulder Batholith	**227.23**
17aa	Dry Intermontane Sagebrush Valleys	**139.82**
17al	Southern Garnet Sedimentary-Volcanic Mountains	**83.33**
17ag	Pioneer-Anaconda Ranges	**58.28**
17h	Alpine Zone	**29.89**
17ah	Eastern Pioneer Sedimentary Mountains	**23.34**
17x	Rattlesnake-Blackfoot-South Swan-Northern Garnet-Sapphire Mountains	**15.35**
17ac	Big Hole	**5.10**
	Total	**1,493.79**

The majority of the TPA is within Powell County, with small areas in Granite, Deer Lodge, and Silver Bow counties, and includes the municipalities of Butte, Anaconda, and Deer Lodge, Montana.

The TPA is bounded by the Boulder Mountains to the east, the Highland and Anaconda Ranges to the south, the Flint Creek Range to the west, and the Garnet Range to the north. The total area is 956,160 acres, or approximately 1,494 square miles. The TPA does not include the Little Blackfoot River watershed which is a separate TPA for which TMDLs were approved by the U.S. Environmental Protection Agency (EPA) in December 2011 (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011).

2.1.2 Topography

Elevations in the TPA range from approximately 1,200 to 3,230 meters (3,900–10,600 ft) above mean sea level (**Figure A-4**). The mean elevation is 1,830 meters (5,930 ft) above sea level. The highest point in the watershed is Mount Haggin, at 10,607 ft. The lowest point is the confluence of the Clark Fork River with Flint Creek at the downstream edge of the TPA at 3,963 ft above sea level.

The TPA includes three discrete valleys. These include a high mountain valley (the Summit Valley around Butte), a broad fault-bounded basin (Deer Lodge Valley) and the narrow Clark Fork Valley northwest of Garrison, Montana.

2.1.3 Geology

Figure A-5 provides an overview of the geology, based on the 1:500,000 scale statewide map (Ross et al., 1955). Description of the geology is derived from more recent, larger-scale mapping projects. The geology of selected areas of the project area has been described and mapped in detail by Portner and Hendrix (2005) and Lewis (1998). The detailed geology of the Upper Clark Fork area is extremely complex and beyond the scope of this characterization. In general, the TPA encompasses fault-bounded valleys filled with unconsolidated sediment and the bedrock mountains that surround them.

2.1.3.1 Bedrock

The Flint Creek Range is composed of folded and faulted sedimentary rocks ranging in age from Cambrian (540 million years ago) through Cretaceous (65 million years ago), with overthrusts of Belt Supergroup rocks mapped in places. The Cretaceous sediments are predominantly fine-grained rocks such as siltstones and shales. This package of sedimentary rocks has been intruded by several generations of Cretaceous and Tertiary igneous rocks. The range is cored by the Philipsburg pluton, a body of resistant Cretaceous granodiorite that holds up the higher peaks. Pleistocene glaciation sculpted the Flint Creek range, producing the rugged alpine geomorphology (Lewis, 1998).

The Boulder Mountains are underlain by a large body of granitic igneous rock, called the Boulder Batholith. The batholith is flanked by volcanic rocks of Tertiary age. These mountains are generally lower in elevation and more rounded than the Flint Creek Range.

2.1.3.2 Basin Sediments

The Deer Lodge Valley features distinctive sloped terraces above the modern fluvial valley, and abutting the mountains. These terraces are composed of Tertiary sediment and are well-drained and sparsely vegetated (Lewis, 1998).

In the Northern Rockies region of the United States, the Tertiary is generally characterized as a time of basin filling, followed by renewed uplift, stream erosion and downcutting in the Quaternary. The basins are filled with several thousand feet of Tertiary basin-fill sediments, with a veneer of overlying Quaternary deposits. Oil wells have reported over 10,000 ft of unconsolidated sediment at the deepest point in the Deer Lodge valley. The narrow Clark Fork Valley between Gold Creek and Drummond is shallower, with bedrock at a depth of roughly 3,000 ft (Kendy and Tresch, 1996). The Summit Valley is a relatively shallow basin, with fewer than 1,000 ft of alluvial deposits at the deepest portion of the basin (LaFave, 2008).

2.1.4 Soils

The United States Geological Survey (USGS) Water Resources Division created a dataset of hydrology-relevant soil attributes, based on the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) STATSGO soil database. The STATSGO data is intended for small-scale (watershed or larger) mapping, and is too general to be used at scales larger than 1:250,000. It is important to realize, therefore, that each soil unit in the STATSGO data may include up to 21 soil components. Soil analysis at a larger scale should use NRCS Soil Survey Geographic database data. The soil attributes considered in this characterization are erodibility and slope.

Soil permeability is reported in inches per hour, and is mapped on **Figure A-6a**. Impermeable soils are mapped in the vicinity of the Anaconda smelter complex.

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-6b**, with soil units assigned to the following ranges: low (0.0–0.2), low-moderate (0.2–0.29) and moderate-high (0.3–0.4). Values of >0.4 are considered highly susceptible to erosion. No values greater than 0.4 are mapped in the TPA.

Nearly 60% of the TPA is mapped as low-moderately erodible soils. Twenty-three percent of the soils in the TPA are assigned low susceptibility to erosion. The remaining 18% of soils are assigned moderate to high susceptibility to erosion.

Several patterns are apparent in the distribution of mapped K-factors. The low and moderate-to-low susceptibility soils correspond to timbered uplands, and moderate-to-high susceptibility soils are confined to the valleys. Moderate-to-high susceptibility soils coincide with areas where Tertiary sediments are mapped, and the Quaternary alluvial valleys incised into these deposits generally have moderate-to-low susceptibility. The majority of the low-susceptibility soils coincides with the granitic rocks of the Philipsburg pluton and is less strongly associated with the Boulder Batholith.

The steepest slopes in the watershed are in the Flint Creek Range. The Boulder and Garnet Ranges differ by exhibiting rounded summits and broad ridges incised with steeply sloping valleys. The valleys and the terraces east of the Deer Lodge valley are distinguished by large areas of low slope. A map of slope is provided in **Figure A-7**.

2.1.5 Surface Water

Within the Upper Clark Fork Phase 2 TPA, the Clark Fork River drains from the confluence of Silver Bow Creek and Warm Springs Creek to the confluence with Flint Creek near Drummond, a distance of approximately 70.6 miles. The Clark Fork River receives one major tributary within the TPA: the Little Blackfoot River. Although this river contributes flow to the Clark Fork River, the Little Blackfoot watershed was the subject of a separate TPA, and is not addressed in this document. Upper Clark Fork watershed hydrography is illustrated in **Figure A-8**.

2.1.5.1 Impoundments

The National Hydrography Dataset (NHD) for lakes includes five impoundments greater than 100 acres in surface area in the project area. These dammed lakes include: Moulton Reservoir Number One (aka Silver Lake (277 acres)), Rock Creek Lake (176 acres), the tailings ponds at Opportunity (~3500 acres), and the Warm Springs Ponds (~500 acres) on Silver Bow Creek. The tailings ponds at Opportunity may be better described as a waste repository to isolate contaminated sediments from water sources. The Berkeley Pit, a former open pit copper mine, is located north of Butte, Montana, and is not considered a dammed impoundment. As of July 2013, the Berkeley Pit had a total depth of 1,047 ft, contained 42.5 billion gallons of water, and covered an area of approximately 415 acres; it may be more accurately described as a groundwater impoundment, and it does not currently discharge to any surface water or groundwater sources. Upgradient of the Berkeley Pit is the Yankee Doodle Tailings Pond, which covers approximately 740 acres and is also not listed as a dammed impoundment in the NHD.

In the project area, there are numerous impoundments less than 100 acres in surface area. These are concentrated in the Upper Clark Fork tributaries in the Flint Creek Range along the western side of the Deer Lodge Valley.

2.1.5.2 Stream Gaging Stations

USGS maintains 15 stream gaging stations within the watershed. An additional 9 gages that were once operating are now inactive. The USGS gaging stations are listed below (**Table 2-2**), and shown in **Figure A-8.**

Table 2-2. USGS Stream Gages in the Upper Clark Fork Phase 2 TPA

Gage Name	Number	Drainage Area	Agency	Period of Record
Blacktail Creek at Butte	12323240	95.4 $miles^2$	USGS	1988 -
Blacktail Creek near Butte	12323200	14.7 $miles^2$	USGS	1983 - 1988
Clark Fork at Deer Lodge	12324200	995 $miles^2$	USGS	1978 -
Clark Fork at Goldcreek	12324680	1,760 $miles^2$	USGS	1977 -
Clark Fork near Drummond	12331600	2,378 $miles^2$	USGS	1972 - 1983
Clark Fork near Galen	12323800	651 $miles^2$	USGS	1988 -
Clark Fork near Garrison	12324300	1,139 $miles^2$	USGS	1961
German Gulch near Ramsay	12323500	40.6 $miles^2$	USGS	1955 - 1969
Gold Creek at Goldcreek	12324660	64.1 $miles^2$	USGS	1963 - 1966
Lost Creek near Anaconda	12323840	26.4 $miles^2$	USGS	2004 -
Lost Creek near Galen	12323850	60.5 $miles^2$	USGS	2003 -
Mill Creek at Opportunity	12323700	43.2 $miles^2$	USGS	2003 -
Mill Creek Near Anaconda	12323670	34.4 $miles^2$	USGS	2004 -
Racetrack Creek below Granite Creek	12324100	39.5 $miles^2$	USGS	1957 - 1973
Racetrack Creek near Anaconda	12324000	39.5 $miles^2$	USGS	1911 - 1912
Silver Bow Creek above Blacktail Creek	12323170	–	USGS	1983 - 1994
Silver Bow Creek at Warm Springs	12323750	394 $miles^2$	USGS	1972 -
Silver Bow Creek above WWTP	12323248	–	USGS	1998 - 2003
Silver Bow Creek at Opportunity	12323600	363 $miles^2$	USGS	1988 -
Silver Bow Creek below Blacktail Creek	12323250	103 $miles^2$	USGS	1983 -
Warm Springs Creek at Warm Springs	12323770	163 $miles^2$	USGS	1983 -
Warm Springs Creek near Anaconda	12323760	157 $miles^2$	USGS	1997 -
Willow Creek at Opportunity	12323720	30.8 $miles^2$	USGS	2003 -
Willow Creek near Anaconda	12323710	13.7 $miles^2$	USGS	2005 -

2.1.6 Groundwater

2.1.6.1 Hydrogeology

Groundwater flow within the valleys is typical of intermontane basins. Groundwater flows towards the center of the basin from the head and sides, and then down valley along the central axis.

The hydrogeology of the Deer Lodge Valley and the Clark Fork Valley is described in Kendy and Tresch (1996), in discussion of the Upper Clark Fork River basin. The Summit Valley has been characterized in other reports (Carstarphen et al., 2004; LaFave, 2008).

Natural recharge occurs from infiltration of precipitation, stream loss and flow out of the adjacent bedrock aquifers. Flood and sprinkler irrigation is a major source of recharge to the valley aquifers, and return flows contribute significantly to streamflow (Nimick, 1993). The Clark Fork is a gaining stream between Racetrack Creek and the town of Garrison.

Four thermal springs have been categorized by the USGS in the Deer Lodge Valley (Kendy and Tresch, 1996): Warm Springs (78°C at 61 gpm), Gregson Hot Springs (70°C at 40 gpm), Anaconda Hot Springs (22°C at 2.9 gpm) and Deer Lodge Prison Hot Springs (26°C at 100 gpm). However, this is likely not a complete list of all thermal hot springs in the Upper Clark Fork Phase 2 TPA.

2.1.6.2 Groundwater Quality

The Montana Bureau of Mines and Geology (MBMG) Groundwater Information Center (GWIC) program monitors and samples a statewide network of wells. Additionally, the GWIC program is engaged in a statewide characterization of aquifers and groundwater resources, by region. The TPA is in Region 5, the Upper Clark Fork River basin. Elevated nitrogen levels are well documented in Summit Valley groundwater (LaFave, 2008). The sources are not well understood, but isotopic evidence suggests a large anthropogenic contribution.

As of December 2013, the GWIC database reports 5,957 wells within the TPA (Montana Bureau of Mines and Geology, 2013). Water quality data is available for 836 of those wells. This is an unusually high percentage, and is due to the extensive groundwater investigations related to environmental cleanup efforts in the watershed. The locations of these data points are shown on **Figure A-9**.

The water quality data typically include general physical parameters: temperature, pH and specific conductance, in addition to inorganic chemistry (common ions, metals and trace elements). MBMG does not generally analyze groundwater samples for organic compounds.

There are 75 public water supplies within the TPA. The majority of these are small transient-non-community systems. Community systems are defined as those systems which serve a population of more than 25 persons (residents) daily or have greater than 15 service connections. The Butte-Silverbow Water Department (and systems that purchase water from Butte) uses surface water; all other public water supplies in the TPA use groundwater. Water quality data is available from these utilities via the Safe Drinking Water Information System State of Montana database. However, the data reflect the finished water provided to users and not raw water at the source.

2.1.7 Stream Morphology

Stream morphology throughout the project area is variable and has been historically altered in many cases to accommodate a variety of land uses and/or transportation networks. In general, streams in the Upper Clark Fork originate in high-elevation, steep, mountainous terrain dominated by cobble substrate and are predominantly driven by snowmelt and runoff. In these areas, the streams are entrenched to moderately entrenched and are characterized by cascading step/pool to riffle dominated channels as gradient decreases. In these upper reaches of the streams, channel form and profile are generally very stable. Gradually, these systems transition downstream to meandering, low gradient systems characterized by riffle/pool complexes with well-defined point bars and broad, well developed floodplains. These low gradient, wide valley portions of the Upper Clark Fork streams are typically where most alteration to stream morphology has occurred and where the most bank instability and impacts from sediment deposition can be found, when it occurs.

Stream morphology in Silver Bow Creek and the Clark Fork River has been significantly altered first by land clearing and mining/smelting activities in the late 1800s and then by large flood events in the early 1900s. Stream morphology has more recently been altered by remediation activities in the associated

Superfund areas in the Clark Fork Basin including the Streamside Tailings Operable Unit (SSTOU) and the Clark Fork River Operable Unit (CFROU).

2.1.8 Climate

Climate in the TPA is typical of mid-elevation intermontane valleys in western Montana, with the local climate varying with elevation.

Average annual precipitation in the watershed ranges from 7 to 10 inches in the Deer Lodge valley to 46 to 50 inches/yr in the Anaconda and Flint Creek mountain ranges (PRISM Group, 2004). The months of May and June typically receive the highest amounts of precipitation, with precipitation in the winter months coming in the form of snow.

Climate data for the TPA, from the Western Regional Climate Center (WRCC), is available from five National Oceanographic and Atmospheric Administration (NOAA) climate stations: Deer Lodge, Deer Lodge 3 W, Anaconda, East Anaconda, and Butte Federal Aviation Administration Airport. **Tables 2-3**, **2-4**, and **2-5** contain climate summaries for the various climate stations throughout the watershed.

The NRCS operates 3 active snowpack telemetry (SNOTEL) sites within the TPA. These sites are: Basin Creek, Barker Lakes, and Warm Springs. SNOTEL sites collects mountain snowpack data throughout the winter months, which can be used for streamflow and water supply forecasts, climate modeling, conservation planning, and many other applications. **Figure A-10** shows the locations of the NOAA and SNOTEL stations, in addition to average annual precipitation.

The precipitation data is mapped by Oregon State University's PRISM Group, based on the records from NOAA stations (PRISM Group, 2004). Climate data is provided by the WRCC, operated by the Desert Research Institute of Reno, Nevada.

Table 2-3. Monthly Climate Summary for Deer Lodge, Montana

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Climate Data for the Deer Lodge 3 W, MT Climate Station: 242275[a]													
Average Max. Temperature (F)	32.2	38.1	44.7	54.6	62.9	71.5	80.2	79.9	69.4	58.3	42.3	33.1	55.6
Average Min. Temperature (F)	9.1	14.2	19.3	25.7	32.8	39.7	42.9	41.3	33.6	26.0	17.1	10.3	26.0
Average Total Precipitation (in.)	0.4	0.3	0.5	0.7	1.8	1.9	1.3	1.3	1.1	0.6	0.4	0.4	10.8
Average Total Snowfall (in.)	8.7	4.2	7.6	3.5	0.5	0.2	0.0	0.0	0.0	1.1	4.5	6.2	36.4
Average Snow Depth (in.)	4.0	2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	1.0
Climate Data for the Deer Lodge, MT Climate Station: 242273[b]													
Average Max. Temperature (F)	31.8	35.6	43.0	55.7	64.9	71.7	82.0	80.6	70.1	58.6	42.7	34.4	55.9
Average Min. Temperature (F)	10.1	12.4	19.0	28.1	35.4	42.0	46.3	44.8	36.9	28.8	19.6	13.9	28.1
Average Total Precipitation (in.)	0.5	0.4	0.6	0.7	1.5	2.3	1.2	0.8	1.0	0.7	0.5	0.5	10.6

Table 2-3. Monthly Climate Summary for Deer Lodge, Montana

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Total Snowfall (in.)	5.3	4.4	4.0	1.2	0.8	0.1	0.0	0.0	0.1	1.2	2.8	5.6	25.5
Average Snow Depth (in.)	2.0	2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0

[a] Period of record 4/15/1959 to 12/31/2005
[b] Period of record 1/1/1893 to 2/28/1959

Table 2-4. Monthly Climate Summary for Anaconda, Montana

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Climate Data for the Anaconda, MT Climate Station: 240199[a]													
Average Max. Temperature (F)	36.6	39.6	47.5	55.8	64.7	73.1	81.7	81.3	70.4	58.1	42.1	34.0	57.1
Average Min. Temperature (F)	15.3	15.9	22.4	28.5	35.9	42.5	47.3	46.2	38.3	30.3	20.2	12.9	29.6
Average Total Precipitation (in.)	0.6	0.5	1.0	1.3	2.0	2.1	1.5	1.5	1.2	0.8	0.9	0.7	14.0
Average Total Snowfall (in.)	10.2	9.5	13.2	7.6	2.0	0.5	0.0	0.2	1.3	3.8	12.0	12.1	72.3
Average Snow Depth (in.)	3.0	3.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	3.0	1.0
Climate Data for the East Anaconda, MT Climate Station: 242604[b]													
Average Max. Temperature (F)	29.3	33.6	39.1	49.6	59.4	67.8	78.8	76.8	65.6	53.7	39.6	32.3	52.1
Average Min. Temperature (F)	14.3	17.8	21.4	29.8	37.8	45.1	52.3	50.7	42.6	34.5	24.4	18.2	32.4
Average Total Precipitation (in.)	0.9	0.7	0.8	1.0	1.8	2.3	1.3	1.1	1.2	0.9	0.8	0.8	13.6
Average Total Snowfall (in.)	11.0	8.2	9.9	6.3	2.9	0.4	0.0	0.1	1.3	3.2	7.5	8.4	59.2
Average Snow Depth (in.)	1.0	2.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0

[a] Period of record 8/1/1982 to 12/31/2005
[b] Period of record 9/1/1905 to 7/31/1980

Table 2-5. Monthly Climate Summary for Butte, Montana

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Climate Data for the Butte FAA Arpt, MT Climate Station: 241318[a]													
Average Max. Temperature (F)	30.0	34.3	40.9	51.1	60.5	69.4	79.7	78.2	66.9	55.5	40.6	31.7	53.2
Average Min. Temperature (F)	7.4	10.7	17.7	27.1	34.8	41.9	47.0	45.2	36.8	28.5	18.1	9.9	27.1
Average Total Precipitation (in.)	0.6	0.5	0.8	1.1	1.9	2.3	1.3	1.2	1.1	0.8	0.6	0.6	12.8
Average Total Snowfall (in.)	8.5	7.3	10.2	6.9	3.7	0.5	0.0	0.1	1.1	3.7	6.5	8.4	56.8
Average Snow Depth (in.)	4.0	4.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	1.0

[a] Period of record 4/2/1894 to 12/31/2005

2.2 Ecological Parameters

2.2.1 Vegetation

The primary cover in the uplands is conifer forest. Conifers are dominated by Lodgepole pine, yielding to Douglas fir and Ponderosa pine at lower elevations. The valleys are characterized by grassland and irrigated agricultural land, with shrublands dominating the Tertiary benches. Landcover and land use are shown on **Figure A-11,** with data coming from the USGS National Land Cover Dataset (NLCD) mapping (United States Geological Survey, 2007).

2.2.2 Aquatic Life

Native fish species present in the TPA include: bull trout, westslope cutthroat trout, mountain whitefish, longnose dace, mottled scuplin, slimy scuplin, northern pike minnow, redside shiner, largescale sucker and longnose sucker. Introduced species present in the TPA include: brook, brown, and rainbow trout, common carp, pumpkinseed, largemouth bass and yellow perch. Bull trout and westslope cutthroat trout are designated "Species of Concern" by Montana Fish, Wildlife & Parks (FWP). Bull trout are further listed as "threatened" by the U.S. Fish & Wildlife Service. Reaches of Racetrack Creek, Warm Springs Creek, and its tributaries have been designated as critical habitat for bull trout (50 Code of Federal Regulations (CFR) Part 17, 2005).

Bull trout are mapped in the Clark Fork River, and in some tributary streams draining the Flint Creek Range: Racetrack, Lost and Warm Springs Creeks (near Anaconda). Bull trout are also mapped in the headwaters tributaries of Warm Springs Creek (Barker, Twin Lakes, Storm Lake, Cable and Foster creeks). Bull trout are not mapped in any streams that drain from the Boulder Mountains. Westslope cutthroat trout are not reported in the Clark Fork River, but are mapped in the upper reaches of most tributaries.

Data on fish species distribution is collected, maintained and provided by FWP (Lindstrom, 2011; Liermann et al., 2009; Lindstrom et al., 2008). Distribution of bull trout, westslope cutthroat trout, and introduced species are shown in **Figure A-12**.

2.2.3 Fires

Wildland fires can be an important and significant source of disturbance in a watershed. These fires are part of the natural processes within an ecosystem, but human activities have vastly altered the occurrence and management of such fires. In recent history, there have not been any significant fires in the Upper Clark Fork Phase 2 TPA. Relatively few fires have occurred in the TPA, with the largest being the Bielenburg fire of 2009, and all other fires burning less than 100 acres (**Table 2-6**). A map of historical fire perimeters can be seen in **Figure A-13**.

Table 2-6. Historical Fires within the Upper Clark Fork Phase 2 TPA (1985–2012)

Fire Name	Fire Year	Agency	Acres
Twin Lakes	2003	USFS	93
Girard Gulch	1988	USFS	*Not reported*
Bielenburg	2009	USFS	1950
Maude	1990	USFS	30
Adams	1987	USFS	16

2.3 Cultural Parameters

2.3.1 Population

An estimated 49,300 persons lived within the TPA in 2010 (United States Census Bureau, 2012). The densest populations are located in the urban areas of Butte, Deer Lodge and Anaconda (**Figure A-14**). Butte is the fifth largest urban area in the state of Montana with a population of approximately 33,525 according to the U.S. Census Bureau 2010 census. The City of Butte and Silver Bow County have a combined city and county government and associated agencies.

2.3.2 Land Ownership

Slightly more than one-half of the TPA is under private ownership. The dominant landholder is the United States Forest Service (USFS), which administers 31% of the land within the TPA (**Table 2-7**). There is a distinct pattern of ownership, with private land concentrated in the valley bottoms and USFS land concentrated in the uplands (**Figure A-15**). The State of Montana also manages a significant portion of the TPA (11.6%). In **Figure A-15**, much of the land in the Silver Bow Creek watershed is listed as 'undetermined'. This is all private land that has not yet been fully described/delineated to current standards mostly due to the extensive mining claims that exist in this area.

Table 2-7. Upper Clark Fork Phase 2 TPA Land Ownership

Owner	Acres	Square Miles	% of Total
Private	554,586	866.5	58.0%
USFS	281,530	439.9	29.5%
BLM	9,843	15.4	2.7%
State Trust Land	37,063	57.9	3.9%
FWP	35,992	56.2	3.8%
Montana Department of Corrections	34,005	53.1	3.6%
Other State Land	113	0.2	0.1%
Water	844	1.3	0.9%
Total	955,622	497.7	—

2.3.3 Land Use

Land use within the TPA is dominated by forest and agriculture (**Table 2-8**). Agriculture in the lowlands is primarily related to the cattle industry (irrigated hay and dry grazing). Information on land use is based on the USGS NLCD (United States Geological Survey, 2007). The data are mapped at 1:250,000 scale. Agricultural land use is illustrated on **Figure A-16**.

Table 2-8. Upper Clark Fork Phase 2 TPA Land Use and Land Cover

Land Use	Acres	Square Miles	% of Total
Evergreen Forest	412,819	645.0	43.2%
Grassland/Herbaceous	223,027	348.5	23.3%
Scrub/Shrub	194,427	303.8	20.3%
Pasture/Hay	44,885	70.1	4.7%
Cultivated Crops	19,557	30.6	2.0%
Developed Open Space	16,512	25.8	1.7%
Developed Low Intensity	9,216	14.4	1.0%
Woody Wetlands	9,215	14.4	1.0%
Barren Land	7,052	11.0	0.7%

Table 2-8. Upper Clark Fork Phase 2 TPA Land Use and Land Cover

Land Use	Acres	Square Miles	% of Total
Developed Medium Intensity	5,121	8.0	0.5%
Paved Roads	4,239	6.6	0.4%
Open Water	3,835	6.0	0.4%
Unpaved Roads	3,766	5.9	0.4%
Lawns	995	1.6	0.1%
Developed High Intensity	421	0.7	< 0.1%
Hobby Farms	138	0.2	< 0.1%
Septic System Drainfields	137	0.2	< 0.1%
Mixed Forest	89	0.1	< 0.1%
Perennial Ice/Snow	73	0.1	< 0.1%
Deciduous Forest	60	0.1	< 0.1%
Emergent Herbaceous Wetlands	3	0.0	< 0.1%

More detailed information on agricultural land use can be obtained from the USDA data. Cultivated crops are not extensive in the TPA. Barley, wheat, potatoes, corn, dry beans and oats are all reported, but the total acreage for these crops is only 3,162 acres. The USDA cropland data layer reports 11,256 acres of alfalfa in the TPA, land that is likely irrigated. Irrigation infrastructure, including diversions and ditch networks are described in an assessment completed in 2008 (Appendix H of Montana Department of Environmental Quality, Planning, Prevention and Assistance Division (2010)).

2.3.4 Transportation Networks

Transportation networks (road and railroads) are illustrated on **Figure A-17**.

2.3.4.1 Roads

The principal transportation routes in the project area are US Interstates 90 and 15, US Highway 12 and Montana Highway 1. Using estimates from watershed modeling efforts, an estimated 800 miles of paved roads and 2,200 miles of unpaved roads are present in the TPA (**Section 5.8.4**). The network of unpaved roads on public and private lands will be further characterized as part of the sediment source assessment.

2.3.4.2 Railroads

Several active railways are present in the TPA, although rail traffic is reduced from the years when mining, milling and smelting were practiced in the TPA. A Montana Rail Link line descends the Little Blackfoot valley and continues west to Missoula. The Burlington Northern Santa Fe (BNSF) railroad maintains a branch line between Butte and Garrison. A Union Pacific line crosses Deer Lodge Pass and joins the BNSF line at Silver Bow. The former Butte, Anaconda and Pacific line is now operated as a passenger/entertainment railroad by the Rarus Railway Company.

2.3.5 Upper Clark Fork Superfund Sites

The Upper Clark Fork Phase 2 TPA was the scene of mining, milling and smelting on a scale of national importance. Like many other mining districts, the metal production began with gold placers in the 1860s, although lode mines soon began to exploit rich silver deposits. Copper came to dominate the Butte mines by the 1880s. Smelters were located in Butte, Anaconda and Garrison. For more than 100 years, Silver Bow Creek was used as a conduit for mining, smelting, industrial and municipal wastes and vast mine tailings were deposited along the creek channel and floodplain. The volume of mining waste has been estimated at over 100 million tons of tailings for the entire mining period ending in 1982

(Andrews, 1987) and over 10 million tons of tailings for Silver Bow Creek alone between 1878 and 1925 (Nimick, 1990).

Extensive flooding along Silver Bow Creek and the Clark Fork River in the early 1900s re-deposited tailings along much of Silver Bow Creek and the Clark Fork River floodplains. Streamflow gaging of the Clark Fork River began in 1899 and indicate that large floods occurred in 1899, 1902 and 1908 with the largest occurring in 1908. Indirect evidence of prolonged high stages during these floods is indicated by tailings deposits that averaged 3 to 4 ft thick along Silver Bow Creek (Titan Environmental Corporation, 1995) and commonly 1 ft thick along the Clark Fork in the Deer Lodge Valley (Nimick and Moore, 1991) prior to the start of remediation activities in the late 1990s. The most likely method of deposition of these deposits was from a prolonged overbank flux of fine tailings onto the floodplain (Smith et al., 1998). The series of floods resulted in floodplain aggradation in a sequence of several layers (Nimick, 1990; Smith et al., 1998).

Partly as a result of the early 20th Century flooding, the Warm Springs Ponds were constructed between 1911 and 1959 to serve as settling ponds on Silver Bow Creek. This system is comprised of 3 ponds (Pond 1 is no longer in use) covering approximately 2,500 acres. The ponds contain an estimated 19 million cubic yards of contaminated sediment, tailings and heavy metal sludge. Dikes at the entry of Warm Springs Ponds were enlarged during 1992–93 to provide containment of untreated Silver Bow Creek flows of up to 3,300 cubic feet per second (cfs) (approximately a 100-year event) (Hornberger et al., 1997).

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) is a federal law designed to clean up sites contaminated with hazardous substances. CERCLA is more commonly referred to as the Superfund program. The law authorized the EPA to identify parties responsible for contamination of sites and compel those parties to clean up the sites. If responsible parties cannot be found, the EPA has the authority to clean up sites itself. CERCLA authorizes both removal and remedial actions and afford flexibility for short and long-term actions.

In the Upper Clark Fork River TMDL Phase 2 TPA, there are 4 Superfund sites divided into 14 Operable Units (OUs) (**Table 2-9**). Superfund removal and remediation activities affect all 4 of the sediment listed Assessment Units (AUs) on Silver Bow Creek and the Clark Fork River mainstem addressed in this TMDL document.

Table 2-9. Superfund Sites and OUs in the Upper Clark Fork Phase 2 TPA

Superfund Site	OUs[a]	Notes
Anaconda Smelter NPL	Old Works/East Anaconda Development Area	
	Community Soils	
	Anaconda regional Water, Waste and Soils	
Milltown Reservoir Sediments/Clark Fork River	***Clark Fork River***	
	Milltown Drinking Water Supply[b]	Outside project area
	Milltown Reservoir Sediments[b]	Outside project area
Montana Pole and Treating Plant	**MPTP**	
Rocker Timber Framing and Treating Plant	***Rocker Timber Framing and Treating Plant***	
Silver Bow Creek/	**Area One**	Subunit of BPSOU

Table 2-9. Superfund Sites and OUs in the Upper Clark Fork Phase 2 TPA

Superfund Site	OUs[a]	Notes
	Berkeley Pit/Mine Flooding	Outside AU
	BPSOU	
	Butte Reduction Works	Subunit of BPSOU
	Butte Residential Soils	Subunit of BPSOU
	LAO	Subunit of BPSOU
	SSTOU	
	Warm Springs Ponds, active area	Outside AU
	Warm Springs Ponds, inactive area	
	West Camp/Travona Shaft Area	Managed with BPSOU
	West Side Soils	

[a] Italicized/bolded OUs are those that directly affect impaired AUs in the Upper Clark Fork Phase 2 TPA
[b] These 2 OUs are managed as a single unit

2.3.5.1 Anaconda Smelter CERCLA Site
The Anaconda smelters operated from the mid-1880s to 1980. Milling and smelting produced wastes with high concentrations of arsenic, as well as copper, cadmium, lead and zinc. These contaminants pose potential risks to human health and the environment. The site is subdivided into five remedial OUs. EPA has issued Records of Decision (RODs) for all five OUs. Remedial activities planned for the Anaconda Smelter site include land reclamation for large tailings ponds (>4,000 acres) and landscapes contaminated by aerial emissions, stream stabilization and storm water Best Management Practices (BMPs).

2.3.5.2 Milltown Reservoir / Clark Fork River CERCLA Site
Only one OU of this CERCLA site is within the TPA boundary: Clark Fork River. The other (Milltown Reservoir Sediments) is downstream of the TPA. Remedial activities planned for the river include removal of some exposed tailings, in-place reclamation of some exposed tailings or other tailings-impacted soils, stream bank stabilization and development of a riparian corridor buffer. Sediments from the drained Milltown Reservoir were transported to the Anaconda Smelter CERCLA site in 2007–2009.

2.3.5.3 Montana Pole and Treating Plant CERCLA Site
The Montana Pole and Treating Plant (MPTP) facility in Butte was listed on the National Priorities List (NPL) in the 1980s following complaints of organic chemicals discharging to Silver Bow Creek. The MPTP site is located in the southwestern corner of Butte and is the location of a former wood treating facility that operated from 1946 to 1983. Contamination of soils, groundwater, and nearby Silver Bow Creek occurred from treating fluids containing PentaChloroPhenol (PCP) that were used and disposed of on site.

The site was added to the NPL in 1987. In 1993, DEQ and EPA issued a ROD. Phase 1, Phase 2 and Phase 3 have been completed and included the removal and treatment of contaminated soils and debris. Phase 4 involves on-going biological treatment of contaminated soils at the site and Phase 5 addresses the remaining contaminated soils beneath Interstate 15/90 that transects the site.

Contaminated groundwater is intercepted in two trenches, treated with granular activated carbon at an onsite treatment plant, and discharged to Silver Bow Creek. One trench, the Near Highway Recovery Trench, is located immediately north of Interstate Highway I-15/90. The second trench, the Near Creek

Recovery Trench, is located at the north boundary of the site, just south of Silver Bow Creek (U.S. Environmental Protection Agency, 2009b).

2.3.5.4 Silver Bow Creek/Butte Area CERCLA Site

Waste rock and smelter tailings were formerly deposited in and along Silver Bow Creek, and floods subsequently redeposited these materials along the floodplain. The site also includes the cities of Butte and Walkerville, as well as the Berkeley Pit former mine site and the interconnected mine workings. The site is subdivided into 13 remedial OUs of which seven are active and six have selected remedies and one (West Side Soils) is still in the assessment phase. Remedial progress on the site varies by OU. EPA has issued RODs for five of the OUs. Remedial action is on-going for the Lower Area One (LAO), Rocker Timber and Framing, Streamside Tailings, Warm Springs Ponds and Mine Flooding OUs. Remedial action involves removal of tailings deposits and waste rock from the floodplain of Silver Bow Creek, floodplain reconstruction, land reclamation, groundwater and storm water controls and water treatment. Remedial activities at the Silver Bow Creek/Butte Area Superfund Site have and will continue to improve the water quality and ecological health of Silver Bow Creek.

More specific site descriptions, remediation boundaries and loading estimates from CERCLA sites are included in **Sections 5.3** and **5.7.5** as well as in **Sections 6.3** and **6.5.1.2** where CERCLA sites are within AUs with sediment and/or nutrient impairments.

2.3.6 Upper Clark Fork RCRA Sites

The Rhodia Silver Bow Elemental Phosphorus Production Plant is a Resource Conservation and Recovery Act (RCRA) site. Ownership of the site changed five times from when the facility first started producing elemental phosphorus in 1950 to when production ceased in 1997 (Barr Engineering Company, 2012). As of 1999, most of the site has been decontaminated with the exception of a 100-ft clarifier unit and most the infrastructure of the former plant has been demolished and removed from the site (Barr Engineering Company, 2012). The Rhodia Silver Bow Elemental Phosphorus Production Plant is addressed in more detail in **Section 6.3.2**.

2.3.7 Livestock Operations

Ranching has been a significant part of the history of land use within the TPA. The Deer Lodge Valley was once the site of one of the most prominent cattle ranches in the west, as evidenced by the Grant-Kohrs Ranch National Historic Site. Currently, cattle ranching and forage production still play an important role in the agricultural economy of the TPA.

Livestock grazing occurs on both public and private lands throughout the TPA. The Montana Livestock Auction and the Montana State Prison Ranch in Deer Lodge are the only Montana Pollutant Discharge Elimination System (MPDES)-permitted Concentrated (or Confined) Animal Feeding Operations (CAFOs) near 303(d) listed waterbodies (Silver Bow Creek and Tin Cup Joe Creek respectively) in the TPA (**Figure A-18**). Animal Feeding Operations (AFOs) that do not meet the definition of a CAFO are not subject to MPDES permitting.

2.3.8 Wastewater

Five Wastewater Treatment Plants (WWTPs) with surface water discharges are located within the TPA (i.e., Butte-Silver Bow (BSB), Deer Lodge, Montana Behavioral Health, Inc. (MBH) (Galen), Rocker, and the State Hospital at Warm Springs). The Rocker WWTP and BSB WWTP discharge directly to Silver Bow Creek which is being addressed within this document for sediment and nutrient impairments. The locations of these outfalls are shown on **Figure A-18**. In addition to the Rocker and BSB WWTPs, the other WWTPs are included in the sediment source assessment for the Clark Fork River.

3.0 Montana Water Quality Standards

The federal CWA 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 and water quality standards in general include three main parts:

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

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

Nondegradation provisions are not applicable to the TMDLs developed within this document because of the impaired nature of the streams addressed. Those water quality standards that apply to this document are reviewed briefly below. More detailed descriptions of Montana's water quality standards may be found in the Montana Water Quality Act (75-5-301,302 Montana Code Annotated (MCA)), and Montana's Surface Water Quality Standards and Procedures (Administrative Rules of Montana (ARM) 17.30.601-670) and Circular DEQ-7 (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, Water Quality Standards Section, 2012).

3.1 Stream Classifications and Designated Beneficial Uses

Waterbodies are classified based on their designated uses. All Montana waters are classified for multiple uses. In the Upper Clark Fork Phase 2 TPA, most streams in the project area are in the 'B-1' use classification category. The exceptions include 4 AUs used for public water supply which have 'A' classifications and 2 AUs with 'C' classifications. Silver Bow Creek is classified as 'I'. 'A-closed' waterbodies include: Hearst Lake drainage to the Lower Hearst Inlet and Fifer Gulch to the Anaconda city limits, Yankee Doodle Creek drainage to and including Moulton Reservoir, and Basin Creek drainage to and including the South Butte water supply reservoir. Warm Springs Creek near Warm Springs from the headwaters to Meyers Dam has a use classification of 'A-1'. The Clark Fork River from Cottonwood Creek to the confluence with the Little Blackfoot River is classified as 'C-1'. The same river is classified as 'C-2' from Warm springs Creek to Cottonwood Creek. All other streams are classified 'B-1'.

'A-Closed' streams must be maintained suitable for drinking, culinary, and food processing purposes after simple disinfection. Streams classified 'A-1' are suitable for drinking, culinary and food processing purposes after conventional treatment for removal of naturally present impurities, whereas waters classified 'B-1' must also be suitable for these same uses after conventional treatment for any impurities, whether naturally present or not. Both 'A-1' and 'B-1' classified waters must be 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. Streams classified as 'C-1' or 'C-2' do not have to be maintained suitable for drinking water. This is the main difference between the 'B' and 'C' classification. The '1' and '2' denotes the suitability of propagation of salmonid fishes and associated aquatic life with '1' being suitable growth and '2' being marginal growth.

Silver Bow Creek is classified as ‘I’. Silver Bow Creek, from headwaters to mouth, is currently undergoing a review process to establish whether a use class can be determined based on available data for Silver Bow Creek. As a result, the TMDL will be written to protect all beneficial uses. One of 4 possibilities will occur: (1) designation will remain ‘I’; (2) use class will become ‘B1’ to reflect the upstream use class of Blacktail Creek, a headwater of Silver Bow Creek; (3) use class will become ‘C2’ to reflect the use class of the receiving waterbody, the Clark Fork River from Warm Springs to Cottonwood Creek; or (4) use class will become ‘C1’ consistent with the Clark Fork downstream of Cottonwood Creek confluence near Deer Lodge.

DEQ determined that 14 waterbody segments in the Upper Clark Fork Phase 2 TPA do not meet the nutrient and sediment water quality standards (**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 not meeting a drinking water standard, and is also applied to conditions where the assessment results indicate a severe level of impairment of aquatic life. A non-supporting level of impairment does not equate to complete elimination of the use. Detailed information about Montana’s use support categories can be found in DEQ’s water quality assessment (Suplee and Sada de Suplee, 2011).

The concentrator tailings pond (Yankee Doodle) and Silver Bow Creek drainage from this pond downstream to Blacktail Creek and the tailings ponds at Warm Springs have no classification and are not on the 303(d) list. Therefore, no TMDL development is necessary for those waters at this time.

Table 3-1. Impaired Waterbodies and Their Impaired Designated Uses in the Upper Clark Fork Phase 2 TPA

Waterbody and Location Description	Waterbody ID	Use Class	Impairment Causea	Impaired Use(s)
CLARK FORK, Cottonwood Creek to Warm Springs	MT76G001_040	C-2	Sedimentation/Siltation	Aquatic Life
CLARK FORK, the Little Blackfoot River to Cottonwood Creek	MT76G001_030	C-1	Sedimentation/Siltation	Aquatic Life
CLARK FORK, Flint Creek to Little Blackfoot River	MT76G001_010	B-1	Sedimentation/Siltation	Aquatic Life
DEMPSEY CREEK, the national forest boundary to mouth (Clark Fork River)	MT76G002_100	B-1	Nitrogen (Total)	Aquatic Life
			Phosphorus (Total)	Aquatic Life
DUNKLEBERG CREEK, T9N R12W S2 to mouth (Un-named Canal), T10N R11W S30	MT76G005_072	B-1	Nitrogen (Total)	Aquatic Life
			Phosphorus (Total)	Aquatic Life
GOLD CREEK, the forest boundary to mouth (Clark Fork River)	MT76G005_092	B-1	Phosphorus (Total)	Aquatic Life
HOOVER CREEK, headwaters to Miller Lake	MT76G005_081	B-1	Phosphorus (Total)	Aquatic Life, Primary Contact Recreation
HOOVER CREEK, Miller Lake to mouth (Clark Fork River)	MT76G005_082	B-1	Nitrogen (Total)	Aquatic Life, Primary Contact Recreation
			Phosphorus (Total)	Aquatic Life, Primary Contact Recreation
LOST CREEK, the south State Park boundary to mouth (Clark Fork River)	MT76G002_072	B-1	Nitrate/Nitrite	Aquatic Life
			Nitrogen (Total)	Aquatic Life
PETERSON CREEK, headwaters to Jack Creek	MT76G002_131		Phosphorus (Total)	Aquatic Life, Primary Contact Recreation
		B-1	Nitrogen (Total)	Aquatic Life, Primary Contact Recreation
			Total Kjeldahl Nitrogen (TKN)	Aquatic Life, Primary Contact Recreation
PETERSON CREEK, Jack Creek to mouth (Clark Fork River)	MT76G002_132	B-1	Phosphorus (Total)	Aquatic Life, Primary Contact Recreation
			Nitrogen (Total)	Aquatic Life, Primary Contact Recreation
SILVER BOW CREEK, headwaters to mouth (Clark Fork River)	MT76G003_020	I	Nitrates	Aquatic Life
			Sedimentation/Siltation	Aquatic Life
			Nitrogen (Total)	Aquatic Life
			Phosphorus (Total)	Aquatic Life

Table 3-1. Impaired Waterbodies and Their Impaired Designated Uses in the Upper Clark Fork Phase 2 TPA

Waterbody and Location Description	Waterbody ID	Use Class	Impairment Causea	Impaired Use(s)
WILLOW CREEK, headwaters to T4N R10W S30	MT76G002_061	B-1	Phosphorus (Total)	Aquatic Life, Primary Contact Recreation
WILLOW CREEK, T4N R10W S30 to mouth (Mill Creek), T4N R10W S11	MT76G002_062		Phosphorus (Total)	Aquatic Life, Primary Contact Recreation
		B-1	Nitrogen (Total)	Aquatic Life, Primary Contact Recreation

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

3.2 Numeric and Narrative 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, frequency, and duration of specific pollutants so as not to impair designated uses.

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

Narrative standards are developed when there is insufficient information to develop numeric standards and/or the natural variability makes it impractical to develop numeric standards. Narrative standards describe the allowable or desired condition. This condition is often defined as an allowable increase above "naturally occurring." DEQ often uses the naturally occurring condition, called a "reference condition," to help 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, BMPs.

For the Upper Clark Fork Phase 2 TPA, a combination of numeric and narrative standards are applicable. The numeric standards apply to nutrients, and narrative standards are applicable for sediment. The specific numeric and narrative standards are summarized in **Appendix B**.

4.0 Defining TMDLs and Their Components

A 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 AFOs, 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.

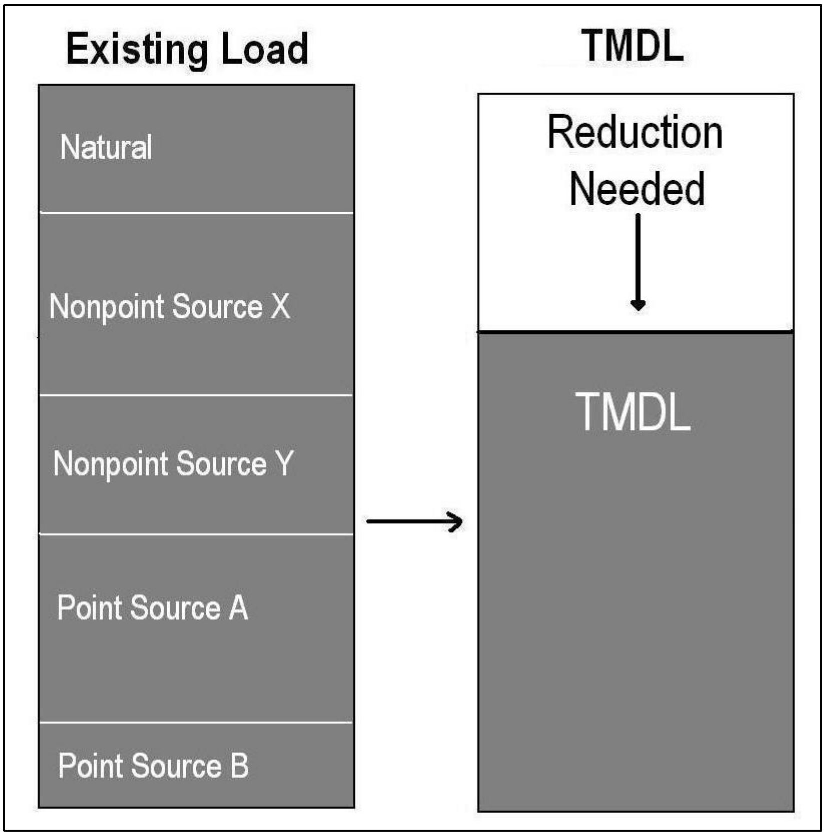

Figure 4-1. Schematic Example of TMDL Development

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 MPDES program. Nonpoint sources are quantified by source categories (e.g., unpaved roads or streambank erosion) and/or by land uses (e.g., agriculture or residential/developed). 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 CWA. 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 BMPs 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.

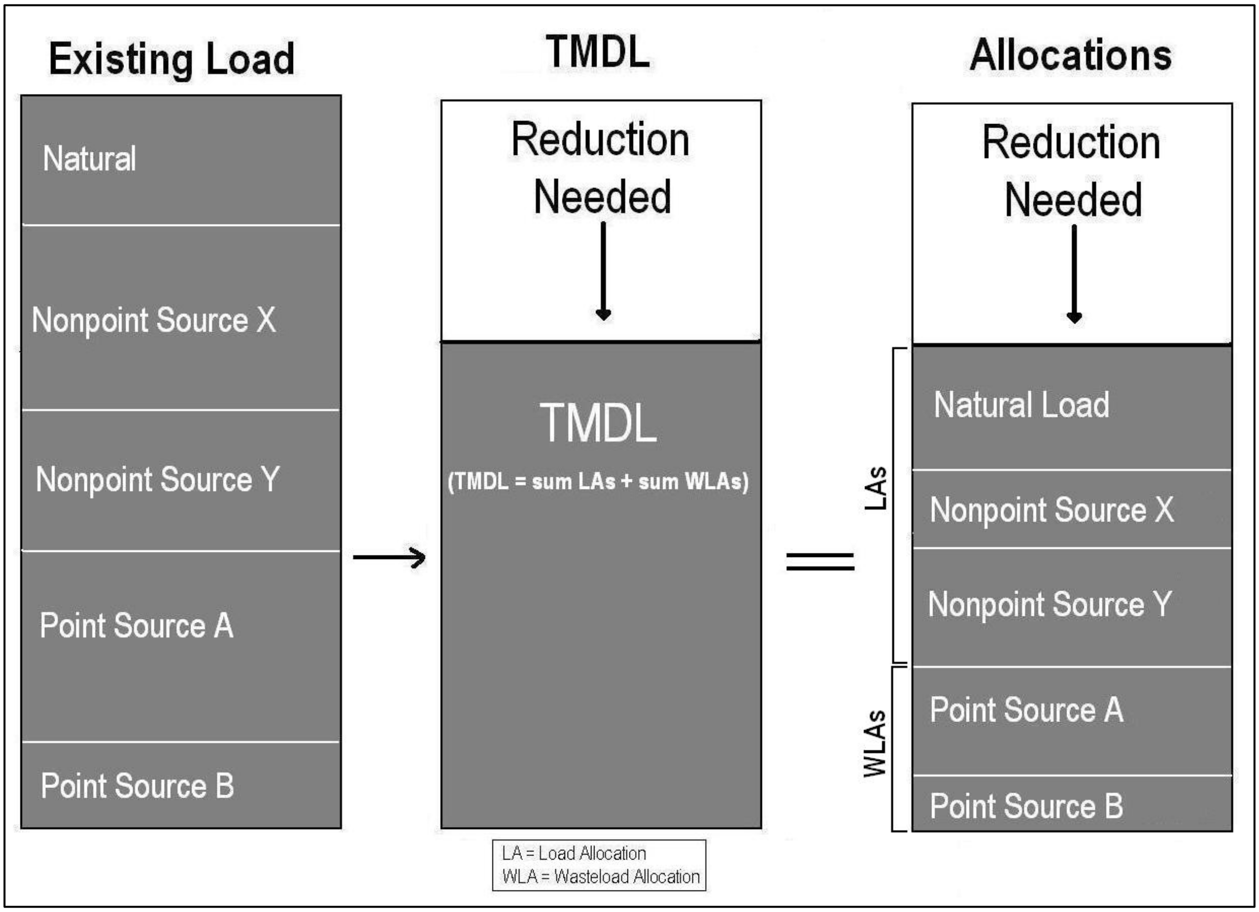

Figure 4-2. Schematic Diagram of a TMDL and Its Allocations

TMDLs must also incorporate a MOS. The MOS accounts for the uncertainty, or any lack of knowledge, about the relationship between the pollutant loads and the quality of the receiving waterbody. 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 (i.e., a TMDL = WLA + LA + MOS) (U.S. Environmental Protection Agency, 1999a; U.S. Environmental Protection Agency, 1999b). The MOS is a required component to help ensure that water quality standards will be met when all allocations are achieved. In Montana, TMDLs typically incorporate implicit margins of safety.

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

4.5 Implementing TMDL Allocations

The CWA and Montana state law (Section 75-5-703 of the Montana Water Quality Act) require WLAs to be incorporated into appropriate discharge permits, thereby providing a regulatory mechanism to achieve load reductions from point sources. Nonpoint source reductions linked to LAs are not required by the CWA or Montana statute, and are primarily implemented through voluntary measures. This document contains several key components to assist stakeholders in implementing nonpoint source controls. **Section 8.0** discusses a restoration and implementation strategy by pollutant group and source category, and provides recommended BMPs per source category (e.g., grazing, cropland, urban, etc.). **Section 7.5** discusses potential funding sources that stakeholders can use to implement BMPs for nonpoint sources. Other site-specific pollutant sources are discussed throughout the document, and can be used to target implementation activities. DEQ's Watershed Protection Section helps to coordinate nonpoint implementation throughout the state and provides resources to stakeholders to assist in nonpoint source BMPs. Montana's Nonpoint Source Management Plan (available at http://www.deq.mt.gov/wqinfo/nonpoint/nonpointsourceprogram.mcpx) further discusses nonpoint source implementation strategies at the state level.

DEQ uses an adaptive management approach to implementing TMDLs to ensure that water quality standards are met over time (outlined in **Section 9.0**). This includes a monitoring strategy and an implementation review that is required by Montana statute (see **Section 9.0**). TMDLs may be refined as new data become available, land uses change, or as new sources are identified.

5.0 Sediment TMDL Components

This section focuses on sediment as a cause of water quality impairment in the Upper Clark Fork Phase 2 TMDL Planning Area (TPA). It describes: (1) how excess sediment impairs beneficial uses, (2) the affected stream segments, (3) the currently available data pertaining to sediment impairments in the watershed, (4) the sources of sediment based on recent studies, and (5) the proposed sediment TMDLs and their rationales.

5.1 The Effects of Excess Sediment on Beneficial Uses

The weathering and erosion of land surfaces and the transport of sediment to, and via, streams are natural phenomena and important in building and maintaining streambanks and floodplains. Yet, excessive erosion and/or the absence of natural sediment barriers (e.g., riparian vegetation, woody debris, beaver dams, and overhanging vegetation) can cause high levels of suspended sediment in streams. In addition, sediment gets deposited in areas that do not naturally have high levels of fine sediment. Uncharacteristically high amounts of sediment in streams can impair beneficial uses, such as support of aquatic life, coldwater fisheries, recreation, and drinking water.

The extensive mining history and sediment deposition history in the Upper Clark Fork watershed, particularly in the Silver Bow Creek drainage, are certainly connected to sediment impacts to beneficial uses. Erosion of mineral soils and weathered bedrock do affect water quality both from suspended sediment and from potential metals toxicity. For Silver Bow Creek and the Clark Fork River, metals and sediments impacts to beneficial uses are intertwined.

High levels of suspended sediment reduce light penetration through water, which can limit the growth of aquatic plants. As a result, aquatic insect populations could also decline. In turn, this can limit fish populations. Deposited sediments can also obscure sources of food, habitat, hiding places, and nesting sites for invertebrate organisms.

Excess sediment is known to impair certain biological processes, including reproduction and survival, of individual aquatic organisms by clogging gills and causing abrasive damage, reducing the availability of suitable spawning sites, and smothering eggs or hatchlings. When fine sediments accumulate on stream bottoms it can also reduce the flow of water through gravels harboring incubating eggs, hinder the emergence of newly hatched fish, deplete oxygen supplies to embryos, and cause metabolic wastes to accumulate around embryos, all resulting in higher mortality rates.

High concentrations of suspended sediment in streams can create murky or discolored water, decreasing recreational use potential and aesthetic appreciation. Excessive sediment can also increase filtration costs for water treatment facilities that provide safe drinking water.

5.2 Stream Segments of Concern

A total of 4 waterbody segments in the Upper Clark Fork Phase 2 TPA appeared on the 2012 Montana 303(d) List for sediment impairments (**Table 5-1**): Silver Bow Creek and three segments of the Clark Fork River from Warm Springs Creek to the Flint Creek confluence. All waterbody segments listed for sediment impairment are also impaired for various forms of habitat alterations (**Table 5-1**), which are non-pollutant causes commonly associated with sediment impairment. TMDLs are limited to pollutants, but implementation of land, soil, and water conservation practices to reduce pollutant loading will inherently address some non-pollutant impairments.

Table 5-1. Waterbody Segments in the Upper Clark Fork Phase 2 TPA with Sediment Listings on the 2012 303(d) List

Stream Segment	Waterbody ID	Sediment Pollutant Listing	Non-Pollutant Causes of Impairment Potentially Linked to Sediment Impairment
SILVER BOW CREEK, headwaters to mouth (Clark Fork River)	MT76G003_020	Sedimentation/Siltation	Physical substrate habitat alterations
CLARK FORK RIVER, Little Blackfoot River to Flint Creek	MT76G001_010	Sedimentation/Siltation	Alteration in streamside or littoral vegetative covers; Physical substrate habitat alterations; low flow alterations
CLARK FORK RIVER, Cottonwood Creek to Little Blackfoot River	MT76G001_030	Sedimentation/Siltation	Alteration in streamside or littoral vegetative covers; Physical substrate habitat alterations; low flow alterations
CLARK FORK RIVER, Warm Springs Creek to Cottonwood Creek	MT76G001_040	Sedimentation/Siltation	Alteration in streamside or littoral vegetative covers

5.3 Upper Clark Fork Environmental History

Given the uniqueness of environmental impacts from large-scale mining and smelting operations in and around Butte, Montana, a brief summary of the extensive sediment deposition and current remediation efforts in the Upper Clark Fork Phase 2 TPA is provided.

5.3.1 History of Sediment Deposition

For more than 100 years, Silver Bow Creek was used as a conduit for mining, smelting, industrial and municipal wastes and vast mine tailings were deposited along the creek channel and floodplain. The volume of mining waste has been estimated at over 100 million tons of tailings for the entire mining period ending in 1982 (Andrews, 1987) and over 10 million tons of tailings for Silver Bow Creek alone between 1878 and 1925 (Nimick, 1990).

Extensive flooding along Silver Bow Creek and the Clark Fork River in the early 1900s re-deposited tailings along much of Silver Bow Creek and the Clark Fork River floodplains. Streamflow gaging of the Clark Fork River began in 1899 and indicate that large floods occurred in 1899, 1902 and 1908 with the largest occurring in 1908. Indirect evidence of prolonged high stages during these floods is indicated by tailings deposits that averaged 3–4 ft thick along Silver Bow Creek (Titan Environmental Corporation, 1995) and commonly 1 ft thick along the Clark Fork in the Deer Lodge Valley (Nimick and Moore, 1991) prior to the start of remediation activities in the late 1990s. The most likely method of deposition of these deposits was from a prolonged overbank flux of fine tailings onto the floodplain (Smith et al., 1998). The series of floods resulted in floodplain aggradation in a sequence of several layers (Nimick, 1990; Smith et al., 1998).

Partly as a result of the early 20th Century flooding, the Warm Springs Ponds were constructed between 1911 and 1959 to serve as settling ponds on Silver Bow Creek. This system is comprised of 3 ponds (Pond 1 is no longer in use) covering approximately 2,500 acres. The ponds contain an estimated 19 million cubic yards of contaminated sediment, tailings and heavy metal sludge. Dikes at the entry of

Warm Springs Ponds were enlarged during 1992–93 to provide containment of untreated Silver Bow Creek flows of up to 3,300 cfs (approximately a 100-year event) (Hornberger et al., 1997).

From 1990–1995, three Superfund response actions were carried out on the ponds (U.S. Environmental Protection Agency, 1990). Tailings were removed from the Mill-Willow bypass, the lime treatment and hydraulic structures were upgraded and large areas of exposed tailings were capped or flooded. In addition, waterfowl ponds and wetlands were constructed throughout the pond and bypass system.

5.3.2 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

CERCLA is a federal law designed to clean up sites contaminated with hazardous substances. CERCLA is more commonly referred to as the Superfund program. The law authorized the EPA to identify parties responsible for contamination of sites and compel those parties to clean up the sites. If responsible parties cannot be found, the EPA has the authority to clean up sites itself. CERCLA authorizes both removal and remedial actions and affords flexibility for short and long-term actions.

5.3.2.1 Silver Bow Creek

Within the drainage of Silver Bow Creek, there are 3 Superfund sites, comprising 11 OUs that directly affect the Silver Bow Creek AU (confluence of Blacktail Creek and the Metro Storm Drain (MSD) to the inlet to Warm Springs Ponds) (**Figure 5-1** and **Table 5-1**). These Superfund OUs include the Butte Priority Soils Operable Unit (BPSOU), LAO, Rocker Timber Framing and Treatment Plant, SSTOU and the West Camp/Travona Shaft Area among others. Background information for several of these OUs is summarized below.

TMDLs for Silver Bow Creek only consider those source areas discharging loads to the stream and, therefore, do not include the Berkeley Pit which does not contribute discharges to Silver Bow Creek. Additionally, the Warm Springs Ponds OU is outside the Silver Bow Creek AU. Warm Springs Ponds are excluded in state statute (Statute 17-5-103(34)(b)(i)) and administrative rule (ARM 17.30.607(1)(a)(iii)) as a state waterbody, so formal assessment of Silver Bow Creek extends only to the inlet of the uppermost pond (21.7 stream miles from the confluence of the MSD and Blacktail Creek). It should be noted that, as it currently operates, the Warm Springs Ponds act as a significant sediment sink and reduce the sediment load from Silver Bow Creek entering the Clark Fork River. The upper reaches of the Clark Fork River in the reach immediately downstream of Warm Spring Ponds is actually considered to be somewhat starved of fine sediment in the water column due to the action of Warm Springs Ponds (CDM-Smith and Applied Geomorphology, Inc., 2013). However, increasing impacts of sediment in the Clark Fork River are noted progressing downstream to Deer Lodge.

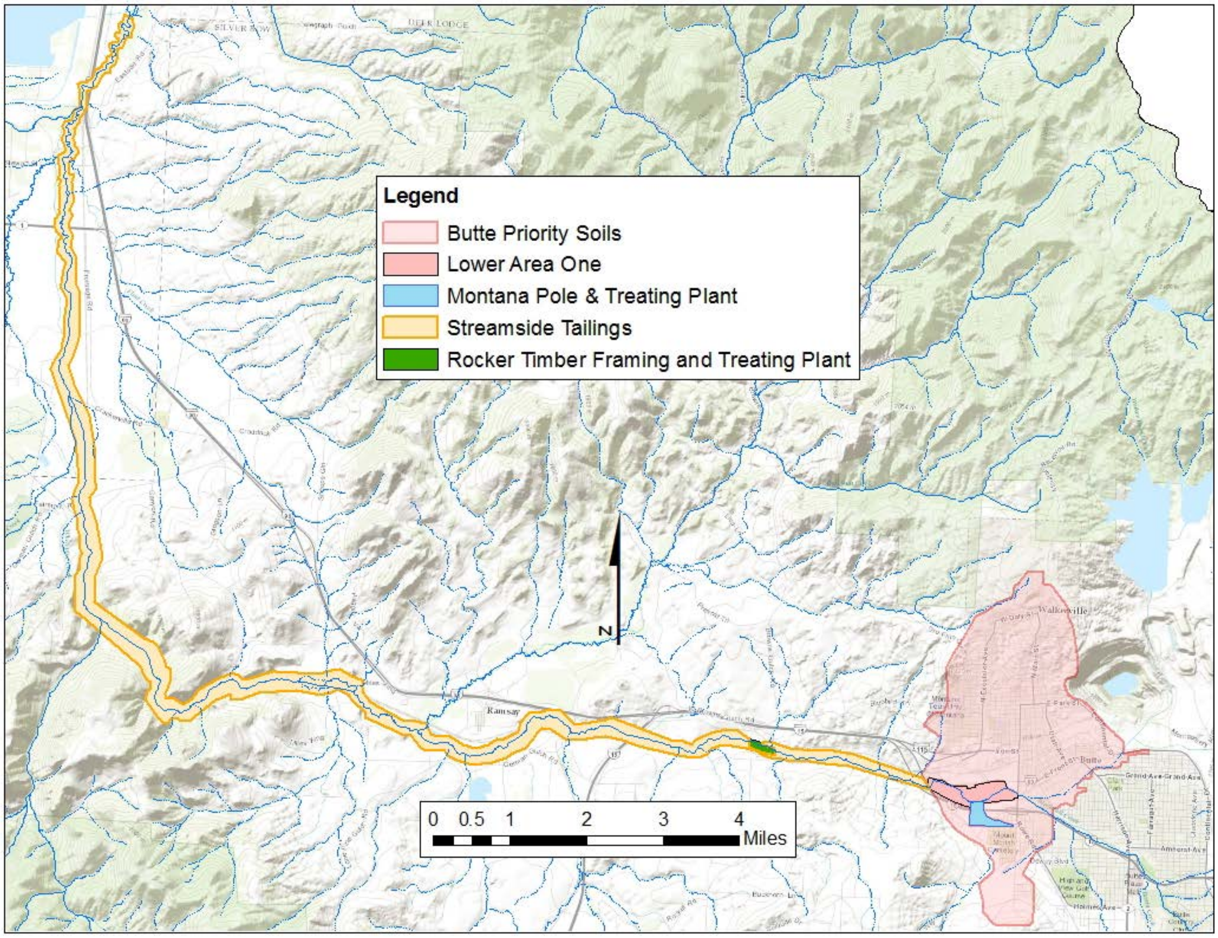

Figure 5-1. Map of Extent of Superfund Units within the Silver Bow Creek AU

In the Upper Clark Fork River TMDL Phase 2 TPA, there are 4 Superfund sites divided into 14 OUs (**Table 5-2**), each representing a separate cleanup activity. Superfund removal and remediation activities affect all 4 of the sediment listed AUs on Silver Bow Creek and the Clark Fork River mainstem addressed in this TMDL document.

Table 5-2. Superfund Sites and OUs in the Upper Clark Fork Phase 2 TPA

Superfund Site	OU[a]	Affected Sediment AU	Notes
Anaconda Company Smelter	Old Works/East Anaconda Development Area	*None*	
	Community Soils	*None*	
	Anaconda regional Water, Waste and Soils	*None*	
Milltown Reservoir Sediments/ Clark Fork River	***Clark Fork River***	MT76G001_040, MT76G001_030, MT76G001_010	
	Milltown Drinking Water Supply[b]	NA	Outside planning area
	Milltown Reservoir Sediments[b]	NA	Outside planning area
Montana Pole and Treating Plant	**MPTP**	MT76G003_020	

Table 5-2. Superfund Sites and OUs in the Upper Clark Fork Phase 2 TPA

Superfund Site	OU[a]	Affected Sediment AU	Notes
Rocker Timber Framing and Treating Plant	***Rocker Timber Framing and Treating Plant***	MT76G003_020	
Silver Bow Creek/ Butte Area	**Area One**	MT76G003_020	Subunit of BPSOU
	Berkeley Pit/Mine Flooding	NA	Outside AU
	BPSOU	MT76G003_020	Subunit of BPSOU
	Butte Reduction Works	MT76G003_020	Subunit of SSTOU
	Butte Residential Soils	MT76G003_020	Subunit of BPSOU
	LAO	MT76G003_020	Subunit of SSTOU
	SSTOU	MT76G003_020	Subunit of SSTOU
	Warm Springs Ponds, active area	NA	Outside AU
	Warm Springs Ponds, inactive area	NA	Outside AU
	West Camp/Travona Shaft Area	MT76G003_020	Managed with BPSOU
	West Side Soils	MT76G003_020	

[a] Italicized/bolded OUs are those that directly affect sediment listed AUs in the Upper Clark Fork Phase 2 TPA
[b] These 2 OUs are managed as a single unit

Butte Priority Soils Operable Unit (BPSOU)

ROD for the BPSOU, which describes the cleanup actions, was signed in September 2006 and focused primarily on metals cleanup activities through removal and remediation of contaminated sediment and tailings deposits (U.S. Environmental Protection Agency, 2006). Phase 1 was an expedited response action which addressed source areas by removing waste dumps, railroad beds and other related mine wastes. Phase II is ongoing and addresses the remaining environmental and human health issues associated with soil, groundwater and surface water. This OU is administered by EPA.

LAO and West Camp/Travona Shaft Area are subunits of the BPSOU.

Lower Area One (LAO)

Administered by the EPA, manganese stockpiles were removed in 1992 and mine tailings (Colorado and Butte Reduction) were removed in 1993–97 from this OU. In addition to removal of contaminated soils, a groundwater collection and treatment system was installed (Butte Treatment Lagoons) and catchment basins were constructed on Missoula Gulch. Treated groundwater and storm water runoff are discharged into Silver Bow Creek upstream of the BSB WWTP discharge to Silver Bow Creek. The Silver Bow Creek stream channel was dewatered and underwent complete reconstruction as part of remediation activities in LAO. Remediation activities are covered by the ROD for the BPSOU (U.S. Environmental Protection Agency, 2006).

West Camp/Travona Shaft Area

Located within the BPSOU immediately to the northwest of the LAO, in 1989, rising mine waters were addressed by a pumping and piping system which sent waters to the BSB WWTP. This prevented basement flooding and discharges of contaminated groundwater to the alluvial aquifer and Silver Bow Creek. The site is administered by EPA as part of the BPSOU.

Montana Pole and Treating Plant (MPTP)
The facility operated as a wood treating facility from 1946 to 1984. Hazardous wastes from the facility were discharged to a ditch next to the plant. Contamination of groundwater from PCP, PAHs, dioxins and furans were documented by the predecessor agency to DEQ, the Montana Department of Health and Environmental Sciences (MDHES) in 1983. A ROD was signed for the site in 1993 (U.S. Environmental Protection Agency, 1993; U.S. Environmental Protection Agency, 2006). Remediation included removal of contaminated soils and pumping and treatment of contaminated groundwater. Treated groundwater is discharged to Silver Bow Creek upstream of the LAO discharge point and the BSB WWTP discharge. The site is administered by DEQ with oversight by EPA.

Streamside Tailings Operable Unit (SSTOU)
The SSTOU is divided into 4 subareas that encompass Silver Bow Creek and its floodplain from the downstream boundary of LAO to the I-90 bridges downstream of the Gregson Creek confluence. In the last 12 years, remediation efforts in the SSTOU have removed much of the tailings and mine waste along the creek and re-constructed/re-contoured the channel while treating some wastes in-situ and establishing native vegetation in the floodplain. Work has been completed in subareas 1 and 2 and is anticipated to be completed in subareas 3 and 4 by the end of 2015. The SSTOU ROD was signed in November 1995 (U.S. Environmental Protection Agency, 1995b).

The design criteria for Silver Bow Creek are guided by the ROD (U.S. Environmental Protection Agency, 2006) and the Comprehensive Remedial Design Work Plan (CRDWP) (Atlantic Richfield Company, 1997). The ROD states "After removal of contaminated sediments, the channel bed and streambank will be reconstructed to an appropriate slope and other critical dimensions with materials of appropriate size, shape and composition. This reconfigured bed will contain suitable bedform morphology (riffles, bars, pools, etc.) for aquatic habitat." Remediation work in the 4 subareas was based on channel stability analyses and conceptual design reports completed by DEQ contractors (Montana Department of Environmental Quality, 1997; Montana Department of Environmental Quality, 2003; Montana Department of Environmental Quality, 2007; Montana Department of Environmental Quality, 2008). Work is on-going in subareas 3 and 4 with expected work completion by 2015.

Rocker Timber Framing and Treating Plant
Located ~7 miles west of Rocker, Montana, the site was used to treat mining timbers with a creosote solution and later an arsenic trioxide solution was also used in the timber treatment process. The ROD was signed in December 1995 (U.S. Environmental Protection Agency, 1995a). Cleanup of contaminated soils and groundwater occurred in 1997. The site is administered by EPA.

5.3.2.2 Clark Fork River
CFROU extends from the outlet of Warm Springs Ponds to upstream of the former Milltown Reservoir at the confluence of the Clark Fork and Blackfoot Rivers east of Missoula, Montana. In 1992, the CFROU was identified as distinct from the Milltown Reservoir. Investigations into the extent and nature of the contamination in the Clark Fork River and associated floodplain began in 1995.

CFROU is delineated into three separate reaches (**Figure 5-2**). Reach A comprises the Clark Fork River from Warm Springs Ponds to Garrison and is identical to the DEQ AUs for the upper and middle segment of the Clark Fork River (MT76G001_040, Warm Springs Creek to Cottonwood Creek and MT76G001_030, Cottonwood Creek to Little Blackfoot River). Reach B, from Garrison to Drummond, includes the entire sediment-listed DEQ AU of the Clark Fork River (MT76G001_010, Little Blackfoot River to Flint Creek). Reach C is outside the bounds of the Upper Clark Fork Phase 2 TPA.

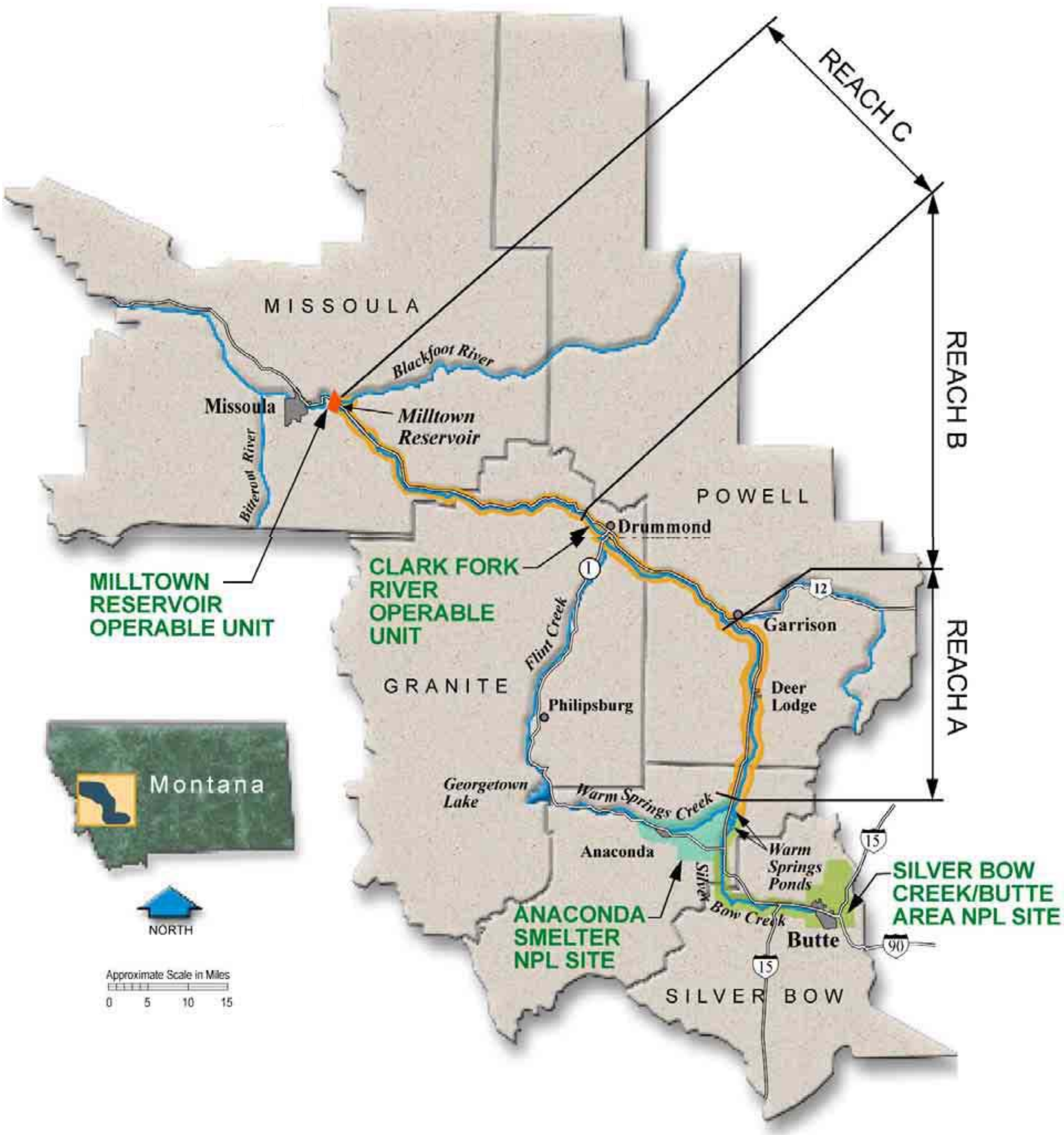

Figure 5-2. CFROU Stream Reaches (U.S. Environmental Protection Agency, 2004)

Clark Fork River Operable Unit (CFROU)
In April 2004, a ROD was signed by EPA and DEQ. The ROD outlines the proposed cleanup of the CFROU. DEQ is the lead agency in this unit and EPA is providing project oversight (U.S. Environmental Protection Agency, 2004). The cleanup proposal includes a combination of removal and in-place treatment of tailings and contaminated soil, followed by re-vegetation. Stabilization of eroding streambanks is an

important part of the remedy, because they contribute approximately 60% of the copper loading to the river via stream bank erosion (U.S. Environmental Protection Agency, 2004). Remedial actions are proposed primarily for Reach A (Warm Springs Ponds to Garrison), and parts of Reach B (Garrison to Drummond).

ROD-prescribed remedial actions in the CFROU in the stream channel and floodplain began in spring 2013. For the purposes of the DEQ Remediation, Reach A of the CFROU (Warm Springs Ponds to the Little Blackfoot confluence) was divided into 7 reaches consisting of 22 phases or sub-reaches often delineated by changed in landowners. As of spring 2013, geomorphic and hydrologic investigations have been conducted in several phases of Reach A:

- Phases 1–2: Warm Springs Ponds – Perkins Lane (Camp, Dresser & McKee and Applied Geomorphology, Inc., 2010)
- Phases 5–8: Dry Cottonwood Creek Ranch and Parcini Pond (Terragraphics, 2012)
- Phases 15–16: Grant-Kohrs Ranch (National Park Service (NPS)) (Tetra Tech, Inc. et al., 2012)

Excepting the phases where investigation/remediation is already occurring, a geomorphic/hydrologic investigation of Reach A was also completed to assist in guiding continued implementation of the ROD in the CFROU (CDM-Smith and Applied Geomorphology, Inc., 2013).

5.4 Information Sources and Assessment Methods to Characterize Sediment Conditions

The sources used to develop the TMDL components include information that was used to determine impairments (see **Section 3.0**). To characterize sediment conditions for TMDL development purposes, a sediment data compilation was completed and additional monitoring was performed during 2011. The below listed data sources represent the primary information used to characterize water quality and/or develop TMDL targets.

- DEQ Assessment Files
- DEQ 2011 Sediment and Habitat Assessments
- DEQ Remediation Division hydrologic and geomorphic investigations on the Clark Fork River
- PACFISH/Inland Native Fish Strategy (INFISH) Biological Opinion (PIBO) Effectiveness Monitoring Program reference and non-reference data
- USFS Regional Reference Data
- Geographic Information System (GIS) data layers
- FWP fisheries inventories
- Streamflow data
- Agency and university documents
- Land-use information

The data will be used to compare existing conditions to waterbody restoration goals and for source assessments. The data will also provide a restoration strategy that, if implemented, will reduce pollutant contributions so that beneficial uses can be supported.

It is worth noting that, while not included here, the Atlantic Richfield Company (ARCO) has been collecting sediment and macroinvertebrate data on Silver Bow Creek, Blacktail Creek, the MSD, and Buffalo Gulch since 2010. Available data for the Silver Bow Creek watershed is quite extensive. DEQ determined that the data outlined below was of quality and scope extensive enough to make an impairment determination independent of the ARCO data collection efforts, which are, themselves, commendable.

5.4.1 DEQ Assessment Files

The DEQ assessment files contain information used to make the existing sediment impairment determinations. However, in the case of Silver Bow Creek and the Clark Fork River upstream of Flint Creek, there has not been a formal assessment done by DEQ on these systems since 2000 for the Clark Fork River and 2001 for Silver Bow Creek. This is due to extensive completed, on-going and planned remediation activities as part of the respective RODs in these CERCLA OUs. The files include a summary of physical, biological, and habitat data collected prior to 2001 as well as other historical information collected or obtained by DEQ. The files also include information on sediment water quality characterization and potentially significant sources of sediment, as well as information on non-pollutant impairment determinations and associated rationale. Files are available electronically on DEQ's CWA Information Center website: http://cwaic.mt.gov/. However, macroinvertebrate data has been collected by DEQ in Silver Bow Creek and the Clark Fork River. Data collected since 2003 from these systems will be used in the sediment assessments.

5.4.2 DEQ 2011 TMDL Sediment and Habitat Assessments

Field measurements of channel morphology and riparian and instream habitat parameters were collected in 2011 from 11 reaches to aid in TMDL development (**Figure 5-3**). Reaches were dispersed among the four segments of concern listed in **Section 5.2**, with each segment having at least two sample reaches. Initially, all streams of interest underwent an aerial assessment procedure by which reaches were characterized by four main attributes not linked to human activity: stream order, valley gradient, valley confinement, and ecoregion. These four attributes represent main factors influencing stream morphology, which in turn influences sediment transport and deposition. The next step in the aerial assessment involved identification of near-stream land uses since land management practices can have a significant influence on stream morphology and sediment characteristics. The resulting product was streams stratified into reaches that allow for comparisons among those reaches of the same natural morphological characteristics, while also indicating stream reaches where land management practices may further influence stream morphology. The stream stratification, along with field reconnaissance, provided the basis for selecting the above-referenced monitoring reaches.

Monitoring reaches were chosen with the goal of being representative of various reach characteristics, land-use categories, and anthropogenic influence. There was a preference toward sampling those reaches where anthropogenic influences would most likely lead to impairment conditions since it is a primary goal of sediment TMDL development to further characterize sediment impairment conditions. Thus, it is not a random sampling design intended to sample stream reaches representing all potential conditions. Instead, it is a targeted sampling design that aims to assess a representative subset of reaches within each 303(d) sediment-listed AU with potential impairment conditions. Although the TMDL development process necessitates this targeted sampling design, it is acknowledged that conditions within sampled reaches are not necessarily representative of conditions throughout the entire stream.

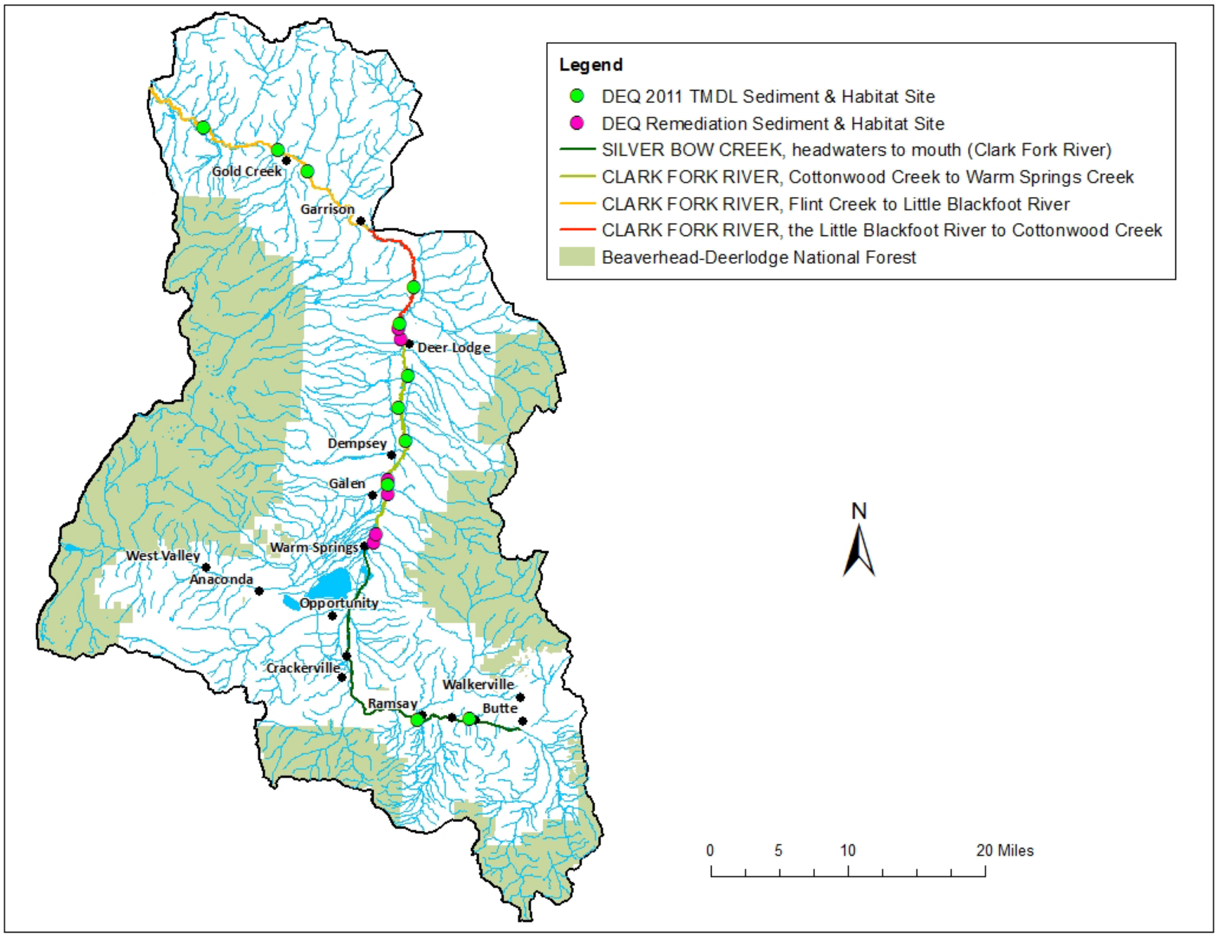

Figure 5-3. DEQ Sediment and Habitat Sampling Locations in the Upper Clark Fork Phase 2 TPA

The field parameters assessed in 2011 include standard measures of stream channel morphology, fine sediment, stream habitat, riparian vegetation, and streambank erosion. Although the sampling areas are frequently referred to as “sites” within this document, to help increase sample sizes and capture variability within assessed streams, they were actually sampling reaches ranging from 500 to 2,000 ft (depending on the channel bankfull width) that were broken into five cells. Generally, a single cross section measurement, pebble count, and riffle grid toss are performed in each cell, and stream habitat, riparian, and bank erosion measures are performed throughout the reach. Field parameters are briefly described in **Section 5.5**, and summaries of all field data and sampling protocols are contained in the 2011 Sediment and Habitat Assessment report (**Appendix C**).

In the stratification (**Table 5-3**), Silver Bow Creek comprises all the MR-0-5-U reach type and the Clark Fork River comprises all of the MR-0-6-U reach type.

Table 5-3. Stratified Reach Types and Sampling Site Representativeness for Silver Bow Creek and the Clark Fork River Upstream of the Flint Creek Confluence

Level III Ecoregion	Valley Gradient	Strahler Stream Order	Confinement[a]	Reach Type	Number of Reaches	Number of Monitoring Sites
Middle Rockies	0–2%	5	U	MR-0-5-U	20	2
		6	U	MR-0-6-U	27	9
				Totals	**47**	**11**

[a] U = Unconfined per DEQ stratification methodology

5.4.3 DEQ Remediation Sediment and Habitat Assessments

As outlined in **Section 5.3.2**, within the Upper Clark Fork Phase 2 TPA the Clark Fork River is part of the CFROU, a CERCLA site. Heavy metals deposition in the Clark Fork River bed, banks and floodplain occurred over a period of at least 100 years as a result of historic mining activities, milling and smelting processes in Butte and Anaconda. DEQ is the lead agency involved in remediation in the CFROU with oversight provided by EPA and the NPS (Grant-Kohrs Ranch section of the Clark Fork River only).

To meet ROD objectives for remediation in the CFROU, hydrologic and geomorphic investigations are conducted to support design of reconstructed streambanks and other river channel modifications in Reach A (Warm Springs Ponds to Little Blackfoot River confluence). As of May 2013, 3 investigations of 6 discrete reaches have been conducted on behalf of the Remediation Division of DEQ in the Clark Fork River upstream of the Little Blackfoot River (**Figure 5-3**). Investigations included:

- Existing streambank condition
- Existing instream pool habitat
- Peak flow hydrology
- Channel geometry through surveyed cross-sections
- Existing bottom of bank materials

From these reports, where collected data was comparable to sediment water quality metrics it was included in water quality targets discussions.

5.4.4 PIBO

The PIBO Effectiveness monitoring program collects data from reference and managed (i.e., non-reference) stream sites on USFS and Bureau of Land Management (BLM) land within the Columbia River basin. Reference sites are defined as having catchment road densities less than 0.5 km/km^2, riparian road densities less than 0.25 km/km^2, no grazing within 30 years, and no known in-channel mining upstream of the site. Within the Upper Clark Fork Phase 2 TPA, data collected between 2002 and 2009 included 14 non-reference sites and 2 reference sites. All sites were located on tributaries to Silver Bow Creek and the Clark Fork River. As no PIBO data was collected on AUs addressed in **Section 5.0**, PIBO data was not used for impairment determinations. PIBO data was used for target development in some cases.

There are a total of eight reference sites within the Beaverhead Deerlodge National Forest (BDNF), but because that is a small dataset for target development and ecoregion is a primary stratification category, all PIBO reference data from the Middle Rockies ecoregion were used for target development. This consists of all sites within the BDNF as well as data from 65 sites collected between 2001 and 2009. Data was collected following protocols described in (U.S. Department of Agriculture, Forest Service, 2006). Relevant data collected during these assessments include width/depth ratios, residual pool depths, pool frequency, and large woody debris frequency.

5.4.5 USFS Regional Reference Data

Regional reference data are available BDNF. BDNF data were collected between 1991 and 2002 from approximately 200 reference sites: 70 of the sites are located in the Greater Yellowstone Area and the remaining sites are in the BDNF, which is also located in southwestern Montana (Bengeyfield, 2004). Applicable reference data are width/depth ratios, entrenchment ratios.

5.5 Water Quality Targets

The concept of water quality targets was presented in **Section 4.1**. This section provides the rationale for each sediment-related target parameter and discusses the basis of the target values.

In developing targets, natural variation throughout the river must be considered. As discussed in more detail in **Section 3.0** and **Appendix B**, 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. "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, the reference condition reflects a waterbody's greatest potential for water quality given historic and current land-use activities. **Although sediment water quality targets typically relate most directly to the aquatic life use, the targets are protective of all designated uses because they are based on the reference approach, which strives for the highest achievable condition.**"

Waterbodies used to determine reference conditions are not necessarily pristine. The reference condition approach is intended to accommodate natural variations from climate, bedrock, soils, hydrology, and other natural physiochemical differences, yet it allows differentiation between natural conditions and widespread or significant alterations of biology, chemistry, or hydrogeomorphology from human activity.

The basis for each water quality target value varies depending on the availability of reference data and sampling method comparability to 2011 DEQ data. As discussed in **Appendix B**, there are several statistical approaches DEQ uses for target development. In addition to the above reference approaches, they also include using percentiles of reference data or of the entire sample dataset, if reference data are limited. For example, if low values are desired (like with fine sediment), and there is a high degree of confidence in the reference data, the 75th percentile of the reference dataset is typically used, whereas if reference data are not available, and the sample streams are predominantly degraded, the 25th percentile of the entire sample dataset is typically used. However, percentiles may be used differently depending on whether a high or low value is desirable, how much the representativeness and range of data varies, how severe human disturbance is to streams in the watershed, and the size of the dataset.

In general, stream sediment and habitat conditions within Silver Bow Creek and the Clark Fork River evaluated by DEQ in 2011 reflected a moderate to severe level of human disturbance given the history of the basin and anthropogenic impacts to these waterbodies. For each target, descriptive statistics were generated relative to any available reference data (e.g., BDNF, PIBO) as well as for the entire sample dataset. The preferred approach for setting target values is to use reference data, where preference is given to the most protective reference dataset. However, Silver Bow Creek and the Clark Fork River presented unique cases. Silver Bow Creek was significantly altered in channel form and habitat condition after more than 100 years of mining and industrial activities in its drainage. Significant remediation activates have been completed in the basin and remediation work will be completed in the SSTOU by 2015. In addition, reference data was available for streams of similar size. Comparatively, the Clark Fork River is a larger river system where remediation work has only recently been started and reference data for comparable systems is limited. For these reasons, sediment-related water quality targets were developed separately for Silver Bow Creek and the Clark Fork River.

The Clark Fork River upstream of the Flint Creek confluence and Silver Bow Creek are both low gradient, C channel types in the Rosgen classification. All targets are expressed for this stream type (low gradient, C channel). Average bankfull widths are between 15 and 50 ft for Silver Bow Creek and are >50 ft for the Clark Fork River.

Although the basis for target values may differ by parameter, the goal is to develop values that incorporate an implicit MOS and that are achievable. MOS is discussed in additional detail in **Section 5.10.2**.

5.5.1 Water Quality Target Summary

The sediment water quality targets for Silver Bow Creek and the Clark Fork River in the Upper Clark Fork watershed are summarized in **Table 5-1** and described in detail in the sections that follow. Consistent with EPA guidance for sediment TMDLs (1999b), water quality targets for Silver Bow Creek and the Clark Fork River in the Upper Clark Fork watershed comprise a combination of measurements of instream siltation, channel form, biological health, and habitat characteristics that contribute to loading, storage, and transport of sediment or that demonstrate those effects. Fine sediment targets and biological data, in conjunction with indicators of excess sediment (i.e., fine sediment, residual pool depth, and field observations), are given the most weight.

These targets are used herein to assess the sediment impairments in Silver Bow Creek and the Clark Fork River upstream of the Flint Creek confluence. There has been great effort and success of remediation activities both completed and planned in Silver Bow Creek and the Clark Fork River mainstem. The targets presented in this TMDL are metrics to gage the relative impairment status of these systems and are <u>not intended to replace or supplant remediation objectives or the RODs for the affected AUs.</u> In the case of Silver Bow Creek, many of the water quality targets presented in **Table 5-4** are based on field data collection from reaches in Silver Bow Creek where remediation activities have been completed.

Target parameters and values are based on the current best available information, but they will be assessed during future TMDL reviews for their applicability and may be modified if new information provides a better understanding of reference conditions or if assessment metrics or field protocols are modified. For all water quality targets, future surveys should document stable (if meeting criterion) or improving trends. The exceedance of one target value does not necessarily equate to a determination that the information supports 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 in a watershed may warrant selecting unique indicator values that differ slightly from those presented below, or special interpretation of the data relative to the sediment target values. Note, the comparison of recent data to targets is performed to evaluate current conditions and if they support the impairment listing but is not a formal impairment determination.

Sediment targets are presented as the average values within a specified AU.

Table 5-4. Sediment Targets for Silver Bow Creek and the Clark Fork River Upstream of Flint Creek

Parameter Type	Target Description	Silver Bow Creek (headwaters to Warm Spring Ponds)	Clark Fork River (upstream of Flint Creek)
Fine Sediment	Percentage of fine surface sediment <6mm and <2mm in riffles via pebble count (reach average)	<6mm: ≤ 31% <2mm: ≤ 18%	<6mm: ≤ 16% <2mm: ≤ 12%
	Percentage of fine surface sediment <6 mm in pool tails via grid toss (reach average)	≤ 5%	≤ 8%
Channel Form and Stability	Bankfull width/depth ratio (reach average)	≤ 23	≤ 43
	Entrenchment ratio (reach average)	> 2.2	> 2.2
Instream Habitat	Residual pool depth (reach average)	> 1.7 ft.	> 2.3 ft.
	Pools/mile	≥ 22	≥ 18
Human Sediment Sources	Significant and controllable sediment sources	Presence of significant and controllable man-caused sediment sources throughout the watershed	
Biological Index	Macroinvertebrate bioassessment impairment threshold	O/E: ≥ 0.80	

5.5.2 Fine Sediment

The percent of surface fines <6 mm and <2 mm is a measurement 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 smothers fish eggs by limiting oxygen availability (Irving and Bjornn, 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 other measures 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% to 40% fine sediment (Bjornn and Reiser, 1991; Mebane, 2001; Relyea et al., 2000). Bryce (2010) evaluated the effect of surficial fine sediment (via reach transect pebble counts) on fish and macroinvertebrates and found that the minimum effect level for sediment <2 mm is 13% for fish and 10% for macroinvertebrates. Literature values are taken into consideration during fine sediment target development; however, because increasing concentrations of fine sediment are known to harm aquatic life, targets are developed using a conservative statistical approach consistent with **Appendix B** and consistent with Montana’s water quality standard for sediment as described in **Section 3.2.1**.

5.5.2.1 Percent Fine Sediment <6 mm and <2 mm in Riffles 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 2011 were performed in three riffles per sampling reach, for a total of at least 300 particles. For DEQ Remediation data as part of CFROU site investigations, pebble counts at each reach were performed from bankfull to bankfull in a single representative riffle, for a total of at least 100 particles (Camp, Dresser & McKee and Applied Geomorphology, Inc., 2010; Terragraphics, 2012; Tetra Tech, Inc. et al., 2012).

Less than 6 mm

Silver Bow Creek drains portions of the Level IV Ecoregion Elkhorn Mountains-Boulder Batholith (17ai); a geologic formation that is composed primarily of undifferentiated granitic rocks which weather readily, supplying sand-sized sediment to Silver Bow Creek and lower-gradient streams in the region. Therefore, the underlying geology is considered the primary long-term source of sediment to reaches on Silver Bow Creek (Montana Department of Environmental Quality, 1997). Fine sediment targets for Silver Bow Creek were developed by comparing pebble count statistics for other sediment-impaired streams which drain from the Elkhorn Mountains-Boulder Batholith Level IV Ecoregion (17ai) to the Silver Bow Creek data collected by DEQ in 2011. Data for other sediment-impaired streams included waterbodies in the middle Big Hole River, Boulder River, Little Blackfoot River and Upper Jefferson River watersheds.

The target for riffle substrate percent fine sediment <6 mm is set at less than or equal to the 25^{th} percentile of the Elkhorn Mountains-Boulder Batholith data which corresponds closely to the 75^{th} percentile of the 2011 Silver Bow Creek data (bold in **Table 5-5**). The 25^{th} percentile was chosen as the Silver Bow Creek data reflects a post-remediation condition that still has sediment point sources in the AU.

Table 5-5. DEQ Data Summary for Percent Fine Sediment <6 mm for Silver Bow Creek

Data Source	Parameter	Percent Fine Sediment <6mm
Elkhorn Mountains-Boulder Batholith (Level IV Ecoregion – 17ai)	Sample Size (n)	15
	25^{th}	**31**
	Median	39
2011 Silver Bow Creek Sample Data	Sample Size (n)	8
	Median	32
	75^{th}	45

Target values are indicated in bold

For the Clark Fork River, a reference dataset for a comparable system is not available. Data collected as part of hydrologic /geomorphic investigations for remedial action in the CFROU was compiled as a comparison to the DEQ 2011 data collection efforts in the AU. The DEQ Remediation data is limited to the upper portions of the Clark Fork River upstream of Cottonwood Creek and the reach that traverses the Grant-Kohrs Ranch (NPS).

Based on the history and existing conditions of the upper drainage, the system has an aggraded floodplain with some entrenched reaches and areas of highly eroding banks. However, the Warm Springs Ponds system captures significant sediment loads from the Silver Bow Creek drainage and likely reduces fine sediment supplies and artificially increases the D50 in the uppermost Clark Fork River segment from the confluence of Warm Springs Creek and Silver Bow Creek downstream to Cottonwood Creek. Given the dynamics of Warm Springs Ponds sediment capture and the low observed fines in the Clark Fork mainstem, the median of the data collected by DEQ in 2011 will be used as the target (bold in **Table 5-6**). At some point in the future, Warm Springs Ponds will no longer be necessary and Silver Bow Creek will discharge directly to the Clark Fork River. The high natural fine sediment load in the Silver Bow

Creek drainage will increase the fine sediment supply in the Clark Fork River when Warm Springs Ponds are taken offline.

Table 5-6. DEQ Data Summary for Percent Fine Sediment <6 mm for the Clark Fork River

Data Source	Parameter	Percent Fine Sediment <6mm
CFROU DEQ Remediation Sample Data	Sample Size (n)	18
	25th	0.3
	Median	3
	75th	5
2011 Clark Fork River Sample Data	Sample Size (n)	28
	25th	9
	Median	**16**
	75th	21

Target values are indicated in bold

Less than 2 mm

As outlined in the previous section, the fine sediment targets for Silver Bow Creek were developed by comparing pebble count statistics for other sediment-impaired streams which drain from the Elkhorn Mountains-Boulder Batholith Level IV Ecoregion (17ai) to the Silver Bow Creek data collected by DEQ in 2011.

The 25th percentile of the Elkhorn Mountains-Boulder Batholith data is lower than the 75th percentile of the Silver Bow Creek dataset (bold in **Table 5-7**). Although the Silver Bow Creek data is post-remediation, the AU does include sediment point sources. For this reason the 25th percentile of the Elkhorn Mountains-Boulder Batholith data was selected as the target condition.

Table 5-7. DEQ Data Summary for Percent Fine Sediment <2 mm for Silver Bow Creek

Data Source	Parameter	Percent Fine Sediment <2mm
Elkhorn Mountains-Boulder Batholith (Level IV Ecoregion – 17ai)	Sample Size (n)	15
	25th	**18**
	Median	22
2011 Silver Bow Creek Sample Data	Sample Size (n)	8
	Median	25
	75th	33

Target values are indicated in bold

For the Clark Fork River, a reference dataset for a comparable system is not available. Data collected as part of hydrologic /geomorphic investigations for remedial action in the CFROU was compiled as a comparison to the DEQ 2011 data collection efforts in the AU. The DEQ Remediation data is limited to the upper portions of the Clark Fork River upstream of Cottonwood Creek and a section on the Grant-Kohrs Ranch (NPS).

Based on the history and existing conditions of the upper drainage, the system has an aggraded floodplain with some entrenched reaches and areas of highly eroding banks. However, the Warm Springs Ponds system captures significant sediment loads from the Silver Bow Creek drainage, reduces fine sediment supplies and artificially increases the D50. Given the dynamics of Warm Springs Ponds sediment capture and the low observed fines in the Clark Fork mainstem, the median of the data collected by DEQ in 2011 will be used as the target (bold in **Table 5-8**).

Table 5-8. DEQ Data Summary for Percent Fine Sediment <2 mm for the Clark Fork River

Data Source	Parameter	Percent Fine Sediment <2mm
CFROU DEQ Remediation Sample Data	Sample Size (n)	18
	25th	0
	Median	3
	75th	5
2011 Clark Fork River Sample Data	Sample Size (n)	33
	25th	5
	Median	**12**
	75th	18

Target values are indicated in bold

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

Grid toss measurements in pool tails is an alternative measure to pebble counts that assesses the level of fine sediment accumulation in macroinvertebrate habitat and potential fish spawning sites. A 49-point grid toss (Kramer et al., 1993) was used to estimate the percent surface fine sediment <6 mm in pool tails in the Clark Fork River and Silver Bow Creek watersheds. Three tosses, or 147 points, were performed then averaged for each pool tail assessed.

As outlined in the previous section, the fine sediment targets for Silver Bow Creek were developed by comparing pebble count statistics for other sediment-impaired streams which drain from the Elkhorn Mountains-Boulder Batholith Level IV Ecoregion (17ai) to the Silver Bow Creek data collected by DEQ in 2011.

The 25th percentile of the Elkhorn Mountains-Boulder Batholith data compares well with the 75th percentile of the Silver Bow Creek dataset (bold in **Table 5-9**), and was selected as the target condition for Silver Bow Creek.

Table 5-9. DEQ Data Percentiles for Percent Fine Sediment <6 mm via Grid Toss in Pool Tails for Silver Bow Creek

Data Source	Parameter	Percent Fine Sediment <6mm in Pool Tails
Elkhorn Mountains-Boulder Batholith (Level IV Ecoregion – 17ai)	Sample Size (n)	15
	25th	**5**
	Median	21
2011 Silver Bow Creek Sample Data	Sample Size (n)	6
	25th	0
	Median	0
	75th	9

Target values are indicated in bold

Unlike for riffle pebble counts, DEQ Remediation site investigations in the CFROU did not include pool tail grid tosses. Pool tail fines in the Clark Fork River were 0 for the 25th and 50th percentiles of the available dataset for the stream suggesting that fines are not impairing spawning habitat in pool tails in the Clark Fork mainstem. As much of the Clark Fork River upstream of the Flint Creek confluence is entrenched, stream power is focused in-channel leading to pool scour/pool development. Observed pool tail fines are likely low for this reason. Therefore, the 75th percentile was chosen as the target value (bold in **Table 5-10**).

Table 5-10. DEQ Data Percentiles for Percent Fine Sediment <6 mm via Grid Toss in Pool Tails for the Clark Fork River

Data Source	Parameter	Percent Fine Sediment <6mm in Pool Tails
2011 Clark Fork River Sample Data	Sample Size (n)	51
	25th	0
	Median	0
	75th	**8**

Target values are indicated in bold

5.5.3 Channel Form and Stability

Parameters related to channel form indicate a stream's ability to store and transport sediment. Stream gradient and valley confinement are two significant controlling factors that determine stream form and function, however, alterations to the landscape and sediment input beyond naturally occurring amounts can affect channel form. Numerous scientific studies have found trends and common relationships between channel dimensions in properly functioning stream systems and those with a sediment imbalance. Two of those relationships are used as targets for Silver Bow Creek and the Clark Fork River and are described below.

5.5.3.1 Width/Depth Ratio and Entrenchment Ratio

The width/depth ratio and the entrenchment ratio provide 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 (e.g., riffles, pools, and near-bank zones).

Changes in both the width/depth ratio and entrenchment ratio can be used as indicators of change in the relative balance between the sediment load and the transport capacity of the stream channel. As the width/depth ratio increases, streams become wider and shallower, suggesting an excess sediment load (MacDonald et al., 1991). As sediment accumulates, the depth of the stream channel decreases, which is compensated for by an increase in channel width when the stream attempts to regain a balance between sediment load and transport capacity.

Conversely, a decrease in the entrenchment ratio signifies a loss of access to the floodplain. Low entrenchment ratios indicate that stream energy is concentrated in-channel during flood events versus having energy dissipate to the floodplain. Accelerated bank erosion and an increased sediment supply often accompany an increase in the width/depth ratio and/or a decrease in the entrenchment ratio (Rosgen, 1996; Knighton, 1998; Rowe et al., 2003). Width/depth and entrenchment ratios were calculated for each 2011 assessment reach based on five riffle cross-section measurements.

Width/Depth Ratio Target Development

Silver Bow Creek has been largely re-contoured/reconstructed as part of the ROD for the SSTOU. Remediation activities have been completed in much of the SSTOU and BPSOU with full completion anticipated by the end of 2015. 2011 DEQ data reflects the remediated condition of the stream channel where sample locations were sited in reaches where remediation work had been completed. For comparison, the BDNF reference dataset for C stream types was compiled. The 75th percentile of the BDNF dataset compares closely with the 75th percentile of the 2011 DEQ data from remediated reaches on Silver Bow Creek. The 75th percentile of the BDNF reference data compared very closely with the 75th percentile of the Silver Bow Creek data suggesting that remediation work on the channel has replicated appropriate width-depth ratios. The 75th percentile of the BDNF data was chosen as the target for width-depth ratio (bold in **Table 5-11**). The target value applies to the average value for each sample reach.

Table 5-11. BDNF Reference and DEQ Data Used for Width/Depth Ratio Targets for Silver Bow Creek

Data Source	Parameter	W/D Ratio
BDNF	Sample Size (n)	30
	75th	**23**
Silver Bow Creek Sample Data	Sample Size (n)	10
	25th	15
	Median	17
	75th	19

Width/depth ratio target values are indicated in bold

The BDNF dataset does not include streams the size of the Clark Fork River. Therefore, it was not used to develop width-depth targets for this system. CFROU DEQ Remediation site investigations conducted extensive channel morphologic measurements in several reaches. The sections where DEQ Remediation investigations have occurred have been identified as entrenched reaches with unnaturally low width-depth ratios. Total measurements and average width/depth ratios from these reports are in **Table 5-12**.

Table 5-12. DEQ Remediation Report Values for Clark Fork River Width/Depth Ratios

Reference Report	Clark Fork Segment	Count	Average W/D Ratio
Camp, Dresser & McKee and Applied Geomorphology, Inc. (2010)	Warm Springs Creek to Cottonwood Creek	120	17.5
Terragraphics (2012)	Warm Springs Creek to Cottonwood Creek	71	18.6
Tetra Tech, Inc. et al. (2012)	Cottonwood Creek to Little Blackfoot River	65	28.0

The Clark Fork River has an armored stream bed and an elevated floodplain as a result of massive overbank sediment deposition in the early 1900s (Camp, Dresser & McKee and Applied Geomorphology, Inc., 2010). An aggraded floodplain is particularly observable in the upper portions of the Clark Fork River mainstem (Warm Springs to Cottonwood Creek). 2011 DEQ field work collected data from nine different reaches in all three AUs upstream of the Flint Creek confluence. Several reaches that were at or approaching desired conditions based on field assessors' observations had a median width-depth ratio of 39. This is close to the median value (50th percentile) of the entire 2011 DEQ dataset which will be used for the target value for the width-depth ratio (bold in **Table 5-13**). This target compares well with other TMDL targets for large rivers in western Montana such as the Tobacco River (≤35), the St. Regis River (≤30) and the Little Blackfoot River (≤35) which joins the Clark Fork River at Garrison, Montana (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2008; Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2011; Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011).

Table 5-13. DEQ Data Used for Width/Depth Ratio Targets for the Clark Fork River

Data Source	Parameter	W/D Ratio
Clark Fork River Sample Data	Sample Size (n)	30
	25th	36
	Median	**43**
	75th	53

Width/depth ratio target values are indicated in bold

Entrenchment Ratio Target Development

The BDNF reference dataset is the only reference data currently available to help develop entrenchment targets. For entrenchment ratio, because it is desirable to have a greater value, the 25th percentile of the

BDNF reference dataset was evaluated for target development. For the remediated reaches in Silver Bow Creek, the 25th percentile of the sample dataset is less than the 25th percentile of the BDNF reference value and in line with the Rosgen delineative criteria (**Table 5-14**). For the Clark Fork River, the 75th percentile of the sample dataset was chosen as the target. There is evidence that the Clark Fork River upstream of Flint Creek is entrenched and the 75th percentile of the Clark Fork data compares well the TMDL target used for other large rivers in western Montana such as the Tobacco River where >2.7 was used (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2011).

Although having a greater entrenchment value (i.e., more floodplain access) is desirable for Silver Bow Creek and the Clark Fork River, because the potential (after implementation of all reasonable land, soil, and water conservation practices) is likely less than the 25th percentile of reference, the Rosgen delineative criteria will be applied as the target for entrenchment ratio (bold in **Table 5-13**) for both Silver Bow Creek and the Clark Fork River. The target value applies to the average value for each sample reach.

Table 5-14. BDNF Reference and Other Data Used for Entrenchment Ratio Targets

Data Source	Parameter	Entrenchment Ratio
BDNF	Sample Size (n)	30
	25th	3.2
Silver Bow Creek Sample Data	Sample Size (n)	10
	25th	2.3
	Median	9.0
	75th	11.7
Clark Fork River Sample Data	Sample Size (n)	30
	25th	1.3
	Median	1.7
	75th	2.8
Rosgen Criteria	Entrenchment Ratio[a]	**>2.2**

Entrenchment ratio target values are indicated in bold
[a] Values are ± 0.2

5.5.4 Instream Habitat Measures

For all instream habitat measures (i.e., residual pool depth, pool frequency), PIBO is the only reference data currently available and is only useful for Silver Bow Creek as PIBO data does not represent streams the size of the Clark Fork River. Clark Fork River targets are based on DEQ data collection efforts.

All of the instream habitat measures are important indicators of sediment input and movement, as well as fish and aquatic life support, but they may be given less weight in the target evaluation if they do not seem to be directly related to the effects of sediment. The use of instream habitat measures in evaluating or characterizing impairment must be considered from the perspective of whether these measures are linked to fine, coarse, or total sediment loading.

5.5.4.1 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 pool habitat quality. Deep pools are important resting and hiding habitat for fish, and provide refuge during temperature extremes and high-flow periods (Nielson et al., 1994; Bonneau, 1998; Baigun, 2003). 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 (fine or coarse), a reduction in channel obstructions (such as large woody debris), and changes in channel form and stability (Bauer and Ralph, 1999).

A reduction in pool depth from channel aggradation may not only alter surface flow during the critical low flow periods, but may also harm fish by altering habitat, food availability, and productivity (May and Lee, 2004; Sullivan and Watzin, 2010). Residual pool depth is typically greater in larger systems. During DEQ sampling in 2011, pools were defined as depressions in the streambed bounded by a “head crest” at the upstream end and “tail crest” at the downstream end, with a maximum depth that was 1.5 times the pool-tail depth (Kershner et al., 2004).

The definition of pools for the PIBO protocol is fairly similar to the definition used for the 2011 Silver Bow Creek/Clark Fork River sample dataset: both use the same criterion to calculate the difference between the maximum depth and pool tail depth. However, the DEQ dataset could potentially have a greater pool frequency and more pools with a smaller residual pool depth because DEQ’s protocol has no minimum pool size requirement, whereas the PIBO protocol only counts pools greater than half the wetted channel.

In comparing the PIBO reference data with the sample data, the PIBO 25th percentile residual pool depth values are all less than the 25th percentile from the sample dataset for Silver Bow Creek, indicating that remediation efforts in Silver Bow Creek are approaching reference values suggesting that remediation work has successfully replicated appropriate values. This also indicates that methodology differences did not seem to affect measured values. The target for residual pool depth target is equal to or greater than the DEQ median value (bold in **Table 5-15**).

Target comparisons should be based on the reach average residual pool depth value. Because residual pool depths can indicate if excess sediment is limiting pool habitat, this parameter will be particularly valuable for future trend analysis, using the data collected in 2011 as a baseline. Future monitoring should document an improving trend (i.e., deeper pools) at sites that fail to meet the target criteria, while a stable trend should be documented at established monitoring sites that are currently meeting the target criteria.

Table 5-15. PIBO Reference and 2009 DEQ Sample Data Percentiles for Residual Pool Depth (ft)

Data Source	Parameter	Median residual pool depth (ft)
PIBO reference (> 15 ft. bankfull width)	Sample Size (n)	56
	25th	1.2
	Median	1.4
2011 Silver Bow Creek Sample Data	Sample Size (n)	6
	25th	1.6
	Median	**1.7**
	75th	2.1

Target values are indicated in bold

The PIBO dataset does not include streams the size of the Clark Fork River. Therefore, it was not used to develop a residual pool depth target for this system. CFROU DEQ Remediation site investigations conducted extensive channel morphologic measurements in several reaches. The sections where DEQ Remediation investigations have occurred have been identified as entrenched reaches with unnaturally low width-depth ratios. Stream power is focused within the channel causing pool scour. Summary statistics from these reports are in **Table 5-16**. Average residual pool depths in these entrenched reaches are 2.4–3.0 ft. and are likely unnaturally high based on the relatively low width-depth ratio.

Table 5-16. DEQ Remediation Report Values for Clark Fork River Residual Pool Depth

Reference Report	Clark Fork Segment	Median Residual Pool Depth[a] (ft)
Camp, Dresser & McKee and Applied Geomorphology, Inc. (2010)	Cottonwood Creek to Warm Springs Ponds	2.4
Terragraphics (2012)	Cottonwood Creek to Warm Springs Ponds	2.7
Tetra Tech, Inc. et al. (2012)	Little Blackfoot River to Cottonwood Creek	3.0

[a] Average value – raw data unavailable

Given that some sections of the Clark Fork River upstream of the Flint Creek confluence are entrenched including those assessed in **Table 5-16**, the most appropriate target is the median value of the 2011 DEQ dataset (bold in **Table 5-17**). As the systems gain access to their floodplains and the width-depth ratios increase, it is expected that residual pool depths will decrease.

Table 5-17. DEQ Data Percentiles for Residual Pool Depth (ft) for the Clark Fork River

Data Source	Parameter	Residual Pool Depth (ft)
2011 Clark Fork River Sample Data	Sample Size (n)	51
	25^{th}	1.6
	Median	**2.3**
	75^{th}	2.9

Target values are indicated in bold

5.5.4.2 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 (Muhlfeld et al., 2001). Sediment may limit pool habitat by filling in pools with fines. Alternatively, the build-up 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.

The PIBO 25^{th} percentile pool frequency value for streams with a bankfull width greater than 15 ft compare favorably with the 75^{th} percentile of the Silver Bow Creek sample dataset. This indicates that pool formation in Silver Bow Creek is still occurring post-remediation and/or that upstream sediment point sources are infilling potential pools before they are fully developed. As Silver Bow Creek drains the west side of the Continental Divide where the USFS Inland Native Fish (aka INFISH) Riparian Management Objectives apply, the INFISH values were evaluated in addition to the sample dataset to determine the most appropriate reference percentile for target development (**Table 5-18**).

Although streams with a bankfull width greater than 50 ft have an INFISH value close to the PIBO reference 25^{th} percentile, the target for streams with a bankfull width greater than 15 ft is set at greater than or equal to the 25^{th} percentile of PIBO reference (bold in **Table 5-18**). The high natural fine sediment loads in the Silver Bow Creek drainage will also depress pool frequency as these fines are transported through the system. As the system recovers post-remediation the long term potential pool frequency in the system may increase and approach the lower estimate of the INFISH riparian management objectives for streams with bankfull width less than 20 ft (56 pools/mile). Pools per mile should be calculated based on the number of measured pools per reach and then scaled up to give a frequency per mile.

Table 5-18. PIBO Reference and 2011 DEQ Sample Data Percentiles for Pool Frequency (pools/mile) and INFISH Riparian Management Objective Values for Silver Bow Creek

Data Source	Parameter	Pool Frequency (pools/mile)
PIBO reference (>15 ft bankfull width)	Sample Size (n)	56
	25th	**22**
	Median	52
2011 Silver Bow Creek Sample Data	Sample Size (n)	2
	25th	13
	Median	16
	75th	19
INFISH Riparian Management Objectives	< 20 ft bankfull width: 96–56 25 ft bankfull width: 47	50 ft bankfull width: 26 100 ft bankfull width: 18

Target values are indicated in bold

The PIBO dataset does not include streams the size of the Clark Fork River. Therefore, it was not used to develop a pool frequency target for this system. CFROU DEQ Remediation site investigations conducted extensive channel morphologic measurements in several reaches. The sections where DEQ Remediation investigations have occurred have been identified as entrenched reaches with unnaturally low width-depth ratios. Stream power is focused within the channel causing pool scour. Summary statistics from these reports are in **Table 5-19**. Average pool frequencies in these reaches are 10–18 pools/mile.

Table 5-19. DEQ Remediation Report Values for Clark Fork River Pool Frequency (pools/mile)

Reference Report	Clark Fork Segment	Average Pool Frequency (pools/mile)
Camp, Dresser & McKee and Applied Geomorphology, Inc. (2010)	Warm Springs Creek to Cottonwood Creek	18
Terragraphics (2012)	Warm Springs Creek to Cottonwood Creek	12
Tetra Tech, Inc. et al. (2012)	Cottonwood Creek to Little Blackfoot River	10

Some sections of the Clark Fork River upstream of the Flint Creek confluence have significant sediment loading from eroding banks in an aggraded floodplain including those assessed in **Table 5-19**. Pool frequency varied between the Clark Fork River sediment/habitat sites from 3 pools/mi to 32 pools/mi. Given the range of instream habitat conditions encountered at Clark Fork River sampling reaches, the median value 2011 DEQ dataset was selected as the target for the impaired segments of the Clark Fork River (bold in **Table 5-20**). This target was selected partly as it compares well with TMDL targets from other relatively large rivers in western Montana such as the Tobacco River (≥12), St. Regis River (≥16) and the Little Blackfoot River (≥15) which joins the Clark Fork River at Garrison, Montana (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2011; Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011; Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2011). The median value is also assumed to best represent achievable conditions on the Clark Fork River upstream of the Flint Creek confluence.

Table 5-20. DEQ Data Percentiles for Pool Frequency for the Clark Fork River

Data Source	Parameter	Pool Frequency (pools/mile)
2011 Clark Fork River Sample Data	Sample Size (n)	9
	25^{th}	9
	Median	**18**
	75^{th}	22

Target values are indicated in bold

5.5.5 Human Sediment Sources

The presence of human sediment sources does not always result in sediment impairment of a beneficial use. When there are no significant identified human sources of sediment within the watershed of a 303(d) listed steam, 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; however, the overall extent of human sources will be used to supplement any characterization of impairment conditions. This includes evaluating human-caused and natural sediment sources, along with field observations and watershed-scale source assessment information obtained using aerial imagery and GIS data layers.

Because sediment transport through a system can take years or decades, and because channel form and stability can influence sediment transport and deposition, any evaluation of human-caused sediment sources must consider both current and historical sediment loading as well as historical alterations to channel form and stability because those changes still have the potential to contribute to sediment and/or habitat impairment. Source assessment analysis will be provided by 303(d) listed waterbody in **Section 5.8**, with additional information in **Appendix C** and **Attachment A**.

5.5.6 Biological Index

Siltation exerts a direct influence on benthic macroinvertebrate communities by filling in spaces between gravel and by limiting attachment sites. Macroinvertebrate communities respond predictably to siltation by shifting from natural or expected taxa to a prevalence of sediment-tolerant taxa (as opposed to those that require clean gravel substrates). Macroinvertebrate bioassessment scores are an assessment of the macroinvertebrate assemblage at a site. DEQ uses one bioassessment methodology to evaluate stream condition and aquatic life beneficial-use support. Aquatic insect communities may be altered as a result of different stressors, such as nutrients, metals, flow, and temperature, and the biological index values must be considered along with other parameters that are more closely linked to sediment.

DEQ uses the Observed/Expected Model (O/E) to assess macroinvertebrate communities. The rationale and methodology for the index is presented in the DEQ Benthic Macroinvertebrate Standard Operating Procedure (SOP) (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2006). The O/E Model compares the taxa that are expected at a site under a variety of environmental conditions with the actual taxa that were found when the site was sampled. It is expressed as a ratio of the Observed/Expected taxa (O/E value). The O/E community shift point toward a more sediment-tolerant taxa for all Montana streams is any O/E value <0.80. Therefore, an O/E score of ≥0.80 is established as a sediment target for Silver Bow Creek and the Clark Fork River.

Unless noted otherwise, macroinvertebrate samples discussed in this document were collected according to DEQ protocols. DEQ protocols have changed some within the last 10 years. All available data collected within that time are presented in this document; however, MAC-R-500, which is a reach-wide composite from both riffles and pools, is considered the most reliable for use with the O/E model.

An index score greater than the threshold value is desirable, and the result of each sampling event is evaluated separately. Because index scores may be affected by other pollutants or forms of pollution, such as habitat disturbance and metals, they will be evaluated in consideration of more direct indicators of excess sediment. In other words, not meeting the biological target does not automatically equate to sediment impairment. Additionally, because the macroinvertebrate sample frequency and spatial coverage is typically low for each watershed, and because of the extent of research showing the harm of excess sediment to aquatic life, meeting the biological target does not necessarily indicate a waterbody is fully supporting its aquatic life beneficial use. For this reason, macroinvertebrate data are not required for a TMDL development determination, and available data will evaluated in conjunction with values for other target parameters.

An important consideration for Silver Bow Creek and the Clark Fork River is the extensive, documented metals contamination of sediments and water which can affect O/E bioassessment scores. Additionally, elevated nutrient concentrations can also affect O/E scores. The target is useful as an indicator of a sediment impairment when and if other pollutants have been addressed.

5.6 Existing Condition and Comparison to Water Quality Targets

This section includes a comparison of existing data with water quality targets, along with a TMDL development determination for each stream segment of concern in the Upper Clark Fork Phase 2 TPA (**Section 5.2**). The TMDL development determination is whether or not recent data supports the impairment listing and whether a TMDL will or will not be completed, but it is not a formal impairment assessment. All waterbodies reviewed in this section are listed for sediment impairment on the 2012 303(d) List. Although inclusion on the 303(d) list indicates impaired water quality, a comparison of water quality targets with existing data helps define the level of impairment and establishes a benchmark to help evaluate the effectiveness of restoration efforts.

5.6.1 Silver Bow Creek (MT76G003_020)

Silver Bow Creek is listed for sedimentation/siltation on the 2012 303(d) List. The listed stream segment includes the 29.2 miles from the confluence of Blacktail Creek and the MSD to the mouth (Clark Fork River). A stormwater conveyance, the MSD is 6,000 ft long beginning near the Civic Center in Butte and terminating where it meets Blacktail Creek to form Silver Bow Creek. Beneath the MSD, there is an eight inch slotted pipeline packed in gravel which captures groundwater inflow which is then pumped to the LAO treatment facility adjacent to Silver Bow Creek. This groundwater is treated for metals before being discharged to Silver Bow Creek. Silver Bow Creek flows through the Warm Springs Ponds before reaching the Clark Fork River. Warm Springs Ponds are excluded in state statute (Statute 17-5-103(34)(b)(i)) and administrative rule (ARM 17.30.607(1)(a)(iii)) as a state waterbody, so formal assessment of Silver Bow Creek extends only to the inlet of the uppermost pond (21.7 miles from the confluence of the MSD and Blacktail Creek). The listed stream segment was first listed for sediment impairment in 1996. The initial impairment determination was made based on the history of mining and smelting operations in Butte and Anaconda and the sediment deposition to the Clark Fork River and associated floodplain following extensive flooding in the early 20th Century including the extensive tailings deposits located within and bordering the Silver Bow Creek floodplain.

5.6.1.1 Physical Condition and Sediment Sources

The Silver Bow Creek channel is undergoing extensive remediation activities as part of the SSTOU ROD with completion of work scheduled for 2015. In light of this work, DEQ sampled reaches in 2011 in Silver Bow Creek where remediation has been completed. Both monitoring locations were sited upstream of Durant Canyon and within the SSTOU (**Figure 5-3**). The upper site (SVB-4-2) was located on Silver Bow Creek immediately south of Rocker. The channel had low habitat diversity. Remediation efforts appear to have resulted in a stable channel with few pools. Sand plugs were observed in the bed and were attributed to low stream power and high aquatic plant density. Riparian health was good due to extensive plantings and streambank erosion was minimal. At the lower site (SVB-9-1), the riparian area was good due and streambank erosion minimal although there were few pools in this reach. There was much less instream aquatic vegetation in this reach than in SVB-4-2.

5.6.1.2 Comparison to Water Quality Targets

The existing data in comparison to targets for Silver Bow Creek (headwaters to Warm Springs Ponds inlet) are summarized in **Table 5-21**. Extensive macroinvertebrate data is available for Silver Bow Creek and reflects locations where water chemistry sampling was conducted to define different point sources and bracket incoming tributaries (**Table 5-22**). All bolded cells are above target thresholds.

Table 5-21. Existing Sediment-Related Data for the Silver Bow Creek (headwaters to Warm Springs Ponds inlet) Relative to Targets

Reach ID	Assessment Year	Mean BFW[a] (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat	
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	W/D Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile
SVB-4-02	2011	24.4	C3	C3	**43**	**40**	**7**	16.5	7.8	**1.6**	**21**
SVB-9-01	2011	24.5	C3	C3	**28**	**43**	1	17.4	10.8	2.1	**11**

[a] BFW = Bankfull width

Table 5-22. Macroinvertebrate Bioassessment Data for Silver Bow Creek

Station ID	Location	Collection Date	Collection Method	O/E
SS-06G	Silver Bow Creek above WWTP Discharge	08-Oct-08	HESS	**0.32**
SS-07	Silver Bow Creek below WWTP Discharge	08-Oct-08	HESS	**0.40**
SS-08	Silver Bow Creek at Rocker	08-Oct-08	HESS	**0.34**
SS-10A	Silver Bow Creek above Sand Creek	09-Oct-08	HESS	**0.35**
SS-10B	Silver Bow Creek below Sand Creek	09-Oct-08	HESS	**0.38**
SS-11C	Silver Bow Creek above Browns Gulch	09-Oct-08	HESS	**0.48**
SS-11D	Silver Bow Creek below Browns Gulch	09-Oct-08	HESS	**0.38**
SS-15A	Silver Bow Creek above German Gulch	09-Oct-08	HESS	**0.50**
SS-15B	Silver Bow Creek below German Gulch	09-Oct-08	HESS	**0.30**
SS-17D	Silver Bow Creek at Stewart St. in Opportunity	13-Oct-08	HESS	1.00
SS-05B	Immediately downstream of Missoula Gulch	05-Nov-09	HESS	**0.32**
SS-06A	Silver Bow Creek at Butte Reduction Works	05-Nov-09	HESS	**0.32**
SS-06G	Silver Bow Creek above WWTP Discharge	05-Nov-09	HESS	**0.40**

Table 5-22. Macroinvertebrate Bioassessment Data for Silver Bow Creek

Station ID	Location	Collection Date	Collection Method	O/E
SS-07	Silver Bow Creek below WWTP Discharge	05-Nov-09	HESS	**0.24**
SS-08	Silver Bow Creek at Rocker	05-Nov-09	HESS	**0.25**
SS-11C	Silver Bow Creek above Browns Gulch	05-Nov-09	HESS	**0.38**
SS-11D	Silver Bow Creek below Browns Gulch	05-Nov-09	HESS	**0.48**
SS-10A	Silver Bow Creek above Sand Creek	06-Nov-09	HESS	**0.35**
SS-14	Silver Bow Creek at Miles Crossing	06-Nov-09	HESS	**0.30**
SS-15A	Silver Bow Creek above German Gulch	06-Nov-09	HESS	**0.40**
SS-15B	Silver Bow Creek below German Gulch	06-Nov-09	HESS	**0.50**
SS-17D	Silver Bow Creek at Stewart St. in Opportunity	06-Nov-09	HESS	**0.71**
SS-10B	Silver Bow Creek below Sand Creek	09-Nov-09	HESS	**0.38**
SS-06A	Silver Bow Creek at Butte Reduction Works	24-Sep-10	HESS	**0.32**
SS-06G	Silver Bow Creek above WWTP Discharge	24-Sep-10	HESS	**0.32**
SS-07	Silver Bow Creek below WWTP Discharge	24-Sep-10	HESS	**0.32**
SS-08	Silver Bow Creek at Rocker	24-Sep-10	HESS	**0.34**
SS-10A	Silver Bow Creek above Sand Creek	27-Sep-10	HESS	**0.43**
SS-10B	Silver Bow Creek below Sand Creek	27-Sep-10	HESS	**0.38**
SS-11C	Silver Bow Creek above Browns Gulch	27-Sep-10	HESS	**0.48**
SS-14	Silver Bow Creek at Miles Crossing	27-Sep-10	HESS	**0.40**
SS-15A	Silver Bow Creek above German Gulch	27-Sep-10	HESS	**0.40**
SS-15B	Silver Bow Creek below German Gulch	27-Sep-10	HESS	**0.50**
SS-17D	Silver Bow Creek at Stewart St. in Opportunity	27-Sep-10	HESS	0.86
SS-11D	Silver Bow Creek below Browns Gulch	28-Sep-10	HESS	**0.48**
SS-06A	Silver Bow Creek at Butte Reduction Works	29-Sep-11	HESS	**0.40**
SS-06G	Silver Bow Creek above WWTP Discharge	29-Sep-11	HESS	**0.40**
SS-07	Silver Bow Creek below WWTP Discharge	29-Sep-11	HESS	**0.40**
SS-08	Silver Bow Creek at Rocker	29-Sep-11	HESS	**0.25**
SS-10A	Silver Bow Creek above Sand Creek	29-Sep-11	HESS	**0.43**
SS-10B	Silver Bow Creek below Sand Creek	29-Sep-11	HESS	**0.48**
SS-11C	Silver Bow Creek above Browns Gulch	29-Sep-11	HESS	**0.48**
SS-11D	Silver Bow Creek below Browns Gulch	29-Sep-11	HESS	**0.38**
SS-14	Silver Bow Creek at Miles Crossing	29-Sep-11	HESS	**0.40**
SS-15A	Silver Bow Creek above German Gulch	29-Sep-11	HESS	**0.50**
SS-15B	Silver Bow Creek below German Gulch	30-Sep-11	HESS	0.90
SS-17D	Silver Bow Creek at Stewart St. in Opportunity	30-Sep-11	HESS	**0.43**
SS-11C	Silver Bow Creek above Browns Gulch	19-Sep-12	HESS	**0.38**
SS-11D	Silver Bow Creek below Browns Gulch	19-Sep-12	HESS	**0.38**
SS-14	Silver Bow Creek at Miles Crossing	19-Sep-12	HESS	**0.51**
SS-15A	Silver Bow Creek above German Gulch	19-Sep-12	HESS	**0.50**
SS-15B	Silver Bow Creek below German Gulch	19-Sep-12	HESS	**0.60**
SS-17D	Silver Bow Creek at Stewart St. in Opportunity	19-Sep-12	HESS	**0.57**
SS-05A	Immediately upstream of Missoula Gulch	20-Sep-12	HESS	**0.32**
SS-06G	Silver Bow Creek above WWTP Discharge	20-Sep-12	HESS	**0.32**
SS-07	Silver Bow Creek below WWTP Discharge	20-Sep-12	HESS	**0.24**
SS-08	Silver Bow Creek at Rocker	20-Sep-12	HESS	**0.34**
SS-10A	Silver Bow Creek above Sand Creek	20-Sep-12	HESS	**0.35**
SS-10B	Silver Bow Creek below Sand Creek	20-Sep-12	HESS	**0.38**
SS-05A	Immediately upstream of Missoula Gulch	02-Nov-12	HESS	**0.32**

Table 5-22. Macroinvertebrate Bioassessment Data for Silver Bow Creek

Station ID	Location	Collection Date	Collection Method	O/E
SS-06G	Silver Bow Creek above WWTP Discharge	02-Nov-12	HESS	**0.32**
SS-07	Silver Bow Creek below WWTP Discharge	02-Nov-12	HESS	**0.24**
SS-08	Silver Bow Creek at Rocker	02-Nov-12	HESS	**0.34**
SS-10A	Silver Bow Creek above Sand Creek	02-Nov-12	HESS	**0.35**
SS-11C	Silver Bow Creek above Browns Gulch	02-Nov-12	HESS	**0.38**
SS-11D	Silver Bow Creek below Browns Gulch	02-Nov-12	HESS	**0.38**
SS-14	Silver Bow Creek at Miles Crossing	02-Nov-12	HESS	**0.51**
SS-15A	Silver Bow Creek above German Gulch	02-Nov-12	HESS	**0.50**
SS-17D	Silver Bow Creek at Stewart St. in Opportunity	02-Nov-12	HESS	**0.57**
SS-10B	Silver Bow Creek below Sand Creek	05-Nov-12	HESS	**0.38**
SS-15B	Silver Bow Creek below German Gulch	05-Nov-12	HESS	**0.60**

Values that do not meet the target threshold are in bold

5.6.1.3 Summary and TMDL Development Determination

Both assessment sites on Silver Bow Creek did not meet riffle pebble count targets for fine sediment and one site did not meet the fine sediment target for pool tail fines. Given the extensive reconstruction and remediation activities in Silver Bow Creek to date, the assessment sites met the targets for channel form and residual pool depth. Although both sites were below the pool frequency target, site SVB-4-02 was just below the target. Overall, fine sediment appears to be an issue in the remediated reaches of Silver Bow Creek as fine sediment continues to move through the system both from natural sources and from continuing remediation work in the watershed.

Of the 71 macroinvertebrate O/E scores calculated for Silver Bow Creek, only 3 met the target of ≥0.80. These three samples were all collected downstream of the German Gulch confluence with Silver Bow Creek. Given the history of the drainage as well as the existing metal and nutrients impairments in addition to the sediment impairment, the fact that >95% of the samples did not meet the target cannot be attributed solely to a sediment impairment but is likely caused by a combination of all 3 pollutant types in the drainage.

Based on the comparison to water quality targets for sediment, habitat and macroinvertebrates, the stream is impaired by sediment and a TMDL will be prepared for Silver Bow Creek.

5.6.2 Clark Fork River, Warm Springs Creek to Cottonwood Creek (MT76G001_040)

The Clark Fork River from Warm Springs Creek to Cottonwood Creek was first listed for sedimentation/siltation impairment on the 1996 303(d) List. The segment flows a total stream distance of 27.8 miles. The initial impairment determination was made based on the history of mining and smelting operations in Butte and Anaconda and the sediment deposition to the Clark Fork River and associated floodplain following extensive flooding in the early 20th Century Impairment of beneficial uses by sediment is tied directly to sediment deposition from upstream source areas. In relation to the CFROU, this AU falls entirely within Reach A (**Figure 5-2**). The selected remedy for the CFROU applies to limited areas within Reach A. Site investigations were initiated in 2009 with active site remediation as part of the selected remedy beginning in 2012 in Reach A.

5.6.2.1 Physical Condition and Sediment Sources

A hydrologic/geomorphic investigation was conducted in 2009 by CDM and AGI on behalf of DEQ in the upper reaches of this segment. Fieldwork in the reach immediately downstream of Warms Springs Ponds to the Perkins Lane crossing corroborated earlier findings by (Smith et al., 1998) and others to an aggraded floodplain from extensive flooding in the early 20th Century that resulted in elevated banks and reduced floodplain access and an entrenched channel. The authors also found that the reduced power of the stream following completion of the Warm Springs Ponds has prevented the stream from reducing entrenchment and re-accessing its floodplain (Camp, Dresser & McKee and Applied Geomorphology, Inc., 2010). Warm Springs Ponds successfully function as a sediment trap but detain flood flows up to the 100-year event (3,300 cfs). Fieldwork also revealed long extents of retreating bank line with active topple failure in addition to discontinuous scalloping (Camp, Dresser & McKee and Applied Geomorphology, Inc., 2010). Mine tailings deposits are commonly exposed in the banks. Thirty-two percent of the 1.3 miles of the assessed bank line was mapped as eroding.

Terragraphics also completed a hydrologic/geomorphic investigation in the Clark Fork River segment between Cottonwood Creek and Warm Springs Creek (2012) in a reach which extended 4.5 river miles from Galen Road to the Powell County line approximately 300 ft north of Gemback Road. Their investigation partly overlapped with the DEQ monitoring site CFR-2-3. The planning reach was described as a single thread, slightly entrenched, sinuous river. The authors also noted the aggraded floodplain and the creation of berms along the banks in some places which both contribute to unnaturally high banks. Eroding stream banks included those with active slumping and low cover. Mine tailings were noted in 73% of the banks surveyed and ranged between a thin veneer and 3 ft thick.

DEQ conducted sediment and habitat surveys on four reaches in this segment of the Clark Fork River (**Figure 5-3**). At the uppermost site (CFR-2-3), mine tailings were identified in eroding banks. An example of a stratified layer of mine tailings is provided in **Figure 5-4**. Beaver activity was observed and riparian buffers were generally well-established. There were some impacts from grazing on the margins of the riparian area but no observed impacts from cattle grazing within the stream.

Figure 5-4. Visible Mine Tailings in Eroding Bank (Dark Orange Layer) in Upper Segment of the Clark Fork River

At site CFR-8-1 there was good woody recruitment to the channel and some historic impacts from cattle grazing were evident. However, bank erosion was linked to extensive mine tailings observed in some eroding banks which inhibit vegetative growth and provided an easily erodible stratified layer in the bank composition. Fine sediment accumulations were also observed in the stream bed as at CFR-2-3. At CFR-12-1, mine tailings were also observed in eroding banks and likely impede rooting depth of riparian vegetation due to their toxicity (United States Geological Survey et al., 2002). Sand and gravel slugs were observed in the reach. Severe bank erosion was found in this reach. High banks were dominated by tailings-tolerant grasses such as tufted hairgrass and redtop. Impacts from cattle grazing were deemed minimal. Site CFR-13-1 was one of the most severely degraded reaches sampled by DEQ in 2011 on the Clark Fork River. Heavy cattle grazing had significant impacts on bank erosion and fine sediment accumulation in the reach. Tailings lenses, discrete layers of mine tailings, in eroding banks and slickens were observed throughout the reach. In addition, berms created in the floodplain have decreased floodplain access and elevated already high banks in some places. Riparian health was poor in the sample reach.

5.6.2.2 Comparison to Water Quality Targets

The existing data in comparison to targets for the Clark Fork River (Cottonwood Creek to Warm Springs) are summarized in **Table 5-23** and **Table 5-24**. All bolded cells are above target thresholds.

Table 5-23. Existing Sediment-Related Data for the Clark Fork River (Warm Springs Creek to Cottonwood Creek) Relative to Targets

Reach ID	Assessment Year	Mean BFW[a] (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat	
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	W/D Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile
CFR-2-3	*2011*	58.1	C3	C3	21	17	0	33.1	**2.0**	3.3	18
CFR-8-1	*2011*	68.0	C3	C3	**23**	**20**	3	33.6	4.5	2.4	32
CFR-12-1	*2011*	75.3	C3	C3	15	10	5	41.5	**1.2**	2.6	21
CFR-13-1	*2011*	67.3	C3	C3	**27**	**20**	5	32.4	2.6	**1.9**	24

[a] BFW = Bankfull width

Table 5-24. Macroinvertebrate Bioassessment Data for the Clark Fork River (Warm Springs Creek to Cottonwood Creek)

Station ID	Location	Collection Date	Collection Method	O/E
CFRB-07	At confluence of Silver Bow Creek and Warms Springs Creek	8/20/2003	HESS	**0.57**
C01CKFKR10	Downstream of Dry Cottonwood Creek	8/8/2012	MAC-R-500	1.00
C01CKFKR11	Downstream of Valiton Ditch outtake	8/9/2012	MAC-R-500	1.23
C01CKFKR12	At mile 191 on I-90	8/9/2012	MAC-R-500	1.22
CFRB-09	Upstream of Cottonwood Creek	8/19/2003	HESS	**0.62**

Values that do not meet the target threshold are in bold

The upper segment of the Clark Fork from Cottonwood Creek to Warm Springs Creek met many of the water quality targets for two monitoring locations. Fine sediment targets for riffles were exceeded at two locations. Two of the four sites did not meet the entrenchment target and the residual pool depth target was not met at CFR-13-1. Conversely, the width/depth ratio target was met at all sites as was the pool frequency target and pool tail fines target.

There are five macroinvertebrate samples available for the segment with differing results. The macroinvertebrate samples collected in 2003 did not meet the target O/E score while the 2012 results were all elevated (>1.20). There are several potential reasons for this. A system the size of the Clark Fork River is outside the experience of the O/E model. Also, given the level of metals and nutrient impairments in the upstream Silver Bow Creek drainage, it is difficult to interpret these results in relation to the sediment condition in the segment. One theory is that extensive remediation efforts in the Silver Bow Creek drainage between 2003 and 2012 decreased the metals toxicity which allowed vibrant growth of the macroinvertebrate population given existing nutrient loading in the system.

Based on the observations from CDM and AGI (Camp, Dresser & McKee and Applied Geomorphology, Inc., 2010) and Terragraphics (2012) in addition to the DEQ collection efforts in 2011, it is evident that this reach is slightly entrenched. The investigative field work also observed high fines in this segment likely as a result of streambank erosion of deposited mine tailings from the flood events in the early 20th Century. The lack of access to the floodplain and altered hydrology of the system points towards a system in transition following extensive, historic sediment deposition. The Warm Springs Ponds prevent channel altering flows to rework and transport the extensive sediment loads in the channel and floodplain deposited during the early 20th Century flood events.

The sediment and habitat information supports the 303(d) listing and a sediment TMDL will be developed for the Clark Fork River from Warm Springs Creek to Cottonwood Creek.

5.6.3 Clark Fork River, Cottonwood Creek to Little Blackfoot River (MT76G001_030)

The Clark Fork River from Cottonwood Creek to Little Blackfoot River was first listed for sedimentation/siltation impairment on the 1996 303(d) List. The segment flows a total stream distance of 14.9 miles. The initial impairment determination was made based on the history of mining and smelting operations in Butte and Anaconda and the sediment deposition to the Clark Fork River and associated floodplain following extensive flooding in the early 20th Century. Impairment of beneficial uses by sediment is tied directly to sediment deposition from upstream source areas. In relation to the CFROU, this AU falls entirely within Reach A (**Figure 5-2**). The selected remedy for the CFROU applies to limited areas within Reach A. Site investigations were initiated in 2009 with active site remediation as part of the selected remedy beginning in 2012 in Reach A.

5.6.3.1 Physical Condition and Sediment Sources

Tetra Tech completed a hydrologic/geomorphic investigation on the Clark Fork River where it flows through the Grant-Kohrs Ranch (NPS) (2012). The NPS took over management of the Grant-Kohrs Ranch in 1972. The authors determined that the reach is largely entrenched with moderate sinuosity and with bank erosion concentrated on migrating cutbanks on meander bends. Bank erosion was severe in some sections. In banks with observable tailings deposits, an average tailings thickness of 14.6 inches was measured (Kapustka, 2002). Bank protection was noticeably absent in much of the sample reach and woody vegetation sparse in some sections. The Tetra Tech study reach from 2012 overlapped the DEQ site CFR-16-2 sampled in 2011.

DEQ conducted sediment and habitat field investigations at 2 sites on the Clark Fork River (Little Blackfoot River to Cottonwood Creek) in September 2011 (**Figure 5-3**). The uppermost site CFR-16-2 was located on the Grant-Kohrs Ranch (NPS). The sample reach was over-widened and mid-channel bars were common in riffles. Severe and widespread bank erosion was observed throughout the reach with extensive calving off of high banks. Riparian areas were dominated by grasses although no cattle were present as the riparian corridor has been fenced out. At the downstream site (CFR-17-2), there were signs of hoof shear and cattle grazing in the reach although it was not severe. Streambank erosion was not as severe as at CFR-16-2 although the channel was over-widened. As at CFR-16-2, the riparian area was dominated by pasture grasses with some shrub cover.

5.6.3.2 Comparison to Water Quality Targets

The existing data in comparison to targets for the Clark Fork River (Little Blackfoot River to Flint Creek) are summarized in **Table 5-25** and **Table 5-26**. All bolded cells are above target thresholds.

Table 5-25. Existing Sediment-Related Data for the Clark Fork River (Cottonwood Creek to the Little Blackfoot River) Relative to Targets

Reach ID	Assessment Year	Mean BFW[a] (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat	
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	W/D Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile
CFR-16-2	*2011*	80.3	C3	C3	**18**	**14**	4	**44.8**	**1.1**	**1.8**	**13**
CFR-17-2	*2011*	96.2	C3	C3	**19**	**13**	**29**	**51.9**	**1.3**	**2.2**	**3**

[a] BFW = Bankfull width

Table 5-26. Macroinvertebrate Bioassessment Data for the Clark Fork River (Cottonwood Creek to the Little Blackfoot River)

Station ID	Location	Collection Date	Collection Method	O/E
C01CKFKR06	Downstream of Deer Lodge	8/21/2012	MAC-R-500	1.33
CFRB-10	Upstream of Kohrs-Bend Fishing Access	8/19/2003	HESS	0.85

Values that do not meet the target threshold are in bold

For the sites assessed by DEQ in 2011, none of the channel form or instream habitat targets were met at either site. The target for pool tail fines was also exceeded at CFR-17-2. In addition, fine sediment targets for <6mm and <2 mm were not met at either location. This suggests that the channel is well entrenched with low pool frequency and shallow pools. While fine sediment accumulation in riffles was not observed in the sample reaches, the lack of adequate pool depth and frequency in an entrenched system suggests that the river may be moving significant sediment loads via bedload.

There are 2 macroinvertebrate samples for this segment of the Clark Fork River. The macroinvertebrate sample collected in 2003 did meet the target O/E score while the 2012 result was elevated (>1.20). There are several potential reasons for this. A system the size of the Clark Fork River is outside the experience of the O/E model. Also, given the level of metals and nutrient impairments in the upstream Silver Bow Creek drainage, it is difficult to interpret these results in relation to the sediment condition in the segment. Extensive remediation efforts in the Silver Bow Creek drainage between 2003 and 2012 may have decreased the metals toxicity and allowed vibrant growth of the macroinvertebrate population given existing nutrient loading in the system.

The sediment and habitat information supports the 303(d) listing and a sediment TMDL will be developed for the Clark Fork River from the Little Blackfoot River to Cottonwood Creek.

5.6.4 Clark Fork River, Little Blackfoot River to Flint Creek (MT76G001_010)

First listed on the 303(d) list for sedimentation/siltation in 1996, the segment of the Clark Fork River between the Little Blackfoot River and the Flint Creek confluence flows 27.8 miles. The initial impairment determination was made based on the history of mining and smelting operations in Butte and Anaconda and the sediment deposition to the Clark Fork River and associated floodplain following extensive flooding in the early 20th Century. Impairment of beneficial uses by sediment is tied directly to sediment deposition from upstream source areas. In relation to the CFROU, this AU falls entirely within Reach B (**Figure 5-2**). The selected remedy for the CFROU applies to limited areas within Reach B and has not yet commenced.

5.6.4.1 Physical Condition and Sediment Sources

In 2011, DEQ performed sediment and habitat assessments at three monitoring sites on the Clark Fork River between the Little Blackfoot River and Flint Creek confluences (**Figure 5-3**). The uppermost site (CFR-22-2) was confined between a railroad grade and I-90 with extensive riprap through the sampled reach in the canyon downstream of the highway rest area near Garrison. Mine tailings were not observed in eroding banks. Riprap and confinement were likely limiting pool development. The riparian condition was fair to good in this section. At the middle site (CFR-24-1), riprap was again observed although it was not nearly as extensive as at CFR-22-2. Moderate bank erosion was observed and was tied to riprap influence more so than land use. Again, the riparian condition was considered relatively robust. At the lowest site (CFR-26-1), historic haying/grazing was tied to current bank condition where current grazing was not observed but historic land use had eliminated overstory and understory vegetation along the bank margins. Banks are inadequately protected from erosion with a mixture of grasses in most places. Much of the adjacent land uses are abandoned pastures with limited riparian areas. Banks are re-vegetating since grazing pressure has been reduced significantly.

5.6.4.2 Comparison to Water Quality Targets

The existing data in comparison to targets for the Clark Fork River (Little Blackfoot River to Flint Creek) are summarized in **Table 5-27**. No macroinvertebrate data is available for this reach from the last 10 years. All bolded cells are above target thresholds.

Table 5-27. Existing Sediment-Related Data for the Clark Fork River (Little Blackfoot River to Flint Creek) Relative to Targets

Reach ID	Assessment Year	Mean BFW[a] (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat	
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	W/D Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile
CFR-22-2	*2011*	118.9	C3	C3	11	7	3	**50.9**	**1.4**	**2.2**	**8**
CFR-24-1	*2011*	119.7	C3	C3	5	3	0	**59.4**	3.5	2.9	18
CFR-26-1	*2011*	113.4	C3	C3	13	12	**13.7**	**45.3**	2.7	2.5	**11**

[a] BFW = Bankfull width

5.6.4.3 Summary and TMDL Development Determination

This segment of the Clark Fork River is meeting water quality targets for fine sediment in riffles although CFR-26-1 exceeded the pool tail fine sediment target. This segment appears to be recovering well from historic agricultural impacts. However, channel form did not meet targets for width/depth in all three sampled reaches and did not meet entrenchment targets in one of three sampled reaches. The confined reach (CFR-22-2) also did not meet residual pool depth or pool frequency targets.

Although several portions of the segment appear to be recovering from historic land-use practices, riprap and berms associated with transportation corridors appear to be contributing to poor channel form. This information supports the 303(d) listing and a sediment TMDL will be developed for the Clark Fork River from the Little Blackfoot River to the Flint Creek confluence.

5.7 Sediment TMDL Development Summary

Based on the comparison of existing conditions with water quality targets, 4 sediment TMDLs will be developed in the Upper Clark Fork Phase 2 TPA. **Table 5-28** summarizes the sediment TMDL development determinations and corresponds to the waterbodies of concern identified in **Section 5.2**.

Table 5-28. Summary of Sediment TMDL Development Determinations

Stream Segment	Waterbody Number	TMDL Development Determination (Y/N)
SILVER BOW CREEK, headwaters to mouth (Clark Fork River)	MT76G003_020	Y
CLARK FORK RIVER, Warm Springs Creek to Cottonwood Creek	MT76G001_040	Y
CLARK FORK RIVER, Cottonwood Creek to Little Blackfoot River	MT76G001_030	Y
CLARK FORK RIVER, Little Blackfoot River to Flint Creek	MT76G001_010	Y

5.8 Sediment Source Assessment and Quantification

This section summarizes the assessment approach, current sediment load estimates, and the determination of the allowable load for each source category. DEQ determines the allowable load by estimating the obtainable load reduction once all reasonable land, soil, and water conservation practices have been implemented. The reduction forms the basis of the allocations and TMDLs provided in **Section 5.9**. This section focuses on four potentially significant sediment source categories and associated controllable human loading for each of these sediment source categories:

- streambank erosion
- upland erosion and riparian health
- permitted point sources
- unpaved roads

EPA's guidance for developing sediment TMDLs states that the basic procedure for assessing sources includes compiling an inventory of all sediment sources to the waterbody. In addition, the guidance suggests using one or more methods to determine the relative magnitude of loading, focusing on the primary and controllable sources (U.S. Environmental Protection Agency, 1999b). Federal 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)).

Using standard DEQ methods for source assessments, DEQ evaluated loading from the primary sediment sources; however, the sediment loads presented here represent relative loading estimates within each source category and should not be considered as actual loading values. Instead, relative estimates provide the basis for percent reductions in loads that can be accomplished via improved land management practices for each source category. In turn, the percent reduction estimates are the basis for setting LAs or WLAs. As better information becomes available and the linkages between loading and instream conditions improve, the loading estimates presented here can be further refined through adaptive management.

For each impaired waterbody segment, sediment loads from each source category were estimated based on field surveys, watershed modeling, and load extrapolation techniques (described below). For sediment loading from upland erosion, a Soil & Water Assessment Tool (SWAT) model was developed for the Upper Clark Fork basin. SWAT is a river basin scale model developed to quantify the impact of land management practices in large, complex watersheds. It incorporates hydrologic, climatic, and water chemistry data with detailed land cover/land-use and topography information to predict pollutant loading for seasonal and annual time frames. The results include a mix of sediment sizes, particularly for bank erosion that involves both fine and coarse sediment loading to the receiving water. Conversely, loading from roads, upland erosion, and permitted point source discharges are predominately fine sediment. The complete methods and results for source assessments for streambank erosion are found in **Appendix C**.

Figure 5-5 identifies the different Clark Fork River segments upstream of the Flint Creek confluence. While referenced by their technical descriptions, for ease of communication the segments will also be referred to by their relative position in the TPA as upper, middle or lower segment of the Clark Fork River in the Upper Clark Fork Phase 2 TPA.

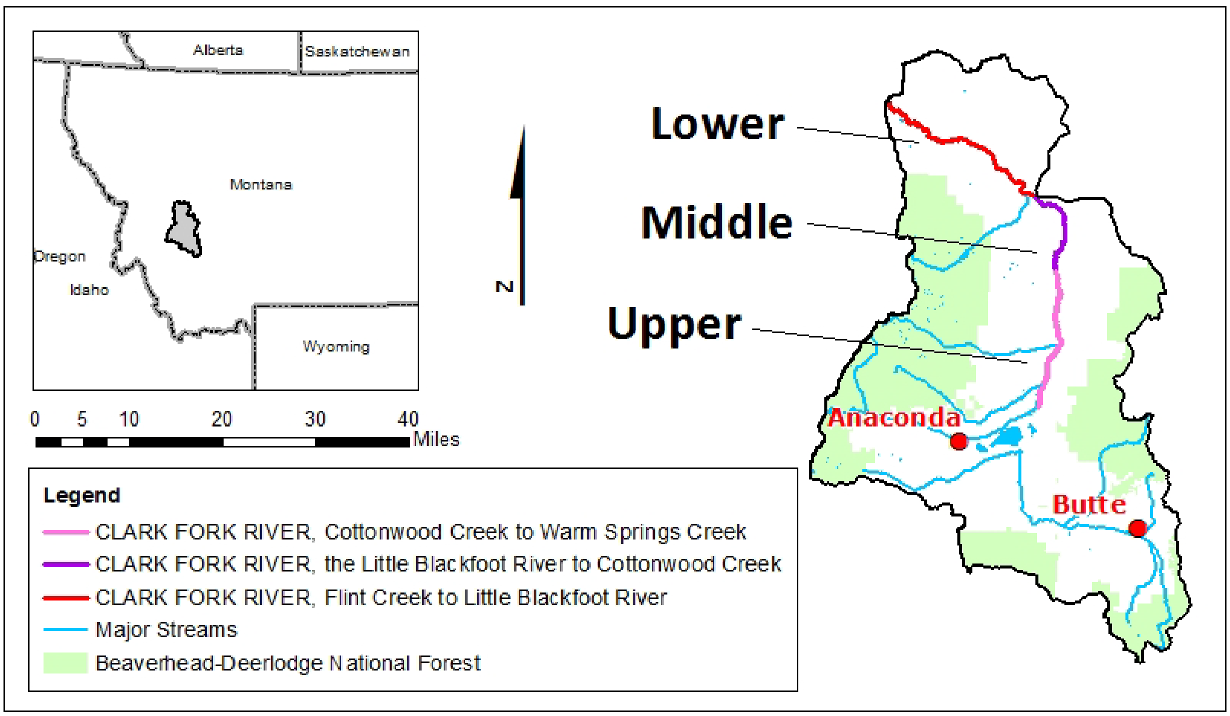

Figure 5-5. Map of Clark Fork River Upper, Middle and Lower AUs

5.8.1 Sediment Loads in Little Blackfoot River TMDL document

Sediment TMDLs for the Little Blackfoot watershed including the Little Blackfoot River were approved by EPA in December 2011 ((Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011)). The Little Blackfoot River TPA comprises ~22% of the Upper Clark Fork River watershed upstream of the Flint Creek confluence. Sediment loading estimates included roads, bank erosion, upland and point sources. For the purposes of estimating sediment loads in the Clark Fork River downstream of the Little Blackfoot River confluence, sediment load estimates and associated reductions are taken directly from the lower Little Blackfoot River sediment TMDL.

For the sediment source assessment and quantification, all estimated loads for the Clark Fork River segment downstream of the Little Blackfoot River confluence **DO NOT INCLUDE** the Little Blackfoot River watershed which will be presented in **Section 5.9** as part of the sediment TMDLs although the lower Clark Fork segment does include Silver Bow Creek estimated loads as well as those for the upper and middle Clark Fork River segments. The sediment TMDL for the Clark Fork River (Little Blackfoot River to Flint Creek) will be presented as two parts: (A) Upper Clark Fork Phase 2 TPA, and (B) the Little Blackfoot River TPA (**Figure 5-5**).

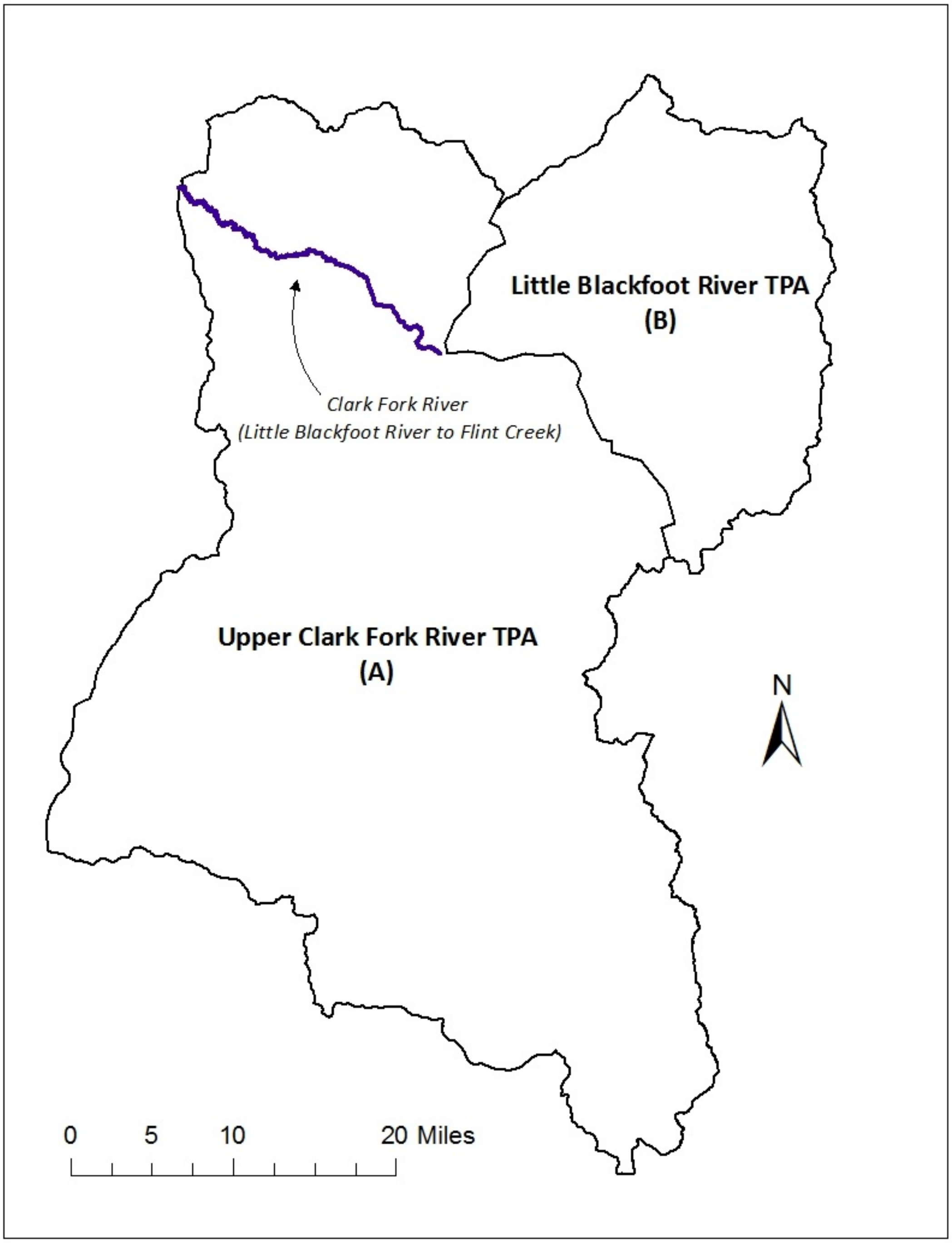

Figure 5-6. Map of TPAs in the Upper Clark Fork 4th Code HUC 17010201

5.8.2 Eroding Streambank Sediment Assessment

Streambank erosion was assessed in 2011 at the 11 full assessment reaches discussed in **Section 5.6**. At each site, eroding streambanks were classified as either actively or slowly eroding, the susceptibility to erosion was assessed by performing Bank Erosion Hazard Index (BEHI) measurements, and the erosive force was determined by evaluating the Near Bank Stress (Rosgen, 1996; Rosgen, 2006). BEHI scores were determined at each eroding streambank based on the following parameters: bank height, bankfull height, root depth, root density, bank angle, and surface protection. In addition to BEHI data collection, the source of streambank erosion was evaluated based on observed human-caused disturbances and the surrounding land-use practices based on the following near-stream source categories:

- transportation
- riparian grazing
- cropland
- mining
- silviculture
- irrigation-shifts in stream energy
- natural sources

Based on the aerial assessment process in which each 303(d) listed waterbody segment is divided into different reaches, streambank erosion data from each 2011 monitoring site was used to extrapolate to the reach scale. Then, the average value for each unique reach category was applied to unmonitored reaches within the corresponding category to estimate loading associated with bank erosion at the listed stream segment and watershed scales.

The most appropriate BMPs will vary by site, but streambank stability and erosion rates are largely a factor of the health of vegetation near the stream, and the application of riparian BMPs are anticipated to lower the amount of actively eroding banks and result in the estimated reductions. Although the reduction may not be achievable in all areas, greater reductions will likely be achievable in some areas. Because channel parameters and other variables must be altered within the SWAT model (see **Section 5.8.3**) to reduce loading associated with bank erosion and it is difficult to get a certain percentage for each impaired watershed, loading reductions achievable via the implementation of riparian BMPs were applied to the existing loads from the SWAT model based on reductions identified in the *Sediment and Habitat Assessment* (**Appendix C**). Additionally, the percentage of streambank erosion from natural versus human sources is based on the streambank assessment (**Appendix C**).

5.8.2.1 Assessment Summary

Because the SWAT model (Appendix F in Montana Department of Environmental Quality, Planning, Prevention and Assistance Division (2010)) used to estimate loading from upland erosion (see **Section 5.8.3**) is calibrated to flow at the USGS gages on the Clark Fork River and to a sediment rating curve based on gage data, bank erosion loads summarized here and used in the TMDL are from the model. Allocations and percent reductions are based on the 2011 bank erosion source assessment and completed/planned remediation activities in Silver Bow Creek and the Clark Fork River (**Table 5-29**). Based on the model output, streambank erosion contributes an estimated 4,795 tons of sediment per year to the Upper Clark Fork River watershed. Sediment loads due to streambank erosion range from 141 tons/yr in Silver Bow Creek to 4,795 tons/yr in the Clark Fork River (Little Blackfoot River to Flint Creek). Significant sources of streambank erosion include riparian grazing, riparian clearing, hay production, transportation, areas of contaminated soils (slickens) and erosion of aggraded floodplain surfaces as a result of early 20th Century floods. The BMP reduction scenario was based on the reduction of the BEHI through implementation of all reasonable land, soil, and water conservation practices. The lack of a significant reduction in the Silver Bow Creek BMP scenario sediment load is due to the fact that 2011 field work sampled two stream reaches where remediation work had been completed versus reaches in the Clark Fork River where remediation had not yet begun prior to 2011 field work (**Table 5-29**). **Appendix C** contains additional information about sediment loads from eroding streambanks in the Upper Clark Fork Phase 2 TPA and the method by which the BMP scenario % reduction was determined.

Table 5-29. Existing and Reduced Sediment Load from Eroding Streambanks for Silver Bow Creek and the Clark Fork River Upstream of Flint Creek Confluence

Sub-Basin	SWAT Existing Sediment Load (tons/yr)	BMP Scenario Sediment Load (tons/yr)	BMP Scenario Percent Reduction (tons/yr)[a]
Silver Bow Creek	348	341	2%
Clark Fork River (Warm Springs Creek to Cottonwood Creek)	1,820	1,378	24%
Clark Fork River (Cottonwood Creek to Little Blackfoot River)	2,785	1,894	32%
Clark Fork River (Little Blackfoot River to Flint Creek)[b]	4,795	3,261	32%

[a] Percent reduction determination is outlined in **Appendix C**
[b] Does not include the Little Blackfoot River watershed

5.8.2.2 Streambank Assessment Assumptions

The following is a summary of the significant assumptions used during the assessment of eroding streambanks:

- Because the SWAT model integrates all sediment sources and loading is based on a sediment rating curve developed using data from USGS gages on Silver Bow Creek and the Clark Fork River, it is assumed that the streambank erosion load from the model is a better estimate of the existing load than that from the field assessment
- The streambank erosion data collected during 2011 represents conditions within the watershed.
- The average annual load per reach type is applicable to other reaches within the same category.
- Sources of bank erosion at the assessed stream segment scale are representative of sources for that watershed.
- The annual streambank erosion rates used to develop the sediment loading numbers were based on Rosgen BEHI studies in Colorado. While the predominant geologies differ between the Colorado research sites and the Upper Clark Fork, the rates are applicable to the Upper Clark Fork watershed and suitable for helping estimate the percentage in streambank-associated loading reductions achievable by implementing riparian BMPs.
- Per the BMP reduction scenario outlined in **Appendix C**, implementation of all reasonable land, soil and water conservation practices can reduce BEHI ratings to Moderate; the decision to use Moderate was based on the current state of the system and the completed and future remediation work plans.

5.8.3 Quantifying Sediment from Upland Sources Using SWAT

The tool used in the Upper Clark Fork to determine the sediment loads from upland sources is the hydrologic simulation model known as the SWAT. To simulate pollutant loading at the watershed scale, SWAT first partitions a watershed into a number of sub-basins. Each sub-basin delineated within the model is simulated as a homogeneous area in terms of climatic conditions, but with additional subdivisions within each sub-basin to represent various soils and land-use types. Each of these subdivisions is referred to as a Hydrologic Response Unit (HRU) and is assumed to be spatially uniform in terms of soils, land-use, topographic, and climatic data. Once the HRU categories have been defined, the model then introduces the hydrologic and land management information in order to generate the sediment loads from the landscape. Data over a 7-year period of record (1994–2000) from four USGS stream gaging locations on the Clark Fork River was used to calibrate the hydrology for this model. The stream gaging locations used for calibration are Silver Bow Creek at Opportunity, Upper Clark Fork River at Deer Lodge, Little Blackfoot River at Garrison, and Upper Clark Fork River at Drummond.

SWAT uses a complicated approach but is built around the relatively simple concepts of the USLE. USLE uses five main factors by which to estimate soil erosion: R * K* LS * C * P, where:

R = rainfall/intensity
K = erodibility
LS = length/slope
C = vegetation cover
P = field practices

Values for these factors were developed and applied to each of the HRUs in each of the sub-basins. USLE values for the HRUs were derived based on literature values, estimates of existing field conditions in the watershed determined through site visits, communication with local stakeholders, and comparisons to previous SWAT model efforts in the nearby Ruby River watershed. HRU categories used in the Upper Clark Fork SWAT model are listed in **Table 5-30**. It is important to note that the USLE does not attribute loading from areas where slope = 0 which may include some slicken areas in the Clark Fork River floodplain.

Table 5-30. SWAT HRU Categories

SWAT Code	Land Cover/Land-Use Description
ALFA	Alfalfa/Grass/Hay (typically irrigated)
BARN	Hobby Farm Livestock
FRSD	Deciduous Forest
FRSE	Evergreen Forest
FRST	Mixed Forest
LAWN	Hobby Farm Lawn
RNGB	Range Brush
RNGE	Range Grass
UIDU	Industrial
URHD	High Density Urban
URLD	Low Density Urban
URMD	Medium Density Urban
URML	Medium/Low Density Urban
WATR	Water
WETF	Wetland

5.8.3.1 Assessment Summary

The initial model outputs represent an estimate of current conditions and practices that result in the upland sediment load. To determine the total allowable load from upland sources, land-use/land cover categories where management practices could be improved are modified to represent those changes on the landscape, and the SWAT model is run again to simulate the resultant sediment loads that exist when all reasonable land, soil, and water conservation practices are employed.

For the purposes of this assessment, only a few land-use categories were modified. These include barnyard, range brush and range grass. It is assumed that in the Upper Clark Fork Phase 2 TPA, these land-use categories have real potential for improvement and are often not meeting all applicable land, soil, and water conservation practices. The sediment contributions from the other land uses in the Upper Clark Fork Phase 2 TPA are presumed to be either negligible in its contribution, or with little potential for altering the current management to reduce sediment contribution from the existing load.

Two scenarios were run in the model. The baseline scenario represents the existing conditions and subsequent sediment loads for most watersheds in the Upper Clark Fork Phase 2 TPA. The improved condition scenario represents the changes that would occur with improved land management practices, including restoration of the riparian buffers to filter sediment from the landscape.

From the model output, an average annual sediment load delivered to the stream is determined for each listed stream's watershed. The average annual upland sediment load is the sum of the average annual loads from each land cover/land-use type (HRU category). This sediment load represents the best estimation of current loading from upland sources. **Table 5-31** presents the modeled existing sediment load as well as the loading reductions achievable with improvement of upland management practices. Additional details about the SWAT model and the achievable reductions by land cover category for each listed stream's watershed are in Appendix F of (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2010).

Table 5-31. Existing and Reduced Sediment Load from Upland Sources for Silver Bow Creek and the Clark Fork River Upstream of Flint Creek Confluence

Watershed[a]	Existing Delivered Sediment Load (tons/yr)	Normalized Existing Load (tons/mile[b]/yr)	Improved Upland Conditions Sediment Load (tons/yr)	Normalized Improved Upland Condition Load (tons/mile[b]/yr)	Percent Reduction
Silver Bow Creek	1,251	3.03	1,199	2.90	4%
Clark Fork River (upstream of Cottonwood Creek)[b]	1,264	1.34	1,183	1.25	7%
Clark Fork River (upstream of Little Blackfoot River)	2,745	2.41	2,560	2.25	7%
Clark Fork River (upstream of Flint Creek)[b]	6,644	4.49	6,096	4.12	8%

[a] Loads are composite and include upstream basins
[b] Includes the effects of Warm Springs Ponds on sediment capture
[c] Does not include the Little Blackfoot River watershed

5.8.3.2 Improved Riparian Condition Scenario

The SWAT model scenario for existing conditions and loading associated with upland sources incorporates the current capacity of riparian buffers within the Upper Clark Fork Phase 2 TPA to filter sediment and prevent it from entering streams. However, riparian vegetation can greatly alter sediment loading to streams, and based on a riparian assessment performed by DEQ in 2008 and 2013 (for Silver Bow Creek), there is significant opportunity for improved riparian health in the Upper Clark Fork watershed. Therefore, in conjunction with the upland loading reductions achievable via implementing BMPs to improve ground cover, a scenario of improved riparian health was incorporated in the SWAT model to estimate the additional upland reductions achievable via the implementation of riparian BMPs.

NRCS recommends a minimum buffer width of 30 ft (Natural Resource Conservation Service, 2011a; Natural Resource Conservation Service, 2011b), and the ability of riparian buffers to effectively filter sediment increases with increasing buffer width. For instance, a 100-ft-wide, well-vegetated riparian buffer is a common recommended buffer width (Mayer et al., 2005; Cappiella et al., 2006) and has been found to filter 75–90% of incoming sediment from reaching the stream channel (Wegner, 1999; Knutson and Naef, 1997). Although sediment removal efficiency is affected by factors such as ground slope, buffer health, and buffer composition, the literature values were used as the basis for applying filter strips of varying widths (i.e., 30, 50, and 100 ft) to estimate additional sediment upland loading reductions that could be achieved with improved riparian conditions.

Aerial assessment techniques using GIS and aerial photos were completed for each stream of interest to provide a coarse summary of riparian conditions in the sub-basins. Delineated reaches were given a riparian condition category of good, fair, or poor based on land use adjacent to the stream, riparian vegetation type and density, and the presence or absence of human related activities near the stream corridor. Based on this, each stream investigated was given corresponding percentages of condition based on the total length of stream assessed.

Based on the above information, sediment reduction factors were chosen to account for the potential in sediment reduction efficiency from improved riparian conditions. The range between filtering capacity between ‘good’ and ‘none’ is roughly 65–80%. A conservative assumption was then made that sediment reduction potential representing ‘poor’ conditions may be close to 25%, ‘moderate’ riparian condition filters 50% of the sediment load, and ‘good’ riparian condition has the effect of reducing upland sediment load by 75%.

To then incorporate riparian filtering capacity, in addition to the load from the improved condition scenario as described in **Section 5.8.3.2**, the riparian condition and associated reduction potential for each stream is applied to simulate the total sediment reduction potential if all land management improvements across the landscape and within the riparian corridor are implemented. For instance, if stream A is determined by the SWAT model desired condition to have a sediment load of 100 tons/yr, and 50% (50 tons/yr) of the stream is considered to be in Good riparian condition, and 50% (50 tons/yr) is considered to be Poor, than a total of 50% (25 tons/yr) of the load from the Poor riparian could be buffered if the riparian condition was improved to Good, resulting in a total load for stream A of 75 tons/yr when all BMPs are implemented (**Table 5-32**). The filtering capacity of the buffers is only applied in the improvement scenarios. Since the model serves only as a representation of existing conditions, it is implied that additional reduction through riparian filters is only applicable once modifications in land management improve riparian condition.

Table 5-32. Example Riparian Buffer Load Reduction Estimate

Riparian Condition			Buffering Capacity	
Category	Percent Stream Length	Upland Load Distribution	Estimated Load Reduction with Buffer Improvement	Upland Load Reduction
Good	50%	50	0%	50
Fair	-	-	25%	-
Poor	50%	50	50%	25
Upland Load From Model		100	Desired Load	75

Anticipated reductions in sediment loading from improved riparian conditions for Silver Bow Creek and the Clark Fork River AUs upstream of Flint Creek range from 21–35% and are presented in **Table 5-33**.

Table 5-33. Upper Clark Fork Phase 2 TPA Existing Riparian Conditions per Watershed Based on Stratification Results

Watershed	Good	Fair	Poor	Total	Percent Reduction with Improved Riparian
Silver Bow Creek[a]	0	62	38	100	35%
Clark Fork River (upstream of Cottonwood Creek)	0	100	0	100	25%
Clark Fork River (upstream of Little Blackfoot River)	0	100	0	100	25%
Clark Fork River (upstream of Flint Creek)[b]	16	83	1	100	21%

[a] Silver Bow Creek has undergone extensive replanting of riparian vegetation; riparian health is fair to poor as much of the riparian area is re-establishing post-remediation activity
[b] Does not include the Little Blackfoot River watershed

5.8.3.3 Assessment Summary

Based on improvements in riparian health, the model indicated that additional reductions in sediment loading ranging from 27% to 39% are achievable. **Table 5-34** shows the difference between the existing upland load and the allowable load with improved upland and riparian conditions.

Table 5-34. Sediment Load from Upland Sources with Improved Upland and Riparian Conditions

Sub-Basin	Existing Delivered Sediment Load (tons/yr)	Normalized Existing Load (tons/mile[b]/yr)	Allowable Delivered Sediment Load with Improved Upland and Riparian Conditions (tons/yr)	Normalized Allowable Load (tons/mile[b]/yr)	Percent Reduction
Silver Bow Creek	1,251	3.03	763	1.85	39%
Clark Fork River (upstream of Cottonwood Creek)[a]	1,264	1.34	887	0.94	29%
Clark Fork River (upstream of Little Blackfoot River)	2,745	2.41	1,920	1.69	30%
Clark Fork River (upstream of Flint Creek)[b]	6,644	4.49	4,816	3.24	27%

[a] Includes the effects of Warm Springs Ponds on sediment capture
[b] Does not include the Little Blackfoot River watershed

5.8.3.4 Determining Allocations

The upland sediment loads are estimations based on the land uses that exist within a watershed, as well as other factors that drive sediment production as described earlier in this section. Further assumptions are made regarding the riparian condition and the ability for improved riparian conditions to effectively reduce sediment loading to the stream. For the purposes of allocating the load amongst the sources, a very simplistic approach is taken here: the total sediment load from upland erosion is portioned amongst the land-use sources based on the percent contribution of each land use. For example, the model output determined an existing upland sediment load of 100 tons/yr coming from four sources: agricultural land (40 tons), forest (30 tons), range (20 tons), and rural residential (10 tons). Therefore the allocation of the total desired load amongst the existing land uses is a 40%, 30%, 20%, 10% split, respectively.

It is fully acknowledged however that this simplistic approach may not represent the true potential for that load reduction within a particular land use. Geography, the association of the riparian conditions to the various land uses, the actual potential for the application of BMPs within a given land use, may all be factors that would otherwise alter the reduction potential of a given source. However, at this most basic scale, this approach does identify the relative contributions among the land-use categories and therefore serves as an initial starting point by which to focus sediment reduction efforts and assess those areas most likely to be affecting the stream, and most likely to have the potential for improvement.

5.8.3.5 Upland Assessment Assumptions

As with any modeling effort, and especially when modeling at a watershed scale, there are a number of assumptions that must be accepted. For upland erosion source assessment, here are the major assumptions:

- The input variables used in the USLE calculations are representative of their respective land-use conditions.
- The land management practices (grazing duration, hay cutting, etc.) for certain land-use categories that define the vegetative cover throughout the year are relatively consistent and representative of practices throughout the watershed.
- The application of riparian filtering is applicable only to the improved conditions and the current model inherently incorporates existing conditions across the landscape.
- The riparian condition as estimated through the aerial assessment is representative of on-the-ground conditions.
- Applying filter strips within SWAT is an acceptable surrogate for improved riparian condition. Filter strips were applied to the land cover categories where they will be most effective, but estimated reductions may not be achievable in all areas and additional reductions may be achievable in some areas where filter strips were not applied.
- The improvement scenarios to riparian condition and land management are reasonable and achievable.
- A substantial portion of upland load after improvements in management practices for each land-use category is a component of the “natural upland load.” The assessment methodology did not differentiate between sediment loads with all reasonable BMPs and “natural” loads.
- **No estimation of anticipated reductions in loading from sediment removal or completion of remediation activities in the SSTOU or CFROU were made by the model.**

5.8.4 Road Sediment Assessment

Roads located near stream channels can impact stream function through a degradation of riparian vegetation, channel encroachment, and sediment loading. Throughout the western United States, road networks are often a significant source of sediment due to their limited maintenance schedules, the dirt and gravel base materials of which they are often constructed, and the topography in which many rural, mountainous roads exist. In the Upper Clark Fork watershed, sediment from roads has been identified as one of three major source categories potentially affecting sediment loads in Silver Bow Creek and the mainstem of the Clark Fork River.

A road assessment study which included unpaved roads and traction sand investigations was completed for the Little Blackfoot River TPA by Water & Environmental Technologies (2009). The Little Blackfoot River watershed is a large sub-watershed contained within the Upper Clark Fork River watershed. Given its geographic location, similar parcel ownership, and land uses as the Upper Clark Fork Phase 2 TPA, sediment load estimates and characterization methodology used in the Little Blackfoot River TPA were applied to the Upper Clark Fork River TPA

5.8.4.1 Quantifying Sediment from Unpaved Roads

To determine sediment loading from unpaved roads in the Upper Clark Fork Phase 2 TPA, a GIS analysis was conducted for the entire watershed using 2012 Topographically Integrated Geographic Encoding and Referencing data. Relevant statistics related to miles of road, road type, road ownership, numbers of crossings, and road/stream proximity were calculated for each drainage area which corresponded to Silver Bow Creek (including the Mill and Willow Creek drainages) and the three segments of the Clark Fork River upstream of Flint Creek (**Figure 5-7**). As noted previously, the Little Blackfoot River TPA was not included in this analysis. However, loading estimates determined for the Little Blackfoot River TPA are incorporated in the sediment TMDL for the Clark Fork River upstream of Flint Creek.

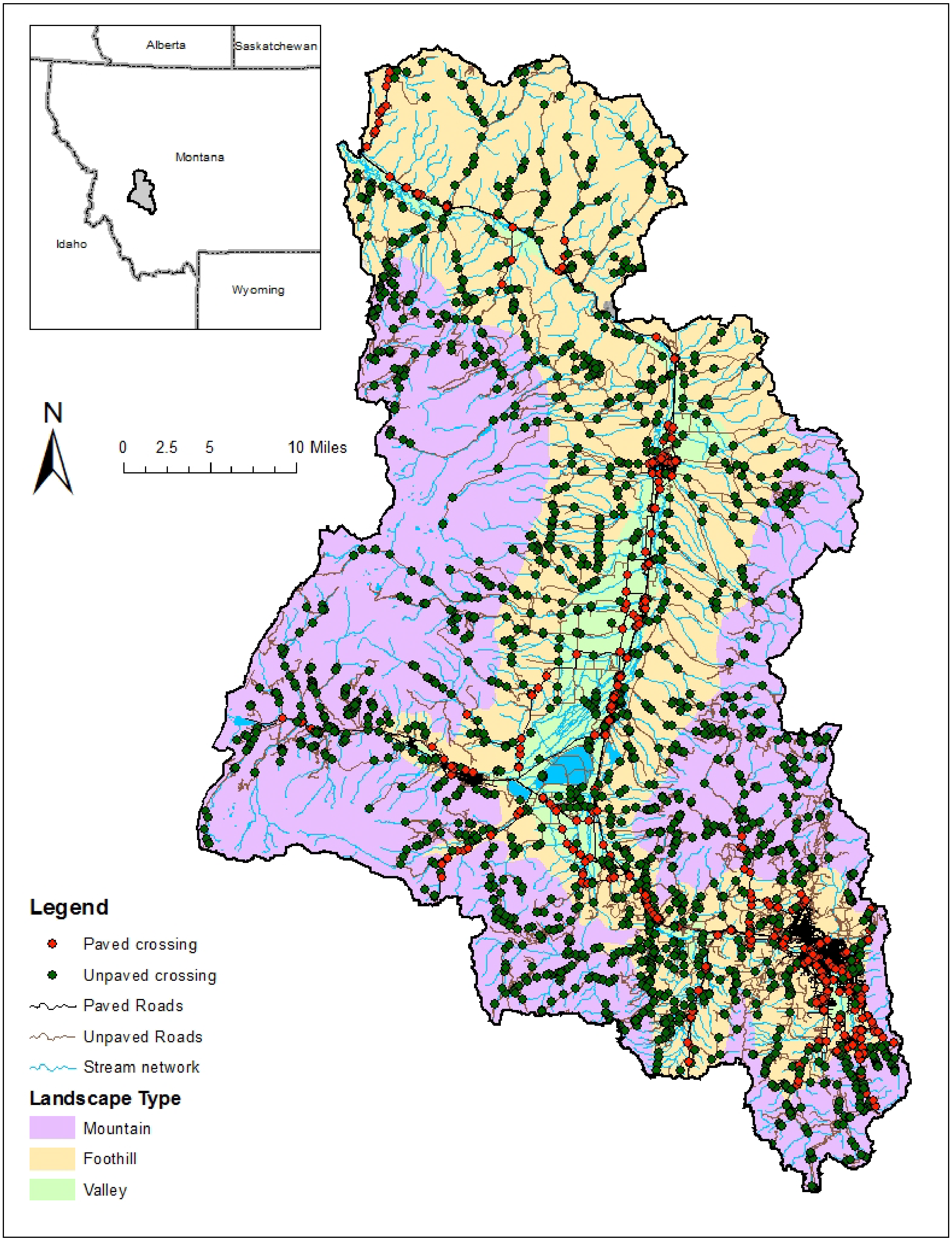

Figure 5-7. Upper Clark Fork Phase 2 TPA Road Assessment Analysis

A few significant statistics are provided in **Table 5-35**. These types of information are often used in sediment-source assessment methodology from roads and provide the basis of comparison to estimate sediment loads from roads in Upper Clark Fork watershed.

Table 5-35. Unpaved Road Statistics for Streams in the Upper Clark Fork Phase 2 TPA

Watershed[a]	Watershed Area (sq. mi.)	Unpaved Road Density (mi./sq. mi.)	Number of Crossings[c]	Road Miles (mi.)	Within 50' of a stream (mi.)
Silver Bow Creek[b]	413.2	2.15	697	887.4	35.2 (4.0%)
Clark Fork River, upstream of Cottonwood Creek	945.9	1.67	1,236	1,575.8	65.4 (4.2%)
Clark Fork River, upstream of Little Blackfoot River	1,139.0	1.61	1,389	1,831.8	70.2 (3.8%)
Clark Fork River, upstream of Flint Creek[d]	1,482.8	1.47	1,665	2,174.1	84.6 (3.9%)

[a] Watershed designation includes all upstream units in the TPA
[b] Includes the Mill and Willow Creek drainages which discharge to Silver Bow Creek at the downstream end of Warm Springs Ponds via the Mill-Willow Bypass as of January 1, 2014
[c] *n*=51 unpaved crossings are within the Butte urban limit boundary
[d] Does not include the Little Blackfoot River watershed

Loading estimates from unpaved roads as assessed in the Little Blackfoot River watershed as part of sediment TMDL development were applied to Upper Clark Fork unpaved road crossings (**Table 5-36**). A full report of how these estimates were arrived at may be found in Appendix E of Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8 (2011). The average sediment contribution from unpaved road crossings and near-stream road segments were extrapolated to all unpaved roads in the watershed based on landscape setting (i.e., mountain, foothill, and valley). To address sediment from unpaved roads in the TMDLs and allocations that follow in **Section 5.9**, a Water Erosion Prediction Project: Roads analysis was also run using BMPs to reduce the road contributing length to 200 ft. The 200-ft BMP scenario is used in this document as a general approximation of an achievable modeled loading reduction to help develop the road crossing allocations. The intent is to ensure that all road crossings have the appropriate BMPs in place to protect water quality via reduced sediment loading. Other potential BMPs include the installation of full structural BMPs at existing road crossings (drive through dips, culvert drains, settling basins, silt fence, etc.), road surface improvement, reduction in road traffic levels (seasonal or permanent road closures), and timely road maintenance to reduce surface rutting.

Table 5-36. Load Estimate Assumptions and BMP Reduction by Landscape Position from the Little Blackfoot River TPA Used in Upper Clark Fork Phase 2 TPA (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011)

Parameter	Condition	Mountain	Foothill	Valley
Unpaved road crossings	Existing (tons/yr)	0.07	0.11	0.03
	BMP scenario - 200' contributing length reduction (tons/yr)	0.02	0.02	0.01
Unpaved parallel road segments within 50' of a stream[a]	Existing (tons/yr/mile)	0.021	0.003	0.012

[a] Unpaved parallel road segments contribute <1% of the total sediment load, and a reduction scenario was not done for this parameter; the BMP scenario for contributing length invariably includes many of these parallel segments

5.8.4.2 Assessment Summary

Based on the source assessment, unpaved roads are estimated to contribute 144.0 tons of sediment per year to the Upper Clark Fork River upstream of Flint Creek (**Table 5-37**). On an area basis, sediment loads due to unpaved roads range from 0.10 tons/sq. mi./yr for the entire Upper Clark Fork Phase 2 TPA to 0.16 tons/sq. mi./yr in the Silver Bow Creek watershed. The concentration of unpaved roads in and around Butte/Silver Bow is the reason why this watershed has the highest calculated loads on an area basis. In the Upper Clark Fork River TPA, 69% of the unpaved road crossings occur on private/county land, 19.5% on land managed by the USFS, and 10.6% on land managed by the State of Montana. The remaining crossings are located on land managed by the BLM, the NPS (Grant-Kohrs Ranch) and land where the owner could not be identified.

Table 5-37. Existing Sediment Load from Unpaved Roads in the Upper Clark Fork Phase 2 TPA

Sub-Basin[a]	Total Sediment Load from Unpaved Roads (tons/yr)	Percent Load Reduction after BMP Application	Total Sediment Load after BMP Application (tons/yr)[d]
Silver Bow Creek[b]	60.5	78%	13.6
Clark Fork River, upstream of Cottonwood Creek	103.7	77%	23.4
Clark Fork River, upstream of Little Blackfoot River	117.2	78%	26.2
Clark Fork River, upstream of Flint Creek[c]	144.0	78%	31.6

[a] Sub-basin designation includes all upstream units in the TPA
[b] Includes the Mill and Willow Creek drainages which discharge to Silver Bow Creek at the downstream end of Warm Springs Ponds via the Mill-Willow Bypass as of January 1, 2014
[c] Does not include the Little Blackfoot River watershed
[d] Due to rounding, differences in loads presented in this table may not correspond to the percent reduction

5.8.4.3 Traction Sand

Traction sand applied to paved roads in the winter can be a significant source of sediment loading to streams. A study by the Montana Department of Transportation (MDT) (Staples et al., 2004) found that traction sand predominantly contains particles less than 6 mm and 2 mm, which are size fractions that can be detrimental to fish and other aquatic life as in-stream concentrations increase (Irving and Bjornn, 1984; Mebane, 2001; Weaver and Fraley, 1991; Shepard et al., 1984; Suttle et al., 2004; Zweig and Rabeni, 2001).

Annual application rates were provided by MDT for highways and urban routes maintained by the State of Montana and by the respective county road departments for all other paved roads within the TPA not maintained by MDT. **Table 5-38** includes the traction sand loading estimates for paved roads in the TPA. Once contributing lengths were determined per department category (1st column) using GIS, the traction sand load estimate (4th column) was used to calculate the total load, which was then summed per watershed area (2nd column in **Table 5-39**).

Table 5-38. Traction Sand Loading Estimates for Paved Roads in the Upper Clark Fork Phase 2 TPA

Department[a, b, c]	Number of Miles	Quantity of Traction Sand (cu. yards)[d]	tons/mile/yr
Powell County Secondary roads	60	50–300	6.25
Silver Bow County Secondary roads	300	1,850	7.71
Deer Lodge County Secondary roads	225	1,200	6.67
Montana Department of Transportation I-90 (MP 154-218)	64	4,998	97.61
Montana Department of Transportation I-90 (MP 227-232)	5	1,189	297.25
Montana Department of Transportation I-15 (MP 112-134)[c] (includes 1-15/1-90 corridor)	22	1,836	104.32
Montana Department of Transportation Highway 276 (MP 0-3.5)	3.5	3	1.07
Montana Department of Transportation Highway 441 (MP 0-7.8)	7.8	149	23.82
Montana Department of Transportation Highway 273 (MP 0-12.1)	12.1	83	8.57
Montana Department of Transportation Highway 272 (MP 0-2)	2	12	7.71
Montana Department of Transportation Highway 48 (MP 0-6.8)	6.8	576	105.82
Montana Department of Transportation Highway 1 (MP 0 – 22)	22	843	47.88
Montana Department of Transportation Highway 2 (MP 76 – 86.3)	10.3	711	86.29
Montana Department of Transportation Highway 271 (MP 0 - 8)	8.0	224	35.00
Montana Department of Transportation Butte/Silver Bow urban routes	51.6	1,197	29.03

[a] MDT traction sand estimates equal the 2011–2013 average tonnage per road segment
[b] Granite County has no paved roads within the Upper Clark Fork Phase 2 TPA
[c] MP = mile post
[d] Conversions were calculated with an assumed bulk density of 1.25 tons/cubic yard

Based on a range of delivery ratios in the Prospect Creek TMDL and literature values for the effectiveness of vegetated buffers (Asmussen et al., 1976; Hall et al., 1983; Han et al., 2005; Mickelson et al., 2003; Montana Department of Environmental Quality, 2012d), a 15% delivery rate was assumed. The delivery rate equates to a buffer length of 50 to 100 ft with 50% vegetative cover. Therefore, total traction sand loading to streams was calculated as contributing length (mi) X loading rate (tons/mi/yr) X 15%.

Sediment loading associated with traction sand was estimated based on application rates multiplied by contributing distances and a delivery ratio. Contributing lengths were identified by querying the GIS database for paved roads within 100 ft of perennial and intermittent streams (Total Existing Load in **Table 5-39**).

The loading reduction potential was estimated by assuming that BMPs could reduce the annual delivery rate to 10% (which equates to 60% vegetative cover). This could be achieved by a combination of BMPs, which may include a lower application rate, street sweeping, improving maintenance of existing BMPs, altering plowing speed at crossings, and structural control measures. It is acknowledged that public safety is a primary factor in the use of traction sand, and the reduction in loading from traction sand is anticipated to be achieved by improving BMPs without sacrificing public safety. Additional details regarding the traction sand assessment are provided in Appendix E of (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011).

5.8.4.4 Assessment Summary

Based on the source assessment, traction sand was identified as a potentially significant source in three segments of the Clark Fork River and in Silver Bow Creek and contributes approximately 311 tons of sediment per year to the Upper Clark Fork Phase 2 TPA (**Table 5-39**). Additional BMPs are estimated to reduce traction sand loading by 33% to all affected waterbodies based on previous road assessment work in the Little Blackfoot River watershed as outlined in Appendix E of (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011)

Table 5-39. Annual Sediment Load (tons/yr) from Traction Sand within the Upper Clark Fork River Watershed

Watershed	Total Existing Load (tons/yr)	Percent Load Reduction After BMP Application[a]	Total Sediment Load After BMP Application
Silver Bow Creek	201.6	33%	134.4
Clark Fork River, upstream of Cottonwood Creek	254.2	33%	169.5
Clark Fork River, upstream of Little Blackfoot River	262.5	33%	175.0
Clark Fork River, upstream of Flint Creek[b]	310.9	33%	207.3

[a] Due to rounding, differences in loads presented in this table may not correspond to a 33% reduction
[b] Does not include the Little Blackfoot River watershed

It is recognized that in reality, in some cases the majority of the sediment load may come from only a few discrete locations within a watershed or some roads may currently have some or all of their roads addressed with appropriate BMPs and the allocations may already have been met. It is expected however, that the derived sediment load and expected reductions in this document serve as a starting point for road management investigations, and a guideline for where to begin additional studies to improve and refine these estimates.

5.8.4.5 Total Estimated Road Sediment Load

The total estimated sediment load from unpaved roads and traction sand to identified receiving waterbodies in the Upper Clark Fork Phase 2 TPA is in **Table 5-40**.

Table 5-40. Annual Sediment Load (tons/yr) from Unpaved Roads and Traction Sand within the Upper Clark Fork River Watershed

Watershed	Total Load (tons/yr)	Percent Load Reduction After BMP Application[a]	Total Sediment Load After BMP Application
Silver Bow Creek	262.1	44%	148.0
Clark Fork River, upstream of Flint Creek[a]	454.9	47%	238.9
Clark Fork River, upstream of Little Blackfoot River	379.7	47%	201.2
Clark Fork River, upstream of Cottonwood Creek	357.9	46%	192.9

[a] Does not include the Little Blackfoot River watershed

5.8.4.6 Road Assessment Assumptions

The estimates and basic analysis used to derived sediment from roads in the Upper Clark Fork is a very simplistic approach that relies on the results of studies from other areas in western Montana, and the western United States. In order for this analysis to be considered a few assumptions must be recognized:

- Road networks in the Upper Clark Fork Phase 2 TPA are similar to road networks Little Blackfoot TPA.
- The Little Blackfoot TPA road assessment used to derive the estimated sediment load per crossing provides a reasonable estimate for expected loads throughout the Upper Clark watershed.
- Focusing on road/stream crossings and their associated approaching road lengths will effectively reduce the majority of the sediment load from roads.
- Distributing the allocation of sediment loads among road ownership is the most pertinent approach given the current lack of on-the-ground information.
- There is a direct relationship between the number of crossings and the distribution in the miles of road, i.e. a land owner who has 80% of the roads in a given watershed is likely to have 80% of the road crossings in a watershed.
- BMPs may have already have been implemented on many roads and therefore the reductions necessary by land owner may be less than described in this document.

5.8.5 Permitted Point Sources

In addition to nonpoint sources, sediment inputs into streams in the Upper Clark Fork Phase 2 TPA come from point sources (i.e., distinct, identifiable sources, such as pipes feeding directly into a waterbody). By law, these point sources must be permitted. As of April 8, 2013, the Upper Clark Fork Phase 2 TPA had 35 active MPDES permitted point sources within sediment-impaired watersheds (**Figure A-18**):

- BSB MS4 (MTR040006)
- BSB WWTP (MT0022012)
- Deer Lodge WWTP (MT0022616)
- Rocker WWTP (MT0027430)
- MBH (MT0021431)
- Renewable Energy Corporation (REC) Advanced Silicon Materials (MT0030350)
- Montana Resources (MT0000191)
- One permit for a domestic sewage treatment lagoon at Montana State Hospital (MTG580004)
- One permit for a fish hatchery operation at Washoe Park Trout Hatchery (MTG130013)

- Two permits for disinfected water (MTG770003 and MTG770031)
- Two CAFOs (MTG010151 and MTG010166)
- Five permits for industrial activity stormwater (MTR000095)
- Seventeen general permits for construction activity stormwater (MTR100000)

One CAFO permit (MTG010151) and one permit for industrial activity stormwater (MTR000296) were addressed with WLAs in a previous TMDL document (Bond et al., 2009; Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2010).

To provide the required WLA for permitted point sources, a source assessment was performed for these point sources. Because of the conditions set within all of the applicable permits, and the nature of sediment loading associated with these permits, the WLAs are not intended to add load limits to the permits; DEQ assumed that the WLAs will be met by adhering to the permit requirements. Discharges of disinfected water will not be given WLAs as their discharges are incidental and contain negligible suspended sediment concentrations. The permit source assessment summaries that follow are in alphabetical order by facility.

5.8.5.1 Butte-Silver Bow MS4 (MTR040006)

MPDES MS4 Permit

Stormwater within the city of Butte is regulated under the General Permit for Storm Water Discharge Associated with Small Municipal Separate Storm Water Sewer System (MS4) (MTR04000). The city and county of BSB are co-permittees with MDT. The permit primarily applies within the city limits, but also includes some receiving waters outside the city. Waterbodies that receive stormwater discharges include: Blacktail Creek, Basin Creek, Grove Gulch Creek, Sand Creek and Silver Bow Creek. The permit states that the MS4 drains an area of approximately 29.7 mi^2 and closely approximates the urban limit boundary (25.3 mi^2). A large part of the MS4 lies within the BPSOU, a designated Superfund site and stormwater originating within the BPSOU is managed under CERCLA. As Silver Bow Creek has a sediment impairment listing on the 2012 303(d) List, a WLA for the city and county of BSB MS4 is required.

Most of the focus on stormwater in Butte has been to address gross exceedances of acute water quality standards for heavy metals in Silver Bow Creek, as impacted by source areas within the BPSOU site. The 2006 BPSOU ROD designated all surface water in Silver Bow Creek, Blacktail Creek, and Grove Gulch to be points of compliance for surface water quality. Stormwater outfalls and surface water in the MSD are exempted as points of compliance for meeting water quality concentration targets. However, MSD discharges into Silver Bow Creek; therefore, the contaminant loads contributing from the MSD cannot cause exceedances of water quality concentration targets in Silver Bow Creek.

The permit does not include effluent limits but requires the development and implementation of a Storm Water Management Program (SWMP) to minimize sediment loading to surface waters. The SWMP must include six minimum control measures: (1) public education and outreach; (2) public involvement/participation; (3) detection and elimination of illicit discharge; (4) control of stormwater runoff from construction sites; (5) management of post-construction stormwater in new development and redevelopment; and (6) pollution prevention/good housekeeping. Additionally, the permit requires semiannual monitoring at two sites, one representing a residential area and the other representing a commercial/industrial area. For the Butte MS4, these monitoring locations are sited at stormwater outlets to Blacktail Creek in the south central portion of the MS4.

Data collection and modeling of MS4

The contributing area of the BSB MS4 may be divided into 2 distinct areas: (1) Butte Hill and (2) 'The Flats' (**Figure 5-8**). Butte Hill includes much of the BPSOU and also includes the area south of the MSD that contributes stormwater flows to the MSD. As part of the ROD for the BPSOU, Butte Hill has undergone most of the investigation and data collection efforts within the MS4 contributing area. 'The Flats' is the moniker attributed to the area south of downtown Butte in and around Burt Mooney Municipal Airport. While this area comprises more area in the MS4 than Butte Hill, it contains the minor share of stormwater infrastructure and data collection efforts in the MS4.

For the purposes of characterizing the MS4 contributing area in **Figure 5-8**, the MS4 contributing area was delineated from a combination of previous modeling efforts in Butte Hill (U.S. Environmental Protection Agency, 2009b) and using current stormwater/sanitary sewer extents in and around Butte, Montana. This delineation resulted in an MS4 contributing area of 13.21 mi^2 which is 44% of the area in the permit but more closely approximates the actual footprint of stormwater infrastructure.

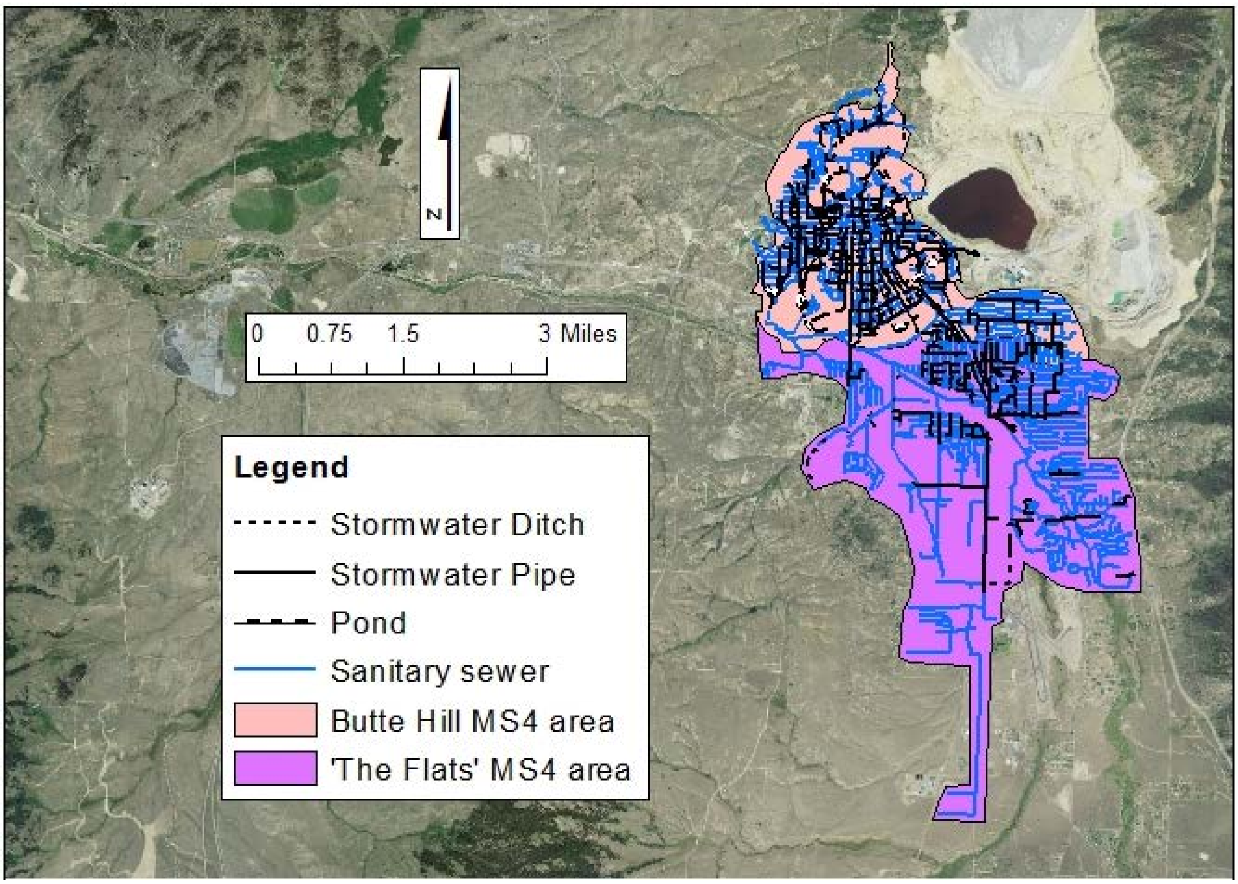

Figure 5-8. BSB MS4 Contributing Area Based on Stormwater and Sanitary Sewer Extent

A further distinction regarding the MS4 contributing area must also be made. A significant portion of the Butte Hill MS4 area discharges stormwater flows to the Berkeley Pit as opposed to the Silver Bow Creek corridor (**Figure 5-9**). As delineated in the EPA 2009 report (U.S. Environmental Protection Agency, 2009b), the area of Butte Hill which drains to the Berkeley Pit comprises approximately 0.67 mi^2 or 13.5% of the MS4 contributing area on Butte Hill (4.94 mi^2). This will be taken into account when estimating the annual sediment load from the BSB MS4 to Silver Bow Creek.

Given the available stormwater data and the basin delineation available from previous reports, annual sediment load estimates were calculated differently for Butte Hill and 'The Flats' portions of the BSB MS4 and will be presented as such.

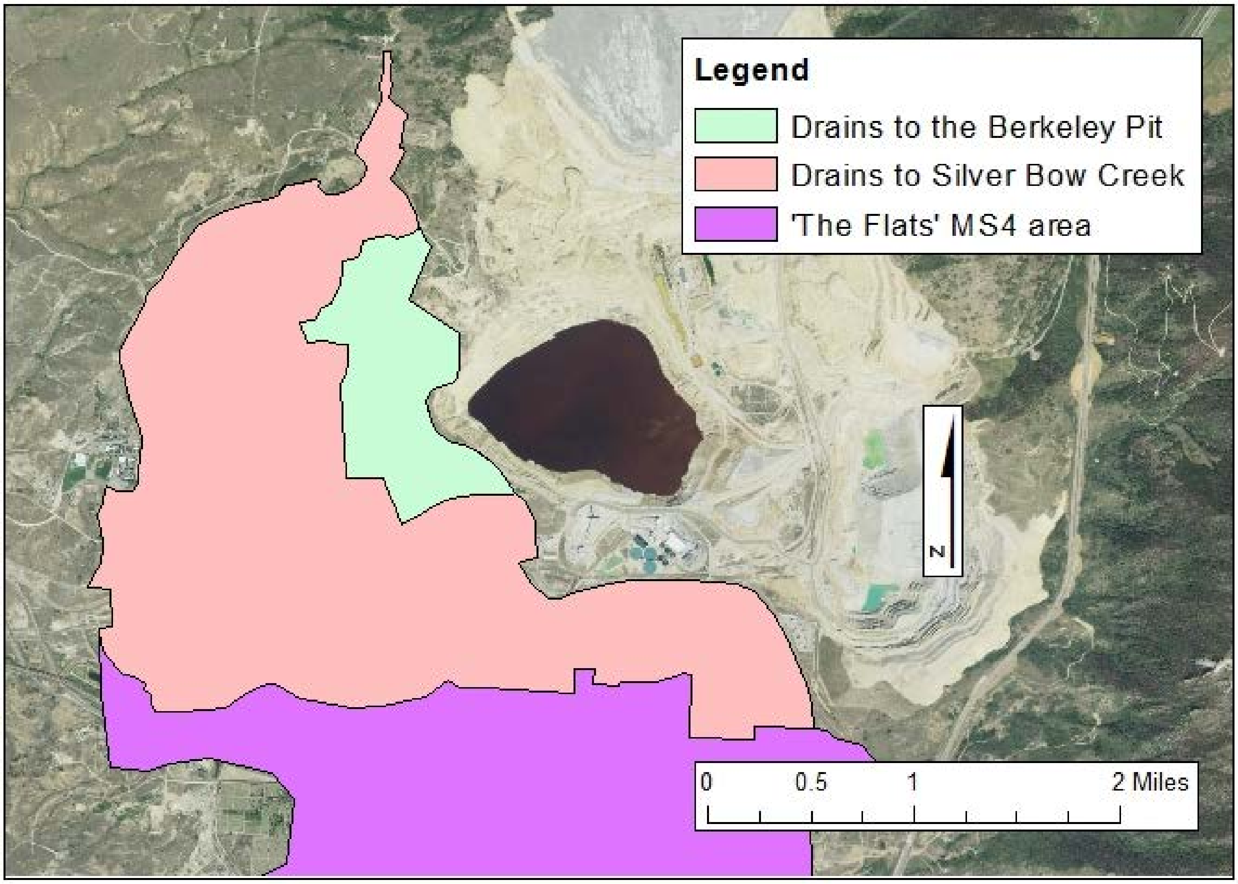

Figure 5-9. Major Sub-Basins within the Butte Hill MS4 Area

Butte Hill MS4 area
The following sub-sections summarize existing MS4 reporting and data collection efforts in the Butte Hill MS4 area.

2011 Butte-Silver Bow Infrastructure Report
BSB contracted with Morrison-Maierle to conduct an assessment of stormwater infrastructure focusing on Butte Hill within the BPSOU. At the request of BSB, detailed hydraulic analyses and design, and water quality modeling were not made part of the investigation. The infrastructure inventory/inspection focused on the underground stormwater infrastructure owned and maintained by BSB. Within the BPSOU, field crews assessed as much of the existing infrastructure as possible. Limited infrastructure was assessed outside of the Butte Hill area and the BPSOU.

Wide variability in lateral pipe conditions was noted ranging from totally functioning pipes to partially decayed pipes, to pipes that were completely blocked with debris or sediment. Additionally, pipe materials included poly vinyl chloride (PVC), concrete pipe, vitrified clay, corrugated metal pipe, slag tile, cobblestone/granite block, wood, asbestos and brick arch pipe.

A total of 2,130 inlets were located and assessed during the field survey, an increase of 353 over the original BSB map. Results of the field assessment indicated that the vast majority of inlets did not contain catch basins for sediment. An extensive manhole survey was also conducted which revealed: extreme manhole depth in some locations, lack of regular intervals between manholes, presence of flow during dry weather conditions. Inspection of the stormwater mains also found numerous illicit connections to the stormwater and sanitary sewer systems.

Also from the report (Butte Silver Bow Public Works Department, 2011):

> The last major maintenance planning on the BSB storm water system was conducted in the late 1960's when the major storm water trunk mains in Buffalo and Missoula Gulch were rehabilitated and expanded. As a result, the existing storm water system, is at the end of its design life, has a significant deferred maintenance backlog, and has no current plan for prioritizing maintenance, repair, upgrades, and expansions. The lack of available funds for infrastructure upgrade and replacement has necessitated that BSB continue to operate a large and complex storm water system, much of which is long past its design life. Many design shortcomings exacerbate functionality issues, such as inlets without sediment basins, brick manhole construction, decaying slag tile and wood piping, and lack of suitable access for workers.

The report outlines the MS4 system and focuses specifically on the older parts of the MS4 on Butte Hill. Deteriorating conditions of an old system, illicit connections and flows during dry periods were observed in nearly all sub-basins on Butte Hill. Sedimentation and blockage of many of the lines was also noted.

2009 EPA HydroCAD model

Contracted by the EPA, CDM performed hydrologic and hydraulic analyses to predict hydrographs, peak flow rates, and maximum runoff volumes for 2-, 5-, 10-, 25-, 50-, and 100-year 24-hour storm events in order to determine the hydraulic capacity of the existing MS4 infrastructure within the boundaries of the BPSOU for all basins with the exception of the Grove Gulch basin. Analyses were based on the NRCS unit hydrograph method and the NRCS Curve Number Method, which incorporates impervious surface area. The model included numerous assumptions due to the complexity of the buried stormwater systems and lack of complete as-built infrastructure drawings. Runoff contributions from the Blacktail Creek were not characterized in the modeling effort as this part of the MS4 lies outside the bounds of the BPSOU. Work performed by CDM relied on previous reports on the MS4 including BSB's Municipal Storm Water System Improvement Plan (U.S. Environmental Protection Agency, 2009b). Based on the HydroCAD model flows, and assuming a Type II 25-year, 24-hour storm event, the report determined that most of the storm drain distribution system is under-designed for present study area conditions. The report concluded that the existing stormwater infrastructure is old and deteriorated, having outlived its design life.

Mine waste was used throughout Butte Hill for construction of infrastructure (e.g., pipe bedding for water, sanitary, and storm sewer lines, as well as road base and structural fill) (U.S. Environmental Protection Agency, 2009b). For the BSB MS4, "*the overriding objective should be to provide the cleanest conduit possible for stormwater to lessen the contaminant load to receiving waters"* (U.S. Environmental Protection Agency, 2009b).

Hydrodynamic devices

Starting in December 2011 and through the spring of 2013, five Hydrodynamic Devices (HDs) for the capture of sediment in the Butte Hill MS4 area were installed. HDs were installed at Texas Avenue, Warren Avenue, Anaconda Road, Montana Street and on Buffalo Gulch at Webster Avenue and Garfield Avene. HDs are used in stormwater management as flow-through devices where cyclonic seperation is used to control water pollution, chiefly suspended sediment, from entering recieiving waterbodies. For the Butte Hill MS4, stormwater data used to estimate annual loading was collected from 2007–09 prior to HD installation. HD performance engineering design reports were used to estimate the decrease in sediment loading from the Butte Hill MS4 area after HD installation. The weighted sediment capture percentage over five operating rates (25–125% of design peak flow routed through the HD) was used for this purpose.

Butte Hill MS4 area sediment water quality

Sediment and flow data from the stormwater system is available at numerous locations within the MS4 stormwater system and in receiving waters as a result of extensive sampling that was conducted by ARCO to aid in MS4 water quality characterization and modeling from 2007–09. For this analysis, sites representative of water quality per respective sub-basin were selected to conduct summary statistics and provide a range of Total Suspended Solids (TSS) concentrations observed in the Butte Hill MS4 area. Engineering design reports for the respective HDs were used to estimate capture rates post-HD installation given that data was collected prior to installation of devices. The HDs treat stormwater from a total of 1070 acres on Butte Hill or 13.4% of the total MS4 drainage area that discharges to Silver Bow Creek omitting those sub-basins that drain to the Berkeley Pit.

It should be noted that the conveyance structures are designed for a Type II storm (4% recurrence probability per year). Overflows in the Berkeley Pit drainage area are routed to the MSD when the Type II storm is exceeded. However, as this is a low probability storm event (4%/yr), the estimated average annual sediment load from the Butte Hill area to the MSD and Silver Bow Creek did not include this load (**Table 5-41**). Also, as not all sub-basins on Butte Hill had stormwater sampling data, data from adjoining basins that closely approximated an un-sampled sub-basin was used to estimate sediment loading. For the Butte Hill area, the estimated annual sediment load post-HD installation to Silver Bow Creek is 263.04 tons/yr (0.10 tons/ac) (**Table 5-41**).

'The Flats' MS4 area sediment water quality

To estimate the annual sediment load from 'The Flats' MS4 area, Discharge Monitoring Report (DMR) data collected by the MS4 from 2010 to 2012 was used (TSS values in **Table 5-41**). DMR data is collected from two outfalls in the MS4 during stormwater runoff events. These 2 sampling sites are located to represent stormwater quality from a commercial/industrial site and a residential site. Total residential and commercial/industrial acreages in 'The Flats' were approximated based on the Silver Bow County zoning map. For 'The Flats' area, the estimated annual sediment load post-HD installation to Silver Bow Creek is 511.90 tons/yr (0.09 tons/ac) (**Table 5-41**).

For the entire MS4 contributing area, the estimated annual sediment load post-HD installation to Silver Bow Creek is 745.95 tons/yr (0.09 tons/ac) (**Table 5-41**). For comparison to observed TSS concentrations in the Butte MS4, the overall median TSS value from the Nationwide Urban Runoff Program (NURP) water quality database is 58 mg/L TSS (*n*=3765); for commercial sites the median is 42 mg/L TSS (*n*=503), and for residential sites the median is 49 mg/L TSS (*n*=1081) (Pitt et al., 2004).

Table 5-41. Estimated Annual Sediment Load from the BSB MS4 to the Silver Bow Creek Drainage

Basin	Sub-Basin	Area Data Source	Area (ac)	Endpoint	n	Years of Collection	Mean TSS (mg/L)	Mean Annual Sediment Load (tons/yr)[a]
Butte Hill	Rail Yard	EPA, 2009	*NA*	*Stormwater contained on site*	*Not applicable*			
	East Buffalo Gulch	EPA, 2009	57	MSD (EBG-OUT)	22	2007–2009	1499	18.65
	West Side Drainage	EPA, 2009	304	Infiltrates in ground or to HCC	*Not applicable*			
	Missoula Gulch	EPA, 2009	939	Silver Bow Creek (SBC-01)	7	2007–2009	36	7.42
	Idaho Street	EPA, 2009	234	Via Missoula Gulch – (SBC-01)	7	2007–2009	36	1.85
	Montana Street	EPA, 2009	31	Silver Bow Creek (MT-OUT)	25	2007–2009	2267	6.56
	Buffalo Gulch	EPA, 2009	302	Silver Bow Creek (BG-01)	25	2007–2009	2267	67.94
	Anaconda Road	EPA, 2009	122	MSD (AB-OUT)	22	2007–2009	1499	19.92
	Warren Avenue	EPA, 2009	84	MSD (WA-SD)	23	2007–2009	1880	8.62
	MSD	EPA, 2009	114	MSD (MSD-OUT)	22	2007–2009	603	4.50
	MSD South Side	EPA, 2009	488	MSD (MSD-SS-OUT)	22	2007–2009	1499	98.58
The Flats	Zoned commercial/ industrial	ArcGIS	1,949	All receiving waterbodies	5	2010–2012	281	91.66
	Zoned open/ residential		3,799	All receiving waterbodies	4	2010–2012	507	420.24
Total			7,968					745.95[b]

[a] Load was estimated using the EPA HydroCAD assumption that 16% of average annual precipitation becomes runoff (1.92 in)
[b] Total includes an estimated 22% reduction in sediment loading due to HD installation in the MS4 in 2011–2013

BMP effectiveness values reported from the International Storm Water BMP Database (Geosyntec Consultants and Wright Water Engineers, Inc., 2011) will be used as the basis for the WLA. The database includes statistics for loading reduction efficiencies from a compilation of studies for a variety of BMPs. The BMPs include bioretention, bioswales, detention basins, filter strips, manufactured devices, media filters, porous pavement, retention ponds, wetland basins, and wetland channels. The effectiveness range among different studies and practices are fairly tight. Studies were summarized by evaluating the 75th percentile, median, and 25th percentile concentration of influent and effluent. The quartiles for each percentile category ranged from a reduction efficiency of 53% to 76%. Using the median influent and effluent concentration, the average percent reduction among these BMPs was 62%.

Although some BMPs are already in place within all land-use categories, but the monitoring data reflect TSS concentrations greater than the 125 mg/L TSS median concentration benchmark value used in the MS4 general permit, a reduction greater than 62% is necessary. This is evident based on the current state of the stormwater infrastructure of the BSB MS4 as documented by (Butte Silver Bow Public Works Department, 2011) and (U.S. Environmental Protection Agency, 2009b). To err on the conservative side the upper limit of reduction efficiencies was used and a 76% reduction was applied to the entire estimated existing load. Using this approach, the WLA is 179 tons of sediment per year from the BSB MS4 to Silver Bow Creek. The WLA comprises 8.5% of the Silver Bow Creek sediment TMDL (**Section 5.9.3.1**).

As stated previously, the WLAs are not intended to add load limits to the permit. DEQ assumed that the WLAs will be met by adhering to the permit requirements. As identified in the permit, monitoring data should continue to be evaluated to assess BMP performance and help determine whether and where additional BMP implementation may be necessary.

5.8.5.2 Butte-Silver Bow WWTP (MT0022012)

The BSB WWTP is authorized to discharge treated wastewater to Silver Bow Creek under MPDES permit number MT0022012 (BSB City/County). The current permit became effective April 1, 2012, and expires March 31, 2017. The BSB WWTP is designed for a capacity 8.55 million gallons per day (mgd), but had a 30-day average flow of 3.52 mgd based on DMR data (2002–11). The WWTP is designed to serve 49,600 people; however, it currently serving approximately 36,000 people.

The treatment process consists of activated sludge with aerobic sludge digestion and seasonal land application of effluent to a sod farm. The headworks consist of grit collection and a mechanically cleaned bar screen. Wastewater that has gone through preliminary treatment is then routed to one of the two aeration basins. The facility includes conventional activated sludge. Mixed liquor from the aeration basins flows to secondary clarifiers and the effluent is chlorinated for disinfection and then dechlorinated prior to discharge.

The plant was built in 1990 and modified in 1998. Currently, plant upgrades are being planned and some construction has taken place. Upgrades were planned to include a new screenings washer/compactor, a new grit pump, a new Parshall flume, UV disinfection, as well as upgrades to the emergency power and supervisory control and data acquisition (SCADA) systems. Phase 2 of the upgrades includes biological nutrient removal and effluent reuse at the Sod Farm or additional public or private lands.

The BSB WWTP has two authorized outfalls. Outfall 001 is a continuous discharge to Silver Bow Creek with no effluent mixing zone. Outfall 002 is seasonal discharge to land application at the BSB sod farm, approximately seven miles west of the WWTP. Outfall 001 is located at 45° 59’ 38” N, 112° 34’ 16” W and Outfall 002 is located at 45° 59’ 43” N, 112° 40’ 12” W. The average monthly permit limit for TSS is 30 mg/L and 2,127 lbs/day (**Table 5-42**).

Table 5-42. Final Effluent Limitations for Outfall 001 from MPDES Permit (0022012)

Parameter	Units	Average Monthly Limit[a]	Average Weekly Limit[a]	Maximum Daily Limit[a]
TSS	mg/L	30	45	NA
	lb/day	2,127	3,190	NA

[a] See definition section of MPDES Permit for explanation of terms

The facility is required to monitor the TSS concentration of its effluent weekly. As part of its DMR, the plant submits a 30-day average TSS concentration and load; since 2002, that concentration has ranged from 5.1 mg/L to 18.2 mg/L, with an average value of 9.3 mg/L (**Table 5-43**). Therefore, the average monthly concentration is well below the permit limit of 30 mg/L (monthly average). Also, since the plant usually discharges at a rate less than its design flow, the average monthly load from 2002 to 2011 was 265.8 lbs/day based on an average discharge of 3.4 mgd. Based on this data, the typical annual TSS load is approximately 48.5 tons. Therefore, its WLA is based on the monthly load limit in the permit and, abiding by the permit conditions, will meet the WLA. Based on the monthly average load limit, the allowable annual load is 388 tons of sediment (i.e., 2,127 lbs/day *365 days * conversion factor = 388 tons). This load is eight times greater than its estimated existing load. The WLA comprises 18.4% of the Silver Bow Creek sediment TMDL (**Section 5.9.3.1**).

Table 5-43. TSS and Discharge Statistics for 30-Day Average Values from DMR Data for BSB WWTP for the Period 2002–2011

Statistic	TSS (mg/L)	Discharge (mgd)
Number of observations	120	120
Minimum value	5.1	2.5
Maximum value	18.2	5.0
Average value	9.3	3.4

5.8.5.3 Concentrated Animal Feeding Operation (MTG010000)

The Montana Livestock Auction (MTG010166) operates under a CAFO General Permit. In addition to the general permit requirements, the permit for the Montana Livestock Auction includes additional considerations which must be met:

1) The facility must be designed, constructed, and operated to contain all process generated wastewaters, plus the precipitation from the runoff of a 25-year, 24-hour rain event. For MTG010166, the weather station to determine the amount of precipitation that occurs at the facility shall be the National Weather Service, Missoula (KMTMISS08) or Butte Airport (KMTBUTTE5). The permittee has the option of maintaining a comparable precipitation gage at the facility.
2) The facility shall prepare an annual waste management plan (AR2) that is site specific and addresses manure and wastewater handling and storage, land application of manure and other nutrient sources, site management, record keeping, and other items outlined in the report.

Compliance with the CAFO General Permit, and the associated DEQ approved AR2 constitute the meeting of all TMDL requirements for sediment for this facility. Under the conditions of the permits, all pollutants are to be contained on site during any and all storm events less than a 25-year, 24 hour rain event. Therefore the TMDL is 0 for this source, under typical rainfall events (less than 25-year storm event). For any rainfall events equivalent to a 25-year, 24 hour duration or greater, full compliance with permit requirements assumes the pollutant load that may enter the receiving waterbody is acceptable.

5.8.5.4 Deer Lodge WWTP (MT0022616)

The Deer Lodge WWTP is authorized to discharge treated wastewater to the Clark Fork River and NPS Grant-Kohrs Ranch (land application) under MPDES permit number MT0022616. The permit became effective March 1, 2013, and expires February 28, 2018.

Deer Lodge operates an aerated lagoon system with ultra-violet effluent disinfection. The facility consists of four lagoon cells with an adjacent emergency pond. The design criteria for this facility were based on year 2000 loading forecasts for a design population of 5,500 people. The design flow is 3.31 mgd in the peak summer months and 1.50 mgd in the peak winter months. The lagoons were constructed in 1985 and upgrades were completed from 2003 through 2004 and included the installation of an ultrasonic flow meter as noted in the 2010 facility inspection report. The volume of the lagoons is 39.7 million gallons. The 30-day average flow from December 2010 through January 2013 was 1.39 mgd. In the previous permit, the Deer Lodge WWTP permit included land application of wastewater effluent to parcels on the Grant-Kohrs Ranch (NPS) during irrigation season. This past management practice is not part of the current permit.

The Deer Lodge WWTP has one permitted outfall location. Outfall 001 is to the Clark Fork River through a 24-inch reinforced concrete pipe and is located at 46° 25’ 44” N and 112° 44’ 18” W with a maximum extent of the mixing zone of 720 ft downstream. The average monthly permit limit for TSS is 45 mg/L and 563 lbs/day (**Table 5-44**).

Table 5-44. Final Effluent Limitations for Outfall 001 from MPDES Permit (0022616)

Parameter	Units	Average Monthly Limit[a]	Average Weekly Limit[a]	Maximum Daily Limit[a]
TSS	mg/L	45	65	NA
	lb/day	563	813	NA

[a] See definition section of MPDES Permit for explanation of terms

The facility is required to monitor the TSS concentration of its effluent weekly. As part of its DMR, the plant submits a 30-day average TSS concentration and load; from December 2010 to January 2013, that concentration ranged from 4.9 mg/L to 47.8 mg/L, with an average value of 14.2 mg/L (**Table 5-45**). Therefore, the average monthly concentration is well below the permit limit of 45 mg/L (monthly average). Also, since the plant usually discharges at a rate less than its design flow, the average monthly load from 2006 to 2011 was 165.6 lbs/day based on an average discharge of 1.39 mgd. Based on this data, the typical annual TSS load is approximately 30.2 tons. Therefore, its WLA is based on the monthly load limit in the permit and, abiding by the permit conditions, will meet the WLA. Based on the monthly average load limit, the allowable annual load is 102.7 tons of sediment (i.e., 563 lbs/day *365 days * conversion factor = 102.7 tons). This load is more than three times greater than its estimated existing load. The WLA comprises 2% of the Clark Fork River (Cottonwood Creek to Little Blackfoot River) sediment TMDL (**Section 5.9.3.3**).

Table 5-45. TSS and Discharge Statistics for 30-Day Average Values from DMR Data for Deer Lodge WWTP for the Period 2010–2013

Statistic	TSS (mg/L)	Discharge (mgd)
Number of observations	26	26
Minimum value	4.9	0.66
Maximum value	47.8	3.34
Average value	14.2	1.39

5.8.5.5 Montana Behavioral Health, Inc. (MT0021431)

MBH is authorized to discharge treated wastewater under MPDES permit number MT0021431. The facility is also known as the Galen WWTP. The MBH MPDES permit was issued August 1, 2012, and expires June 31, 2017. The WWTP serves the residents and employees of MBH (approximately 175 people) and is located in Galen, Montana. The facility is downstream of Butte and Anaconda and upstream of Deer Lodge on the Clark Fork River.

MBH operates a 0.10 mgd activated sludge package plant with 30-day average flows (January 2003 to December 2012) of 0.016 mgd. Influent flow is screened and de-gritted prior to primary clarification. Secondary treatment includes aeration basins and a secondary clarifier. Ultraviolet disinfection is used for virus inactivation. Solids are anaerobically digested and dried in drying beds. The collection system was completely replaced in 2002. Therefore, infiltration/inflow (I/I) to the system is very low. The facility was constructed in 1950 and upgraded in 1987 and 2002 through 2003.

MBH is permitted for one surface water outfall located at 46° 14’ 35”N, 112° 46’ 35” W. MBH discharges into an “unnamed field irrigation ditch tributary to the Clark Fork River” (MPDES Permit Number MT0021431). There is no mixing zone granted for this outfall. The discharge pipeline is approximately one mile long from the Outfall 001 effluent sample point (following UV) to the unnamed ditch. The average monthly permit limit for TSS is 30 mg/L and 15.8 lbs/day (**Table 5-46**).

Table 5-46. Final Effluent Limitations for Outfall 001 from MPDES Permit (0021431)

Parameter	Units	Average Monthly Limit[a]	Average Weekly Limit[a]	Maximum Daily Limit[a]
TSS	mg/L	30	45	NA
	lb/day	15.8	25.0	NA

[a] See definition section of MPDES Permit for explanation of terms

The facility is required to monitor the TSS concentration of its effluent weekly. As part of its DMR, the plant submits a 30-day average TSS concentration and load; from January 2003 to December 2012, that concentration ranged from 1.7 mg/L to 37.0 mg/L, with an average value of 9.4 mg/L (**Table 5-47**). Therefore, the average monthly concentration is well below the permit limit of 30 mg/L (monthly average). Also, the average monthly load from 2003 to 2012 was 1.2 lbs/day based on an average discharge of 0.016 mgd. Based on this data, the typical annual TSS load is approximately 0.2 tons. Therefore, its WLA is based on the monthly load limit in the permit and, abiding by the permit conditions, will meet the WLA. Based on the monthly average load limit, the allowable annual load is 2.9 tons of sediment (i.e., 15.8 lbs/day *365 days * conversion factor = 2.9 tons). This load is more than 14 times greater than its estimated existing load. The WLA comprises <1% of the Clark Fork River (Warm Springs Creek to Cottonwood Creek) sediment TMDL (**Section 5.9.3.1**).

Table 5-47. TSS and Discharge Statistics for 30-Day Average Values from DMR Data for MBH WWTP for the Period 2010–2013

Statistic	TSS (mg/L)	Discharge (mgd)
Number of observations	120	119
Minimum value	1.7	0.003
Maximum value	37.0	0.123
Average value	9.4	0.016

5.8.5.6 Montana Resources (MT0000191)

Montana Resources is authorized to discharge wastewater to Silver Bow Creek via the MSD under MPDES permit number MT0000191. Montana Resources operates an open pit copper and molybdenum mine and processing facility in Butte, Montana. The current permit became effective September 1, 2012, and expires August 31, 2017. Effluent from the Horseshoe Bend Water Treatment Plant (HSB) at Montana Resources is reused in the mining operations and is not discharged to Silver Bow Creek.

Although unused the permit does identify one authorized outfall, Outfall 004, for intermittent discharge to the Silver Bow Creek via the Butte MSD. The discharge point is located at approximately 45° 59’ 12” N, 112° 32’ 13” W. The treatment process at the HSB consists of a two-stage high density sludge lime precipitation water treatment process. Currently, the effluent water is used as process water at the Montana Resources facility and is not discharged to Silver Bow Creek. Storm water is drained into the Continental and Berkeley Pit and included in the process water. Domestic wastewater is discharged to the BSB WWTP.

Although the outfall is not currently used, the permit considers the mixing zone to be nearly instantaneous. The average monthly permit limit for TSS is 20 mg/L and 840 lbs/day (**Table 5-48**).

Table 5-48. Final Effluent Limitations for Outfall 001 from MPDES Permit (0000191)

Parameter	Units	Average Monthly Limit[a]	Average Weekly Limit[a]	Maximum Daily Limit[a]
TSS	mg/L	20	NA	20
	lb/day	840	NA	30

[a] See definition section of MPDES Permit for explanation of terms

As Montana Resources has no history of discharging at Outfall 004, the facility is meeting its permit limits for TSS concentration and load at the facility. The WLA for Montana Resources is set at its permit level for TSS for an annual load of 153.3 tons/yr. If the facility was discharging to the MSD and Silver Bow Creek, the WLA would comprise 7.3% of the Silver Bow Creek sediment TMDL (**Section 5.9.3.1**).

5.8.5.7 Montana State Hospital (MTG580004)

The Montana State Hospital in Warm Springs has its own wastewater treatment facility and is authorized to discharge under MPDES permit number MTG580004. This is a general permit for domestic sewage treatment lagoons. The general permit was approved on January 1, 2013 and expires on December 31, 2017. The facility is downstream of Butte but upstream of Galen.

The Montana State Hospital wastewater treatment facility services the clients, staff (resident and non-resident), resident staff dependents, and non-campus users of the hospital. Approximately 500 people are served by this system. The treatment system consists of three facultative lagoons that operate with aerobic, anaerobic, and facultative microorganisms with design retention time of 180 days and actual retention of ~85 days. The system has a single outfall to a ditch which joins the Clark Fork River immediately downstream of the confluence of Warm Springs Creek and Silver Bow Creek at 46° 11' 7.4"N, 112° 46' 38.2"W.

Under the general permit for the facility, the average monthly permit limit for TSS is 30 mg/L and 69 lbs/day (**Table 5-49**).

Table 5-49. Final Effluent Limitations for Outfall 001 from MPDES Permit (0000191)

Parameter	Units	Average Monthly Limit[a]	Average Weekly Limit[a]	Maximum Daily Limit[a]
TSS	mg/L	30	45	NA
	lb/day	69	103	NA

[a] See definition section of MPDES Permit for explanation of terms

The facility is required to monitor the TSS concentration of its effluent weekly. As part of its DMR, the plant submits a 30-day average TSS concentration and load; from January 2003 to December 2012, that concentration ranged from 1.0 mg/L to 83.0 mg/L, with an average value of 15.8 mg/L (**Table 5-50**). The average monthly limit was exceeded in 6% of reported 30 day averages for the facility. Therefore, the average monthly concentration is well below the permit limit of 30 mg/L (monthly average). Also, the average monthly load from 2003 to 2012 was 32.5 lbs/day based on an average discharge of 0.246 mgd. Based on this data, the typical annual TSS load is approximately 5.9 tons. Therefore, its WLA is based on the monthly load limit in the permit and, abiding by the permit conditions, will meet the WLA. Based on the monthly average load limit, the allowable annual load is 12.6 tons of sediment (i.e., 69 lbs/day *365 days * conversion factor = 12.6 tons). This load is more than four times greater than its estimated existing load. The WLA comprises <1% of the Clark Fork River (Warm Springs Creek to Cottonwood Creek) sediment TMDL (**Section 5.9.3.2**).

Table 5-50. TSS and Discharge Statistics for 30-Day Average Values from DMR Data for the Montana State Hospital WWTP for the Period 2010–13

Statistic	TSS (mg/L)	Discharge (mgd)
Number of observations	118	118
Minimum value	1.0	0.006
Maximum value	83.0	0.642
Average value	15.8	0.246

5.8.5.8 Renewable Energy Corporation Advanced Silicon Materials (MT0030350)

The REC Advanced Silicon Materials is authorized to discharge wastewater to Sheep Gulch, a tributary of Silver Bow Creek, under MPDES permit number MT0030350. The permit became effective November 1, 2010, and expires October 31, 2015.

REC Advanced Silicon Materials produces high purity polycrystalline silicon for use in the electronics industry. The process consists of refining metallurgical grade silicon. The blowdown water from the cooling tower is the major source of discharge from REC. Other sources, as listed on the MPDES Permit application are storm water associated with industrial activity, reverse osmosis/continuous deionization system, air pollution control scrubbers, polysilicon reactor and product finishing, miscellaneous drains and seals, and storm water not associated with industrial activity. Total dissolved solids in the form of sodium silicate are present in the process water.

REC Advanced Silicon Materials has an MPDES discharge to Sheep Gulch which flows into Silver Bow Creek. Discharge 001 is the primary discharge from the facility to Sheep Gulch. Two other discharges are included in the permit: 002 is for stormwater discharge and 003 is a direct discharge to Silver Bow Creek that has never been used and is identified for potential future use. Outfall 001 is located at 45° 58' 21 " N and 112° 41' 23” W and discharges to Sheep Gulch. Outfall 002 is located at 45° 59' 57 " N and 112° 41' 3” W and is a stormwater discharge/overflow from retention ponds and discharges to Sheep Gulch. According to the REC Advanced Silicon Health Safety and Environment manager, the facility is sited on approximately 250 acres, 80 of which are developed. The storm water retention ponds were designed to contain and provide infiltration to groundwater for the 100-yr storm event (1% recurrence interval). The permit requires that sampling should occur within the first 30 minutes after the system is activated, but there has not yet been to data an event where the retention ponds discharged stormwater flows to Sheep Gulch. The permit does not contain limits for Outfall 002.

Outfall 003 is located at 46° 0' 15 " N and 112° 41' 36” W and discharges to Silver Bow Creek. However, according to the REC Advanced Silicon Health Safety and Environment manager, this outfall was never constructed and never used. It may likely be a carryover from the initial permit application before final design plans for the facility were determined.

No outfall has a mixing zone for any parameter. Average monthly permit limit for TSS per outfall is in **Table 5-51**.

Table 5-51. Final Effluent Limitations for Outfall 001 from MPDES Permit (0027430)

Parameter	Units	Outfall	Average Monthly Limit[a]	Maximum Daily Limit[a]
TSS	mg/L	1	30	100
		3	1000	NA

[a] See definition section of MPDES Permit for explanation of terms

The facility is required to monitor the TSS concentration of its effluent weekly. As part of its DMR, the plant submits a 30-day average TSS concentration and load; from 2003 to 2012, that concentration ranged from 1 mg/L to 62.0 mg/L, with an average value of 11.9 mg/L (**Table 5-52**). Therefore, the average monthly concentration is well below the permit limit of 30 mg/L (monthly average). The average monthly load from 2006 to 2011 was 64.9 lbs/day based on an average discharge of 0.65 mgd. Based on this data, the typical annual TSS load is approximately 11.8 tons. Therefore, its WLA is based on the monthly load limit in the permit and, abiding by the permit conditions, will meet the WLA. Based on the monthly average load limit using the average plant discharge and the average monthly concentration limit, the allowable annual load is 29.9 tons of sediment (i.e., 30 mg/L *0.65 mgd *365 days * conversion factor = 29.9 tons). This load is more than 2.5 times greater than its estimated existing load.

Table 5-52. TSS and Discharge Statistics for 30-Day Average Values for Outfall 001 for REC Advance Silicon Materials for the Period 2003–13 to Sheep Gulch

Statistic	TSS (mg/L)	Discharge (mgd)
Number of observations	120	120
Minimum value	1.0	0.06
Maximum value	62.0	0.94
Average value	11.9	0.65

No DMR data is reported for Outfall 002. As covered under the permit, this is a stormwater discharge which requires the permittee to develop and implement a Storm Water Pollution Prevention Plan (SWPPP). The purpose of the SWPPP is to identify sources of pollution to storm water and to select

BMPs to eliminate or minimize pollutant discharges at the source and/or to remove pollutants contained in the storm water runoff. The facility must implement the provisions of the SWPPP required under this part as a condition of the permit. This applies to stormwater generated from precipitation that is both commingled and independent of process wastewater generated by the facility prior to the regulated point source discharge. The stormwater system is given a WLA of 0 when not active. It is assumed that following the stormwater permit requirements including the SWPPP will not result in sediment impairing the receiving waterbodies.

For Outfall 003, the permit requires that continuous flow monitoring equipment must be installed at Outfall 003 prior to the commencement of any discharge from that location. For the purposes of providing a WLA for Outfall 003, it is assumed that discharge volume and concentration would be the same at Outfall 003 as it has been recorded at Outfall 001 given that the facility has a well-designed stormwater capture and infiltration system. Based on the monthly average load limit using the average plant discharge at Outfall 001 and the average monthly concentration limit, the allowable annual load is 29.9 tons of sediment (i.e., 30 mg/L *0.65 mgd *365 days * conversion factor = 29.9 tons). The permit limit should be lowered to 30 mg/L for Outfall 003.

The WLA for Outfall 001 and Outfall 003 comprises 2.8% of the Silver Bow Creek sediment TMDL (**Section 5.9.3.1**).

5.8.5.9 Rocker WWTP (MT0027430)

The Rocker WWTP is authorized to discharge treated wastewater to Silver Bow Creek under MPDES permit number MT0027430. The permit became effective June 1, 2013, and expires May 31, 2018. The Rocker WWTP serves the County and Water Sewer District of Rocker located near Butte, Montana. Approximately 70–80% of the flow comes from businesses with the remainder originating from residential. The population that the Rocker WWTP serves is unknown.

The Rocker WWTP was upgraded from a three-cell aerated lagoon system that was constructed in 1986 to an activated sludge package plant in 1995. The design flow for the lagoon system is 0.035 mgd and the design flow of the activated sludge plant is 0.050 mgd. Disinfection is achieved by chlorination prior to discharge. The 30-day average flow from approximately December 2006 through December 2011 was 0.024 mgd (~24,700 gpd). Based on communication with Rocker WWTP plant staff, there is approximately 6,800 linear feet of pipelines, both gravity and force main.

Rocker WWTP has one permitted outfall. Outfall 001 discharges into Silver Bow Creek and is located at 46° 00' 08" N and 112° 37' 40" W. The permitted mixing zone is 200 ft downstream of the discharge point. The average monthly permit limit for TSS is 30 mg/L and 13 lbs/day (**Table 5-53**).

Table 5-53. Final Effluent Limitations for Outfall 001 from MPDES Permit (0027430)

Parameter	Units	Average Monthly Limit[a]	Average Weekly Limit[a]	Maximum Daily Limit[a]
TSS	mg/L	30	45	NA
	lb/day	13	19	NA

[a] See definition section of MPDES Permit for explanation of terms

The facility is required to monitor the TSS concentration of its effluent weekly. As part of its DMR, the plant submits a 30-day average TSS concentration and load; from 2007 to 2011, that concentration ranged from below detection limit (<1 mg/L) to 48.0 mg/L, with an average value of 17.5 mg/L (**Table 5-54**). Therefore, the average monthly concentration is well below the permit limit of 30 mg/L (monthly average). Also, since the plant usually discharges at a rate less than its design flow, the average monthly load from 2006 to 2011 was 3.7 lbs/day based on an average discharge of 0.024 mgd. Based on this data, the typical annual TSS load is approximately 0.68 tons. Therefore, its WLA is based on the monthly load limit in the permit and, abiding by the permit conditions, will meet the WLA. Based on the monthly average load limit, the allowable annual load is 2.3 tons of sediment (i.e., 13 lbs/day *365 days * conversion factor = 2.3 tons). This load is more than three times greater than its estimated existing load. The WLA comprises <1% of the Silver Bow Creek sediment TMDL (**Section 5.9.3.1**).

Table 5-54. TSS and Discharge Statistics for 30-Day Average Values from DMR Data for the Rocker WWTP for the Period 2007–11

Statistic	TSS (mg/L)	Discharge (mgd)
Number of observations	58	60
Minimum value	< 1	0.018
Maximum value	48	0.029
Average value	17.5	0.025

5.8.5.10 Washoe Park Trout Hatchery (MTG130013)

The Washoe Park Trout Hatchery (Washoe), operated by FWP, is a non-domestic wastewater point source discharger located near Anaconda. The hatchery maintains the only native westslope cutthroat trout broadstock. Opened in 1907, it was the first state-run hatchery in Montana. Washoe is permitted to discharge to Warm Springs Creek under a Montana Fish Farm Discharge Permit (General Permit). The permit was issued July 1, 2011, and expires June 30, 2016.

Under the general permit, the facility reports TSS (mg/L) semi-annually. There are no permit limits for TSS although the facility is required to develop and implement a BMP plan to minimize the discharge of hatchery wastes to state waters. The Washoe Park Trout Hatchery is not subject to numeric limits as the facility produces less than 20,000 lbs of fish/yr outlined in the general permit. Records indicate that the facility averages ~13,000 lbs/yr.

Data is limited for the Washoe Park Trout Hatchery. Average discharge from the facility to Warm Springs Creek is 2360 gpm (5.26 cfs). TSS data includes only four observations from the DMR data. Of these, three are below detection limits (<2 mg/L TSS). The remaining observation is 190 mg/L TSS. Given the number of non-detects and a large outlier in the TSS dataset for Washoe Park DMR data from other trout hatcheries in Montana were reviewed to determine whether TSS data was available for other fish hatcheries with discharge rates that were similar to Washoe Park. The review determined that four other state-run trout fish hatcheries had similar characteristics to Washoe Park (**Table 5-55**). The available dataset included 15 observations with an average TSS concentration of 4.5 mg/L.

Table 5-55. Summary of Selected State-Run Fish Trout Hatchery DMR Data

Hatchery name	Average Discharge (cfs)	Average TSS (mg/L)	Number of TSS samples
Big Spring Creek, lower	5.16	3	1
Bluewater Springs	5.96	9	3
Giant Springs	12.15	5.2	3
Murray Springs	7.58	2.8	8
Total	7.71	4.5	15

The existing Washoe Park Trout Hatchery sediment load is calculated using the average discharge rate for the facility and the average TSS concentration from similar state-run trout fish hatcheries in

Montana. The average sediment load from the Washoe Park Trout Hatchery is estimated to be 127.8 lbs/day. This equates to 23.3 tons/yr. The WLA for the facility is set to 23.3 tons/yr. The WLA comprises <1% of the Clark Fork River (Warm Springs Creek to Cottonwood Creek) sediment TMDL (**Section 5.9.3.1**).

5.8.5.11 Construction Storm Water Permits (MTR100000)

Because construction activities at any given site are temporary and relatively short term, the number of construction sites covered by the general permit at any given time varies. Collectively, these areas of severe ground disturbance have the potential to be significant sediment sources if proper BMPs are not implemented and maintained. Each construction stormwater permittee is required to develop a SWPPP that identifies the stormwater BMPs that will be in place during construction. Before a permit is terminated, disturbed areas must have a vegetative density equal to or greater than 70% of the pre-disturbed level (or an equivalent permanent method of erosion prevention). Inspection and maintenance of BMPs is required, and although Montana stormwater regulations provide the authority to require stormwater monitoring, water quality sampling is typically not required (Heckenberger, Brian, personal communication 2009).

The permit files were reviewed to determine the amount of disturbed land associated with each permit. In the Silver Bow Creek watershed, the estimated level of disturbance is 93 acres for eight permits. This expands to 274 disturbed acres for 17 permits for the Upper Clark Fork River TPA, which does not include the Little Blackfoot River watershed. The SWPPPs contain BMPs, such as silt fencing, retention basins, fiber rolls, erosion control blankets, and vegetated buffers.

To estimate the potential sediment loading for the construction sites if adequate BMPs are not followed, an upland erosion rate for disturbed ground with less than 15% cover was multiplied by the amount of disturbed acreage associated with each permit (**Table 5-56**). This is a conservative estimate since permit cycles are multiple years and it is unlikely that all 274 acres will be disturbed in a single year. The erosion rate (1.37 tons/ac/yr) from a recently completed upland model for the Little Blackfoot watershed was used for disturbed ground (Montana Department of Environmental Quality, 2012c).

The Upper Clark Fork watershed is also in the Middle Rockies ecoregion, and 1.37 tons/ac/yr was determined to be an appropriate estimate of the annual erosion potential for disturbed ground within the Upper Clark Fork Phase 2 TMDL. To estimate the reduction in loading associated with following proper BMPs and adhering to permit requirements, a 65% reduction was applied based on studies from EPA and the International Storm Water Best Management Practices Database (Geosyntec Consultants and Wright Water Engineers, Inc., 2008; U.S. Environmental Protection Agency, 2009a). The reduced loads (**Table 5-56**) will be used to set the WLAs for construction stormwater permits. Because following permit conditions meet the intent of the WLA for construction stormwater, any future permits within any watersheds with sediment TMDLs in the Upper Clark Fork basin will meet the TMDL by following all permit conditions, including the SWPPP. The WLA comprises <1% of the sediment TMDL for all sediment TMDLs that include construction stormwater permits (**Section 5.9.3**).

Table 5-56. Sediment Loading and Reductions from Permitted Construction Sites

Watershed	Loading Rate (tons/ac/yr)	Annual Disturbed Acres	Estimated Load Without Adequate BMPs (tons/yr)	BMP Sediment Load (tons/yr)	Percent Reduction
Silver Bow Creek	1.37	93	127.2	44.5	65%
Clark Fork River (Little Blackfoot River to Flint Creek)[a]	1.37	274	160.9	56.3	65%
Clark Fork River (Cottonwood Creek to Little Blackfoot River)	1.37	157	46.5	16.3	65%
Clark Fork River (Warm Springs Creek to Cottonwood Creek)	1.37	123	41	14.4	65%

[a] Does not include the Little Blackfoot River watershed

5.8.5.12 Industrial Storm Water Permit (MTR000095)

In the Upper Clark Fork Phase 2 TPA there are 5 general permits for industrial stormwater:

- MTR000068 (Affco Inc.)
- MTR000194 (BSB Landfill)
- MTR000296 (Sun Mountain Lumber)
- MTR000292 (Pacific Steel and Recycling)
- MTR000488 (BSB WWTP and sod farm)

Affco Inc. is located in Anaconda and drains to Warm Springs Creek (tributary to the Clark Fork River), Sun Mountain Lumber is located in Deer Lodge and drains to the Clark Fork River and the other three are located in and around Butte in the Silver Bow Creek watershed. There are no monitoring requirements and no monitoring data available. The permit for Sun Mountain Lumber was addressed in a previous document (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2010).

Under the stipulations of the permit, facilities maintain an approved SWPPP. The SWPPP sets forth the procedures, methods, and equipment used to prevent the pollution of stormwater discharges. In addition, the SWPPP describes general practices used to reduce pollutants in stormwater discharges. According to the SWPPP, the facility's primary BMP is to use conveyances that minimize contact between runoff and sediment and other pollutants.

According to **Attachment B** (Monitoring Parameter Benchmark Concentrations) within the general stormwater permit, the benchmark value for TSS is 100 mg/L; this means that the TSS concentration of runoff from the site should not exceed 100 mg/L if permit conditions are followed. Based on the site size (acres), an average annual precipitation rate of 12 inches (from Burt Mooney Municipal Airport in Butte) and the benchmark value of 100 mg/L, the maximum allowable annual sediment load for each site is 0.14 tons/ac/yr (**Table 5-57**). The WLA is provided because it is a requirement for permitted point sources but is not intended to add load limits to the permit. DEQ assumed that the WLA will be met by adhering to the permit requirements, including the SWPPP. The WLA comprises between <1% to 1.4% of the sediment TMDLs for all sediment TMDLs that include industrial stormwater permits (**Sections 5.9.3.1 and 5.9.3.2**).

Table 5-57. Sediment Loading and Reductions from Permitted Construction Sites

Watershed	Permit[a]	Loading Rate (tons/ac/yr)	Permitted Area (ac)	BMP Sediment Load (tons/yr)	Percent Reduction
Silver Bow Creek	MTR000194	0.14	198	27.7	0%
	MTR000292	0.14	4.45	0.6	0%
	MTR000488	0.14	13.05	1.8	0%
Clark Fork River (Warm Springs Creek to Cottonwood Creek)	MTR000068	0.14	27	3.8	0%

[a] Analysis assumes permittees are implementing a SWPPP and not discharging in excess of benchmark values

5.8.6 Other Point Source Discharges
In the Upper Clark Fork Phase 2 TPA, there are two point sources that discharge directly to a sediment-impaired AU. Superfund (CERCLA) remediation efforts at LAO and MPTP discharge treated water from groundwater capture systems directly to Silver Bow Creek. Based on facility design and available discharge data, both sites contribute negligible sediment loads to Silver Bow Creek.

There are also several facilities in the TPA which are not permitted under MPDES or authorized under CERCLA; the Anaconda WWTP, Ramsay WWTP and the Fairmont Hot Springs WWTP in addition to Ranchland Packing do not discharge directly to an impaired waterbody and therefore are not addressed with sediment WLAs (although all are included in source assessments in **Section 6.0**).

5.8.7 Source Assessment Summary
Based on field observations and associated source assessment work, all assessed source categories represent significant controllable loads. Each source category has different seasonal loading rates, and the relative percentage of the total load from each source category does not necessarily indicate its importance as a loading source. Instead, because of the coarse nature of the source assessment work, and the unique uncertainties involved with each source assessment category, the intention is to separately evaluate source effects within each assessment category (e.g., bank erosion, upland erosion, roads, and point sources). Results for each source assessment category provide an adequate tool to focus water quality restoration activities in the Upper Clark Fork Phase 2 TPA; they indicate the relative contribution of different sub-watersheds or land cover types for each source category and the percent loading reductions that can be achieved with the implementation of improved management practices (**Appendix C** and **Attachment A**).

5.9 TMDL and Allocations

The sediment TMDLs for the Upper Clark Fork Phase 2 TPA will be based on a percent reduction approach, discussed in **Section 4.0.** This approach will apply to the loading allocated among sources as well as to the TMDL for each waterbody. An implicit MOS will be applied, further discussed in **Section 5.10**.

5.9.1 Application of Percent Reduction and Yearly Load Approaches
Cover et al. (2008) observed a correlation between sediment supply and instream measurements of fine sediment in riffles and pools. DEQ assumed that a decrease in sediment supply, particularly fine sediment, will correspond to a decrease in the percent fine sediment deposition within the streams of interest and result in attaining sediment-related water quality standards. A percent-reduction approach is preferable because there is no numeric standard for sediment to calculate the allowable load and

because of the uncertainty associated with the loads derived from the source assessment (which are used to establish the TMDL), particularly when comparing different load categories, such as road crossings to bank erosion. Additionally, the percent-reduction TMDL approach is more applicable for restoration planning and sediment TMDL implementation because this approach helps focus on implementing water quality improvement practices (BMPs) versus focusing on uncertain loading values.

An annual expression of the TMDLs was determined as the most appropriate timescale because sediment generally has a cumulative effect on aquatic life and other designated uses, and all sources in the watershed are associated with periodic loading. Each sediment TMDL is stated as an overall percent reduction of the average annual sediment load that can be achieved after summing the individual annual source allocations and dividing them by the existing annual total load. EPA encourages TMDLs to be expressed in the most applicable timescale but also requires TMDLs to be presented as daily loads (Grumbles, Benjamin, personal communication 2006). Daily loads are provided in **Appendix D**.

5.9.2 Development of Sediment Allocations by Source Categories

The percent-reduction allocations are based on BMP scenarios for each major source type (e.g., streambank erosion, upland erosion, roads, and permitted point sources). These BMP scenarios are discussed in **Section 5.8** and associated appendices/attachments. They reflect reasonable reductions as determined from literature, agency and industry documentation of BMP effectiveness, and field assessments. Sediment loading reductions can be achieved through a combination of BMPs, and the most appropriate BMPs will vary by site. Sediment loading was evaluated at the watershed scale and associated sediment reductions are also applied at the watershed scale based on the fact that many sources deliver sediment to tributaries that then deliver the sediment load to the impaired waterbodies.

It is important to recognize that the first critical step toward meeting the sediment allocations involves applying and/or maintaining the land management practices, or BMPs, that will reduce sediment loading. 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 sediment allocation for that location. For many nonpoint source activities, it can take several years to decades 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 after implementing grazing BMPs or allowing re-growth in areas of past riparian harvest. 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 sediment loading.

Progress toward TMDL and individual allocation achievement can be gaged by adhering to point source permits, implementing BMPs for nonpoint sources, and improving or attaining the water quality targets defined in **Section 5.5**. Any effort to calculate loads and percent reductions for comparison with TMDLs 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.

The following subsections present additional allocation details for each sediment source category.

The sediment TMDLs for the three segments of the Clark Fork River in the Upper Clark Fork River Phase 2 TPA did not directly incorporate the sediment allocations identified per sediment-impaired tributary TMDLs in a previous Upper Clark Fork TMDL document (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2010). However, the sediment source loading estimates and allocation approaches outlined in **Section 5.8** are identical to the methods used in the 2010 document. Therefore, it is assumed that sediment TMDLs for the Clark Fork River do not alter the tribuatry sediment TMDLs from the previous document, but incorporated their methodology and allocation approach to the sub-basin scale excluding the Little Blackfoot River TPA.

All TMDLs for the Silver Bow Creek and the Clark Fork River are watershed TMDLs and incorporate loads from upstream segments/watershed areas.

5.9.2.1 Streambank Erosion

Streambank stability and erosion rates are closely linked to the health of the riparian zone. Reductions in sediment loading from bank erosion are expected to be achieved by applying BMPs within the riparian zone. Sediment loads associated with bank erosion are identified by separate source categories (e.g., transportation, grazing, natural) in **Attachment A**; however, because of the inherent uncertainty in extrapolating this level of detail to the watershed scale, and also because of uncertainty regarding the effects of past land management activity, all sources of bank erosion were combined to express the TMDL and allocations.

DEQ acknowledges that the annual sediment loads, and the method by which to attribute human and historic influence, are estimates based on aerial photography, best professional judgment, and limited access to on-the-ground reaches. The assignment of bank erosion loads to the various land uses is not definitive but was done to direct efforts to reduce the loads toward those causes that are likely having the biggest effect on the investigated streams. Ultimately, local land owners and managers are responsible for identifying the causes of bank erosion and for adopting practices to reduce bank erosion wherever practical.

5.9.2.2 Upland Erosion

The allocation to upland sources includes application of BMPs to present land-use activities as well as recovery from past land-use influences, such as riparian harvest. No reductions were allocated to natural sources, which are a significant portion of all upland land-use categories. For all upland sources, the largest percent reduction will be achieved via riparian improvements. The anticipated loading reductions achievable by implementing upland and riparian BMPs for each land cover category are presented in Appendix F in Montana Department of Environmental Quality, Planning, Prevention and Assistance Division (2010). For the TMDL, the allocation to upland erosion sources is presented as a single load and percent reduction.

5.9.2.3 Roads

The allocation to roads can be met by incorporating and documenting that all road crossings and parallel segments with potential sediment delivery to streams have the appropriate BMPs in place. Routine maintenance of the BMPs is also necessary to ensure that sediment loading remains consistent with the intent of the allocations. At some locations, road closure or abandonment alone may be appropriate. Further, because of the low erosion potential linked to native vegetation growth on the road surface, additional BMPs may not be necessary.

5.9.2.4 Permitted Point Sources

All WLAs are expected to be met by adhering to permit conditions. As Silver Bow Creek is in the Clark Fork River watershed, WLAs identified in the Silver Bow Creek drainage are included in the Clark Fork

River sediment TMDLs. Existing loads and WLAs for point source discharges in upstream watersheds will be composited and referenced for the separate Clark Fork River segment sediment TMDLs.

5.9.3 Allocations and TMDL for Each Stream

The following subsections present the existing quantified sediment loads, allocations, and TMDL for each waterbody (**Tables 5-58** through **5-61**). Note, sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices. Because TMDLs are presented on a watershed basis, TMDLs include all loading to stream segments upstream of the specific segment for which a TMDL is written.

TMDLs are presented from upstream to downstream in the Upper Clark Fork Phase 2 TPA starting with Silver Bow Creek and working downstream through the three separate Clark Fork River segments to the Flint Creek confluence. Composite WLAs for each upstream watershed area is presented in downstream segments. The Upper Clark Fork tributaries composite WLA first appears in the Clark Fork River segment Warm Springs Creek to Cottonwood Creek as this is where it is first applicable.

5.9.3.1 Silver Bow Creek (MT41H003_081)

Table 5-58. Sediment Source Assessment, Allocations and TMDL for Silver Bow Creek

Sediment Sources		Current Estimated Load (tons/yr)[a]	Total Allowable Load (tons/yr)[a]	LAs (percent reduction)
Roads		262	148	44%
Streambank Erosion		348	341	2%
Upland Sediment Sources		1,251	763	39%
Point Source WLA	BSB MS4 (MTR040006)	746	179	76%
	BSB WWTP (MT0022012)	49	388	0%
	Montana Livestock Auction (MTG010166)	0	0[b]	0%
	Montana Resources (MT0000191)	0	153	0%
	REC Advanced Silicon Materials (MT0030350) (Outfalls 001 and 003)	12	60	0%
	REC Advanced Silicon Materials (MT0030350) (Outfall 002 - stormwater)	0	0[b]	0%
	Rocker WWTP (MT0027430)	<1	2	0%
	Construction Storm Water Permit (MTR100000)	127	45	65%
	Industrial Storm Water Permit (MTR000095)	0	30[b]	0%
Total Sediment Load		2,795	2,109	25%

[a] Values were rounded to the nearest whole number, differences in loads presented in this table may not correspond to the identified percent reduction

[b] Under typical rainfall conditions. For rainfall events equivalent to the 25-year storm or greater, TSS LAs will be achieved by following MPDES permit requirements

5.9.3.2 Clark Fork River, Warm Springs Creek to Cottonwood Creek (MT76G001_040)

Table 5-59. Sediment Source Assessment, Allocations and TMDL for Clark Fork River, Warm Springs Creek to Cottonwood Creek

Sediment Sources		Current Estimated Load (tons/yr)[a]	Total Allowable Load (tons/yr)[a]	LAs (percent reduction)
Upper Clark Fork tributaries TMDLs WLAs composite[c] (DEQ 2010)		0	5[b]	0%
Silver Bow Creek WLAs composite (see **Section 5.9.3.1**)		934	857	8%
Roads		358	193	46%
Streambank Erosion		2,027	1,581	22%
Upland Sediment Sources		1,264	887	30%
Point Source WLA	Montana Behavioral Health (MT0021431)	<1	3	0%
	Montana State Hospital (MTG580004)	6	13	0%
	Washoe Park Trout Hatchery (MTG130013)	23	23	0%
	Construction Storm Water Permit (MTR100000)	41	14	65%
	Industrial Storm Water Permit (MTR000095)	0	4[b]	0%
Total Sediment Load		4,653	3,580	23%

[a] Values were rounded to the nearest whole number, differences in loads presented in this table may not correspond to the identified percent reduction
[b] Under typical rainfall conditions. For rainfall events equivalent to the 25-year storm or greater, TSS LAs will be achieved by following MPDES permit requirements.
[c] Includes industrial storm water permit for Sun Mountain Lumber and CAFO permit for Montana State Prison Ranch on Tin Cup Joe Creek

5.9.3.3 Clark Fork River, Cottonwood Creek to Little Blackfoot River (MT76G001_030)

Table 5-60. Sediment Source Assessment, Allocations and TMDL for Clark Fork River, Cottonwood Creek to Little Blackfoot River

Sediment Sources		Current Estimated Load (tons/yr)[a]	Total Allowable Load (tons/yr)[a]	LAs (percent reduction)
Silver Bow Creek WLAs composite (see **Section 5.9.3.1**)		934	857	27%
Upper Clark Fork tributaries TMDLs WLAs composite[c] (DEQ 2010)		0	5[b]	0%
Clark Fork River (Warm Springs Creek to Cottonwood Creek) WLAs composite (see **Section 5.9.3.2**)		70	57	19%
Roads		380	201	47%
Streambank Erosion		2,785	1,894	32%
Upland Sediment Sources		2,745	1,920	30%
Point Source WLA	Deer Lodge WWTP (MT0022616)	30	103	0%
	Construction Storm Water Permit (MTR100000)	46	16	65%
Total Sediment Load		6,990	5,053	28%

[a] Values were rounded to the nearest whole number, differences in loads presented in this table may not correspond to the identified percent reduction
[b] Under typical rainfall conditions. For rainfall events equivalent to the 25-year storm or greater, TSS LAs will be achieved by following MPDES permit requirements.
[c] Includes industrial storm water permit for Sun Mountain Lumber and CAFO permit for Montana State Prison Ranch on Tin Cup Joe Creek

5.9.3.4 Clark Fork River, Little Blackfoot River to Flint Creek (MT76G001_010)

Table 5-61. Sediment Source Assessment, Allocations and TMDL for Clark Fork River, Little Blackfoot River to Flint Creek

Sediment Sources		Current Estimated Load (tons/yr)[a]	Total Allowable Load (tons/yr)[a]	LAs (percent reduction)
Silver Bow Creek WLAs composite (see **Section 5.9.3.1**)		934	857	8%
Upper Clark Fork tributaries TMDLs WLAs composite[c] (DEQ 2010)		0	5[b]	0%
Clark Fork River (Warm Springs Creek to Cottonwood Creek) WLAs composite (see **Section 5.9.3.2**)		70	57	19%
Clark Fork River (Cottonwood Creek to Little Blackfoot River) WLAs composite (see **Section 5.9.3.3**)		76	119	0%
Little Blackfoot River TMDL (see **Figure 5-6**; (DEQ 2012c))		14828	12068	19%
Roads		455	239	47%
Streambank Erosion		4795	3261	32%
Upland Sediment Sources		6644	4816	28%
Point Source WLA	Construction Storm Water (MTR100000)	161	56	65%
Total Sediment Load		27,963	21,478	23%

[a] Values were rounded to the nearest whole number, differences in loads presented in this table may not correspond to the identified percent reduction
[b] Under typical rainfall conditions. For rainfall events equivalent to the 25-year storm or greater, TSS LAs will be achieved by following MPDES permit requirements.
[c] Includes industrial storm water permit for Sun Mountain Lumber and CAFO permit for Montana State Prison Ranch on Tin Cup Joe Creek

5.10 SEASONALITY AND MARGIN OF SAFETY

Seasonality and MOS are both required elements of TMDL development. This section describes how seasonality and MOS were applied during development of the Upper Clark Fork Phase 2 TPA sediment TMDLs.

5.10.1 Seasonality

All TMDL documents must consider the seasonal applicability of water quality standards as well as the seasonal variability of pollutant loads to a stream. Seasonality was addressed in several ways:

- The applicable narrative water quality standards (**Appendix B**) are not seasonally dependent, although low-flow conditions provide the best ability to measure harm-to-use based on the selected target parameters. The low-flow or base-flow condition represents the most practical time period for assessing substrate and habitat conditions, and also represents a time period when high fine sediment in riffles or pool tails will likely influence fish and aquatic life. Therefore, meeting targets during this time frame represents an adequate approach for determining standards attainment.

- The substrate and habitat target parameters within each stream are measured during summer or autumn low-flow conditions consistent with the time of year when reference stream measurements are conducted. This time period also represents an opportunity to assess effects of the annual snow runoff and early spring rains, which is the typical time frame for sediment loading to occur.
- The DEQ sampling protocol for macroinvertebrates identifies a specific time period for collecting samples based on macroinvertebrate life cycles. This time period coincides with the low-flow or base-flow condition.
- All assessment modeling approaches are standard approaches that specifically incorporate the yearly hydrologic cycle specific to the Upper Clark Fork Phase 2 TPA. The resulting loads are expressed as average yearly loading rates to fully assess loading throughout the year.
- Allocations are based on average yearly loading, and the preferred TMDL expression is as an average yearly load reduction, consistent with the assessment methods.

5.10.2 Margin of Safety

Natural systems are inherently complex. Any approach used to quantify or define the relationship between pollutant loading rates and the resultant water quality effects, no matter how rigorous, will include some level of uncertainty or error. To compensate for this uncertainty and ensure water quality standards are attained, a MOS is required as a component of each TMDL. 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 incorporates an implicit MOS in a variety of ways:

- By using multiple targets to assess a broad range of physical and biological parameters known to illustrate the effects of sediment in streams and rivers. These targets serve as indicators of potential impairment from sediment and also help signal recovery, and eventual standards attainment, after TMDL implementation. Conservative assumptions were used during development of these targets; as discussed for each target parameter in **Section 5.5.1**, an effort was made to select achievable water quality targets, but in all cases, the most protective statistical approach was used. **Appendix B** contains additional details about statistical approaches used by DEQ.
- This approach addresses some of the uncertainty associated with sampling variability and site representativeness and recognizes that capabilities to reduce sediments exist throughout the watershed.
- Sediment impairment is typically identified based on excess fine sediment but the targets and TMDLs address both coarse and fine sediment delivery.
- By properly incorporating seasonality into target development, source assessments, and TMDL allocations (details provided in **Section 5.10.1**).
- By using an adaptive management approach to evaluate target attainment and allow for refinement of LA, targets, modeling assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development (discussed in **Sections 5.10**, **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. Specifically, each major source category must meet percent reductions to satisfy the TMDL because of the relative loading uncertainties between assessment methodologies.
- By developing TMDLs at the watershed scale to address all potentially significant human-related sources beyond just the impaired waterbody segment scale. This approach should also reduce

loading and improve water quality conditions within other tributary waterbodies throughout the watershed.

5.11 TMDL Development Uncertainties and Adaptive Management

A degree of uncertainty is inherent in any study of watershed processes. While uncertainties are an undeniable fact of TMDL development, mitigation and reduction of uncertainty through adaptive management is a key component of TMDL implementation. The process of adaptive management is predicated on the premise that TMDLs, allocations, and their supporting analyses are not static but are subject to periodic modification or adjustment as new information and relationships are better understood. Within the Upper Clark Fork Phase 2 TPA, adaptive management for sediment TMDLs relies on continued monitoring of water quality and stream habitat conditions, continued assessment of effects from human activities and natural conditions, and continued assessment of how aquatic life and coldwater fish respond to changes in water quality and stream habitat conditions.

As noted in **Section 5.10.2**, adaptive management represents an important component of the implicit MOS. This document provides a framework to satisfy the MOS by including sections focused on TMDL implementation, monitoring, and adaptive management (**Sections 9.0** and **10.0**). Furthermore, state law (ARM 75-5-703) requires monitoring to gage progress toward meeting water quality standards and satisfying TMDL requirements. These TMDL implementation monitoring reviews represent an important component of adaptive management in Montana.

Perhaps the most significant uncertainties within this document involve the accuracy and representativeness of (a) field data and target development and (b) the accuracy and representativeness of the source assessments and associated load reductions. These uncertainties and approaches used to reduce uncertainty are discussed in following subsections.

5.11.1 Sediment and Habitat Data Collection and Target Development

Some of the uncertainties regarding accuracy and representativeness of the data and information used to characterize existing water quality conditions and develop water quality targets are discussed below.

5.11.1.1 Data Collection

The stream sampling approach used to characterize water quality is described in **Attachment A**. To control sampling variability and improve accuracy, the sampling was done by trained environmental professionals using a standard DEQ procedure developed for creating sediment TMDLs (Montana Department of Environmental Quality, 2010). This procedure defines specific methods for each parameter, including sampling location and frequency, to ensure proper representation and applicability of results. Before any sampling, a Sampling and Analysis Plan (SAP) was developed to ensure that all activity was consistent with applicable quality control and quality assurance requirements. Site selection was a major component of the SAP and was based on a stratification process described in **Attachment A**. The stratification work ensured that each stream included one or more sample sites representing a location where excess sediment loading or altered stream habitat could affect fish or aquatic life.

Even with the applied quality controls, a level of uncertainty regarding overall accuracy of collected data will exist. There is uncertainty regarding whether the appropriate sites were assessed and whether an adequate number of sites were evaluated for each stream. Also, there is the uncertainty of the representativeness of collecting data from one sampling season. These uncertainties are difficult to quantify and even more difficult to eliminate given resource limitations and occasional stream access problems.

5.11.1.2 Target Development

DEQ evaluated several data sets to ensure that the most representative information and most representative statistic was used to develop each target parameter, consistent with the reference approach framework outlined in **Appendix B**. Using reference data is the preferred approach for target setting; however, some uncertainty is introduced because of differing protocols between the available reference data and DEQ data for the Upper Clark Fork Phase 2 TPA. These differences were acknowledged within the target development discussion and taken into consideration during target setting. For each target parameter, DEQ stratified the Upper Clark Fork sample results and target data into similar categories, such as stream width or Rosgen stream type, to ensure that the target exceedance evaluations were based on appropriate comparison characteristics.

The established targets are meant to apply under median conditions of natural background and natural disturbance. DEQ recognizes that under some natural conditions, such as a large fire or flood event, it may be impossible to satisfy one or more of the targets until the stream and/or watershed recovers from the natural event. Under these conditions the goal is to ensure that management activities do not significantly delay achievement of targets compared with the time for natural recovery to occur.

Also, human activity should not significantly increase the extent of water quality effects from natural events. For example, extreme flood events can cause a naturally high level of sediment loading that could be significantly increased from a large number of road crossing or culvert failures.

Because sediment target values are based on statistical data percentiles, DEQ recognizes that it may be impossible to meet all targets for some streams even under normal levels of disturbance. On the other hand, some target values may underestimate the potential of a given stream, and it may be appropriate to apply more protective targets upon further evaluation during adaptive management. It is important to recognize that the adaptive management approach provides flexibility to refine targets as necessary to ensure resource protection and to adapt to new information concerning target achievability.

5.11.2 Source Assessments and Load Reduction Analyses

Each assessment method introduces uncertainties regarding the accuracy and representativeness of the sediment load estimates and percent load reduction analyses. For each source assessment, assumptions must be made to evaluate sediment loading and potential reductions at the watershed scale. Because of these uncertainties, conclusions may not represent existing conditions and achievable reductions at all locations in the watershed. Uncertainties are discussed independently for the three major source categories: bank erosion, upland erosion, and unpaved road crossings.

5.11.2.1 Bank Erosion

Bank erosion loads were initially quantified using the DEQ protocols (Montana Department of Environmental Quality, 2010) and the standard BEHI methodology, defined in **Attachment A**. Before any sampling, a SAP was developed to ensure that all activity was consistent with applicable quality control and quality assurance requirements. Site selection was a major component of the SAP and was based on a stratification process described in **Attachment A**. The results were then extrapolated across the Upper Clark Fork watershed to provide an estimate of the relative bank erosion loading from various stream segments in the Clark Fork River and Silver Bow Creek and associated stream reaches. Based on this process, the relative contribution from human versus natural sources, as well as the potential for reduction with the implementation of riparian BMPs, was estimated and used for TMDL allocations. Stratifying and assessing each unique reach type was not practical, therefore adding to uncertainty associated with the load extrapolation results.

The final quantification of bank erosion loads was derived from the SWAT model; because the model integrates all sediment sources, it was assumed that load estimates from the model are more accurate than the field estimates. There is some uncertainty with the bank erosion loads from the model because insufficient data were available to truly calibrate the model and the calibration period was run using a sediment rating curve developed from available data. Additional uncertainty comes from the model because streambank erosion is not directly estimated but is calculated based on the difference between the load at the outlet for each stream and the sum of upland and in-channel loading.

There is additional uncertainty regarding the amount of bank erosion linked to human activities and the specific human sources, as well as the ability to reduce the human-related bank erosion levels. This uncertainty is largely associated with past disturbances; it is extremely difficult to identify the level to which they still affect streambank erosion, how much is associated with human sources, and what the dominant human sources are. Even if difficult to quantify, the linkages between human activity, such as riparian clearing and bank erosion, are well established, and these linkages clearly exist at different locations throughout the Upper Clark Fork watershed. Evaluating bank erosion levels, particularly where BMPs have been applied along streams, is an important part of adaptive management that can help define the level of human-caused bank erosion as well as the relative effect that bank erosion has on water quality throughout the Upper Clark Fork watershed.

5.11.2.2 Upland Erosion

A professional modeler determined upland erosion loads by applying a landscape USLE within a SWAT model of the Upper Clark Fork Phase 2 TPA in a previous TMDL, defined in Appendix F of Montana Department of Environmental Quality, Planning, Prevention and Assistance Division (2010). As with any model, there will be uncertainty in the model input parameters, including land use, land cover, and assumptions regarding existing levels of BMP application. For example, only one vegetative condition was assigned per land cover type. In other words, the model cannot reflect land management practices that change vegetative cover from one season to another, so an average condition is used for each scenario in the model. The potential to reduce sediment loading was based on modest land cover improvements, along with riparian improvements, to reduce the generation of eroded sediment particles. Thus, there is uncertainty regarding existing erosion prevention BMPs and the ability to reduce erosion with additional BMPs.

The upland erosion model integrates sediment delivery based on riparian health; riparian health evaluations linked to the stream stratification work are discussed in **Attachment A**. The riparian health classifications were performed using aerial imagery and a coarse classification system (i.e., poor, fair, and good). This particularly introduced uncertainty in watersheds that had limited woody vegetation but that may have had a high buffering capacity from other vegetation, such as wetland grasses.

Additionally, because of the coarseness of the categories, the process resulted in a large quantity of riparian vegetation being classified as fair, which limits analysis of fine-scale differences. However, the analysis was not performed with the expectation that it would identify specific locations for implementation of additional BMPs. Instead it was performed to simulate the buffering capacity of riparian vegetation and emphasize the importance of a healthy riparian buffer. Even with these uncertainties, the ability to reduce upland sediment erosion and delivery to nearby waterbodies is well documented in literature, and the estimated reductions are consistent with literature values for riparian buffers.

5.11.2.3 Roads

Loading from roads was based on field assessments and modeling of BMP scenarios in the Little Blackfoot River drainage as part of a separate TMDL document. As the Little Blackfoot River drainage is a large sub-basin of the Upper Clark Fork River watershed, road assessment work performed in the Little Blackfoot River sun-basin was used to inform assumptions and calculations in the Upper Clark Fork River watershed.

As described in Appendix E of Montana Department of Environmental Quality (Montana Department of Environmental Quality, 2012c), the road crossings sediment load was estimated via a standardized simple yearly model developed by USFS. This model relies on a few basic input parameters that are easily measured in the field, as well as inclusion of precipitation data from local weather stations. A total of 24 sites were randomly selected for evaluation, representing about 5% of the total population of roads. The results from these 24 sites were extrapolated to the whole population of roads stratified by road surface type and precipitation class.

The reduction potential for all roads was also based on road ownership, although DEQ acknowledges that actual reductions will vary by site, depending on the existing maintenance level and site-specific factors. Random selection of the stratified sites was intended to capture a representative subset of the road crossings for existing conditions and level of BMP implementation. However, some uncertainty is introduced because of the small sample size relative to the total number of road crossings.

Although the traction sand assessment indicated traction sand is a minor source of sediment, there is some uncertainty because the assessment was not performed during the spring, when its effects are most apparent. Also, although the culvert assessment is a coarse level assessment, there is uncertainty in the peak flow capacity that was calculated for each culvert because it is based on regional regression equations, which may substantially overestimate or underestimate peak flow.

6.0 NUTRIENT TMDL COMPONENTS

This section focuses on nutrient causes of water quality impairment in the Upper Clark Fork Phase 2 TPA. The section (1) describes how excess nutrients impair beneficial uses, (2) discusses the affected stream segments, (3) discusses the currently available data pertaining to nutrient impairments in the Upper Clark Fork Phase 2 TPA, (4) describes the sources of nutrients based on recent studies and loading estimates, and (5) proposes nutrient TMDLs and their rationales.

6.1 NUTRIENT EFFECTS ON BENEFICIAL USES

Nitrogen and phosphorus are naturally occurring elements required for healthy functioning of aquatic ecosystems. Streams in particular are dynamic systems that depend on a balance of nutrients, which can enter streams from various sources. Healthy streams strike a balance between organic and inorganic nutrients from sources such as natural erosion, groundwater discharge, and instream biological decomposition. This balance relies on autotrophic organisms (e.g., algae) to consume excess nutrients and on the cycling of biologically fixed nitrogen and phosphorus into higher levels on the food chain, as well as on nutrient decomposition (e.g., changing organic nutrients into inorganic forms). Human influences may alter nutrient cycling, damaging biological stream function and degrading water quality. The effects on streams of total nitrogen (TN), nitrate+nitrite (NO_3+NO_2; a component of TN), and total phosphorus (TP) are all considered in assessing the effects on beneficial uses.

Excess nitrogen in the form of dissolved ammonia (which is typically associated with wastewater) can be toxic to fish and other aquatic life. Excess nitrogen in the form of nitrate in drinking water can inhibit normal hemoglobin function in infants. In addition, excess nitrogen and phosphorus from human sources can cause excess algal growth, which in turn depletes the supply of dissolved oxygen, killing fish and other aquatic life. Excess nutrient concentrations in surface water create blue-green algae blooms (Priscu, 1987), which can produce toxins lethal to aquatic life, wildlife, livestock, and humans. Aside from the toxicity effects, nuisance algae can shift the structure of macroinvertebrate communities, which may also negatively affect the fish that feed on macroinvertebrates (U.S. Environmental Protection Agency, 2010). Additionally, changes in water clarity, fish communities, and aesthetics can harm recreational uses, such as fishing, swimming, and boating (Suplee et al., 2009). Nuisance algae can also increase the cost of treating drinking water or pose health risks if ingested in drinking water (World Health Organization, 2003).

Where instream nutrient concentrations are grossly elevated over naturally occurring concentrations, net primary production may lead to anoxic conditions in the water column. Under redox conditions, some sediment-bound metals may be released into the water column further impairing water quality. This mechanism may be plausible under certain loading scenarios in the Silver Bow Creek watershed.

6.2 STREAM SEGMENTS OF CONCERN

Streams of concern in the Upper Clark Fork Phase 2 TPA include those listed as impaired for nitrogen and/or phosphorous on the 2012 303(d) List (**Table 6-1**). However, this document reflects 2013 impairment determinations made by DEQ's Water Quality Planning Bureau. DEQ used data collected during the past several years to update nutrient assessments on all streams identified in **Table 6-1**. The assessment results are presented in **Section 6.4.3**, along with an updated nutrient impairment summary (see **Table 6-26**) for the planning area.

Table 6-1. Stream Segments of Concern for Nutrients and Nutrient Pollutant Impairments Based on the 2012 303(d) List

Stream Segment	Waterbody ID	Nutrient Impairment Identified on 2012 303(d) List
Dempsey Creek	MT76G002_100	Yes
Dunkleberg Creek	MT76G005_072	Yes
Gold Creek	MT76G005_092	Yes
Hoover Creek, lower	MT76G005_082	Yes
Hoover Creek, upper	MT76G005_081	No
Lost Creek	MT76G002_072	Yes
Petersen Creek, upper	MT76G002_131	Yes
Peterson Creek, lower	MT76G002_132	No
Silver Bow Creek	MT76G003_020	Yes
Willow Creek, lower	MT76G002_062	No
Willow Creek, upper	MT76G002_061	Yes

6.3 Upper Clark Fork Environmental History

A brief summary of sediment deposition in the Upper Clark Fork was outlined in **Section 5.3.1**. It is mentioned here as much of the deposition history and past and on-going remediation work directly affect nutrient loading to Silver Bow Creek, one of the nutrient listed tributaries addressed in this document.

6.3.1 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

CERCLA is a federal law designed to clean up sites contaminated with hazardous substances. More commonly referred to as the Superfund program, the law authorized the EPA to identify parties responsible for contamination of sites and compel those parties to clean up the sites. If responsible parties cannot be found, the EPA has the authority to clean up sites itself. CERCLA authorizes both removal and remedial actions and afford flexibility for short and long-term actions.

In the Upper Clark Fork Phase 2 TPA, there are 5 Superfund sites divided into 19 OUs (**Table 6-2**). Of the nutrient-impaired streams in the project area, Superfund removal and remediation activities affect only the Silver Bow Creek AU (MT76G003_020) addressed in this TMDL document.

Table 6-2. Superfund Sites and OUs in the Upper Clark Fork Phase 2 TPA

Superfund Site	OU[a]	Affected Nutrient AU	Notes
Anaconda Company Smelter	Old Works/East Anaconda Development Area	*None*	
	Community Soils	*None*	
	Anaconda regional Water, Waste and Soils	*None*	
Milltown Reservoir Sediments/ Clark Fork River	*Clark Fork River*	*None*	
	Milltown Drinking Water Supply[b]	NA	Outside planning area
	Milltown Reservoir Sediments[b]	NA	Outside planning area
Montana Pole and Treating Plant	**MPTP**	MT76G003_020	

Table 6-2. Superfund Sites and OUs in the Upper Clark Fork Phase 2 TPA

Superfund Site	OU[a]	Affected Nutrient AU	Notes
Rocker Timber Framing and Treating Plant	***Rocker Timber Framing and Treating Plant***	MT76G003_020	
Silver Bow Creek/ Butte Area	**Area One**	MT76G003_020	Subunit of BPSOU
	Berkeley Pit/Mine Flooding	NA	Outside AU
	BPSOU	MT76G003_020	Subunit of BPSOU
	Butte Reduction Works	MT76G003_020	Subunit of SSTOU
	Butte Residential Soils	MT76G003_020	Subunit of BPSOU
	LAO	MT76G003_020	Subunit of SSTOU
	SSTOU	MT76G003_020	Subunit of SSTOU
	Warm Springs Ponds, active area	NA	Outside AU
	Warm Springs Ponds, inactive area	NA	Outside AU
	West Camp/Travona Shaft Area	MT76G003_020	Managed with BPSOU
	West Side Soils	MT76G003_020	

[a] Italicized/bolded OUs are those that directly affect nutrient listed AUs in the Upper Clark Fork Phase 2 TPA
[b] These 2 OUs are managed as a single unit

6.3.2 Upper Clark Fork RCRA Sites

The Rhodia Silver Bow Elemental Phosphorus Production Plant is a RCRA site. Ownership of the site changed five times from when the facility first started producing elemental phosphorus in 1950 to when production ceased in 1997 (Barr Engineering Company, 2012). In the late 1960s, the plant was granted a permit to discharge stormwater runoff, uncontaminated cooling water, and septic system water through a concrete discharge pipe. Direct discharge to Silver Bow Creek ceased in 1975 with final upgrades to facility infrastructure and septic system. The pipe system was removed in 2004 and 2005.

Following facility closure in 1997, most of the facility was decontaminated and demolished in 1998–1999 (Barr Engineering Company, 2012). Structures remaining on site include a 100-ft clarifier, two office buildings, and several other miscellaneous buildings and silos.

6.3.3 Silver Bow Creek

Within the drainage of Silver Bow Creek, there are three Superfund sites, comprising ten OUs, which directly affect the Silver Bow Creek AU (confluence of Blacktail Creek and the MSD to the inlet to Warm Springs Ponds) (**Figure 6-1**). These Superfund OUs and subunits include the BPSOU, LAO, Rocker Timber Framing and Treatment Plant, SSTOU, MPTP, and the West Camp/Travona Shaft Area among others.

TMDLs for Silver Bow Creek only consider those source areas discharging loads to the stream and, therefore, do not include the Berkeley Pit, which does not discharge to Silver Bow Creek. Additionally, the Warm Springs Ponds OU is outside the Silver Bow Creek AU. Warm Springs Ponds are excluded in state statute (Statute 17-5-103(34)(b)(i)) and administrative rule (ARM 17.30.607(1)(a)(iii)) as a state waterbody, so formal assessment of Silver Bow Creek extends only to the inlet of the uppermost pond (21.7 stream miles from the confluence of the MSD and Blacktail Creek). It is important to note that increased nutrient loads can create reducing conditions within the bed sediment which can result in the release of metals (including arsenic) associated with redox-sensitive minerals (e.g., iron oxides) within the sediments in Warms Springs Ponds.

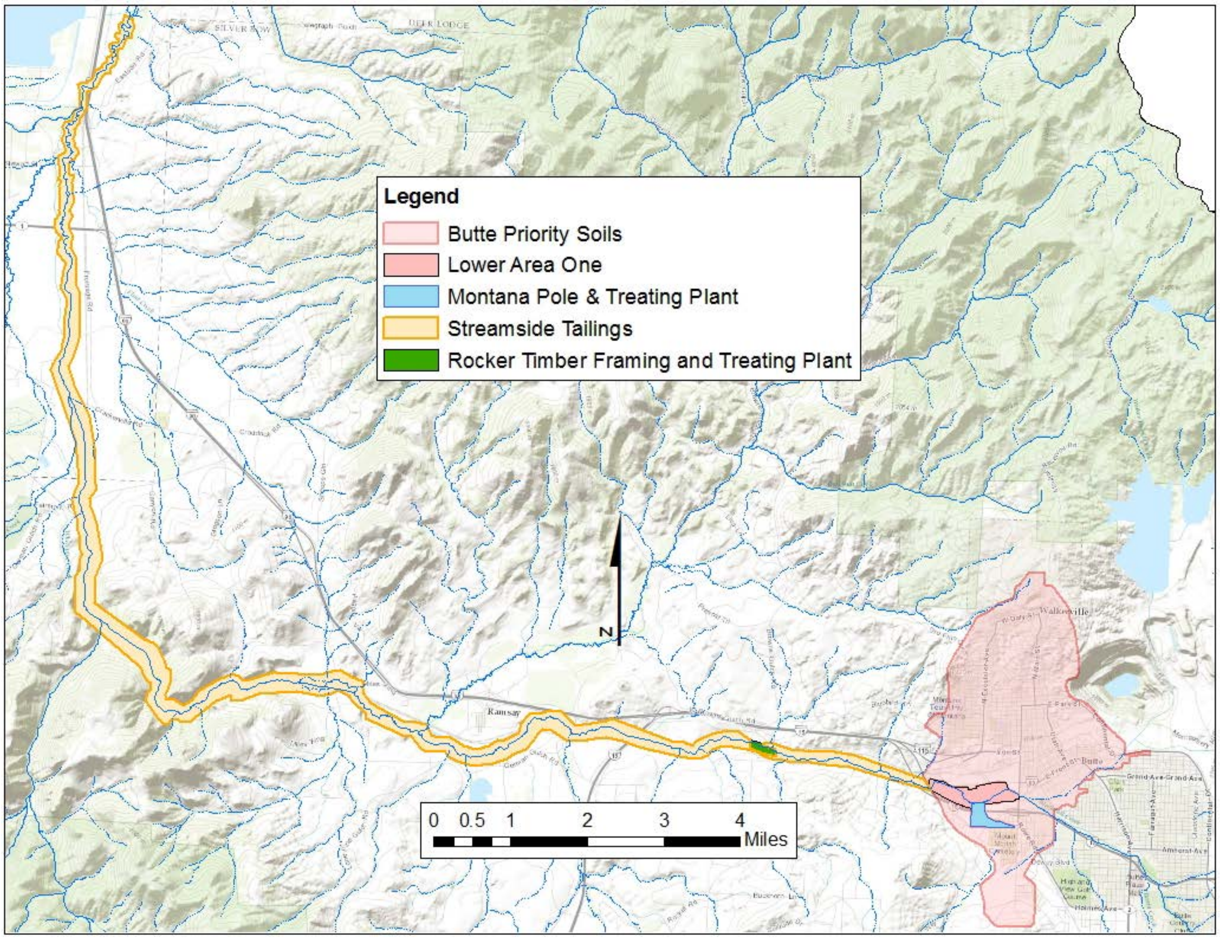

Figure 6-1. Map of Extent of Superfund Units within the Silver Bow Creek AU

6.3.3.1 Butte Priority Soils Operable Unit (BPSOU)

The ROD for the BPSOU was signed in September 2006 and focused primarily on metals cleanup activities through removal and remediation of contaminated sediment and tailings deposits (U.S. Environmental Protection Agency, 2006). Phase 1 was an expedited response action which addressed source areas by removing waste dumps, railroad beds and other related mine wastes. Phase II is ongoing and addresses the remaining environmental and human health issues associated with soil, groundwater and surface water. This OU is administered by the EPA.

6.3.3.2 Lower Area One (LAO)

Administered by the EPA, manganese stockpiles were removed in 1992 and mine tailings (Colorado and Butte Reduction) were removed in 1993–97 from this OU. In addition to removal of contaminated soils, a groundwater collection and treatment system was installed (Butte Treatment Lagoons) and catchment basins were constructed on Missoula Gulch. Treated groundwater and storm water runoff are discharged Silver Bow Creek upstream of the BSB WWTP outfall to Silver Bow Creek. The stream channel was dewatered and underwent complete reconstruction as part of remediation activities in LAO. Remediation activities are covered by the ROD for the BPSOU (U.S. Environmental Protection Agency, 2006).

6.3.3.3 Montana Pole and Treating Plant (MPTP)

The facility operated as a wood treating facility from 1946 to 1984. Contamination of groundwater from PCP, PAHs, dioxins and furans were documented by the predecessor agency to DEQ, the MDHES, in 1983. Hazardous wastes from the facility were discharged to a ditch next to the plant. A ROD was signed for the site in 1993 (U.S. Environmental Protection Agency, 1993; U.S. Environmental Protection Agency, 2006). Remediation included removal of contaminated soils and pumping and treatment of contaminated groundwater. Treated groundwater is discharged to Silver Bow Creek upstream of the LAO discharge point and the BSB WWTP discharge. The site is administered by DEQ with oversight by EPA.

6.3.3.4 Streamside Tailings Operable Unit (SSTOU)

The SSTOU is divided into 4 subareas that encompass Silver Bow Creek and its floodplain from the downstream boundary of LAO to the I-90 bridges downstream of the Gregson Creek confluence. Since 2001, remediation efforts in the SSTOU have removed much of the tailings and mine waste along the creek and re-constructed/re-contoured the channel while treating some wastes in-situ, and established native vegetation in the floodplain. Work has been completed in subareas 1 and 2 and is anticipated to be completed in subareas 3 and 4 by the end of 2015. The SSTOU ROD was signed in November 1995 (U.S. Environmental Protection Agency, 1995b).

The design criteria for Silver Bow Creek are guided by the ROD (U.S. Environmental Protection Agency, 2006) and the CRDWP (Atlantic Richfield Company, 1997). The ROD states, "After removal of contaminated sediments, the channel bed and streambank will be reconstructed to an appropriate slope and other critical dimensions with materials of appropriate size, shape and composition. This reconfigured bed will contain suitable bedform morphology (riffles, bars, pools, etc.) for aquatic habitat." Remediation work in the four subareas was based on channel stability analyses and conceptual design reports completed by DEQ contractors (Montana Department of Environmental Quality, 1997; Montana Department of Environmental Quality, 2003; Montana Department of Environmental Quality, 2007; Montana Department of Environmental Quality, 2008).

6.3.3.5 Rocker Timber Framing and Treating Plant

Located approximately seven miles west of Rocker, Montana, the site was used to treat mining timbers with a creosote solution and later an arsenic trioxide solution was also used in the timber treatment process. The ROD was signed in December 1995 (U.S. Environmental Protection Agency, 1995a). Cleanup of contaminated soils and groundwater occurred in 1997. The site is administered by EPA.

6.3.3.6 West Camp/Travona Shaft Area

Located within the BPSOU immediately to the northwest of the LAO, in 1989, rising mine waters were addressed by a pumping and piping system that sent waters to the Metro Plant. This prevented basement flooding and discharges of contaminated groundwater to the alluvial aquifer and Silver Bow Creek. The site is administered by EPA as part of the BPSOU.

6.4 Water Quality Data Sources

DEQ's nutrient water quality assessment method has specific objectives and decision-making criteria for assessing the validity and reliability of data. DEQ uses a Data Quality Analysis (DQA) process to evaluate data for use in assessments and decision making. The DQA considers the technical, representativeness, currency, quality, and the spatial and temporal components of the readily available data. The specific data requirements are detailed in the nutrient assessment method (Suplee and Sada de Suplee, 2011).

Primary data sources used to evaluate existing instream nutrient concentrations in the Upper Clark Fork Phase 2 TPA include the following:

1) **DEQ Monitoring and Assessment sampling.** In support of TMDL development, the Monitoring and Assessment Section of the Water Quality Planning Bureau at DEQ collected water chemistry, chlorophyll-*a* (chl-*a*) and macroinvertebrate samples from impaired tributaries with the exception of Silver Bow Creek.
2) **DEQ Remediation sampling.** As part of several different projects, contractors collected water chemistry and macroinvertebrate samples from the Clark Fork River mainstem and several tributaries including significant sampling efforts on Silver Bow Creek upstream of Warm Springs Ponds.
3) **DEQ Assessment Files.** The files contain information used to make the existing nutrient impairment determinations. This includes water quality and algal data results and historical information collected or obtained by DEQ.
4) **USFS PIBO Data.** USFS's PIBO group collects macroinvertebrate data throughout the Mountain West. Data collected in 2003, 2008 and 2011 on identified AUs was used in the analysis.

Secondary data sources used to evaluate existing instream nutrient concentrations in the Upper Clark Fork River watershed:

- Groundwater/surface water quality data from MBMG's GWIC database
- USGS's National Water Information System database
- DMR data from permitted point source dischargers

Primary data sources include those collected in the AUs and within the specific waterbody segment(s). Only primary data sources that passed DEQ's DQA process were used to make impairment determinations. Secondary data sources include data collected as part of DMR by MPDES permittees and other groundwater and surface water data sources used to quantify or describe point and nonpoint sources within a sub-basin. This includes surface water data collected outside the summer period (July 1 to September 30) when nutrient water quality targets apply.

Because these sampling events represent the most recent, and the most exhaustive, water quality characterization of nutrients, DEQ used data from these events as the primary source for evaluating water quality targets and assessing nutrient sources. Raw data from these sources are extensive and are not included but are publicly available via EPA's EPA STOrage and RETrieval database water quality database and DEQ's EQuIS water quality database. Data are also available from DEQ upon request.

The following section provides an evaluation of water quality conditions with respect to nutrients for stream segments of concern in the Upper Clark Fork River Phase 2 TPA. **Figure 6-2** identifies the streams of concern for nutrients and the available water quality data for the Upper Clark Fork River Phase 2 TPA, excluding MBMG data for surface water and groundwater.

It is worth noting that, while not included here, ARCO has been collecting nutrient data on Silver Bow Creek, Blacktail Creek, the MSD, and Buffalo Gulch since 2012. Available data for the Silver Bow Creek watershed is quite extensive. DEQ determined that the data outlined below was of quality and scope extensive enough to make an impairment determination independent of the ARCO data collection efforts which are, themselves, commendable.

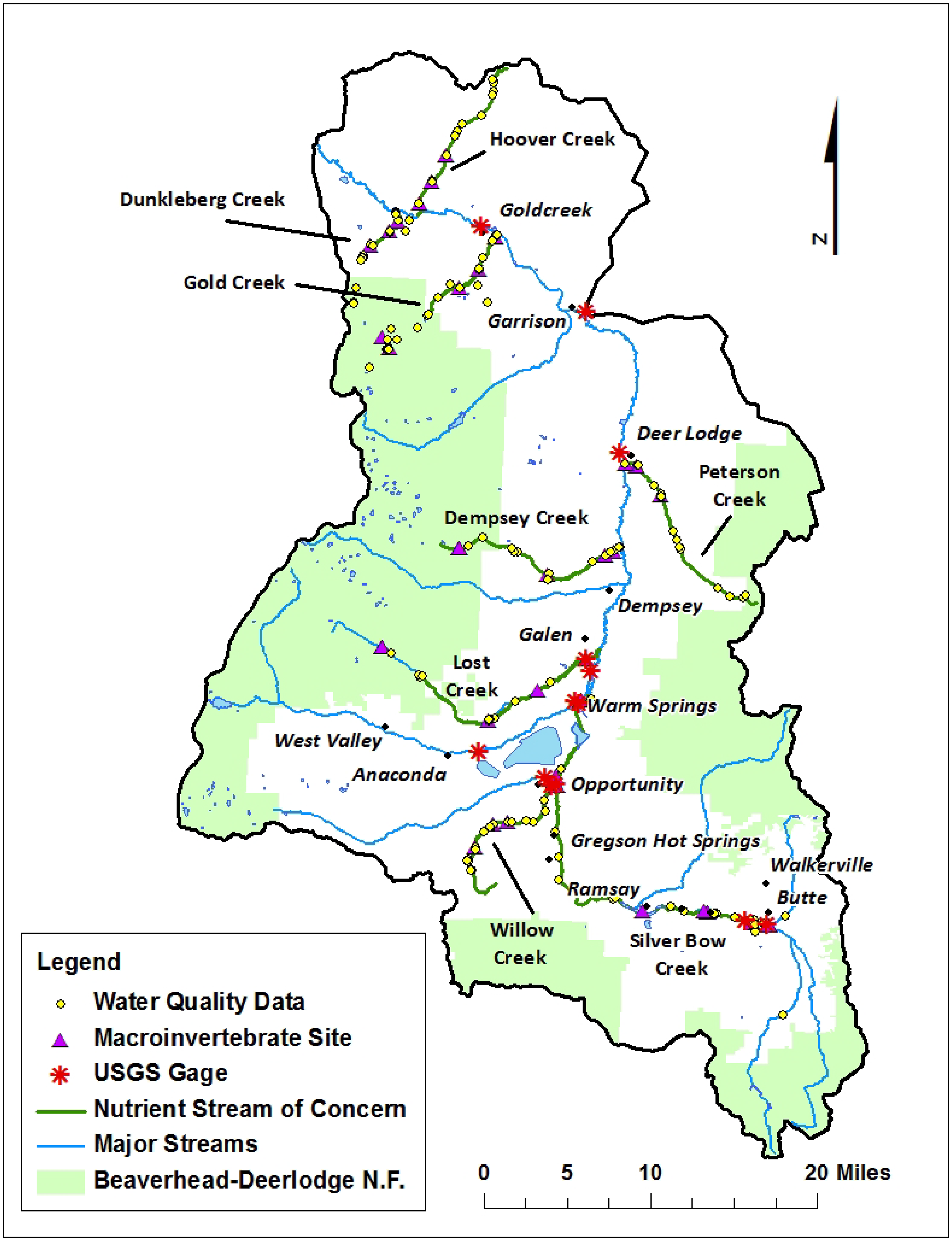

Figure 6-2. Nutrient Sampling Sites on the Streams of Concern

TMDL water quality targets are numeric indicators used to evaluate attainment of water quality standards. They are discussed in **Section 4.0**. The following section presents nutrient water quality targets and compares those values with recently collected nutrient data in the Upper Clark Fork Phase 2 TPA using DEQ's draft assessment methodology (Suplee and Sada de Suplee, 2011). To be consistent with DEQ's draft assessment methodology, and because analytical methods have improved, only data from the past 10 years (2003–12) are included in the review of existing data. Additionally, many of the nutrient samples collected before 2005 were analyzed for total Kjeldahl nitrogen (TKN), which DEQ has since replaced with total persulfate nitrogen as the preferred analytical method for determining TN. TN has also replaced TKN as a preferred parameter for evaluating nitrogen impairment. It should be noted that DEQ Circular 12 includes both of these analytical methods as means of determining TN.

6.4.1 Nutrient Water Quality Standards

Montana's water quality standards for nutrients (nitrogen and phosphorous forms) are narrative and are addressed via narrative criteria requiring that state surface waters be free from substances attributable to municipal, industrial, or agricultural practices or other discharges that produce nuisance conditions; create concentrations or combinations of material toxic or harmful to aquatic life; or create conditions that produce undesirable aquatic life [ARM 17.30.637(1)]. DEQ is currently developing numeric nutrient criteria at levels consistent with the requirements of narrative criteria. These draft numeric criteria are the basis for the nutrient TMDL targets consistent with EPA's TMDL development guidance (http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/strategy/) and federal regulations (40 CFR §131.11(a) & (b)).

6.4.2 Nutrient Target Values

Nutrient water quality targets include nutrient concentrations in surface waters and measures of benthic algae chl-*a* (a form of undesirable aquatic life at elevated concentrations). The target concentrations for nitrogen and phosphorus are established at levels found to protect aquatic life and recreation. Since 2002, Montana has conducted a number of studies in order to develop numeric criteria for nutrients (N and P forms) and has developed draft nutrient criteria for TN, TP, and chl-*a* concentration, based on two factors: (1) the results of public perception surveys (Suplee et al., 2009) on what level of algae was perceived as undesirable and (2) the results of nutrient stressor-response studies to determine nutrient concentrations that will maintain algal growth below undesirable levels and to identify reference values (Suplee et al., 2008). When algal levels in a stream increase, shifts in biomass and community structure are likely as dissolved oxygen concentrations decrease and salmonid growth and survival becomes impaired.

The target values are based on the most sensitive uses; therefore, the nutrient TMDLs are protective of all designated uses. Nutrient targets for TN, TP, and chl-*a* are based on the draft nutrient criteria and are presented in **Table 6-3**.

The draft nutrient criteria apply during summer months (generally July 1–September 30), when algal growth has the highest potential to affect beneficial uses. Note that targets in this document are established specifically for nutrient TMDL development in the Upper Clark Fork Phase 2 TPA and may or may not apply to streams in other TPAs. See **Section 6.8.1** for the adaptive management strategy related to nutrient water quality targets.

Table 6-3. Nutrient Targets in the Upper Clark Fork Phase 2 TPA

Parameter	Target Values
	Middle Rockies (Level III)
Nitrate+Nitrite (NO_3+NO_2)	≤ 0.100 mg/L
Total Nitrogen (TN)	≤ 0.300 mg/L
Total Phosphorous (TP)	≤ 0.030 mg/L
Chlorophyll-*a*	≤ 125 mg/m² (≤35 g AFDM/m^2)[a]

[a] AFDM = ash-free dry mass

Within the Upper Clark Fork Phase 2 TPA, there are a few special considerations concerning water quality targets that should be mentioned. These are the Gold Creek and Dunkleberg Creek complex in the northern portion of the TPA and the influence of volcanic surficial geologies on instream TP concentrations.

6.4.2.1 Gold Creek/Dunkleberg Creek Complex
A special note on the Dunkleberg Creek and Gold Creek AUs is warranted. Extensive research on Gold Creek and several of its tributaries that enter the mainstem in the lower portion of the sub-watershed has been conducted by two separate University of Montana graduate theses (Carey, 1991; Krier, 2004), the Tri-State Water Quality Council (McDowell and Watkins, 2004), and the Watershed Restoration Coalition (WRC) using a DEQ 319 grant (KirK Environmental, LLC, 2004) in addition to tributary monitoring by DEQ personnel. This body of work provides evidence that a natural, geologic source of dissolved phosphorus occurs in the Gold Creek and Dunkleberg Creek drainages. However, given current land uses and irrigation management of these watersheds, DEQ is unable to separate natural phosphorus loads from those caused by anthropogenic activities in the watershed. If, at some future time, water quality can be determined to have been restored to a condition where all reasonable land, soil and water conservation practices have been implemented, collected data may be used to develop site-specific water quality targets for Dunkleberg Creek and Gold Creek downstream of the forest boundary which are different than the Level III Middle Rockies Ecoregion targets.

6.4.2.2 Influence of Volcanic Geology
Analysis of DEQ reference data suggested that there is a subset of DEQ reference sites within the Middle Rockies ecoregion that are influenced by volcanic geology. This volcanic geology promotes higher phosphorus concentrations than what is typically seen in Middle Rockies ecoregion streams as a whole. Volcanic geology constitutes a significant portion of several nutrient-impaired streams in the Upper Cark Fork Phase 2 TPA including Hoover Creek, Peterson Creek, Willow Creek, and Browns Gulch (tributary to Silver Bow Creek). As the parent material for soil development in the aforementioned impaired streams, these systems are at potentially higher risk of target exceedance for TP due to sediment deposition/transport of phosphorus-enriched soils. However, data analysis was limited and existing data were not strong enough to support alternative water quality targets to those in **Table 6-3**. In addition, volcanic derived soils are often more highly erodible than other soils with different parent materials in a similar climatic regime. Hoover Creek, Browns Gulch, Peterson Creek and Willow Creek have completed sediment TMDLs and a sediment TMDL for Silver Bow Creek is included in **Section 5.9.3.1** of this document.

6.4.3 Existing Conditions and Comparison with Targets
DEQ evaluated nutrient target attainment by comparing existing water quality conditions with the water quality targets in **Table 6-3**, using the methodology in DEQ's guidance document "2011 Assessment

Methodology for Determining Wadeable Stream Impairment due to Excess Nitrogen and Phosphorus Levels" (Suplee and Sada de Suplee, 2011). For each waterbody segment, a data summary will be presented along with a comparison of existing data with targets, using the assessment methodology and a TMDL development determination. Because most of the impairment listings are based on older data, or were listed before numeric criteria were developed, each stream segment will be evaluated for impairment from NO_3+NO_2, TN, and TP using data collected within the past 10 years. TMDL development determinations will depend on results of the data evaluation, and these updated impairment conclusions will be captured in the 2014 303(d) List and associated 2014 Water Quality IR.

The assessment methodology uses two statistical tests (Exact Binomial Test and the One-Sample Student's T-test for the Mean) and a chl-*a*/ash-free dry mass (AFDM) threshold value to evaluate water quality data for compliance with established target values. In general, water quality targets are not attained (a) when nutrient chemistry data has a target exceedance rate of >20% (Exact Binomial Test), (b) when the results of mean water quality nutrient chemistry exceed target values (Student T-test), or (c) when a single chl-*a* result exceeds benthic algal target concentrations (125 mg/m^2 or 35 g AFDM/m^2). In some cases, the chl-*a* SOP allows for a visual assessment where the collector determines that at all sampling transects, chl-*a* densities are less than 50 mg/m^2. In these cases, samples are not collected and the site is qualitatively assessed as having a chl-*a* density <50 mg/m^2. Where water chemistry and algae data do not provide a clear determination of impairment status, or when other limitations exist, the Hilsenhoff Biotic Metric (HBI) biometric is considered in further evaluating whether nutrient targets have been achieved, as directed by the assessment methodology. The HBI is a biometric based on tolerance values. A large number of macroinvertebrate taxa have been assigned a numeric value which represents the organism's tolerance to organic pollution (Barbour et al., 1999). HBI is then calculated as a weighted average tolerance value of all individuals in a sample (Suplee and Sada de Suplee, 2011). Higher index values indicate increasing tolerance to pollution.

Periphyton biometrics were developed by DEQ for Montana as an indicator of impairment. The exception to this use of diatoms is the Middle Rockies Level III Ecoregion, for which there are no validated diatom increaser metrics. The Upper Clark Fork Phase 2 TPA is entirely within the Middle Rockies ecoregion and, therefore, diatom metrics were not included in impairment assessments.

Note: to ensure a higher degree of certainty for removing an impairment determination and making any new determination, the statistical tests are configured differently for an unlisted nutrient form than for a listed nutrient form, which may result in a different number of allowable exceedances for nutrients within a single stream segment. This helps assure that assessment reaches do not fluctuate between listed and delisted status by the change in results from a single additional sample.

6.4.3.1 Dempsey Creek (MT76G002_100)

On the 2012 303(d) List, Dempsey Creek is listed for NO_3+NO_2. First listed in 2000, the AU includes Dempsey Creek from the USFS administrative boundary to the mouth (Clark Fork River) and encompasses a distance of 13.44 miles. The stream flows through large irrigated acreages and two main irrigation canals cross the channel (Morrison Ditch and West Side Canal).

Extensive sampling was conducted from 2007 to 2011 and includes >30 water chemistry samples for NO_3+NO_2, TN, and TP. There are also 21 chl-*a* samples, 9 AFDM samples and 8 macroinvertebrate samples (**Table 6-4**). One chl-*a* sample was above criteria (>125 mg/m^2) although none of the AFDM samples indicated impairment. Of 32 water chemistry samples, the NO_3+NO_2, TN and TP targets were exceeded in 9%, 31%, and 38% of samples respectively. Therefore, TN and TP both failed the binomial statistical test although both passed the student t-test (**Table 6-5**). The failure of the binomial test for TN and TP in addition to the macroinvertebrate data, which found 3 of 8 samples exceeded the HBI threshold (>4) indicate that Dempsey Creek is impaired by TN and TP. However, Dempsey Creek was determined to not be impaired for NO_3+NO_2. TMDLs for TN and TP will be prepared for this AU. The single chl-*a* exceedance is linked to the TN and TP impairments.

Table 6-4. Nutrient Data Summary for Dempsey Creek

Nutrient Parameter	Sample Timeframe	n	Min (mg/L)	Max (mg/L)	Mean (mg/L)	80^{th} Percentile (mg/L)
Nitrate+Nitrite	2007–11	32	<0.01	0.27	0.03	<0.01
TN	2007–11	32	<0.05	0.81	0.26	0.45
TP	2007–11	32	<0.005	0.06	0.02	0.04
Chlorophyll-*a*	2010–11	21	<0.01	158	20.78	23.88
AFDM	2010–11	9	3.45	25.87	7.65	6.91
Macroinvertebrate HBI	2003–11	8	2.19	5.59	3.54	4.29

Table 6-5. Assessment Method Evaluation Results for Dempsey Creek

Nutrient Parameter	Sample Size	Target Value (mg/L)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	TMDL Required?
Nitrate+Nitrite	32	0.100	3	PASS	PASS	FAIL	PASS	NO
TN	32	0.300	10	FAIL	PASS			YES
TP	32	0.030	12	FAIL	PASS			YES

6.4.3.2 Dunkleberg Creek (MT76G005_072)

The Dunkleberg Creek AU is from T9N R12W S2 to the mouth (Un-named canal); a total distance of 4.05 miles. At present, the stream does not terminate at the Clark Fork River into which it historically flowed. The stream was first listed for a TN impairment in 1990. It is listed for a TN nutrient impairment on the 2012 303(d) List.

Sampling was conducted from 2007 to 2011 and includes 18 water chemistry samples for NO_3+NO_2, TN and TP. There are six chl-*a* samples, two AFDM samples, and three macroinvertebrate samples (**Table 6-6**). None of the chl-*a* samples were above criteria (>125 mg/m^2) and none of the AFDM samples indicated impairment. However, TN failed the binomial test and TP failed both statistical tests (**Table 6-7**). In available data, TP exceeded the target in 72% of samples. The results of the statistical tests in addition to the macroinvertebrate data that found 1 of 3 samples exceeded the HBI threshold (>4) indicate that Dunkleberg Creek is impaired for TP. Dunkleberg Creek has an existing listing for TN and assessment data suggest that the stream is still impaired for TN. A TN and a TP TMDL will be prepared for Dunkleberg Creek.

Table 6-6. Nutrient Data Summary for Dunkleberg Creek

Nutrient Parameter	Sample Timeframe	n	Min (mg/L)	Max (mg/L)	Mean (mg/L)	80^{th} Percentile (mg/L)
Nitrate+Nitrite	2007–10	18	<0.01	0.19	0.05	0.08
TN	2007–11	18	0.08	0.38	0.20	0.26
TP	2007–11	18	0.02	0.07	0.04	0.06
Chlorophyll-*a*	2010–11	6	0.90	8.15	3.88	6.73
AFDM	2010–11	2	3.2	10.8	*NA*	*NA*
Macroinvertebrate HBI	2011	3	2.63	5.09	3.71	4.42

Table 6-7. Assessment Method Evaluation Results for Dunkleberg Creek

Nutrient Parameter	Sample Size	Target Value (mg/L)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	TMDL Required?
Nitrate+Nitrite	18	0.100	1	PASS	PASS	PASS	PASS	NO
TN	18	0.300	2	FAIL	PASS			YES
TP	18	0.030	13	FAIL	FAIL			YES

6.4.3.3 Gold Creek (MT76G005_092)

The segment of Gold Creek from the USFS boundary to the mouth with the Clark Fork River is listed for a TN impairment on the 2012 303(d) List. This segment includes 7.77 stream miles and was first listed for TN in 1990.

Extensive sampling was completed in the Gold Creek AU from 2003 to 2010 with >15 water chemistry samples for NO_3+NO_2, TN, and TP (**Table 6-8**). The available data also include chl-*a* (*n*=8), AFDM (*n*=8), and macroinvertebrates (*n*=4). NO_3+NO_2 and TN passed both statistical tests while TP failed both the binomial and student's t-test (**Table 6-9**). In available data, TP exceeded the target in 34% of samples. The chl-*a* and AFDM did not exceed thresholds for impairment although 3 of 4 macroinvertebrate samples exceeded the HBI score of 4 indicating an impaired condition. It is possible that the fine substrate found through much of the lower drainage is not conducive to growth of chlorophyll. The results of the analysis clearly indicate that the AU is not impaired for NO_3+NO_2 or TN but that the segment is impaired for TP based on a water quality target of 0.030 mg/L TP. Therefore the stream will be delisted for TN and a TP TMDL will be developed for Gold Creek.

Table 6-8. Nutrient Data Summary for Gold Creek

Nutrient Parameter	Sample Timeframe	n	Min (mg/L)	Max (mg/L)	Mean (mg/L)	80th Percentile (mg/L)
Nitrate+Nitrite	2003–10	35	<0.01	0.03	0.01	0.02
TN	2007–10	16	<0.05	0.53	0.13	0.14
TP	2007–10	16	<0.005	0.12	0.04	0.06
Chlorophyll-*a*	2010–11	8	1.80	10.71	5.50	7.70
AFDM	2010–11	8	3.58	13.96	5.69	6.83
Macroinvertebrate HBI	2011	4	2.75	5.76	4.58	5.52

Table 6-9. Assessment Method Evaluation Results for Gold Creek

Nutrient Parameter	Sample Size	Target Value (mg/L)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	TMDL Required?
Nitrate+Nitrite	35	0.100	0	PASS	PASS	PASS	PASS	NO
TN	16	0.300	1	PASS	PASS			NO
TP	16	0.030	7	FAIL	FAIL			YES

6.4.3.4 Hoover Creek, upper (MT76G005_081)

The upper segment of Hoover Creek is not listed for a nutrient impairment on the 2012 303(d) List. The AU includes Hoover Creek from the headwaters to Miller Lake, a dammed impoundment on Hoover Creek. This is a total distance of 5.1 miles.

All sampling on upper Hoover Creek was conducted in 2010 and includes 12 water chemistry samples for NO_3+NO_2, TN and TP (**Table 6-10**). Also collected were four samples each for chl-*a* and AFDM. No macroinvertebrate data are available for this segment of Hoover Creek. NO_3+NO_2 and TN passed both statistical tests while TP failed both the binomial and student's t-test (**Table 6-11**). In available data, TP exceeded the target in 100% of samples. There were no exceedances of the chl-*a* threshold of 125 mg/m^2 for the samples collected. However, 2 of 4 AFDM samples exceeded the threshold of 35 g/m^2. The assessment summary clearly identifies TP as impairing beneficial uses in upper Hoover Creek and the segment will be listed for a TP impairment and a TP TMDL will be developed.

Table 6-10. Nutrient Data Summary for Upper Hoover Creek

Nutrient Parameter	Sample Timeframe	n	Min (mg/L)	Max (mg/L)	Mean (mg/L)	80^{th} Percentile (mg/L)
Nitrate+Nitrite	2010	12	<0.01	0.05	0.02	0.04
TN	2010	12	0.11	0.27	0.17	0.18
TP	2010	12	0.09	0.14	0.11	0.13
Chlorophyll-*a*	2010	4	2.15	4.85	3.91	4.56
AFDM	2010	4	7.30	314.60	144.68	272.84
Macroinvertebrate HBI	NA	0	NA	NA	NA	NA

Table 6-11. Assessment Method Evaluation Results for Upper Hoover Creek

Nutrient Parameter	Sample Size	Target Value (mg/L)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	TMDL Required?
Nitrate+Nitrite	12	0.100	0	PASS	PASS	PASS	FAIL	NO
TN	12	0.300	0	PASS	PASS			NO
TP	12	0.030	12	FAIL	FAIL			YES

6.4.3.5 Hoover Creek, lower (MT76G005_082)

On the 2012 303(d) List, Hoover Creek downstream of Miller Lake is listed for a TN impairment. First listed in 1990, the AU includes Hoover Creek from Miller Lake, a dammed impoundment on Hoover Creek, to the mouth (Clark Fork River). This is a total distance of 7.05 miles.

Extensive water quality sampling was conducted on the lower segment of Hoover Creek between 2007 and 2011 and includes 20 water chemistry samples for NO_3+NO_2, TN, and TP (**Table 6-12**). In addition, 12 chl-*a* and 10 AFDM samples between 2007 and 2011 were also collected as well as 3 macroinvertebrate samples in 2011. Of 20 water chemistry samples, the NO_3+NO_2, TN and TP targets were exceeded in 30%, 60%, and 95% of samples respectively (**Table 6-13**). TN and TP failed both statistical tests although there were no exceedances of chl-*a* (>125 mg/m^2) or AFDM (>35 g/m^2) observed in this segment. However, 2 of 3 macroinvertebrate HBI scores were >4 indicating an impairment. The statistical results indicate a TN and TP nutrient impairment on lower Hoover Creek. TN and TP TMDLs will be prepared for the lower segment of Hoover Creek.

NO_3+NO_2 failed the binomial test and passed the t-test. As the stream was determined to be impaired for TN, it will not be listed for NO_3+NO_2. Had TN not been determined to be impaired lower Hoover Creek, a new NO_3+NO_2 listing would have been created to address nitrogen.

Table 6-12. Nutrient Data Summary for Lower Hoover Creek

Nutrient Parameter	Sample Timeframe	n	Min (mg/L)	Max (mg/L)	Mean (mg/L)	80th Percentile (mg/L)
Nitrate+Nitrite	2007–11	20	<0.01	0.39	0.07	0.12
TN	2007–11	20	0.14	1.38	0.46	0.62
TP	2007–11	20	0.03	0.47	0.11	0.13
Chlorophyll-*a*	2010–11	14	2.70	9.89	6.71	9.65
AFDM	2010–11	12	3.76	17.56	9.77	14.72
Macroinvertebrate HBI	2011	3	3.80	5.36	4.74	5.24

Table 6-13. Assessment Method Evaluation Results for Lower Hoover Creek

Nutrient Parameter	Sample Size	Target Value (mg/L)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	TMDL Required?
Nitrate+Nitrite	20	0.100	6	FAIL	PASS			NO
TN	20	0.300	12	FAIL	FAIL	PASS	FAIL	YES
TP	20	0.030	19	FAIL	FAIL			YES

6.4.3.6 Lost Creek (MT76G002_072)

On the 2012 303(d) List, Lost Creek is listed for Nitrate/Nitrite (Nitrite + Nitrate as N). First listed in 1990, the AU includes Lost Creek from the south state park boundary to mouth (Clark Fork River). This is a total distance of 19.07 miles.

Extensive water quality sampling was conducted on Lost Creek downstream of the Lost Creek State Park between 2007 and 2011 and includes 21 water chemistry samples for NO_3+NO_2, TN, and TP (**Table 6-14**). In addition, 9 chl-*a* and 4 AFDM samples between 2007 and 2011 were also collected as well as 8 macroinvertebrate samples between 2003 and 2011. Of 21 water chemistry samples, the NO_3+NO_2, TN, and TP targets were exceeded in 33%, 38%, and 0% of samples respectively (**Table 6-15**). TP passed both statistical tests while NO_3+NO_2 failed both the binomial test and the t-test and TN failed the binomial test. There were two exceedances of chl-*a* (>125 mg/m^2) and no exceedances of AFDM (<35 g/m^2) observed in this segment. Of the eight macroinvertebrate samples, three exceeded the HBI threshold of 4 indicating impairment. The existing NO_3+NO_2 impairment is supported by the data. In addition, the waterbody is determined to be impaired by TN given a combination of a failure of the binomial test and chl-*a* exceedances. Because the $N0_3$+ $N0_2$ impairment is reflected in the TN data, a TMDL for $N0_3$+ $N0_2$ will be not developed but will be addressed by the TMDL for TN.

Table 6-14. Nutrient Data Summary for Lost Creek

Nutrient Parameter	Sample Timeframe	n	Min (mg/L)	Max (mg/L)	Mean (mg/L)	80th Percentile (mg/L)
Nitrate+Nitrite	2007–11	21	<0.005	0.47	0.10	0.17
TN	2007–11	21	<0.100	0.56	0.25	0.42
TP	2007–11	21	<0.005	0.02	0.01	0.01
Chlorophyll-*a*	2010–11	9	1.30	183.0	50.02	83.8
AFDM	2010–11	4	3.26	17.80	8.59	12.92
Macroinvertebrate HBI	2003–11	8	1.83	5.21	3.13	4.66

Table 6-15. Assessment Method Evaluation Results for Lost Creek

<table>
<tr><th>Nutrient Parameter</th><th>Sample Size</th><th>Target Value (mg/L)</th><th>Target Exceedances</th><th>Binomial Test Result</th><th>T-test Result</th><th>Chl-a Test Result</th><th>AFDM Test Result</th><th>TMDL Required?</th></tr>
<tr><td>Nitrate+Nitrite</td><td>21</td><td>0.100</td><td>7</td><td>FAIL</td><td>FAIL</td><td rowspan="3">FAIL</td><td rowspan="3">PASS</td><td>YES</td></tr>
<tr><td>TN</td><td>21</td><td>0.300</td><td>8</td><td>FAIL</td><td>PASS</td><td>YES</td></tr>
<tr><td>TP</td><td>21</td><td>0.030</td><td>0</td><td>PASS</td><td>PASS</td><td>NO</td></tr>
</table>

6.4.3.7 Petersen Creek, upper (MT76G002_131)

On the 2012 303(d) List, upper Peterson Creek is listed for a TKN, TN and TP impairments. First listed in 2006, the AU includes Peterson Creek from the headwaters to the Jack Creek confluence. This is a total distance of 6.27 miles.

Water quality sampling was conducted on upper Peterson Creek between 2007 and 2010 and includes 16 water chemistry samples for NO_3+NO_2, TN, and TP (**Table 6-16**). In addition, 8 chl-*a* and 4 AFDM samples between 2007 and 2011 were also collected. There is no macroinvertebrate data available for this segment. Of 16 water chemistry samples, the NO_3+NO_2, TN and TP targets were exceeded in 0%, 6%, and 44% of samples respectively (**Table 6-17**). NO_3+NO_2 and TN passed both statistical tests while TP failed the binomial test and passed the t-test. There was 1 exceedance of chl-*a* (>125 mg/m^2) and 1 exceedance of AFDM (<35 g/m^2) observed in this segment.

DEQ does not have a formal assessment method for TKN for which this segment is currently listed. Although TN passed both statistical tests and there was only a single exceedance of the water quality target in the data, chl-*a,* and AFDM exceeded targets and there is not enough data to support a TN delisting in the segment. Therefore, TN and TKN will remain listed as nutrient impairments on upper Peterson Creek and a TN TMDL will be developed to address the existing TN and TKN impairments on the segment. A TP TMDL will also be completed.

Table 6-16. Nutrient Data Summary for Upper Peterson Creek

Nutrient Parameter	Sample Timeframe	n	Min (mg/L)	Max (mg/L)	Mean (mg/L)	80th Percentile (mg/L)
Nitrate+Nitrite	2007–10	16	<0.010	0.02	0.006	0.005
TN	2007–10	16	<0.100	0.35	0.15	0.20
TP	2007–10	16	0.01	0.07	0.03	0.05
Chlorophyll-*a*	2010	8	3.46	135.00	21.56	8.99
AFDM	2010	4	6.13	201.40	54.86	85.44
Macroinvertebrate HBI	NA	0	NA	NA	NA	NA

Table 6-17. Assessment Method Evaluation Results for Upper Peterson Creek

<table>
<tr><th>Nutrient Parameter</th><th>Sample Size</th><th>Target Value (mg/L)</th><th>Target Exceedances</th><th>Binomial Test Result</th><th>T-test Result</th><th>Chl-a Test Result</th><th>AFDM Test Result</th><th>TMDL Required?</th></tr>
<tr><td>Nitrate+Nitrite</td><td>16</td><td>0.100</td><td>0</td><td>PASS</td><td>PASS</td><td rowspan="3">FAIL</td><td rowspan="3">FAIL</td><td>NO</td></tr>
<tr><td>TN</td><td>16</td><td>0.300</td><td>1</td><td>PASS</td><td>PASS</td><td>YES</td></tr>
<tr><td>TP</td><td>16</td><td>0.030</td><td>7</td><td>FAIL</td><td>PASS</td><td>YES</td></tr>
</table>

6.4.3.8 Petersen Creek, lower (MT76G002_132)

The lower segment of Peterson Creek has no nutrient impairment listings on the 2012 303(d) List. The AU flows a distance of 6.27 miles from the Jack Creek confluence to the mouth (Clark Fork River).

Water quality sampling was conducted on lower Peterson Creek between 2007 and 2011 and includes >20 water chemistry samples for NO_3+NO_2, TN, and TP (**Table 6-18**). In addition, 7 chl-*a* and 4 AFDM samples were collected in 2010 and 2011 in addition to 3 macroinvertebrate samples collected between in 2011. For all water chemistry samples, the NO_3+NO_2, TN and TP targets were exceeded in 0%, 88%, and 100% of samples respectively (**Table 6-19**). NO_3+NO_2 passed both statistical tests while TN and TP failed both the binomial test and the t-test. There was 1 exceedance of chl-*a* (>125 mg/m^2) but zero exceedances of AFDM (<35 g/m^2) observed in this segment. One of 3 macroinvertebrate samples had an HBI score >4 indicating impairment.

The results of the assessment indicate that the beneficial uses in the lower segment of Peterson Creek are impaired by TN and TP. TMDLs will be prepared for both TN and TP for lower Peterson Creek.

Table 6-18. Nutrient Data Summary for Lower Peterson Creek

Nutrient Parameter	Sample Timeframe	n	Min (mg/L)	Max (mg/L)	Mean (mg/L)	80th Percentile (mg/L)
Nitrate+Nitrite	2007–11	23	<0.01	0.05	0.01	0.02
TN	2007–11	24	0.18	1.10	0.54	0.68
TP	2007–11	23	0.05	0.35	0.17	0.22
Chlorophyll-*a*	2010–11	12	<0.01	147.0	27.31	32.94
AFDM	2010–11	7	4.60	14.2	8.34	10.58
Macroinvertebrate HBI	2011	3	3.23	5.90	4.36	5.11

Table 6-19. Assessment Method Evaluation Results for Lower Peterson Creek

Nutrient Parameter	Sample Size	Target Value (mg/L)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	TMDL Required?
Nitrate+Nitrite	23	0.100	0	PASS	PASS			NO
TN	24	0.300	21	FAIL	FAIL	FAIL	PASS	YES
TP	23	0.030	23	FAIL	FAIL			YES

6.4.3.9 Silver Bow Creek (MT76G003_020)

Silver Bow Creek is listed for nitrates on the 2012 303(d) List. The AU includes the 29.2 miles from the headwaters to the mouth (Clark Fork River). The headwaters are defined as the confluence of Blacktail Creek and the MSD. A stormwater conveyance, MSD is approximately 6,000 ft long beginning near the Civic Center in Butte and terminating where it meets Blacktail Creek to form Silver Bow Creek. Beneath the MSD, there is an 8-inch slotted pipeline packed in gravel which captures groundwater inflow that is then pumped to the LAO treatment facility adjacent to Silver Bow Creek. This groundwater is treated for metals before being discharged to Silver Bow Creek. Silver Bow Creek flows through the Warm Springs Ponds before reaching the Clark Fork River. Warm Springs Ponds are excluded in state statute (Statute 17-5-103(34)(b)(i)) and administrative rule (ARM 17.30.607(1)(a)(iii)) as a state waterbody, so formal assessment of Silver Bow Creek extends only to the inlet of the uppermost pond (21.7 miles downstream from the confluence of the MSD and Blacktail Creek). The AU was first listed for nitrates in 1996.

Available nutrient data for Silver Bow Creek upstream of the Warm Springs Ponds inlet are extensive and include 80 samples for $N0_3$+ $N0_2$ and TP and 35 samples for TN (**Table 6-20**). There are no chl-*a* or AFDM data available for the reach but there are 36 macroinvertebrate samples collected in this segment between 2010 and 2012. In the assessment reach, TN, TP, and $N0_3$+ $N0_2$ data exceeded their respective water quality targets for Middle Rockies (0.300 mg/L TN, 0.03 mg/L TP, 0.100 mg/L $N0_3$+ $N0_2$) in 100% of samples (**Table 6-21**). There were no non-detects. The 35 TN data points have a mean of 3.53 mg/L, >11 times the criterion of 0.300 mg/L. The 80 TP data points have a mean of 0.45 mg/L, 15 times the criterion of 0.030 mg/L. The 80 $N0_3$+ $N0_2$ data points have a mean of 2.34 mg/L, >23 times the criterion of 0.100 mg/L. All but 2 macroinvertebrate samples of a total of 36 had an HBI score of >4 indicating impairment.

None of the data from the mixing zone of the WWTP discharge points were used in the analysis. There were no ammonia exceedances of variable standards.

TN, TP, and $N0_3$+ $N0_2$ exceeded both statistical tests and although there are no chl-*a* or AFDM data for this reach, the gross exceedances of water quality targets for all 3 water quality nutrient parameters combined with the macroinvertebrate results indicate a nutrient impairment. Silver Bow Creek from the confluence of the MSD and Blacktail Creek to the Warm Springs Ponds inlet is impaired by nutrients. A TN and TP TMDL will be developed for Silver Bow Creek. Because the $N0_3$+ $N0_2$ impairment is reflected in the TN data, a TMDL for $N0_3$+ $N0_2$ will be not developed but will be addressed by the TMDL for TN.

Table 6-20. Nutrient Data Summary for Silver Bow Creek, Headwaters to Warm Springs Ponds Inlet

Nutrient Parameter	Sample Timeframe	n	Min (mg/L)	Max (mg/L)	Mean (mg/L)	80^{th} Percentile (mg/L)
Nitrate+Nitrite	2003–12	80	0.50	5.63	2.34	3.00
TN	2003–12	35	1.22	11.00	3.53	4.21
TP	2003–12	80	0.04	1.90	0.45	0.62
Chlorophyll-*a*	NA	0	NA			
AFDM	NA	0	NA			
Macroinvertebrate HBI	2010–12	36	2.58	8.11	5.69	6.57

Table 6-21. Assessment Method Evaluation Results for Silver Bow Creek, Headwaters to Warm Springs Ponds Inlet

Nutrient Parameter	Sample Size	Target Value (mg/L)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	TMDL Required?
Nitrate+Nitrite	80	0.100	80	FAIL	FAIL			YES
TN	35	0.300	35	FAIL	FAIL	NA	NA	YES
TP	80	0.030	80	FAIL	FAIL			YES

6.4.3.10 Willow Creek, upper (MT76G002_061)

On the 2012 303(d) List, upper Willow Creek is listed for a TP impairment. First listed in 2006, the AU includes Willow Creek from the headwaters to T4N R10W S30. This is a total distance of 6.13 miles.

Extensive water quality sampling was conducted on upper Willow Creek between 2004 and 2011 and includes >15 water chemistry samples for NO_3+NO_2, TN, and TP (**Table 6-22**). In addition, five chl-*a* and five AFDM samples were collected in 2010 and 2011 in addition to one macroinvertebrate sample collected in 2004. For all water chemistry samples, the NO_3+NO_2, TN and TP targets were exceeded in 0%, 0%, and 95% of samples respectively (**Table 6-23**). NO_3+NO_2 and TN passed both statistical tests while TP failed both the binomial test and the student's t-test. There were no exceedances of chl-*a* (>125 mg/m^2) and one exceedance of AFDM (<35 g/m^2) observed in this segment. The single macroinvertebrate sample had an HBI score <4.

The assessment supports the existing TP listing and a TP TMDL will be developed for upper Willow Creek.

Table 6-22. Nutrient Data Summary for Upper Willow Creek

Nutrient Parameter	Sample Timeframe	n	Min (mg/L)	Max (mg/L)	Mean (mg/L)	80th Percentile (mg/L)
Nitrate+Nitrite	2004–11	20	<0.01	0.06	0.01	0.02
TN	2010–11	19	0.09	0.24	0.16	0.21
TP	2004–11	20	0.02	0.07	0.04	0.05
Chlorophyll-*a*	2010–11	5	5.19	20.47	12.15	9.53
AFDM	2010–11	5	3.11	42.12	12.80	14.01
Macroinvertebrate HBI	2004	1	NA	NA	2.52	NA

Table 6-23. Assessment Method Evaluation Results for Upper Willow Creek

Nutrient Parameter	Sample Size	Target Value (mg/L)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	TMDL Required?
Nitrate+Nitrite	20	0.100	0	PASS	PASS			NO
TN	19	0.300	0	PASS	PASS	PASS	FAIL	NO
TP	20	0.030	19	FAIL	FAIL			YES

6.4.3.11 Willow Creek, lower (MT76G002_062)

The lower segment of Willow Creek is not listed for a nutrient impairment on the 2012 303(d) List. The AU includes Willow Creek from T4N R10W S30 to the mouth (Mill Creek) and flows a distance of 7.1 miles.

Extensive water quality sampling was conducted on upper Willow Creek between 2004 and 2011 and includes >15 water chemistry samples for NO_3+NO_2, TN, and TP (**Table 6-24**). In addition, 11 chl-*a* and 4 AFDM samples were collected in 2010 and 2011 in addition to 2 macroinvertebrate samples collected in 2004 and 2011. For all water chemistry samples, the NO_3+NO_2, TN, and TP targets were exceeded in 0%, 44%, and 82% of samples respectively (**Table 6-25**). NO_3+NO_2 passed both statistical tests while TN failed the binomial test and TP failed both the binomial test and the student's t-test. There were no exceedances of chl-*a* (>125 mg/m^2) or AFDM (<35 g/m^2) observed in this segment. Both macroinvertebrate samples had HBI scores >4 indicating impairment.

The new TN and TP listings on lower Willow Creek are supported by the statistical test results. TP failed the both statistical tests and TN failed only the binomial test. As the initial assessment for TN was inconclusive, HBI scores were reviewed. As both HBI scores were >4 indicating impairment, the segment was determined to be impaired for TN. TN and TP TMDLs will be developed for the lower segment of Willow Creek.

Table 6-24. Nutrient Data Summary for Lower Willow Creek

Nutrient Parameter	Sample Timeframe	n	Min (mg/L)	Max (mg/L)	Mean (mg/L)	80th Percentile (mg/L)
Nitrate+Nitrite	2004–11	17	<0.01	0.07	0.02	0.03
TN	2007–11	16	0.10	0.52	0.28	0.40
TP	2004–11	17	0.01	0.16	0.08	0.12
Chlorophyll-*a*	2010–11	6	1.20	93.00	29.80	59.00
AFDM	2010	4	1.11	10.07	4.57	6.42
Macroinvertebrate HBI	2004, 2011	2	4.84	7.06	6.12	6.82

Table 6-25. Assessment Method Evaluation Results for Lower Willow Creek

Nutrient Parameter	Sample Size	Target Value (mg/L)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	TMDL Required?
Nitrate+Nitrite	17	0.100	0	PASS	PASS	PASS	PASS	NO
TN	16	0.300	7	FAIL	PASS			YES
TP	17	0.030	14	FAIL	FAIL			YES

6.4.4 Nutrient TMDL Development Summary

Table 6-26 summarizes the updated nutrient 303(d) listings for the Upper Clark Fork Phase 2 TPA and updated TMDL development determinations for the waterbodies of concern identified in **Section 6.4.3**. Eighteen TMDLs will be developed for TN and TP, addressing a total of 21 nutrient causes of impairment based on the use of TN as a surrogate TMDL for NO_3+NO_2, and TKN. Note that when compared to **Table 6-1**, TMDLs will be developed for 3 segments not previously identified as impaired for nutrients including upper Hoover Creek, lower Peterson Creek and lower Willow. The updated impairment determinations will be reflected in the 2014 303 (d) Water Quality IR.

Additionally in 2013, DEQ assessed Cable Creek and Storm Lake Creek, which both have non-pollutant chl-*a* listings. DEQ determined that both streams were not impaired for nutrients.

Table 6-26. Summary of Nutrient TMDL Development Determinations

Stream Segment	Waterbody ID	2013 Updated Nutrient Impairment(s)	TMDLs Prepared
DEMPSEY CREEK, national forest boundary to mouth (Clark Fork River)	MT76G002_100	TN, TP	TN, TP
DUNKLEBERG CREEK, T9N R12W S2 to mouth (Un-named Canal), T10N R11W S30	MT76G005_072	TN, TP	TN, TP
GOLD CREEK, the forest boundary to mouth (Clark Fork River)	MT76G005_092	TP	TP
HOOVER CREEK, headwaters to Miller Lake	MT76G005_081	TP	TP
HOOVER CREEK, Miller Lake to mouth (Clark Fork River)	MT76G005_082	TN, TP	TN, TP
LOST CREEK, the south State Park boundary to mouth (Clark Fork River)	MT76G002_072	NO_3+NO_2, TN	TN[a]
PETERSON CREEK, headwaters to Jack Creek	MT76G002_131	TN, TKN, TP	TN[b], TP
PETERSON CREEK, Jack Creek to mouth (Clark Fork River)	MT76G002_132	TN, TP	TN, TP
SILVER BOW CREEK, headwaters to mouth (Clark Fork River)	MT76G003_020	NO_3+NO_2, TN, TP	TN[a], TP

Table 6-26. Summary of Nutrient TMDL Development Determinations

Stream Segment	Waterbody ID	2013 Updated Nutrient Impairment(s)	TMDLs Prepared
WILLOW CREEK, headwaters to T4N R10W S30	MT76G002_061	TP	TP
WILLOW CREEK, T4N R10W S30 to mouth (Mill Creek)	MT76G002_062	TN, TP	TN, TP

[a] TN TMDL is a surrogate for NO_3+NO_2 impairment
[b] TN TMDL is a surrogate for TKN impairment

6.5 Source Assessment, TMDL, and Allocation Approaches

This section provides the overall approach used for source assessment, TMDL development, and allocations. This approach is then applied to each of the eleven stream segments.

6.5.1 Source Assessment Approach

Assessment of existing nutrient (i.e., nitrate, nitrogen and phosphorus) sources is needed to develop LAs to specific source categories. Water quality sampling data collected from 2003 through 2012 represents the most recent data for determining existing nutrient water quality conditions. This data was collected with the objectives of (1) evaluating attainment of water quality targets and (2) assessing load contributions from nutrient sources within the Upper Clark Fork Phase 2 TPA. These data form the primary dataset from which existing water quality conditions were evaluated and from which nitrate, TN and TP loading estimates are derived. Data used to conduct these analyses is publicly available at: http://www.epa.gov/storet/dw_home.html.

This section characterizes the type, magnitude, and distribution of sources contributing to nutrient loading to impaired streams, provides loading estimates for significant source types, and establishes the approach applied toward establishing the TMDLs for each stream and allocations to specific source categories. Source types include natural, septic, and other human-caused sources and are described in further detail for each stream. Source characterization links nutrient sources, nutrient loading to streams, and water quality response, and supports the formulation of the LA portion of the TMDL. As described in **Section 6.4.2**, nitrate, TN, and TP water quality targets are applicable during the summer growing season (i.e., July 1 to September 30) and as a result TMDLs will only apply during this season as well. Consequently, source characterizations are focused mainly on sources and mechanisms that influence nutrient contributions during this period. Total loading estimates are established for the summer growing season time period and are based on observed water quality data and flow conditions measured during this time period. LA estimates for natural, septic, and other human-caused sources are also established for the summer growing season time period and are based on literature values and simple models.

Source characterization and assessment was conducted by using monitoring data collected from the TPA from 2004 through 2012 and simple modeling. Box plots area used to display nutrient values measured from the impaired streams and determine spatial patterns in nutrient concentrations. In descriptive statistics, box plots area a convenient way of graphically depicting groups of numerical date through their five number summaries. Box plots depict the smallest observation (sample minimum), 25th percentile, median, 75th percentile, and the largest observation (sample maximum). Box plots display differences between the data without making any assumptions of the underlying statistical distribution of the data. The spacing between the different parts of the box indicates the degree of dispersion and skewness in data and identifies outliers. For data representation, when sample data was below detection limits the detection limit was used.

Land use in the Upper Clark Fork Phase 2 TPA primarily consists of agriculture (livestock grazing), silviculture (timber harvest), and historical mining along with urban areas in the Summit Valley and, to a lesser extent, in the Deer Lodge Valley. Of the watersheds for which TMDLs will be developed (**Table 6-26**), only Silver Bow Creek contains sites in the watershed with MPDES surface water point source permits. Nutrient sources in most of the listed tributaries consist primarily of (1) natural sources derived from airborne deposition, vegetation, soils, and geologic weathering; and (2) human-caused sources (agriculture, subsurface wastewater treatment and disposal, silviculture, and mining). These sources may include a variety of discrete and diffuse pollutant inputs that have differing pathways to a waterbody.

6.5.1.1 Nonpoint Sources of Nutrients

Nutrient inputs into streams in the Upper Clark Fork Phase 2 TPA come from several nonpoint sources (i.e., diffuse sources that cannot easily be pinpointed). DEQ's source area-based assessment evaluated nutrient contributions from the following nonpoint sources:

- Agriculture (cropping and pasture/rangeland)
- Silviculture (timber harvest)
- Mining
- Subsurface wastewater disposal and treatment (individual, community septic systems and WWTPs that discharge to groundwater)
- Natural background

Agriculture

There are several possible mechanisms for the transport of nutrients from agricultural land to surface water during the growing season. The potential pathways include: the effect of winter grazing on vegetative health and its ability to uptake and nutrients and minimize erosion in upland and riparian areas, breakdown of excrement and loading via surface and subsurface pathways, delivery from grazed forest and rangeland during the growing season, transport of fertilizer applied in late spring via overland flow and groundwater, and the increased mobility of phosphorus caused by irrigation-related saturation of soils in pastures (Green and Kauffman, 1989).

<u>Pastures/Rangeland</u>

Grazing on forest and in pastures is common in the Upper Clark Fork Phase 2 TPA. Cattle are allowed to roam and are not deliberately concentrated along the valley bottoms during the growing season. Horses may also be allowed to roam and graze though they have been mostly observed on small acreage lots that are fenced.

Pastures are managed for hay production during the summer and for grazing during the fall and spring. Hay pastures are thickly vegetated in the summer; less so in the fall through spring. The winter grazing period is long (October–May), and trampling and feeding further reduces biomass when it is already low. Commercial fertilizers are used infrequently in the watershed, and naturally applied cattle manure is a more significant source of nutrients. Cattle manure occurs in higher quantities on pasture ground from October through May because of higher cattle density than that found on range and forested areas.

Rangeland differs from pasture in that rangeland has much less biomass and therefore contributes fewer nutrients from biomass decay. However, manure deposition does play a role. Similar to the forest areas, rangeland is grazed during the summer in the watershed and is managed similarly to the grazing in the forest areas. This manure deposition can result in significant nutrient contribution to an impaired waterbody via tributaries.

More specifically, livestock grazing on state and federal lands is another potential nutrient source in nutrient impaired waterbodies. Grazing allotment data was collected from the Montana Department of Natural Resources & Conservation (DNRC), BLM, and USFS and was compiled per impaired waterbody watershed as total Animal Unit Months (AUM) per drainage (**Table 6-27**). For the purposes of this compilation where allotments spanned sub-watershed boundaries, AUMs were assigned as a percentage of area in each respective sub-watershed. It is recognized that this is a coarse assumption. Grazing duration and total AUMs were determined only for those areas draining to an impaired waterbody. These numbers constitute the existing permits and represent a maximum possible. No attempts were made to verify stocking densities. This compilation is for coarse source assessment purposes only. Of the grazing allotments in the Upper Clark Fork Phase 2 TPA, it is an approximate 50-50 split between those state/federal leases that allow year round grazing and those limited to <4 months during the summer/early fall period.

Table 6-27. Summary of Current Livestock Grazing Numbers on State and Federal Lands in Watersheds with Nutrient Impaired Waterbodies

Drainage Basin[a]	Total Permitted AUMs	Federal/State Lands with Grazing Leases (ac)	Federal/State Land with Grazing Permits as Percentage of Total Drainage Area	Density of Leased Federal/State Land (AUMs/ac)
Dempsey Creek	249	4,362	24.0%	0.06
Dunkleberg Creek	415	4,022	35.0%	0.10
Gold Creek (inc. Pikes Peak Creek)	2,162	24,607	57.7%	0.09
Hoover Creek	358	2,805	14.2%	0.13
Lost Creek	49	2,090	5.4%	0.02
Peterson Creek	843	7,207	36.2%	0.12
Silver Bow Creek	6,174	95,969	28.8%	0.06

[a] Willow Creek, in the southern portion of the TPA, does not have any existing grazing permits on the single section of DNRC administered land in the sub-watershed

__**Irrigated and Dryland Cropping**__

Cropping in the Upper Clark Fork Phase 2 TPA is predominately irrigated production of alfalfa hay and pasture/hay, with smaller acreages of irrigated and dryland small grain production. This category also includes sod farms. Irrigated lands are usually in continuous production and have annual soil disturbance and fertilizer inputs. Dryland cropping may have fallow periods of 16 to 22 months, depending on site characteristics and landowner management. Nutrient pathways include overland runoff, deep percolation, and shallow groundwater flow, which transport nutrients off site.

Silviculture (Timber Harvest)

Silviculture practices inevitably cause some measure of downstream effects that may or may not be significant over time. Changes in land cover will alter the rate at which water evapotranspires and thus the water balance; in that the distribution of water between base flow and runoff will change. Disturbances of the ground surface will also disrupt the hydrological cycle. The combination of these changes can alter water yield, peak flows, and water quality (Jacobson, 2004). Changes in biomass uptake and soil conditions will affect the nutrient cycle. Elevated nitrate concentrations result from increased leaching from the soil as mineralization is enhanced. This increase generally only lasts up to 2 or 3 years before returning to pre-harvest levels (Feller and Kimmins, 1984; Likens et al., 1978; Martin and Harr, 1989). Nutrient uptake by biomass is also greatly reduced after timber harvest, leaving more nutrients available for runoff. Loading from silviculture is not estimated in this document because timber harvest occurs in specific locations within a watershed that differ from one year to the next. In addition, the effect of timber harvest on instream nutrient levels is short term and would be difficult to model as a general effect. In lieu of loading estimates, water quality data was examined in relationship to harvest records to determine if timber harvest is having an identifiable effect.

A coarse assessment of recent timber operations (since 2005) was made based on USFS data for the watersheds of interest in the Upper Clark Fork that have nutrient impaired waterbodies. This data was used to better understand recent operations by scale, prescription, and location in comparison with available water chemistry data. It is used where appropriate to inform the source assessment. Some specific instances will be discussed, such as in the Hoover Creek drainage where timber harvest operations on private lands in the headwaters significantly reduced forest cover and increased road density in the past 10 years. Additionally, large timber harvest operations in the Willow Creek drainage in the mid-1980s will also be discussed.

Mining

Surface water quality can be degraded by releases of contaminants from mine waste material or from co-mingling with acid mine drainage from mine adits. Nutrients impacts from mining can be the result of the use of blasting (e.g., TNT) which introduces nitrate and the use of cyanide which introduces TN. Concentration of potential contaminants depends on whether or not these methods were used, the timing of when mining has taken place, mechanism of chemical release, streamflow, and water chemistry. Like timber harvest, mining has taken place at specific locations within the Upper Clark Fork Phase 2 TPA. In addition, outside of Butte, much of the mining in the area ceased during or before the mid-1900s. As a result, loading from mining was not estimated; instead, water quality data was examined in relationship to specific mine locations to determine if mining was having an identifiable effect on nutrient loading.

In places where phosphorus mining and/or processing occurred, tailings deposits, contaminated groundwater and sedimentation from mining impacted areas could deliver phosphorus to stream reaches. In addition, tailings piles from historic placer mining operation may also accelerate natural sediment erosion processes. For these reasons, where applicable, phosphorus from mining activities was included in the source assessment.

Subsurface Wastewater Treatment and Disposal

Discharge of septic effluent from individual septic systems, community septic systems, and WWTPs which discharge to groundwater may all contribute to nutrient loading in streams depending on a combination of discharge, soils, and distance from the downgradient waterbody. Septic systems, even when operating as designed, can contribute nutrients to surface water through subsurface pathways. These sources will be accounted for by using a combination of septic density mapping and calculated loads to groundwater and receiving waterbodies for several wastewater treatment facilities in the Upper Clark Fork Phase 2 TPA. These loads include infiltration/percolation (I/P) and/or facultative lagoons employed by the city of Anaconda, Fairmont Hot Springs, and the town of Ramsay. Included in this category is the unpermitted Ranchland Packing plant in Butte, which processes livestock. Several of these facilities are not permitted under MPDES having been grandfathered as groundwater discharge facilities. Significant alterations to existing operations at these unpermitted facilities should trigger the need for a groundwater discharge permit. Following are coarse loading estimates for several wastewater treatment facilities with groundwater discharges or the potential to discharge to groundwater. These estimates are intended to provide only a rough approximation of potential nutrient sources and impacts from the described facilities. Where determined to be a notable source, they will be included in the respective source assessment per waterbody in **Section 6.6**.

Anaconda WWTP (MTX000231)

The groundwater discharge permit for the Anaconda Wastewater Holding Ponds and I/P Beds Facility became effective on April 1, 2014, and expires on March 31, 2019. The following analysis of the facility operation and groundwater discharge is intended to provide a quantitative estimate of loading from the facility in the Lost Creek drainage. It is not intended to alter the existing permit for the facility but is included here as part of the source assessment in the Lost Creek drainage.

Treated lagoon effluent from a 2-cell aerated treatment system in the Warms Springs Creek drainage flows approximately 1.75 miles northeast crossing over into the Lost Creek drainage to the holding and infiltration/percolation (HIP) facility located on Galen Road (State Highway 273) (DOWL HKM, 2012). Built in 1991, the complex includes two holding ponds and five percolation ponds. Space is provided for up to ten additional ponds. Average flows to the HIP facility in the Lost Creek drainage on Galen Road were estimated by DOWL HKM as 0.89 mgd (1.38 cfs) in the winter and 1.133 mgd (1.75 cfs) in the summer (DOWL HKM, 2012). Any of the effluent that is not evaporated or land-applied is discharged to the groundwater.

Seasonal irrigation is conducted on agricultural land approximately one mile north of the ponds, owned by Ueland Ranches. Prior to 2009, wheel lines were used to deliver effluent to 300 acres of irrigated lands. In 2009, the wheel lines were replaced with more efficient center pivots and irrigated acreage increased to approximately 322 acres.

Based on a 2011 assessment of the WWTP HIP facility by DOWL HKM, the I/P cells discharge 114.8 million gallons to groundwater over a period of 129 days which begins 81 days after the end of the irrigation season (DOWL HKM, 2012). This translates to a discharge of 0.48 cfs during those 129 days. It takes 81 days to fill the 2 storage ponds at the site, which are then routed to the I/P beds. The period of I/P discharge is generally from late fall to early spring. It is approximately 1,250 feet along the dominant groundwater flow pathway from the I/P beds to Lost Creek. The Gardiner Ditch flows northward from Warm Springs Creek (near Anaconda) and runs approximately 200 feet west of the HIP facility. DOWL HKM working on behalf of the Anaconda WWTP determined the dominant groundwater pathway to be N30°E. This coarse loading analysis examines the fate and transport of the effluent that is discharged to groundwater at the HIP facility during the non-irrigation season.

Although monitoring wells were installed at the HIP facility in the early 1990s, for unknown reasons sampling was discontinued after 1–2 years (DOWL HKM, 2012).

The hydraulic conductivity (K) of the aquifer underlying the facility, based on a 24-hour pump test of the aquifer conducted on site, was determined as 165 ft/day (Spratt & Associates, 1990). Note that hydraulic gradient values are necessary to determine groundwater travel time to Lost Creek. Hydraulic gradient values have not been determined in this area.

DOWL HKM, under contract by the city of Anaconda, installed three groundwater monitoring wells around the HIP facility in 2013. One was located upgradient of the facility on the southwest corner and two were located downgradient of the pond system to the northeast. **Table 6-28** displays the change in nitrogen concentrations between the upgradient and downgradient sites.

Table 6-28. June 27, 2013, Monitoring Well Results from Anaconda WWTP HIP Facility on Galen Road

MW	Landscape Position	$NO_2 + NO_3$ (mg/L)	TKN (mg/L)	TN[1] (mg/L)
MW-1B	upgradient	0.19	ND	0.19
MW-5	downgradient	1.65	0.15	1.80
MW-6	downgradient	1.87	0.09	1.96

[a] Calculated by DEQ; ND = not detected

In order to estimate the TN load from the facility to Lost Creek, a rough loading estimate was calculated using available parameters and data from the HIP facility as reported by Anaconda WWTP and its contractors (**Table 6-29**). This loading estimate includes several coarse assumptions and is intended only to provide a relative load estimate based on the known and presumed operating parameters of the facility. It is not intended to assess potential permit limits or allowable loading.

This analysis determined that groundwater discharge from the HIP facility on Galen Road contributes 25.8 lbs/day of TN to Lost Creek during the summer period (**Table 6-29**). A reduction of 80% for TN loading was assumed for several reasons including soils, depth to groundwater, and the groundwater flow path from the I/P beds to the extensive wetland complex east of the facility.

Table 6-29. City of Anaconda WWTP TN Load Calculations from HIP Facility to Lost Creek

Parameter	Value	Units	Notes
Discharge via I/P beds	310,080	gpd	For a period of 129 days, 81 days after end of irrigation season
	0.48	cfs	
Influent TN concentration	18	mg/L	Measured effluent concentration prior to discharge to first holding pond
Estimated holding ponds retention time	81	days	Between end of irrigation season and discharge from I/P cells
Influent TN concentration * exp (-0.0075*Retention time)[1]	9.8	mg/L TN	TN reduction based on holding ponds retention time
Load (I/P discharge * concentration)	25.4	lbs/day TN	
Estimated reduction via denitrification and uptake[1]	80	%	Assumed reduction via denitrification/uptake between I/P discharge and recharge to Lost Creek
Estimated TN load to Lost Creek	5.08	lbs/day	

[1] DEQ SRF Section personnel, personal communication (2012)

As Lost Creek is does not have a TP nutrient impairment on the 2012 303(d) List, the estimated TP load from the facility to Lost Creek was not determined. However, TP loading from the HIP facility to Lost Creek is not thought to be significant. The coarse loading estimate provided above does suggest that the facility may be a relatively significant source of TN to Lost Creek during the summer period. It may be compared to the example Lost Creek TMDL in **Section 6.6.6.3**. Additional sampling is recommended to better delineate loading dynamics from the HIP facility in the Lost Creek drainage.

Fairmont Hot Springs (unpermitted)

The Fairmont Hot Springs WWTP is an unpermitted facility in the Gregson Creek watershed. Gregson Creek flows into Silver Bow Creek where the Crackerville Road (Highway 1) crosses Silver Bow Creek. The facility was constructed in 1972 and consists of 2 clay lined lagoon cells (total of 13.0 acres and 25.4 million gallons storage) with a combined detention time of 538 days. The population served by the facility is not known definitively but is estimated at 850 persons. Effluent is treated via settling and application of wastewater to 450 acres of hay/pasture during the summer months.

A site inspection by the Technical and Financial Assistance Bureau of the Planning, Prevention, and Assistance Division of DEQ was conducted by a professional engineer on April 18, 2013. The facultative treatment and storage ponds were constructed in 1972 and were found to be generally in good shape. Some needed rehabilitation of ditches and conveyance structures was noted. During irrigation season, effluent is used to irrigate adjoining fields. One issue that was noted in the inspection was the use of irrigated parcels for winter feeding areas thus possibly overloading these areas with nutrients. The inspection noted that the lagoon evaporation system can treat more wastewater than it currently receives without exceeding land application rates or storage capacity. Excessive hydraulic loading could lead to surface runoff and pollutant loads (including nutrients) reaching surface water. The site inspection determined that the only potential route for this to occur is from leakage from the irrigation pump. The facility currently does not accept wastes from septage dumping.

Although the total amount of effluent used for irrigation is not known, given the size and population served by the facility and the amount of acreage available for irrigation, DEQ engineers determined that with proper waste management the system can work. However, winter feeding of cattle on the irrigated parcels may be overloading the system with nutrients leading to nutrient rich groundwater discharges to Gregson Creek, a tributary to Silver Bow Creek.

From the April 2013 inspection and facility description, there are two potential groundwater pathways of WWTP effluent to Gregson Creek. One is the winter feeding/manure deposition on land irrigated with effluent during the summer months. The second is seepage from the lagoon system to groundwater, with downgradient recharge to Gregson Creek and subsequent loading to Silver Bow Creek. The first pathway will not be addressed in this section, as it falls under land-use management and is not directly attributable to the WWTP effluent. It will be addressed in the existing load summary and allocations for Silver Bow Creek in **Section 6.6.9**. The second pathway will be addressed with a coarse loading estimate for TN and TP.

The TN and TP load to groundwater was determined based on the daily seepage rate (23,249 gpd or 0.035 cfs (Cell 1 + Cell 2)) and the median influent TN and TP concentrations from a similarly designed and operated WWTP in Amsterdam-Churchill, in the Gallatin Valley. The estimate recognized the different flow pathways through the facility to Cell 1 (wastewater and hot spring water) and the bypass channel from the hot spring source water to Cell 2. Estimated loads to groundwater were different for TN and TP. To determine treatment load reductions, a decay equation was used for TN, while a general reduction of 30% was applied to TP concentrations (**Tables 6-30** and **6-31**).

This loading estimate includes several coarse assumptions and is intended only to provide a relative load estimate based on the known and presumed operating parameters of the facility. The allowable lagoon seepage rate from the time of construction was used in the calculation.

Table 6-30. Fairmont Hot Springs WWTP TN Load Calculations to Gregson Creek

	Parameter	Value	Units	Notes
Cell 1	Influent flow	41,000	gpd	Assumes 28,500 gpd wastewater and 12,500 gpd hot water waste
		0.064	cfs	
	Design allowable lagoon seepage (1972)	24	in/yr	2013 design standard = 6 in/yr
	Estimated volume discharged to groundwater via seepage	7,690	gpd	Area of Cell 1 (4.3 acres) * 24 in/yr seepage
		0.011	cfs	
	Estimated influent TN concentration	32.1	mg/L TN	Amsterdam-Churchill WWTP (*n* = 9)
	Estimated retention time	205	days	
	Influent TN concentration * exp (-0.0075*Retention time)[1]	6.9	mg/L TN	Estimated outflow concentration
	TN load to groundwater (seepage*concentration)	0.44	lbs/day TN	
Cell 2	Influent flow	879659	gpd	
		1.36	cfs	
	Design allowable lagoon seepage (1972)	24	in/yr	2013 design standard = 6 in/yr
	Estimated volume discharged to groundwater via seepage	15559	gpd	Area of Cell 2 (8.7 acres) * 24 in/yr seepage
		0.024	cfs	
	Estimated influent TN concentration from Cell 1	5.9	mg/L TN	Includes Cell 1 inflow and dilution effect of hot spring bypass inflow
	Estimated retention time	333	days	
	Influent TN concentration * exp (-0.0075*Retention time)[1]	0.48	mg/L TN	Estimated outflow concentration
	TN load to groundwater (seepage*concentration)	0.06	lbs/day TN	
Total	Estimated load to groundwater via seepage	0.51	lbs/day TN	Cell 1 + Cell 2
	Estimated reduction via denitrification and uptake[1]	80	%	
	Estimated TN load to Gregson Creek	0.10	lbs/day TN	

[1] DEQ SRF Section personnel, personal communication (2012)

In the case of TN, assuming a removal efficiency of 80% in the TN load between the bottom of the 2 cells and Gregson Creek, the estimated load from the Fairmont Hot Springs WWTP is 0.10 lbs/day.

Table 6-31. Fairmont Hot Springs WWTP TN Load Calculations to Gregson Creek

	Parameter	Value	Units	Notes
Cell 1	Influent flow	41,000	gpd	Assumes 28,500 gpd wastewater and 12,500 gpd hot water waste
		0.064	cfs	
	Design allowable lagoon seepage (1972)	24	in/yr	2013 design standard = 6 in/yr
	Estimated volume discharged to groundwater via seepage	7,690	gpd	Area of Cell 1 (4.3 acres) * 24 in/yr seepage
		0.011	cfs	
	Estimated influent TP concentration	32.1	mg/L TP	Amsterdam-Churchill WWTP (*n* = 9)
	30% reduction via retention/settling[1]	22.4	mg/L TP	Estimated outflow concentration
	TP load to groundwater (seepage*concentration)	1.44	lbs/day TP	
Cell 2	Influent flow	879659	gpd	
		1.36	cfs	
	Design allowable lagoon seepage (1972)	24	in/yr	2013 design standard = 6 in/yr

Table 6-31. Fairmont Hot Springs WWTP TN Load Calculations to Gregson Creek

	Parameter	Value	Units	Notes
	Estimated volume discharged to groundwater via seepage	15559	gpd	Area of Cell 2 (8.7 acres) * 24 in/yr seepage
		0.024	cfs	
	Estimated influent TP concentration from Cell 1	13.7	mg/L TP	Includes Cell 1 inflow and hot spring bypass inflow
	30% reduction via retention/settling[1]	9.62	mg/L TP	Estimated outflow concentration
	TP load to groundwater (seepage*concentration)	1.25	lbs/day TP	
Total	Estimated load to groundwater via seepage	2.69	lbs/day TP	Cell 1 + Cell 2
	Estimated reduction via adsorption/uptake[1]	98	%	
	Estimated TP load to Gregson Creek	0.05	lbs/day TP	

[1] DEQ SRF Section personnel, personal communication (2012)

For TP, assuming a removal efficiency of 98% in the TP load between the bottom of the 2 cells and Gregson Creek, the estimated load from the Fairmont Hot Springs WWTP is 0.05 lbs/day TP. There is still some question whether these estimates accurately quantify the impacts of the Fairmont Hot Springs WWTP on water quality in Gregson Creek as there are no water quality samples from Gregson Creek.

Based on the TN and TP loading estimates outlined above, the Fairmont Hot Springs WWTP is likely having a relatively negligible impact on water quality in Gregson Creek under its current operation and management. It may be compared to the example Silver Bow Creek TMDLs in **Sections 6.6.9.5** and **6.6.9.6**.

Ramsay WWTP (unpermitted)

The Ramsay WWTP is a two-cell, non-discharging facultative lagoon with Total Containment (TC). Based on a personal communication with Pat McDermott in 2005, the system consists of 39 sewer hookups plus the Ramsay School with an estimated influent flow of 0.015 mgd. Cell 1 is approximately 1.43 acres (250 ft X 250 ft); Cell 2 is larger at 1.75 acres but has no record of use. Built in 1972, the allowable seepage rate for a facultative lagoon at that time was 24 in/yr.

In determining potential nutrient loads from the Ramsay WWTP to Silver Bow Creek, it was noted that the dominant groundwater flow path to Silver Bow Creek is intercepted by a railroad grade. At the base of this railroad grade and in line with the dominant groundwater flowpath, there is a small surface water body (0.8 acre). It may be assumed that this pond is fed by groundwater recharge and some overland runoff. The railroad grade actually serves to isolate the north side of the embankment outside the 100-year floodplain as delineated by the Federal Emergency Management Agency.

The TN and TP load to groundwater was determined based on the daily leakage rate (2,562 gpd or 0.004 cfs) and the median influent TN and TP concentrations from a similarly designed and operated WWTP in Amsterdam-Churchill in the Gallatin Valley. Estimated loads to groundwater were different for TN and TP. To determine treatment load reductions, a decay equation was used for TN while a general reduction of 30% was applied to TP concentrations (**Tables 6-32** and **6-33**).

This loading estimate includes several coarse assumptions and is intended only to provide a relative load estimate based on the known and presumed operating parameters of the facility. The allowable lagoon seepage rate from the time of construction was used in the calculation.

Table 6-32. Town of Ramsay WWTP TN Load Calculations to Silver Bow Creek

Parameter	Value	Units	Notes
Influent flow to system	15,000	gpd	Assumes 10,000 gpd from hookups and 5,000 gpd from Ramsay School
	0.023	cfs	
Design allowable lagoon seepage (1972)	24	in/yr	2013 design standard = 6 in/yr
Estimated volume discharged to groundwater via seepage from Cell 1	2,562	gpd	Area of cell 1 * 24 in/yr seepage
	0.004	cfs	
Median influent TN concentration	45.5	mg/L TN	Amsterdam-Churchill WWTP (*n* = 9)
Estimated lagoon retention time	5.6	days	= daily seepage/daily inflow
Influent TN concentration * exp (-0.0075*Retention time) [1]	43.6	mg/L TN	Estimated outflow concentration
Load (Leakage*concentration)	0.94	lbs/day TN	
Estimated reduction via denitrification and uptake[1]	80	%	
Estimated TN load to Silver Bow Creek	0.19	lbs/day TN	

[1] DEQ SRF Section personnel, personal communication (2012)

In the case of TN, assuming a removal efficiency of 80% in the TN load between the bottom of cell 1 and Silver Bow Creek, the estimated load from the Ramsay WWTP is 0.19 lbs/day TN.

Table 6-33. Town of Ramsay WWTP TP Load Calculations to Silver Bow Creek

Parameter	Value	Units	Notes
Influent flow to system	15,000	gpd	Assumes 10,000 gpd from hookups and 5,000 gpd from school
	0.023	cfs	
Design allowable lagoon seepage (1972)	24	in/yr	2013 design standard = 6 in/yr
Estimated volume discharged to groundwater via seepage from Cell 1	2,562	gpd	Area of cell 1 * 24 in/yr seepage
	0.004	cfs	
Median influent TP concentration	46.1	mg/L TP	Amsterdam-Churchill WWTP (*n* = 9)
30% TP reduction in facultative lagoon[1]	32.3	mg/L TP	Estimated outflow concentration
Load (Leakage*concentration)	0.69	lbs/day TP	
98% removal efficiency in soil matrix for TP[1]	0.01	lbs/day TP	

[1] DEQ SRF Section personnel, personal communication (2012)

For TP, a 98% removal efficiency was used to calculate the TP load to Silver Bow Creek from the bottom of cell 1 based on a design seepage rate of 24 in/yr. The estimated load was 0.01 lbs/day TP. There is still some question whether these estimates accurately quantify the impacts of the Ramsay WWTP on water quality in Silver Bow Creek.

Based on the TN and TP loading estimates outlined above, the Ramsay WWTP is likely having a negligible impact on water quality in Browns Gulch or Silver Bow Creek under its current operation and management. It may be compared to the example Silver Bow Creek TMDLs in **Sections 6.6.9.5** and **6.6.9.6**.

Ranchland Packing (unpermitted)

The Ranchland Packing facility is located in between the CERCLA LAO ponds/discharge and the BSB WWTP discharge to Silver Bow Creek. The facility ponds were constructed as TC ponds, however, it is not known how effective the ponds remain>15 years post-construction. The facility did apply for a CAFO permit from DEQ in 2007. However, it was determined that the facility did not require a permit, as it did not meet the minimum threshold for animal confinement doe a small CAFO. The facility discharges process wastewater to several ponds and does not have a direct discharge to Silver Bow Creek. However, the facility was identified as a nutrient source to Silver Bow Creek in 2004 (Water & Environmental Technologies, 2004). Water quality sampling was unable to determine the potential impacts of Ranchland Packing on instream water quality, as several significant nutrient-rich inputs including BSB WWTP effluent and Summit Valley groundwater discharges to the creek in this reach made it difficult to separate sources conclusively (Water & Environmental Technologies, 2004). Given the lack of understanding around the timing, volume, seasons of use, and properties of the effluent stored in the TC ponds, no estimate of groundwater discharge is made here.

Potential loading from the facility to Silver Bow Creek will not be determined here but the facility will be included in the subsurface wastewater treatment and disposal LA for Silver Bow Creek nutrient TMDLs.

It is recommended that any future implementation plans in the Silver Bow Creek drainage include site and water quality investigations at the facility to determine potential groundwater pathways and nutrient loading to Silver Bow Creek and/or the treatment ponds in LAO.

Natural Background

LAs for natural background sources in all applicable impaired segments are based on median concentration values from reference sites in the Middle Rockies Level III Ecoregion during the July 1 to September 30 growing season (nitrate = 0.02 mg/L (Suplee et al., 2008), TN = 0.095 mg/L, and TP = 0.01 mg/L (Suplee and Watson, 2013). Reference sites were chosen to represent stream conditions where human activities may be present but do not negatively harm stream uses. The effects of natural events such as flooding, fire, and beetle kill may be captured at these sites. Natural background loads are calculated by multiplying the median reference concentration by the measured median growing season streamflow.

6.5.1.2 Point Sources of Nutrients

In addition to nonpoint sources, nutrient inputs into streams in the Upper Clark Fork Phase 2 TPA come from point sources (i.e., distinct, identifiable sources, such as pipes feeding directly into a waterbody). Point sources include WWTPs and a MS4 storm water system. By law, these point sources must be permitted. As of April 8, 2013, the Upper Clark Fork Phase 2 TPA had 32 active MPDES permitted point sources within nutrient-impaired watersheds (**Figure A-18**). Of these 32 MPDES point sources, only six have direct nutrient discharges that directly affect nutrient-impaired streams in the Upper Clark Fork Phase 2 TPA:

- Montana Resources (MT0000191)
- Butte-Silver Bow MS4 (MTR0000191)
- Butte-Silver Bow WWTP (MT0022012)
- Rocker WWTP (MT0027430)
- One CAFOs (MTG010166)
- Renewable Energy Corporation Advanced Silicon Materials (MT0030350)

As will be outlined below, Montana Livestock Auction and Montana Resources do not actively discharge at present. In addition, there are two continuous discharges from Superfund sites regulated under CERCLA which are also discussed.

Point source descriptions and estimated nutrient loads are presented in order from upstream to downstream per their respective discharge location to Silver Bow Creek, which is the only impaired waterbody in this document which has nutrient point source discharges. Estimates include the sum of natural background and human loading from each point source. The physical locations of these point source dischargers and a few potential groundwater nutrient sources identified in **Section 6.5.1.1** (Ramsay WWTP, Ranchland Packing) are identified in **Figure 6-3**.

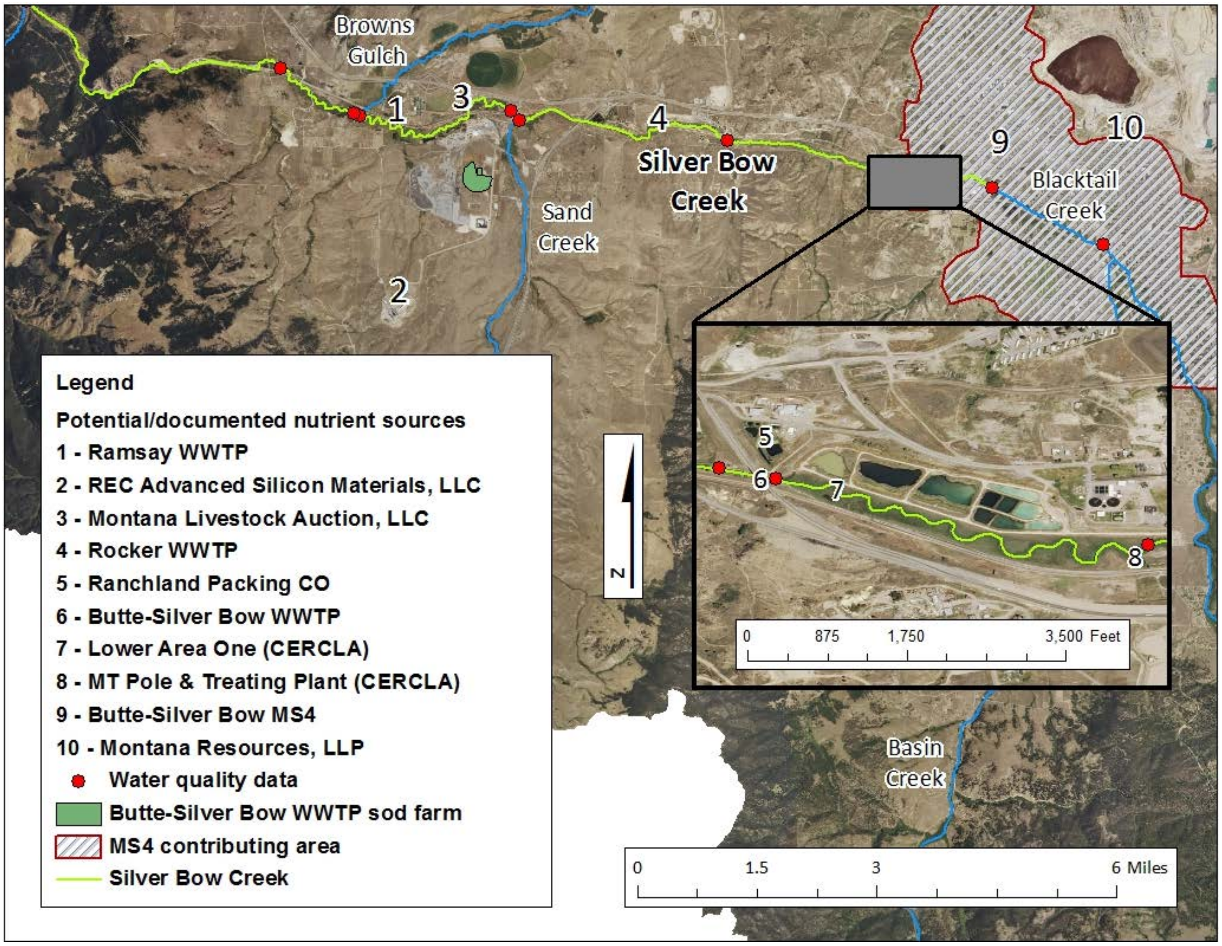

Figure 6-3. Locations of MPDES Permitted and Unpermitted Potential Nutrient Sources in Upper Silver Bow Creek

Montana Resources (MT0000191)

Montana Resources is authorized to discharge wastewater to Silver Bow Creek via the MSD under MPDES permit number MT0000191. The current permit became effective September 1, 2012, and expires August 31, 2017. Effluent from the HSB at Montana Resources is reused in the mining operations and is not discharged to Silver Bow Creek. Montana Resources has not reported a discharge of treated process wastewater since operations commenced in 1986.

Water is used in many areas of the mine and flows via gravity, siphon, and pumps through a variety of conveyance methods including ditches and pipes on the site. Water is recycled throughout the site, resulting in no water being discharged from the outfall. Stormwater is drained into the Continental and Berkeley Pit and included in the process water. Domestic wastewater is discharged to the BSB WWTP.

Although unused, the permit does identify one authorized outfall, Outfall 004, for intermittent discharge to the Silver Bow Creek via the Butte MSD. The discharge point is located at approximately 45° 59’ 12”

N, 112° 32’ 13” W. The treatment process at the HSB consists of a two-stage high density sludge lime precipitation water treatment process. Currently, the effluent water is used as process water at the Montana Resources facility and is not discharged to Silver Bow Creek. Storm water is drained into the Continental and Berkeley Pit and included in the process water. Domestic wastewater is discharged to the BSB WWTP.

Although Outfall 004 is not currently used, the permit considers the mixing zone to be nearly instantaneous. The current permit allows an average monthly load of 84 lbs/day TN which includes an average monthly limit of 2.0 mg/L TN and a maximum daily limit of 3.0 mg/L TN. TP is not included in the effluent limits for Outfall 004. At a loading rate of 84 lbs/day TN, the facility would have to discharge at a concentration of 0.300 mg/L TN and a flow of 51.85 cfs to avoid causing or contributing to an impairment in Silver Bow Creek

Given the discharge history at MTG0000191, the estimated existing load from the facility to Silver Bow Creek is 0 lbs TN/day and 0 lbs TP/day.

Butte-Silver Bow MS4 (MTR040006)

MPDES MS4 Permit

Stormwater within the city of Butte is regulated under the General Permit for Storm Water Discharge Associated with Small Municipal Separate Storm Water Sewer System (MS4) (MTR04000). The city and county of BSB are co-permittees with MDT. The permit primarily applies within the city limits, but also includes some receiving waters outside the city. Waterbodies that receive stormwater discharges include: Blacktail Creek, Basin Creek, Grove Gulch Creek, Sand Creek and Silver Bow Creek. The permit states that the MS4 drains an area of approximately 29.7 mi^2 and closely approximates the urban limit boundary (25.3 mi^2). A large part of the MS4 lies within the BPSOU, a designated Superfund site and stormwater originating within the BPSOU is managed under CERCLA. As Silver Bow Creek has a nutrient impairment listing on the 2012 303(d) List, a WLA for the city and county of BSB MS4 is required.

Most of the focus on stormwater in Butte has been to address gross exceedances of acute water quality standards for heavy metals in Silver Bow Creek, as impacted by source areas within the BPSOU site. The 2006 BPSOU ROD designated all surface water in Silver Bow Creek, Blacktail Creek, and Grove Gulch to be points of compliance for surface water quality. Stormwater outfalls and surface water in the MSD are exempted as points of compliance. However, MSD discharges into Silver Bow Creek; therefore, the contaminant loads contributing from the MSD cannot cause exceedances of surface water contaminant concentrations in Silver Bow Creek.

The permit does not include effluent limits, but requires the development and implementation of a SWMP to minimize nutrient loading to surface waters. The SWMP must include six minimum control measures: (1) public education and outreach; (2) public involvement/participation; (3) detection and elimination of illicit discharge; (4) control of stormwater runoff from construction sites; (5) management of post-construction stormwater in new development and redevelopment; and (6) pollution prevention/good housekeeping. Additionally, the permit requires semiannual monitoring at two sites; one representing a residential area and the other representing a commercial/industrial area. For the Butte MS4, these monitoring locations are sited at stormwater outlets to Blacktail Creek in the south central portion of the MS4.

Data Collection and Modeling of MS4

The contributing area of the BSB MS4 may be divided into 2 distinct areas: (1) Butte Hill and (2) 'The Flats' (**Figure 6-4**). Butte Hill includes much of the BPSOU and also includes the area south of the MSD that contributes stormwater flows to the MSD. As part of the ROD for the BPSOU, Butte Hill has undergone most of the investigation and data collection efforts within the MS4 contributing area. 'The Flats' is the moniker attributed to the area south of downtown Butte in and around Burt Mooney Municipal Airport. While 'The Flats' comprises more area in the MS4 than Butte Hill, it contains the minor share of stormwater infrastructure and data collection efforts in the MS4.

For the purposes of further characterizing the MS4 stormwater system identified in **Figure 6-4**, the MS4 contributing area was delineated by DEQ from a combination of previous modeling efforts in Butte Hill (U.S. Environmental Protection Agency, 2009b) and using current stormwater/sanitary sewer extents in and around Butte, Montana. This DEQ delineation resulted in an MS4 contributing area of 13.21 mi^2 which is 44% of the area in the permit, but more closely approximates the actual footprint of stormwater infrastructure.

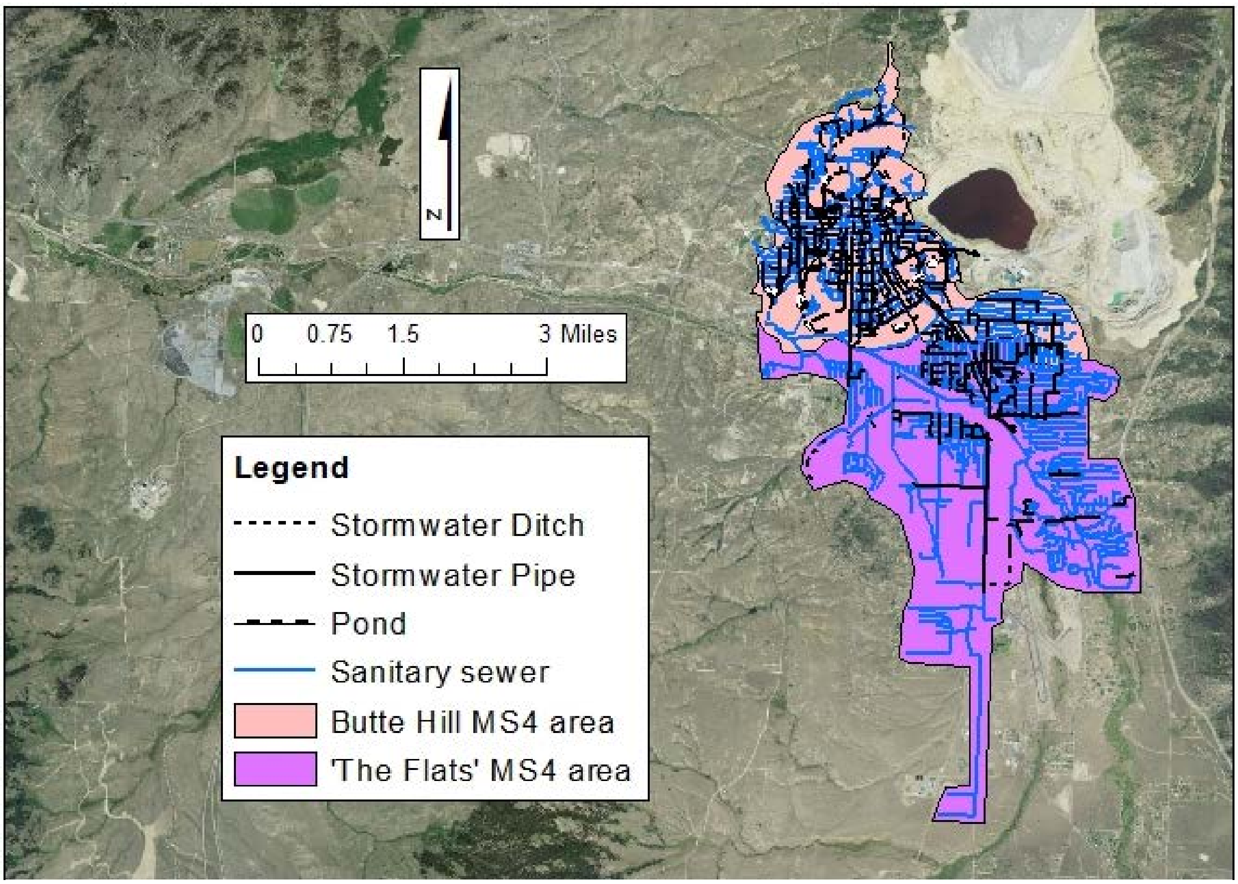

Figure 6-4. BSB MS4 Contributing Area Based on Stormwater and Sanitary Sewer Extent

A further distinction regarding the MS4 contributing area must also be made. A significant portion of the Butte Hill MS4 area discharges stormwater flows to the Berkeley Pit as opposed to the Silver Bow Creek corridor (**Figure 6-5**). As delineated in the EPA 2009 report (U.S. Environmental Protection Agency, 2009b), the area of Butte Hill which drains to the Berkeley Pit comprises approximately 0.67 mi^2 or

13.5% of the MS4 contributing area on Butte Hill (4.94 mi^2). This will be taken into account when estimating the nutrient load from the BSB MS4 to Silver Bow Creek.

Given the available stormwater data and the basin delineation available from previous reports, summer period (July 1 to September 30) nutrient load estimates were calculated differently for Butte Hill and 'The Flats' portions of the BSB MS4 and will be presented as such.

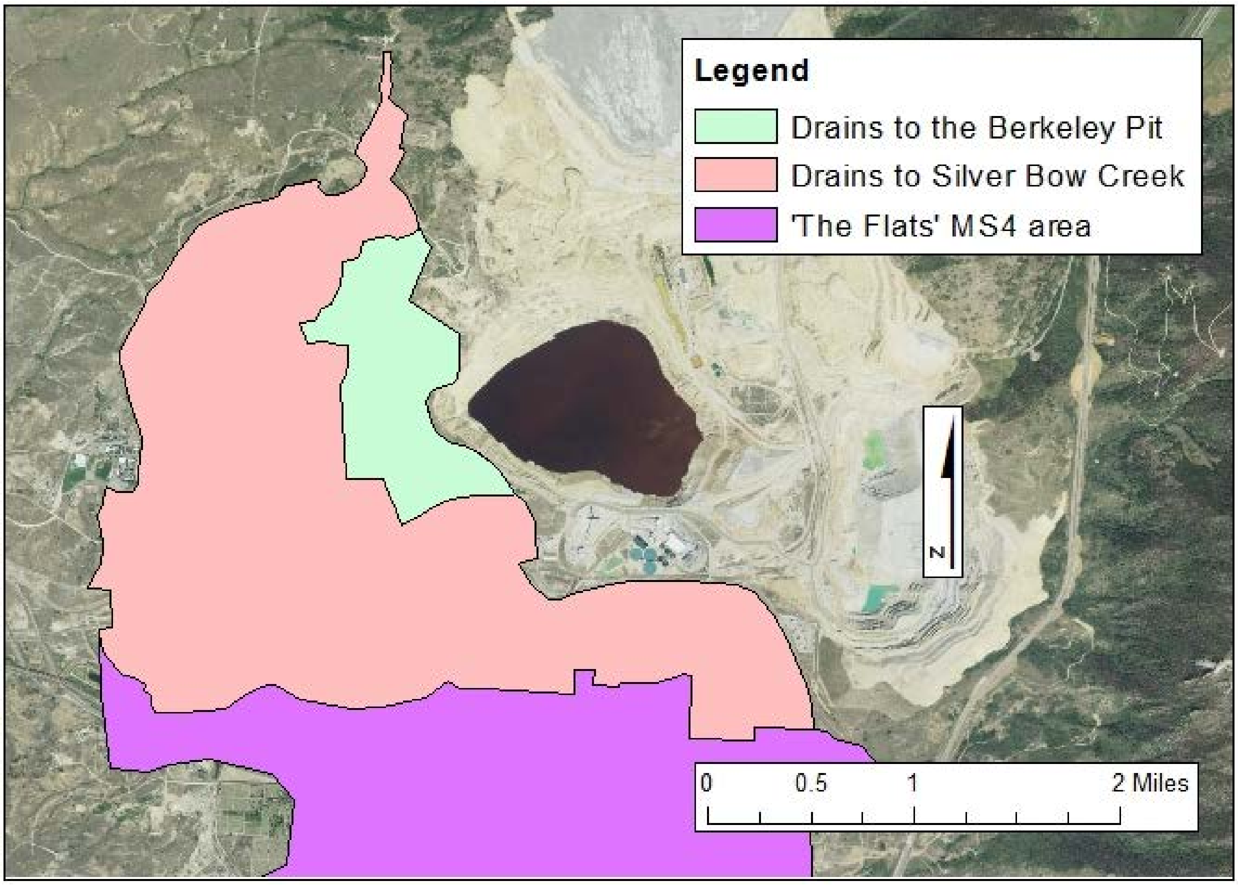

Figure 6-5. Major Sub-Basins within the Butte Hill MS4 Area

Butte Hill MS4 Area

The following sub-sections summarize existing MS4 reporting and data collection efforts in the Butte Hill MS4 area.

2011 Butte-Silver Bow Infrastructure Report

BSB contracted with Morrison-Maierle, Inc. to conduct an assessment of stormwater infrastructure focusing on Butte Hill within the BPSOU. At the request of BSB, detailed hydraulic analyses and design, and water quality modeling were not made part of the investigation. The infrastructure inventory/inspection focused on the underground stormwater infrastructure owned and maintained by BSB. Within the BPSOU, field crews assessed as much of the existing infrastructure as possible. Limited infrastructure was assessed outside of the Butte Hill area and the BPSOU.

Wide variability in lateral pipe conditions was noted ranging from totally functioning pipes to partially decayed pipes, to pipes that were completely blocked with debris or sediment. Additionally, documented pipe materials included PVC, concrete pipe, vitrified clay, corrugated metal pipe, slag tile, cobblestone/granite block, wood, asbestos and brick arch pipe.

A total of 2,130 inlets were located and assessed during the field survey, an increase of 353 over the original BSB map. Results of the field assessment indicated that the vast majority of inlets did not contain catch basins for sediment. An extensive manhole survey was also conducted which revealed some issues of concern: extreme manhole depth in some locations, lack of regular intervals between manholes, presence of flow during dry weather conditions. Inspection of the stormwater mains also found numerous illicit connections to the stormwater and sanitary sewer systems.

Also from the report (Butte Silver Bow Public Works Department, 2011):

> The last major maintenance project on the BSB storm water system was conducted in the late 1960's when the major storm water trunk mains in Buffalo and Missoula Gulch were rehabilitated and expanded. As a result, the existing storm water system, is at the end of its design life, has a significant deferred maintenance backlog, and has no current plan for prioritizing maintenance, repair, upgrades, and expansions. The lack of available funds for infrastructure upgrade and replacement has necessitated that BSB continue to operate a large and complex storm water system, much of which is long past its design life. Many design shortcomings exacerbate functionality issues, such as inlets without sediment basins, brick manhole construction, decaying slag tile and wood piping, and lack of suitable access for workers.

The report outlines the MS4 system and focuses specifically on the older parts of the MS4 on Butte Hill. Deteriorating conditions of an old system, illicit connections and flows during dry periods were observed in nearly all sub-basins on Butte Hill. Sedimentation and blockage of many of the lines was also noted.

2009 EPA HydroCAD model

Contracted by the EPA, CDM, Inc. (now CDM Smith, Inc.) performed hydrologic and hydraulic analyses to predict hydrographs, peak flow rates, and maximum runoff volumes for the 2-, 5-, 10-, 25-, 50-, and 100-year 24-hour storm events in order to determine the hydraulic capacity of the existing MS4 infrastructure within the boundaries of the BPSOU for all basins with the exception of the Grove Gulch basin. Analyses were based on the NRCS unit hydrograph method and the NRCS Curve Number Method. The model included numerous assumptions due to the complexity of the buried stormwater systems and lack of complete as-built infrastructure drawings. Runoff contributions from the Blacktail Creek were not characterized in the modeling effort, as this part of the MS4 lies outside the bounds of the BPSOU. Work performed by CDM relied on previous reports on the MS4 including BSB's Municipal Storm Water System Improvement Plan (Butte Silver Bow Public Works Department, 2011). Based on the HydroCAD model flows, and assuming a Type II 25-year, 24-hour storm event[1], the report determined that most of the storm drain distribution system is under-designed for present study area conditions. The existing stormwater infrastructure is old and seriously deteriorated, having outlived its design life.

[1] The SCS hypothetical storm method implements the four synthetic rainfall distributions developed by the NRCS from observed precipitation events. Each distribution contains rainfall intensities arranged to maximize the peak runoff for a given total storm depth. The four distributions correspond to different geographic regions; Montana falls into the Type II geographic region (Soil Conservation Service, Department of Agriculture, 1986)

Mine waste was used throughout Butte Hill for construction of infrastructure (e.g., pipe bedding for water, sanitary, and storm sewer lines, as well as road base and structural fill) (U.S. Environmental Protection Agency, 2009b). For the BSB MS4, the overriding objective should be to provide the cleanest conduit possible for stormwater to lessen the contaminant load to receiving waters (U.S. Environmental Protection Agency, 2009b).

Hydrodynamic Devices

Starting in December 2011 and through the spring of 2013, five HDs were installed in the Butte Hill MS4 area for the capture of sediment. HDs were installed at Texas Avenue, Warren Avenue, Anaconda Road, Montana Street and on Buffalo Gulch at Webster Avenue and Garfield Avenue on Butte Hill. No HDs were installed in 'The Flats' portion of the MS4. HDs are used in stormwater management as flow-through devices and use cyclonic seperation to control water pollution, chiefly suspended sediment, from entering recieiving waterbodies. For the Butte Hill MS4, stormwater data used to estimate annual loading was collected from 2007 to 2009 prior to HD installation. BMP effectiveness values for HDs (manufactured device-physical) were reported by the International Storm Water BMP Database (Geosyntec Consultants, Inc. and Wright Water Engineers, Inc., 2012). In this report, the authors determined that HDs significantly decreased TP concentrations by 37%, via sediment capture, using median values from a total of 22 studies. However, neither TKN nor NO_2+NO_3 concentrations were significantly decreased by HDs in the analysis (Geosyntec Consultants, Inc. and Wright Water Engineers, Inc., 2012). NURP literature and data review suggest that between 29% and 48% of stormwater runoff is organic nitrogen. However, no information could be found to determine if HDs significantly decrease organic nitrogen. As HDs are primarily installed for sediment capture and are not a BMP that is used for nutrient retention/removal, load estimates for the BSB MS4 will assume a 0% reduction in TN post-HD installation. An estimated 37% reduction in TP was applied to sub-basins within Butte Hill where HDs have been installed; a reduction of 37% is this identified sub-basins led to an overall reduction of 4.8% of the estimated TP load from the MS4 to Silver Bow Creek. None of the installed HDs described above are in sub-basins where DMR data is collected from representative commerical and residenital locations; therfore, DMR data is unaffected by the HDs.

<u>Estimated Annual TN Load from the BSB MS4</u>

Butte Hill MS4 Area TN Load

Inorganic N and flow data from the stormwater system is available at numerous locations within the MS4 stormwater system and in receiving waters; a result of extensive sampling that was conducted by ARCO to aid in MS4 water quality characterization and modeling from 2007 to 2009. For this analysis, sites representative of water quality per respective sub-basin were selected to conduct summary statistics and provide a range of NO_3 concentrations observed in the Butte Hill MS4 area.TN concentrations from the Butte Hill MS4 area were estimated and assumed that the measured inorganic N on Butte Hill comprised 38.5% of TN per NURP data compilation.

It should be noted that the conveyance structures are designed for a Type II storm. Overflows in the Berkeley Pit drainage area are routed to the MSD when the Type II storm is exceeded. However, as this is a low probability storm event, these flows were not included in the estimated summer period nutrient loads from the Butte Hill area to the MSD and Silver Bow Creek (**Table 6-34**). Also, as not all sub-basins on Butte Hill had stormwater sampling data, data from adjoining basins that closely approximated an un-sampled sub-basin was used to estimate sediment loading.

For the Butte Hill area, the estimated summer period (July 1 to September 30) TN load post-HD installation to Silver Bow Creek is 34.96 lbs/summer period (0.01 lbs/ac).

'The Flats' MS4 Area TN Load

To estimate the annual TN load from 'The Flats' MS4 area, DMR data collected by the MS4 from 2010 to 2012 was used (**Table 6-34**). DMR data is collected from two outfalls in the MS4 during stormwater runoff events. These two sampling sites are located to represent stormwater quality from a commercial/industrial site and a residential site. Total open/residential and commercial/industrial acreages in 'The Flats' were approximated based on the Silver Bow County zoning map.

For 'The Flats' area, the estimated summer period (July 1 to September 30) TN load to Silver Bow Creek is 275.21 lbs/summer period (0.05 lbs/ac). No HDs were installed in 'The Flats'.

The estimated summer period (July 1 to September 30) TN load post-HD installation from the MS4 contributing area to Silver Bow Creek is 310.16 lbs/summer period (0.04 lbs/ac) (July 1 to September 30) (**Table 6-34**). For comparison to observed TN concentrations in the Butte MS4, the overall median TN value from the NURP water quality database is 1.57 mg/L TN (*n*=3765); for commercial sites the median is 2.20 mg/L TN (*n*=497), and for residential sites the median is 2.00 mg/L TN (*n*=1069) (Pitt et al., 2004).

Table 6-34. Estimated Summer (July 1 to September 30) TN Load from the BSB MS4 to the Silver Bow Creek Drainage

Basin	Sub-Basin	Area Data Source	Area (ac)	Endpoint	n	Years of Collection	Mean TN (mg/L)[a]	TN Load (lbs/summer)[b, c]
Butte Hill	Rail Yard	EPA, 2009	*NA*	*Stormwater contained on site*	*Not applicable*			
	East Buffalo Gulch	EPA, 2009	57	MSD (EBG-OUT)	22	2007–09	1	1.19
	West Side Drainage	EPA, 2009	304	Infiltrates in ground or to HCC	*Not applicable*			
	Missoula Gulch	EPA, 2009	939	Silver Bow Creek (SBC-01)	7	2007–09	0.3	5.90
	Idaho Street	EPA, 2009	234	Via Missoula Gulch – (SBC-01)	7	2007–09	0.3	1.47
	Montana Street	EPA, 2009	31	Silver Bow Creek (MT-OUT)	25	2007–09	0.9	0.58
	Buffalo Gulch	EPA, 2009	302	Silver Bow Creek (BG-01)	25	2007–09	0.9	5.70
	Anaconda Road	EPA, 2009	122	MSD (AB-OUT)	22	2007–09	1.0	2.56
	Warren Avenue	EPA, 2009	84	MSD (WA-SD)	23	2007–09	2.4	4.22
	MSD	EPA, 2009	114	MSD (MSD-OUT)	22	2007–09	1.3	3.11
	MSD South Side	EPA, 2009	488	MSD (MSD-SS-OUT)	22	2007–09	1.0	10.23
The Flats	Zoned commercial/industrial	ArcGIS	1,949	All receiving waterbodies	5	2010–12	2.1	84.14
	Zoned open/residential		3,799	All receiving waterbodies	4	2010–12	2.4	191.07
Total			7,968					310.16

[a] Assumes that measured inorganic N on Butte Hill = 38.5% of TN per NURP data compilation

[b] Load was estimated using the 30-year precipitation record to determine that on average 30% of annual precipitation falls during the summer period and that 16% of this precipitation becomes runoff (0.09 in) as per the EPA HydroCAD assumption (U.S. Environmental Protection Agency, 2009b)

[c] Summer period is July 1 to September 30

Estimated Annual TP Load from the BSB MS4

Butte Hill MS4 Area TP Load

As opposed to sediment and inorganic N, no phosphorus data was collected by ARCO within the MS4 stormwater system from 2007 to 2009. Therefore, only DMR TP data is available to characterize stormwater loading from the Butte Hill portion of the MS4. Given the current and historical commercial/industrial uses in the Butte Hill area, the average commercial/industrial TP value from the DMR data was used to estimate TP loads from Butte Hill. However, a 37% reduction in TP concentration was applied for those sub-basins where a HD is currently installed.

It should be noted that the conveyance structures are designed for a Type II storm. Overflows in the Berkeley Pit drainage area are routed to the MSD when the Type II storm is exceeded. As this is a low probability storm event, these loads were not included in the estimated average summer period nutrient loads from the Butte Hill area to the MSD and Silver Bow Creek (**Table 6-35**).

For the Butte Hill area, the estimated summer period (July 1 to September 30) TP load post-HD installation to Silver Bow Creek is 31.47 lbs/summer period (0.01 lbs/ac).

'The Flats' MS4 Area TP Load

To estimate the annual TP load from 'The Flats' MS4 area, DMR data collected by the MS4 from 2010 to 2012 was used (**Table 6-35**). DMR data is collected from two outfalls in the MS4 during stormwater runoff events. These two sampling sites are located to represent stormwater quality from a commercial/industrial site and a residential site. Total residential and commercial/industrial acreages in 'The Flats' were approximated based on the Silver Bow County zoning map.

For 'The Flats' area, the estimated summer period (July 1 to September 30) TP load to Silver Bow Creek, is 62.01 lbs/summer period (0.01 lbs/ac). No HDs were installed in 'The Flats'.

The estimated summer period (July 1 to September 30) TP load post-HD installation from the MS4 contributing area to Silver Bow Creek is 93.47 lbs/summer period (0.01 lbs/ac) (July 1 to September 30) (**Table 6-35**). For comparison to observed TP concentrations in the Butte MS4, the overall median TP value from the NURP water quality database is 0.27 mg/L TP (*n*=3765); for commercial sites the median is 0.22 mg/L TP (*n*=497), and for residential sites the median is 0.30 mg/L TP (*n*=1069) (Pitt et al., 2004).

Table 6-35. Estimated Summer (July 1 to September 30) TP Load from the BSB MS4 to the Silver Bow Creek Drainage

Basin	Sub-Basin	Area Data Source	Area (ac)	Endpoint	n	Years of Collection	Mean TP (mg/L)	TP Load (lbs/summer)[a, b]
Butte Hill	Rail Yard	EPA, 2009	*NA*	*Stormwater contained on site*	*Not applicable*			
	East Buffalo Gulch	EPA, 2009	57	MSD (EBG-OUT)	5	2010–12	0.7	0.87
	West Side Drainage	EPA, 2009	304	Infiltrates in ground or to HCC	*Not applicable*			
	Missoula Gulch	EPA, 2009	939	Silver Bow Creek (SBC-01)	5	2010–12	0.7	14.33
	Idaho Street	EPA, 2009	234	Via Missoula Gulch – (SBC-01)			0.7	3.57
	Montana Street	EPA, 2009	31	Silver Bow Creek (MT-OUT)			0.7	0.37
	Buffalo Gulch	EPA, 2009	302	Silver Bow Creek (BG-01)			0.7	3.52
	Anaconda Road	EPA, 2009	122	MSD (AB-OUT)			0.7	2.75
	Warren Avenue	EPA, 2009	84	MSD (WA-SD)			0.7	0.61
	MSD	EPA, 2009	114	MSD (MSD-OUT)			0.7	1.10
	MSD South Side	EPA, 2009	488	MSD (MSD-SS-OUT)			0.7	4.35
The Flats	Zoned commercial/industrial	ArcGIS	1,949	All receiving waterbodies			0.7	14.36
	Zoned open/residential		3,799	All receiving waterbodies	5		1.0	47.65
Total			7,968					93.47[c]

[a] Load was estimated using the 30-year precipitation record to determine that on average 30% of annual precipitation falls during the summer period and that 16% of this precipitation becomes runoff (0.09 in) as per the EPA HydroCAD assumption (U.S. Environmental Protection Agency, 2009b)

[b] Summer period is July 1 to September 30

[c] Total includes an estimated 4.8% reduction in TP loading due to HD installation in the MS4 in 2011–13

CERCLA Discharge from MPTP

MPTP is a CERCLA site (Superfund) on the south side of Silver Bow Creek. The site treats groundwater for polynuclear aromatic hydrocarbons (PAHs), pentachorophenol (PCP), and dioxins and furans, and discharges treated groundwater directly to Silver Bow Creek (**Figure 6-6**). MPTP operated as a wood treating facility from 1946 to 1984. During most of this period, a solution of about 5% PCP mixed with petroleum carrier oil was used to preserve poles, posts, and bridge timbers. Hazardous substances from the pole-treating operations were discharged into a ditch next to the plant.

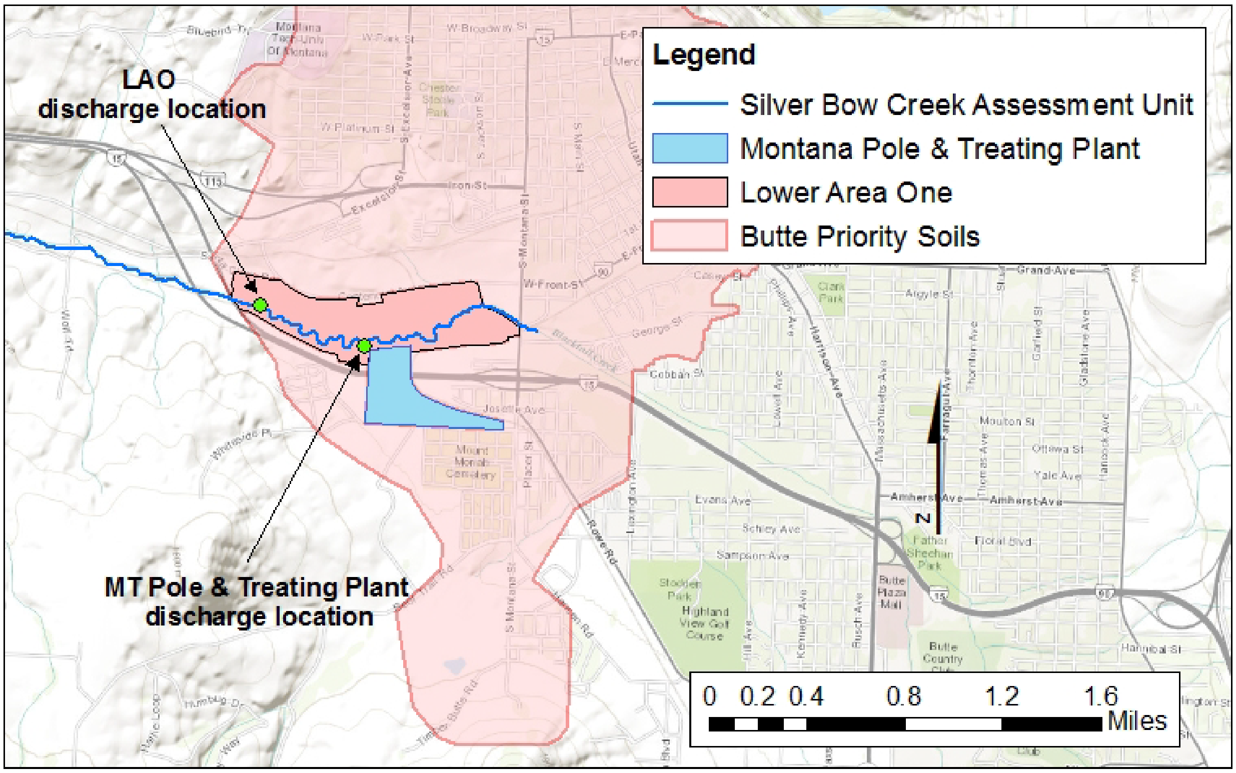

Figure 6-6. CERCLA Superfund Discharge Locations for LAO and MPTP on Silver Bow Creek

Following a citizen complaint in 1983, the MDHES, now DEQ, conducted an investigation and discovered an oil seep on the south side of Silver Bow Creek. Further investigation of the site revealed oil-saturated soils adjacent to the creek and on MPTP property. Subsequent sampling confirmed the presence of PCP, polynuclear aromatic hydrocarbons (PAHs), and dioxins/furans in site soils and oil samples. There is no known source of nitrogen on the MPTP site.

A nitrogen and oxygen isotopic analysis of a sample collected from a monitoring well on the MPTP site suggested a fertilizer or possibly an explosive source of nitrogen (LaFave, 2008). This sample also had the greatest nitrate concentration (45.5 mg/L) in the dataset (*n*=239). LaVelle Powder produced explosives (presumably ammonia-nitrate based) for mining operations and was located in the area south of Greenwood Ave and immediately to the west of St. Patrick's Cemetery on S. Montana Street in Butte, Montana, from 1954 to 1996. This location adjoins the MPTP property and is upgradient of that facility.

Water quality and flow data is available for the MPTP discharge to Silver Bow Creek for the summer period (July 1 to September 30) (**Table 6-36**). The difference in flow between years reflects changes in pumping rates at MPTP to account for construction activities on the north side of Silver Bow Creek at the BSB WWTP. Once BSB's construction is complete, long-term pumping rates at the MPTP should be in the range of 300–350 gpm (0.67–0.78 cfs).

Table 6-36. Water Quality Data for MPTP CERCLA Discharge to Silver Bow Creek, 2006–11, Collected by MBMG and DEQ

Statistic	$N0_3$-N (mg/L)[a]	PO_4-P (mg/L)[a]	Discharge (cfs)
Period of observations	2004–11	2006–11	2011–12
Number of observations	8	8	24
Minimum value	6.50	<0.05	0.40
Maximum value	8.07	0.074	0.96
Mean value	7.28	NA	0.64

[a] Data collected by MBMG of effluent within plant prior to discharge to channel to Silver Bow Creek

MBMG surface water quality data collected at the MPTP discharge to Silver Bow Creek (*n*=8) had a range of 6.50–8.07 mg/L $N0_3$-N, and a mean of 7.28 mg/L $N0_3$-N (**Table 6-36**). Orthophosphate was below reporting limits in 7 of 8 samples. This agrees with data collected by Plumb in 2007 (2009) from the actual channel from MPTP which enters Silver Bow Creek. Two summer period observations had a mean concentration of 7.65 mg/L $N0_3$-N (Plumb, 2009). Plumb did not test for orthophosphate.

Using the mean $N0_3$-N (mg/L) concentration of 7.28 mg/L and the anticipated long-term discharge of 325 gpm (0.72 cfs), the inorganic load from MPTP to Silver Bow Creek is 28.30 lbs/day $N0_3$-N. As a groundwater discharge, $N0_3$-N concentrations are assumed to be very close to TN (95% of TN = inorganic). Assuming 95% of the TN load at the facility is inorganic, the estimated existing load from MPTP to Silver Bow Creek is 29.79 lbs TN/day.

As a groundwater discharge, it can be assumed that TP loads are negligible. All but one observance in the available dataset was below detection limits for orthophosphate, although the reporting limits (0.05 mg/L and 0.10 mg/L) are both greater than the target concentration for the Middle Rockies (0.03 mg/L). While this analysis assumes TP loads from MPTP to Silver Bow Creek are negligible, additional sampling at lower detection limits is warranted to verify this assumption. This analysis will assume that TP is discharged from the facility at the target concentration of 0.03 mg/L. Using a flow rate of 0.72 cfs, this translates to a daily load of 0.12 lbs/day TP.

CERCLA Discharge from LAO

Administered by the EPA, manganese stockpiles were removed in 1992 and mine tailings (Colorado and Butte Reduction) were removed in 1993–97 from the BPSOU. In addition to removal of contaminated soils, a groundwater collection and treatment system was installed (Butte Treatment Lagoons) and catchment basins were constructed on Missoula Gulch. Treated groundwater and stormwater runoff are discharged Silver Bow Creek upstream of the BSB WWTP discharge to Silver Bow Creek. Remediation activities are covered by the ROD for the BPSOU (U.S. Environmental Protection Agency, 2006). The stream channel was dewatered and underwent complete reconstruction as part of remediation activities in LAO.

The Butte Treatment Lagoons treat approximately 1,200 gallons per minute of water. The treatment system is a two part process. Lime is added to the groundwater, causing the heavy metals to drop out of the water. Then the water travels through a series of wetlands to meet State of Montana water quality standards for metals prior to discharge to Silver Bow Creek (**Figure 6-5**).

Water quality data collected by DEQ includes flow measurements and $N0_3$-N among other water quality parameters. The mean summer period (July to September 30) discharge rate from 2009 to 2011 was 2.52 cfs and the mean $N0_3$-N concentration was 0.87 mg/L for samples collected between 2007 and 2011 during the summer period (**Table 6-37**).

Table 6-37. Water Quality Data for LAO CERCLA Discharge to Silver Bow Creek, 2006–11

Statistic	$N0_3$-N (mg/L)	Discharge (cfs)
Period of observations	2007–11	2009–11
Number of observations	15	259
Minimum value	0.20	0.85
Maximum value	1.60	3.44
Mean value	0.87	2.52

Using the mean $N0_3$-N concentration of 0.87 mg/L and mean discharge of 2.52 cfs, the inorganic load from the LAO to Silver Bow Creek is 11.84 lbs/day $N0_3$-N. As a groundwater discharge, it can be assumed that TP loads are negligible and that $N0_3$-N concentrations are very close to TN (95% of TN = inorganic). Assuming 95% of the TN load at the facility is inorganic, the estimated existing load from LAO to Silver Bow Creek is 12.46 lbs TN/day. This analysis will assume that TP is discharged from the facility at the target concentration of 0.03 mg/L. Using a flow rate of 2.52 cfs, this translates to a daily load of 0.41 lbs/day TP.

The LAO is a groundwater capture system, and this analysis assumed that most of this TN load comes from the Summit Valley including septic effluent and leaking storm and sanitary sewer lines as documented in the BSB stormwater infrastructure report (Butte Silver Bow Public Works Department, 2011). However, it is recognized that groundwater seepage from the Ranchland Packing storage ponds may be entering the LAO ponds system and be part of the nutrient load from LAO to Silver Bow Creek.

As stated in **Section 6.5.1.1.** (Subsurface Wastewater Treatment and Disposal, Ranchland Packing), a lack of facility design and construction and water quality data for the Ranchland Packing facility resulted in any load from the facility being composited with the Blacktail Creek/Summit Valley groundwater LA and not to the LAO WLA. Future assessment and monitoring should incorporate site and water quality investigations to determine whether groundwater discharges of nutrients from the Ranchland Packing pond system are occurring and whether flow pathways are intercepting the LAO ponds and/or the Silver Bow Creek channel.

Butte-Silver Bow WWTP (MT0022012)

The BSB WWTP is authorized to discharge treated wastewater to Silver Bow Creek under MPDES permit number MT0022012 (BSB City/County). The current permit became effective April 1, 2012, and expires March 31, 2017. The BSB WWTP is designed for a capacity 8.55 mgd, but had a 30-day average flow of 3.39 mgd based on DMR data (2002–11). The WWTP is designed to serve 49,600 people; however, it currently serves approximately 36,000 people.

The treatment process consists of activated sludge with aerobic sludge digestion and seasonal land application of effluent to a sod farm. At the sod farm, the BSB WWTP is allowed to apply effluent at agronomic rates by complying with the June 30, 1999, Spray Irrigation Authorization Circular DEQ-2 review letter (and any subsequent updates). The headworks consist of grit collection and a mechanically cleaned bar screen. Wastewater that has gone through preliminary treatment is then routed to one of the two aeration basins. The facility includes conventional activated sludge. Flow from the aeration basins is conveyed to secondary clarifiers and the effluent is chlorinated for disinfection and then dechlorinated prior to discharge.

The plant was built in 1990 and modified in 1998. Currently, plant upgrades are being planned and some construction has taken place. Upgrades were planned to include a new screenings washer/compactor, a new grit pump, a new Parshall flume, and UV disinfection, as well as upgrades to the emergency power and SCADA systems. Phase 2 of the upgrades includes biological nutrient removal and effluent reuse at the Sod Farm or additional public or private lands. Final design and treatment capabilities for the new facility have not yet been determined.

The VNRP was accepted by the EPA in 1998. This agreement sought to restore beneficial uses in the Clark Fork River and included nutrient load reduction strategies for several WWTPs including BSB. However, the VNRP intended the BSB WWTP to meet nutrient concentration targets at the confluence of Silver Bow Creek, Mill-Willow Bypass and Warm Springs Creek, approximately 20 miles downstream of Butte. The VNRP was not intended to restore beneficial uses on Silver Bow Creek. The BSB WWTP benefited significantly from Warm Springs Ponds, which acts as a nutrient sink for Silver Bow Creek, and of Warm Springs Creek as a conduit for clean dilution water for the Clark Fork (Tri-State Water Quality Council, 2009).

The BSB WWTP has two authorized outfalls. Outfall 001 is a continuous discharge to Silver Bow Creek with no effluent mixing zone. Outfall 002 is seasonal discharge to land application at the BSB sod farm, approximately seven miles west of the WWTP near the confluence of Sand Creek and Silver Bow Creek. Outfall 001 is located at 45° 59’ 38” N, 112° 34’ 16” W and Outfall 002 is located at 45° 59’ 43” N, 112° 40’ 12” W. Outfall 001 currently has a permitted average monthly limit of 97 lbs/day TN and 9.7 lbs/day TP. Outfall limits for 002 at the sod farm are outlined in 1999 Spray Irrigation Authorization Circular DEQ-2 review letter (and any subsequent updates).

DMR data from 2002 to 2011 was analyzed for the BSB WWTP. Summer period (July 1 to September 30) data is summarized in **Table 6-38**.

Table 6-38. BSB WWTP July 1 to September 30 DMR Summary for 2002–11

Statistic	TN (mg/L)	TP (mg/L)	Discharge (cfs)
Period of observations	2002–11	2002–11	2002–11
Number of observations	30	30	30
Minimum value	12.40	0.89	4.40
Maximum value	21.50	2.70	6.28
Mean value	17.07	1.65	5.25

A one-way analysis of variance statistical test was completed for discharge, TN and TP by month for the summer period (July 1 to September 30). The analysis failed to reject the null hypothesis (α=0.05) of a difference in means by month for any of the parameters. As the mean and median values are very close for each of the parameters, mean values are used to estimate the summer period nutrient loading from the BSB WWTP to Silver Bow Creek.

Using the mean flow and TN values, the load to Silver Bow Creek from the BSB WWTP discharge during the summer period is 483.93 lbs/day TN. Using the mean flow and TP values, the load to Silver Bow Creek from the BSB WWTP discharge during the summer period is 46.78 lbs/day TP.

Except during periods of snowmelt or rain events, discharge from the WWTP comprises roughly ¼ to ½ of the total flow in upper Silver Bow Creek (Gammons et al., 2011). Due to the WWTP discharge, a nightly hypoxic zone can extend a distance of 2.4 miles downstream of the WWTP discharge, beginning at the west end of the I15 overpass (Gammons et al., 2011). Total recovery of dissolved oxygen concentrations to levels observed upstream of the WWTP discharge has been documented as first occurring >6 miles downstream of the WWTP discharge (Naughton, 2013).

Town of Rocker WWTP (MT0027430)

The Rocker WWTP is authorized to discharge treated wastewater to Silver Bow Creek under MPDES permit number MT0027430. The permit became effective June 1, 2013, and expires May 31, 2018. The Rocker WWTP serves the County and Water District of Rocker located near Butte, Montana. According to communications with Rocker WWTP staff, approximately 70–80% of the flow comes from businesses; the remainder is residential. The total population served by the Rocker WWTP is unknown.

The Rocker WWTP was upgraded from a three-cell aerated lagoon system that was constructed in 1986 to an activated sludge package plant in 1995. The design flow for the lagoon system is 0.035 mgd and the design flow of the activated sludge plant is 0.050 mgd. Disinfection is achieved by chlorination prior to discharge. The 30-day average flow from approximately December 2006 through December 2011 was 0.024 mgd (≈24,700 gpd). Based on communication with Rocker WWTP plant staff, there is approximately 6,800 linear feet of pipelines, both gravity and force main.

Rocker WWTP has one permitted outfall. Outfall 001 discharges into Silver Bow Creek and is located at 46° 00’ 08” N and 112° 37’ 40” W. The permitted mixing zone is 200 ft downstream of the discharge point. Outfall 001 currently has a permitted average monthly limit of 6.4 lbs/day TN and 4.9 lbs/day TP.

Comprehensive data collection for multiple constituents and flow started in late 2006. DMR data from 2007 to 2011 was analyzed for the Rocker WWTP. Summer period (July 1 to September 30) data is summarized in **Table 6-39**.

Table 6-39. Rocker WWTP July 1 to September 30 DMR Summary for 2007–11

Statistic	TN (mg/L)	TP (mg/L)	Discharge (cfs)
Period of observations	2007–11	2007–11	2007–11
Number of observations	15	15	15
Minimum value	7.23	1.84	0.034
Maximum value	30.70	41.10	0.045
Mean value	18.00	13.94	0.041

A one-way analysis of variance statistical test was completed for discharge, TN and TP by month. The analysis failed to reject the null hypothesis (α=0.05) of a difference in means by month for any of the parameters. As the mean and median values are very close for each of the parameters, mean values are used to estimate the summer period nutrient loading from the Rocker WWTP to Silver Bow Creek.

Using the mean flow and TN values, the load to Silver Bow Creek from the Rocker WWTP discharge during the summer period is 3.99 lbs TN/day. Using the mean flow and TP values, the load to Silver Bow Creek from the Rocker WWTP discharge during the summer period is 3.09 lbs TP/day.

Montana Livestock Auction (MTG010166)

The Montana Livestock Auction operates under a CAFO General Permit. In addition to the general permit requirements, the permit for the Montana Livestock Auction includes additional considerations, which must be met:

1) The facility must be designed, constructed, and operated to contain all process generated wastewaters, plus the precipitation from the runoff of a 25-year, 24-hour rain event. The weather station to determine the amount of precipitation that occurs at the facility shall be the National Weather Service, Missoula (KMTMISS08) or Butte Airport (KMTBUTTE5). The permittee has the option of maintaining a comparable precipitation gage at the facility.
2) The facility shall prepare an annual waste management plan (AR2) that is site specific and addresses manure and wastewater handling and storage, land application of manure and other nutrient sources, site management, record keeping, and other items outlined in the report.

Compliance with the CAFO General Permit, and the associated DEQ approved annual waste management plan (AR2) constitute the meeting of all TMDL requirements for nutrients for this facility. Under the conditions of the permits, all pollutants are to be contained on site during any and all storm events less than a 25-year, 24 hour rain event. Therefore the WLA is 0 for this source, under typical rainfall events (less than 25-year storm event). Research of facility operations found that, currently, all produced manure is transported off site for use by a commercial compost producer.

Given the discharge history at MTG010166, the estimated existing load from the facility to Silver Bow Creek is 0.0 lbs TN/day and 0.0 lbs TP/day.

Renewable Energy Corporation Advanced Silicon Materials (MT0030350)

The REC Advanced Silicon Materials is authorized to discharge wastewater to Sheep Gulch, a tributary of Silver Bow Creek, under MPDES permit number MT0030350. The permit became effective November 1, 2010, and expires October 31, 2015.

The REC Advanced Silicon Materials MPDES permit identifies three outfall locations. Discharge 001 is the primary discharge from the facility to Sheep Gulch. Two other discharges are included in the permit: 002 is for stormwater discharge and 003 is a direct discharge to Silver Bow Creek that has never been used and is identified for potential future use. Outfall 001 is located at 45° 58' 21 " N and 112° 41' 23" W and discharges to Sheep Gulch. Outfall 002 is located at 45° 59' 57 " N and 112° 41' 3" W and is a stormwater discharge/overflow from retention ponds and discharges to Sheep Gulch. Outfall 003 is located at 46° 0' 15 " N and 112° 41' 36" W and discharges to Silver Bow Creek. No outfall has a mixing zone for any parameter.

Under the previous permit cycle, DMR data was collected quarterly. Since the new permit was issued for the facility in late 2010, monitoring has been conducted monthly (**Table 6-40**).

Table 6-40. Water Quality Data for REC Advanced Silicon Materials to Sheep Gulch for the Summer Period (July 1 to September 30), Collected by the Facility

Statistic	$N0_3$-N (mg/L)	TN (mg/L)	PO_4-P (mg/L)	Discharge (cfs)
Period of observations	2011–12	2011–12	2011–12	2011–12
Number of observations	6	6	6	6
Minimum value	<0.01	<0.3	0.17	1.28
Maximum value	0.04	0.3	0.24	1.42
Mean value	NA	NA	0.20	1.35

It is difficult to determine the TN load from the REC facility to Sheep Gulch. The water quality target for TN in the Middle Rockies ecoregion is 0.300 mg/L, which is also the reporting limit used for samples collected at Outfall 001. For purposes of estimating the existing TN load from the facility, it will be assumed that REC is discharging at the target of 0.300 mg/L TN. Using the average discharge of 1.35 cfs and the Middle Rockies TN target of 0.300 mg/L, the estimated TN load is 2.19 lbs TN/day. PO_4-P data exceeded the Middle Rockies TP target of 0.03 mg/L in all 6 samples. Using the mean summer period (July 1 to September 30) discharge of 1.35 cfs and the mean PO_4-P concentration of 0.20 mg/L, the TP load from Outfall 001 discharge to Sheep Gulch is calculated to be 1.46 lbs TP/day. In lieu of any TP data for the discharge, this assumes that PO_4-P comprises 100% of TP for the discharge.

No DMR data is reported for Outfall 002. As covered under the permit, this is a stormwater discharge which requires the permittee to develop and implement a SWPPP. The purpose of the SWPPP is to identify sources of pollution to stormwater and to select BMPs to eliminate or minimize pollutant discharges at the source and/or to remove pollutants contained in the storm water runoff. The facility must implement the provisions of the SWPPP required under this part as a condition of the permit. This applies to stormwater generated from precipitation that is both commingled and independent of process wastewater generated by the facility, prior to the regulated point source discharge. It is assumed that following the stormwater permit requirements including the SWPPP will not result in nutrient(s) impairment of the receiving waterbodies. The storm water retention ponds were designed to contain and provide infiltration to groundwater for the 100-yr storm event (1% recurrence interval). The permit requires that sampling should occur within the first 30 minutes after the system is activated, but there has not yet been an event where the retention ponds discharged stormwater flows to Sheep Gulch.

For Outfall 003, the permit requires that continuous flow monitoring equipment must be installed prior to the commencement of any discharge from that location. No infrastructure has been built at the permitted outfall location and none is planned. The current load from Outfall 003 to Silver Bow Creek is 0.0 lbs/day TN and 0.0 lbs/day TP.

6.5.2 Approach to TMDL Development and Allocations

6.5.2.1 TMDL Equation

TMDL calculations for TN and TP are based on the following formula:

Equation 1: TMDL = (X) (Y) (5.4)

TMDL= Total Maximum Daily Load in lbs/day
X = water quality target in mg/L (TN = 0.30 mg/L or TP = 0.030 mg/L)
Y = streamflow in cfs
5.4 = conversion factor

Note that the TMDL is not static, as flow increases the allowable (TMDL) load increases as shown by the TP example in **Figure 6-7**.

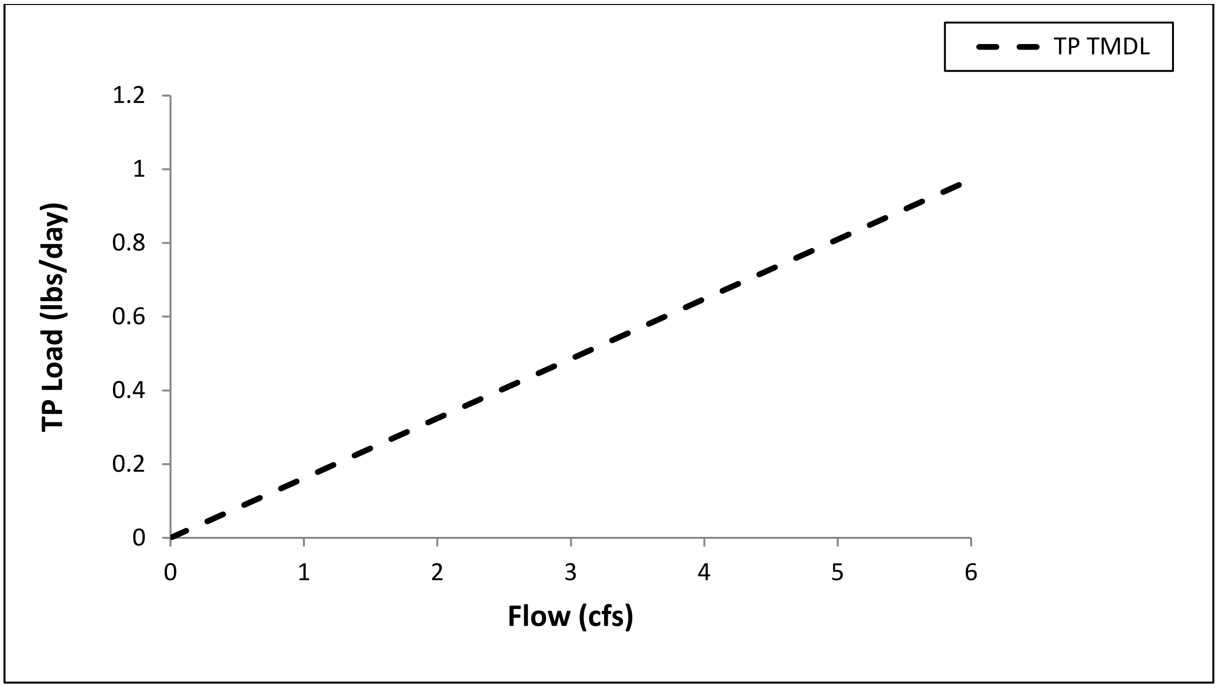

Figure 6-7. Example TMDL for TP from 0 to 6 cfs

Approach to TMDL Allocations
As discussed in **Section 4.0**, the TN and TP TMDLs for applicable impaired waterbody AUs consist of the sum of LAs to individual source categories (**Tables 6-41** and **6-42**). LAs will be calculated for the following source categories: (1) Natural background, and (2) Human-caused (agriculture, silviculture, mining, and subsurface wastewater treatment and disposal). In the absence of individual WLAs and an explicit MOS, the TMDLs for TN, and TP in each waterbody are equal to the sum of the individual loads as follows:

Equation 2: $TMDL = LA_{NB} + LA_{H}$

LA_{NB} = Load Allocation to natural background sources

LA_{H} = Load Allocation to agriculture, silviculture, mining, and subsurface wastewater treatment and disposal sources

The exception to this approach is Silver Bow Creek. Silver Bow Creek contains many discrete point sources in addition to numerous tributary streams in the watershed. Sampling data is extensive enough that loading from sub-watersheds and point sources is broken out.

Equation 3: $TMDL = LA_{NB} + LA_{H(\text{Blacktail Creek/Summit Valley})} + LA_{H(\text{Sand Creek})} + LA_{H(\text{Browns Gulch})} + LA_{H(\text{German Gulch})} + LA_{H(\text{Gregson Creek})} + LA_{H(\text{Mill-Willow Bypass (incl. Mill and Willow Creeks)})} + LA_{H(\text{Silver Bow Creek near channel})} + WLA_{x}$

LA_{NB} = Load Allocation to natural background sources

$LA_{H(sub\text{-}watershed)}$= Load Allocation to agriculture, silviculture, mining, and subsurface wastewater treatment and disposal sources per respective sub-watershed

WLA_{x} = Wasteload Allocation per respective point source

Table 6-41. TN LA Source Categories and Descriptions for the Upper Clark Fork Phase 2 TPA

Source Category	LA Descriptions
Natural Background	• soils and local geology • natural vegetative decay • wet and dry airborne deposition • wild animal waste • natural biochemical processes that contribute nitrogen to nearby waterbodies
Human-Caused (Agricultural, Silviculture, Mining, Subsurface Wastewater Treatment and Disposal)	• domestic animal waste • fertilizer • loss of riparian and wetland vegetation along streambanks • limited nutrient uptake due to loss of overstory • cyanide breakdown from leaching • runoff from exposed rock containing natural background nitrate • residual chemicals left over from mining practices • human waste

Table 6-42. TP LA Source Categories and Descriptions for the Upper Clark Fork Phase 2 TPA

Source Category	LA Descriptions
Natural Background	• soils and local geology • natural vegetative decay • wet and dry airborne deposition • wild animal waste • natural biochemical processes that contribute phosphorus to nearby waterbodies
Human-Caused (Agricultural, Silviculture, Mining, Subsurface Wastewater Treatment and Disposal)	• domestic animal waste • fertilizer • loss of riparian and wetland vegetation along streambanks • limited nutrient uptake due to loss of overstory • runoff from exposed rock containing natural background phosphorus • human waste

Natural Background Allocation

Natural background loading is discussed in **Section 6.5.1.1**. The natural background load is calculated as follows:

Equation 4: LA_{NB} = (X) (Y) (5.4)

LA_{NB} = Load Allocated to natural background sources
X = natural background concentration in mg/L (TN = 0.095 mg/L or TP = 0.01 mg/L)
Y = streamflow in cfs (median from the applicable stream)
5.4 = conversion factor

Allocations for Human-Caused Sources

The LA to human-caused sources is calculated as the difference between the allowable daily load (TMDL) and the natural background load:

Equation 5: LA_H = TMDL – LA_{NB}

LA_H = Load Allocation to agriculture, silviculture, mining, and subsurface wastewater treatment and disposal sources

This will be used for all TMDLs with the exception of Silver Bow Creek. For Silver Bow Creek, the same method will be applied but will be specific per identified sub-watershed within the large Silver Bow Creek drainage.

6.5.2.2 Total Existing Load

To estimate the total existing loading for the purpose of estimating a required load reduction, the following equation will be used:

Equation 6: Total Existing Load = (X) (Y) (5.4)

X = measured concentration in mg/L (80th percentile[1] from the applicable stream)
Y = streamflow in cfs (median from the applicable stream)
5.4 = conversion factor

[1] The 80th percentile will be used because it corresponds to the exceedance rate allowed by the Exact Binomial Test used for water quality assessment described in **Section 6.4.3**.

6.6 Source Assessments, TMDLs, Allocations, and Reductions for Each Stream

The below sections describe the most significant natural and human-caused sources in more detail, establish TMDLs and LAs to specific source categories, provide nutrient loading estimates for natural, septic, and human-caused source categories to nutrient-impaired stream segments, and estimate reductions necessary to meet water quality targets for the following streams:

- Dempsey Creek (MT76G002_100)
- Dunkleberg Creek (MT76G005_072)
- Gold Creek (MT76G002_132)
- Hoover Creek, upper (MT76G005_082)
- Hoover Creek, lower (MT76G005_081)
- Lost Creek (MT76G002_072)
- Peterson Creek, upper (MT76G002_132)
- Peterson Creek, lower (MT76G002_131)
- Silver Bow Creek (MT76G003_020)
- Willow Creek, upper (MT76G002_062)
- Willow Creek, lower (MT76G002_061)

The existing loads are used to estimate load reductions by comparing them to the allowable (TMDL) load and computing a required percent reduction to meet the TMDL. These load reduction estimates can be complicated by nutrient uptake within the stream. TN and/or TP target exceedances, or the extent by which they exceed a target, can be masked by nutrient uptake.

No load reductions are given for natural background allocations. To reduce the impacts of adding septic systems in the future, Type II systems may be installed to decrease nitrogen loading and/or systems may be installed further away from streams to allow for more nutrients attenuation.

6.6.1 Dempsey Creek (MT76G002_100)

6.6.1.1 Assessment of Water Quality Results

The source assessment for Dempsey Creek consists of an evaluation of TN and TP concentrations and exceedances of chl-*a* and/or AFDM within the impaired segment of Dempsey Creek. This is followed by the quantification of the most significant human caused sources of nutrients. It should be noted that FWP lists Dempsey Creek as being chronically dewatered (dewatering is a significant issue in most years) from the confluence of the north and south forks to the mouth (Clark Fork River). In addition, a sediment TMDL for Dempsey Creek was completed in 2010 (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2010). **Figure 6-8** presents the approximate locations of data pertinent to the source assessment in the sub-watershed.

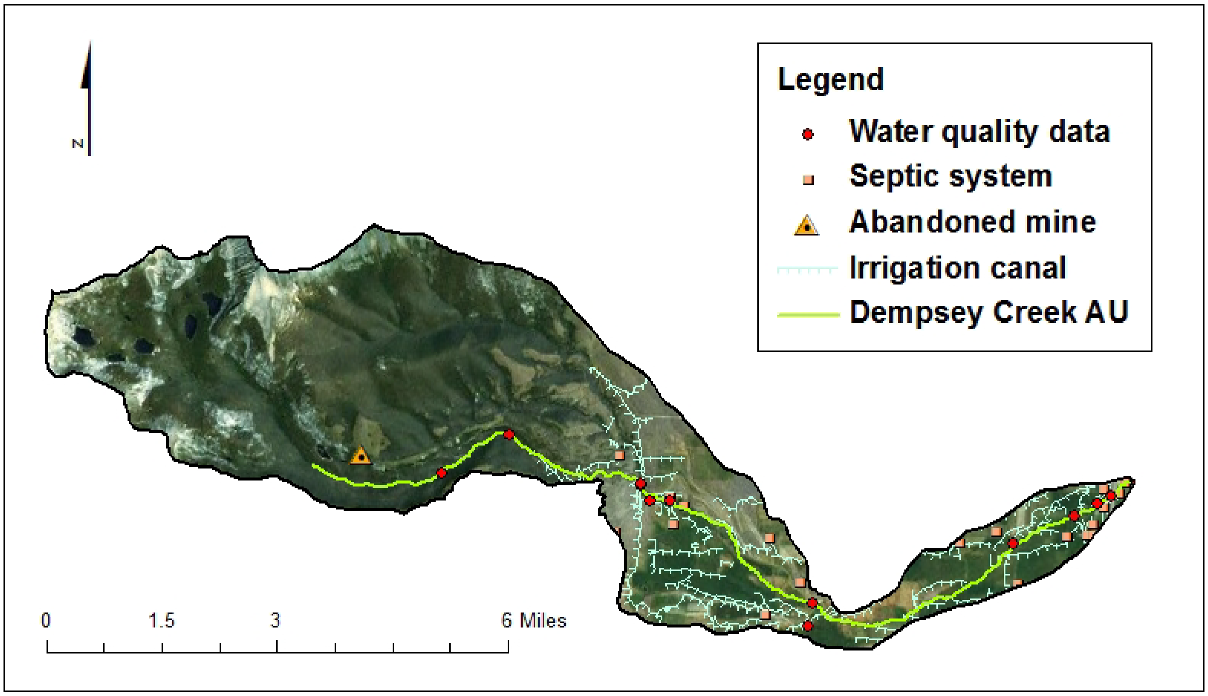

Figure 6-8. Dempsey Creek Sub-Watershed with Water Quality Sampling Locations

Total Nitrogen

DEQ collected water quality samples from Dempsey Creek during the growing season over the 2003–11 time period (**Section 6.4.3.1**, **Table 6-4**). With the exception of a single sample collected upstream of the forest boundary, all target exceedances were observed at sampling locations at and downstream of the Dempsey Lake Road crossing (lower drainage near the 'neck' in **Figure 6-8**). **Figure 6-9** presents summary statistics for TN concentrations at sampling sites in Dempsey Creek. TN concentrations were in excess of the target in 8 of 9 samples collected downstream of the Dempsey Lake Road crossing. In the following figure, includes the North Fork at Mouth and Unnamed Spring Creek, which are both tributaries to the Dempsey Creek AU. Included in **Figure 6-9** is data collected from an unnamed spring creek which yielded TN concentrations at >2 times the target concentration of 0.30 mg/L TN. The sole chl-*a* target exceedance occurred at the Greenhouse Road Bridge.

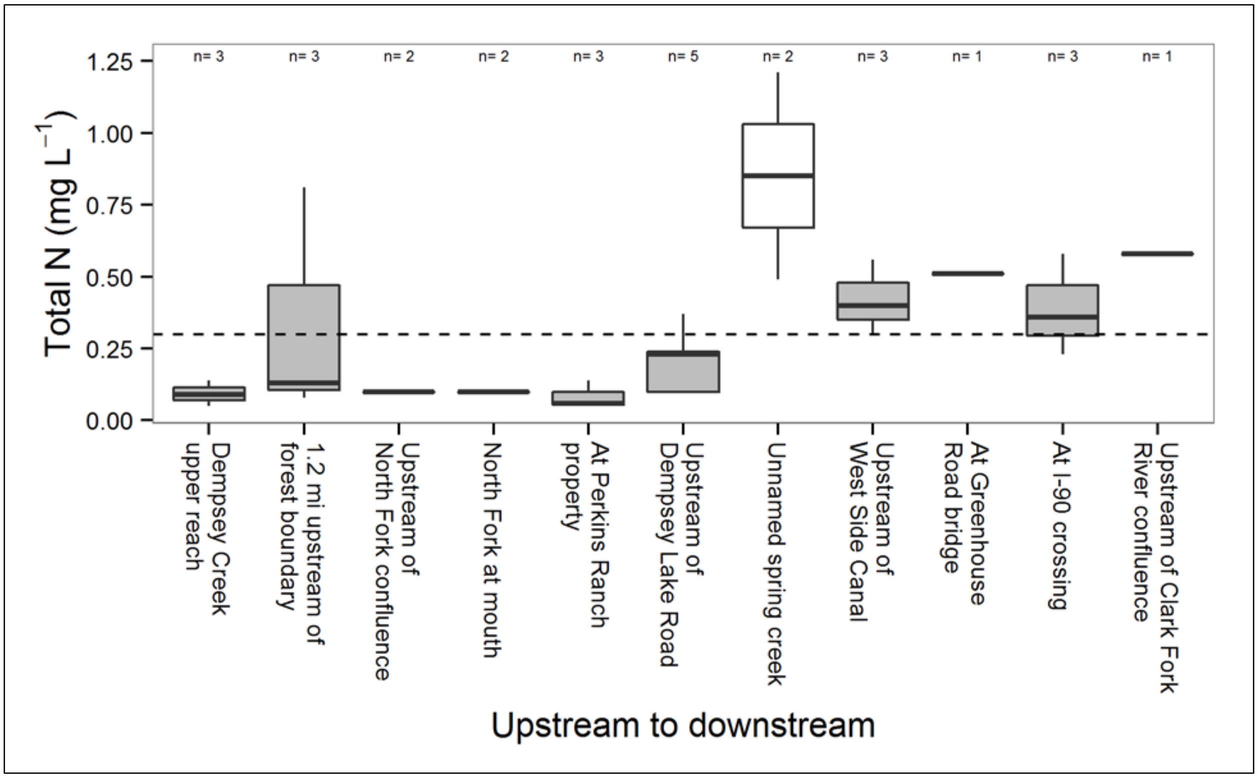

Figure 6-9. Boxplot of TN Concentrations in Dempsey Creek (2007–11) (Gray Boxes Are Mainstem Samples, White Boxes Are Tributaries, Dashed Line Is Target)

In **Figure 6-10**, sample data from the AU was plotted as a ratio to the TN target. Synoptic sampling around the unnamed spring creek was done for two events in the summer of 2010. A July 2010 event recorded decreasing flows between the station located upstream of Dempsey Lake Road and the site upstream of the West Side Canal due to irrigation withdrawals even as TN concentrations increased in the stream. A late September 2010 sampling event recorded increasing flows at the sites bracketing the unnamed spring creek in addition to increasing TN concentrations in the stream. In the 2nd event, the unnamed spring creek load comprised 25.5% of the TN load measured at the next downstream station (upstream of West Side Canal).

Exceedances of the TN target are plotted in **Figure 6-11**. Reductions needed to achieve the TMDL range from 17% to 63%, with a median reduction of 44%.

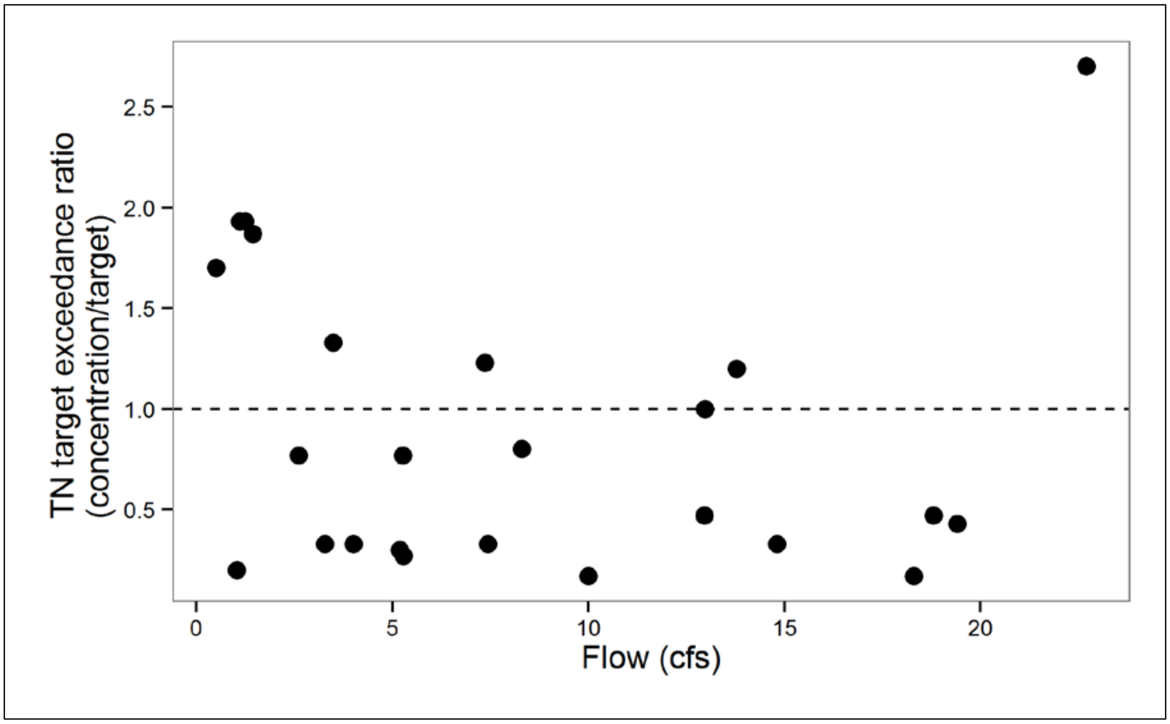

Figure 6-10. TN Target Exceedance Ratio in Dempsey Creek (2007–11) (>1 Indicates Exceedance)

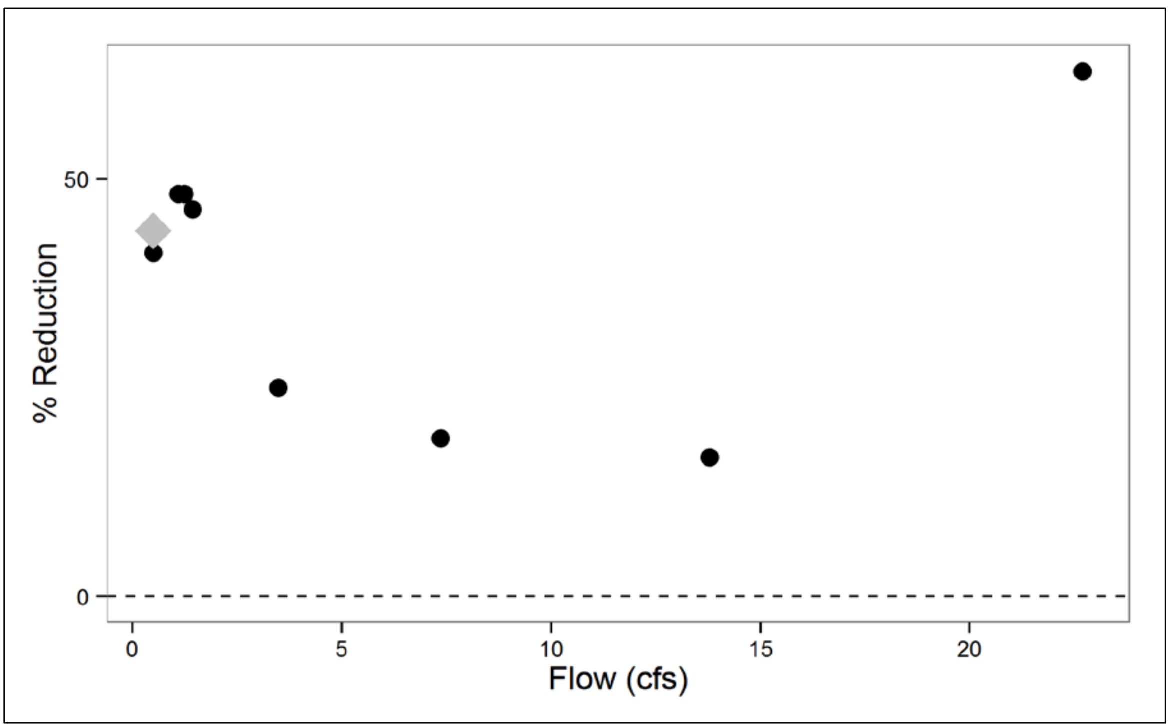

Figure 6-11. Scatterplot of Mainstem Observations and Respective Percent Reductions Necessary to Achieve the TN TMDL in Dempsey Creek (the Gray Diamond Is the Median (50th percentile) Observation of Samples that Exceeded the TN TMDL (2007–11))

Total Phosphorus

DEQ collected water quality samples from Dempsey Creek during the growing season over the 2003–11 time period (**Section 6.4.3.1**, **Table 6-4**). In examining the TP concentration data for Dempsey Creek, no exceedances of the water quality target were observed upstream of the Dempsey Lake Road crossing (**Figure 6-12**). However, nearly all samples exceeded the target concentration downstream of Dempsey Lake Road. Samples collected from an unnamed spring creek were also found to in exceedance of the target concentration. The sole chl-*a* target exceedance occurred in the lower AU at Greenhouse Road.

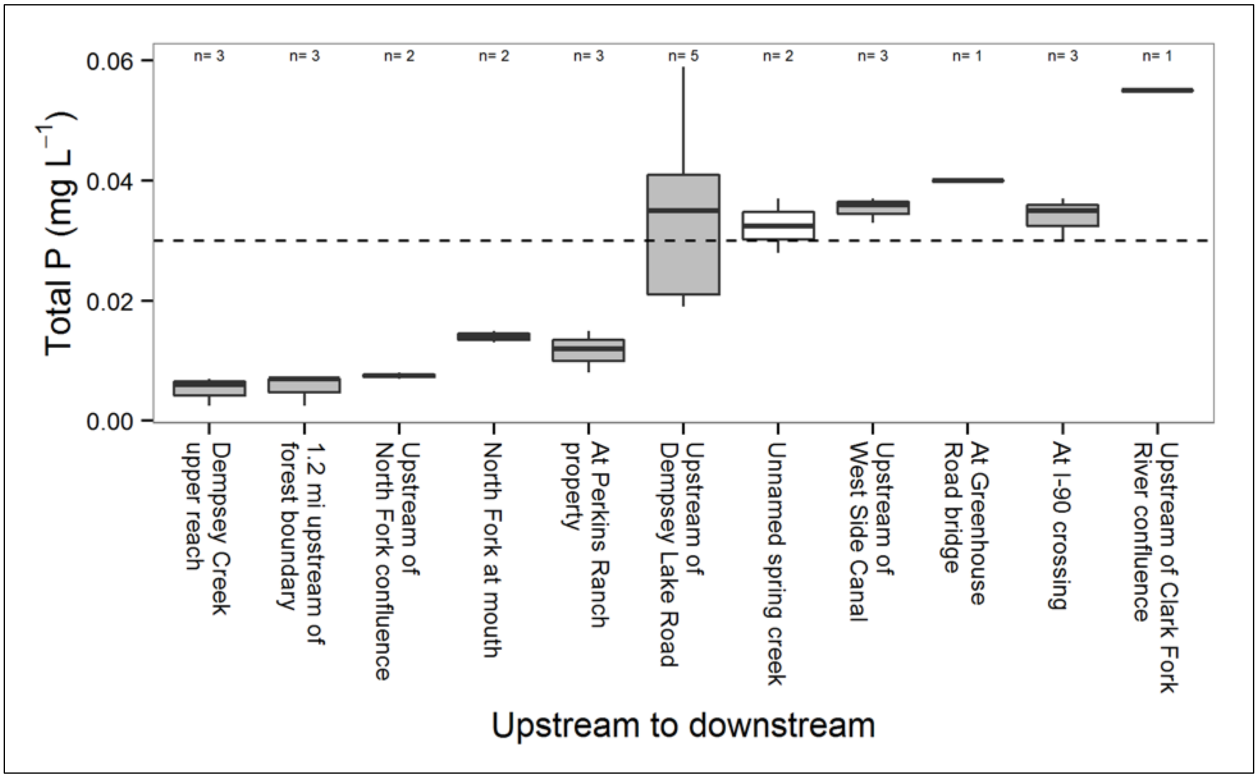

Figure 6-12. Boxplot of TP Concentrations in Dempsey Creek (2007–11) (Gray Boxes Are Mainstem Samples, White Boxes Are Tributaries, Dashed Line Is Target)

For two synoptic sampling events in July and September 2010, the unnamed spring creek provided dilution of instream TP concentrations. This is expected as the tributary is a spring creek comprised of groundwater recharge from upgradient irrigated and dryland cropping portions of the Dempsey Creek sub-watershed and would not be expected to have elevated TP concentrations given its likely source area.

Target exceedance ratios were plotted for all Dempsey Creek samples. Exceedances ranged from 1 to 2 times the target value and at a range of flows from ~1 cfs to 14 cfs (**Figure 6-13**). Exceedances of the TP target are plotted in **Figure 6-14**. Reductions needed to achieve the TMDL range from 9% to 49% with a median reduction of 22.0%.

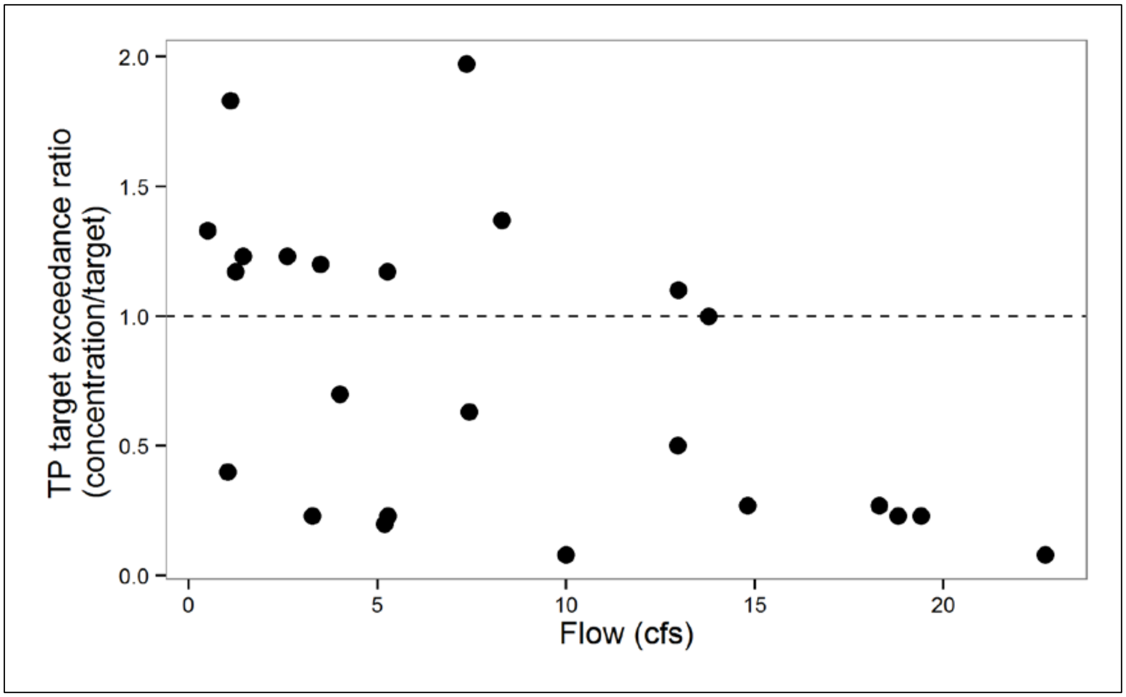

Figure 6-13. TP Target Exceedance Ratio for Dempsey Creek (2007–11) (>1 Indicates Exceedance)

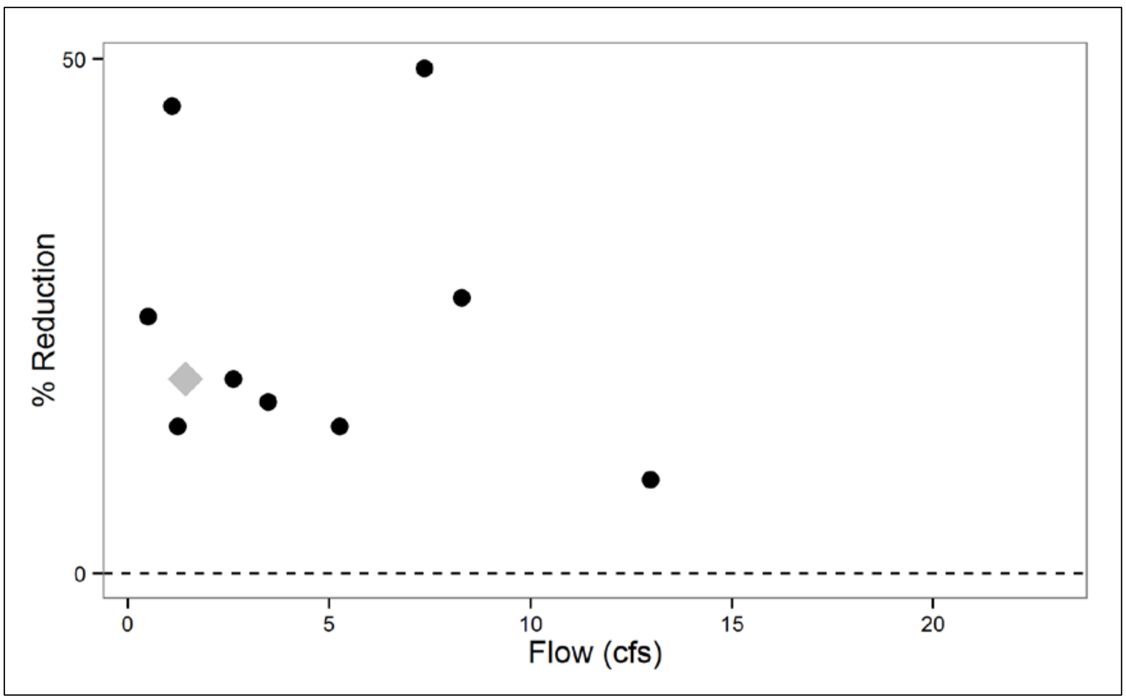

Figure 6-14. Scatterplot of Mainstem Observations and Respective Percent Reductions Necessary to Achieve the TP TMDL in Dempsey Creek (the Gray Diamond Is the Median (50th percentile) Observation of Samples that Exceeded the TP TMDL (2007–11))

6.6.1.2 Assessment of Loading by Source Categories

Agriculture

The primary land use and most significant nutrient source in the Dempsey Creek sub-watershed is agriculture. Grazing allotments comprise 4,362 acres on USFS administered lands in the drainage with a current maximum of 249 permitted AUMs (**Table 6-27**). However, based on water quality data, irrigated agriculture appears to be the more important source of nutrients. Irrigated cropland includes barley, wheat, alfalfa and hay. Irrigation diversions often dewater the stream in late summer in the lower sub-watershed (Liermann et al., 2009). Within the sub-watershed and including livestock sources, irrigation return flows from overland runoff and groundwater recharge in the lower drainage are likely flow pathways by which nutrients are reaching Dempsey Creek. In addition nutrient loads are transported into the Dempsey Creek drainage from irrigation canals originating outside the drainage.

The majority of the Dempsey Creek irrigation network is located within the lower half of the basin and has significant interaction (losses/gains) between the adjacent sub-watersheds through the connection of 20+ ditches (Confluence, Inc., 2008). There are several inter-sub-watershed transfers of irrigation water to the Dempsey Creek sub-watershed, with the 2 largest being the Morrison Ditch (also called the #21 ditch (Confluence, Inc., 2008) and the West Side Canal. The Morrison Ditch originates at a point of diversion on Racetrack Creek. The West Side Canal begins at a point of diversion on the Clark Fork River approximately where Modesty Creek flows into the Clark Fork River. From aerial photographs, it appears that both of these canals are piped across the Dempsey Creek channel as discharge/channel width do not appear to increase downstream of these crossings and irrigation conveyance infrastructure is visible. This analysis assumed that no load is directly transferred at these crossings.

For TN and TP, water quality collected from these 2 ditches was found to be equal to or greater than the nutrient targets (**Table 6-43**). Water lost to groundwater as the ditches cross the drainage or where flows are diverted for use within the drainage may ultimately contribute to the Dempsey Creek TN and TP nutrient loads.

Table 6-43. Nutrient Water Quality Data for Irrigation Canals in the Dempsey Creek Sub-Watershed

Canal/Ditch Name	No. of Samples[a]	Mean Flow (cfs)	Mean TN (mg/L)	Mean TP (mg/L)
Morrison Ditch	2	7.3	0.32	0.05
West Side Canal	2	22.0	0.35	0.03

[a] Data collected in July and September 2010

Mining

There is one abandoned mine, a copper lode prospect mine, in the headwaters of Dempsey Creek. The site is having no discernible impacts on nutrient water quality.

Silviculture (includes timber harvest)

For TN, there was an exceedance of the target concentration in Dempsey Creek upstream of the forest boundary on 8/25/2011. However, there have been no recent forest management activities on USFS administered lands in the Dempsey Creek drainage, upstream of the forest boundary. The cause of this exceedance is unknown but it is unlikely that it came from forest practices.

Subsurface Wastewater Disposal and Treatment

According to DEQ records, there are 19 individual septic systems in the Dempsey Creek sub-watershed and while several are within a few hundred feet of the channel, the majority of these systems are located outside the main floodway. Based on the number of systems, their lack of clustering and their relative distance from the stream, septic effluent is considered a minor contributor to the existing Dempsey Creek TN and TP daily loads.

Summary
The source assessment for Dempsey Creek suggests that the most important source of nutrients in the sub-watershed is from grazing and cropping on irrigated lands. The irrigation conveyance infrastructure appears to be transporting a portion of the observed Dempsey Creek nutrient loads from outside the watershed, namely from diversion points on Racetrack Creek and the Clark Fork River with possible influence from nutrient sources in the intervening distance between point of diversion and place of use.

6.6.1.3 TN TMDL, Allocations, and Current Loading
The TMDL for TN is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the TN TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TN TMDL for Dempsey Creek uses **Equation 1**, with the median measured flow from all sites during 2007–11 sampling (6.32 cfs):

***Equation 1*: *TMDL* = (0.30 mg/L) (6.32 cfs) (5.4) = 10.24 lbs/day**

Equation 4 is the basis for the natural background LA for TN. To continue with the example at a flow of 6.32 cfs, this allocation is as follows:

***Equation 4*: LA_{NB} = (0.095 mg/L) (6.32 cfs) (5.4) = 3.24 lbs/day**

Using **Equation 5**, the combined human-caused TN LA at 6.32 cfs can be calculated:

***Equation 5*: LA_{H} = 10.24 lbs/day – 3.24 lbs/day = 7.00 lbs/day**

An example total existing load is calculated as follows using **Equation 6,** the 80th percentile of TN values measured from Dempsey Creek from 2007 to 2011 (0.444 mg/L) and the median measured flow of 6.32 cfs:

***Equation 6*: *Total Existing Load* = (0.444 mg/L) (6.32 cfs) (5.4) = 15.15 lbs/day**

The portion of the existing load attributed to human sources is 11.91 lbs/day, which is determined by subtracting out the 3.24 lbs/day background load. This 11.91 lbs/day value represents the load measured within the stream after potential nutrient uptake.

Table 6-44 contains the results for the example TN TMDL, LAs, and current loading. In addition, it contains an example percent reduction to the human-caused LA required to meet the water quality target for TN. At the median growing season flow of 6.32 cfs and the 80th percentile of measured TN values, the current loading in Dempsey Creek is greater than the TMDL. Under these example conditions a 41% reduction of human-caused sources and an overall 34% reduction of TN in Dempsey Creek would result in the TMDL being met. The source assessment of the Dempsey Creek watershed indicates that irrigated agriculture is the most likely source of TN in Dempsey Creek; load reductions should focus on limiting and controlling TN loading from this source. Meeting LAs for Dempsey Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 7.0**. Inter-sub-watershed transfers of irrigation flows complicate nutrient loading dynamics.

Table 6-44. Dempsey Creek TN Example TMDL, LAs, Current Loading, and Reductions

Source Category	Allocation and TMDL (lbs/day)[a]	Existing Load (lbs/day)[a]	Percent Reduction
Natural Background	3.24	3.24	0%
Human-caused (primarily irrigated agriculture)	7.00	11.91	41%
	TMDL = 10.24	**Total = 15.15**	**Total = 32%**

[a] Based on a median growing season flow of 6.32 cfs

6.6.1.4 TP TMDL, Allocations, and Current Loading

The TMDL for TP is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the TP TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TP TMDL for Dempsey Creek uses **Equation 1**, with the median measured flow from all sites during 2007–11 sampling (6.32 cfs):

***Equation 1**: TMDL* **= (0.03 mg/L) (6.32 cfs) (5.4) = 1.02 lbs/day**

Equation 4 is the basis for the natural background LA for TP. To continue with the example at a flow of 6.32 cfs, this allocation is as follows:

***Equation 4**:* LA_{NB} **= (0.01 mg/L) (6.32 cfs) (5.4) = 0.34 lbs/day**

Using **Equation 5**, the combined septic and other human-caused TP LA at 6.32 cfs can be calculated:

***Equation 5**:* LA_{H} **= 1.02 lbs/day – 0.34 lbs/day = 0.68 lbs/day**

An example total existing load is calculated as follows using **Equation 6**, the 80th percentile of TP values measured from Dempsey Creek from 2007 to 2011 (0.037 mg/L) and the median measured flow of 6.32 cfs:

***Equation 6**: Total Existing Load* **= (0.037 mg/L) (6.32 cfs) (5.4) = 1.26 lbs/day**

The portion of the existing load attributed to human sources is 0.92 lbs/day, which is determined by subtracting out the 0.34 lbs/day background load from the existing load. This 0.92 lbs/day value represents the load measured within the stream after potential nutrient uptake.

Table 6-45 contains the results for the example TP TMDL, LAs, and current loading. In addition, it contains an example percent reduction to the human-caused LA required to meet the water quality target for TP. The percent reduction to natural background is assumed to be 0%. At the median growing season flow of 6.32 cfs and the 80th percentile of measured TP values, the current loading in Dempsey Creek is greater than the TMDL. Under these example conditions, a 26% reduction of human-caused sources and an overall 19% reduction of TP in Dempsey Creek would result in the TMDL being met. The source assessment of the Dempsey Creek watershed indicates that livestock grazing and irrigated agriculture is the most likely source of TP; load reductions should focus on limiting and controlling TP loading from these sources. Meeting LAs for Dempsey Creek may be achieved through a variety of water quality planning and implementation actions and is addressed **Section 7.0**. Inter-sub-watershed transfers of irrigation flows complicate nutrient loading dynamics.

Table 6-45. Dempsey Creek TP Example TMDL, LAs, Current Loading, and Reductions

Source Category	Allocation and TMDL (lbs/day)[a]	Existing Load (lbs/day)[a]	Percent Reduction
Natural Background	0.34	0.34	0%
Human-caused (primarily livestock grazing/irrigated ag.)	0.68	0.92	26%
	TMDL = 1.02	**Total = 1.26**	**Total = 19%**

[a] Based on a median growing season flow of 6.32 cfs

6.6.2 Dunkleberg Creek (MT76G005_072)

6.6.2.1 Assessment of Water Quality Results

The source assessment for Dunkleberg Creek consists of an evaluation of TN and TP concentrations and exceedances of chl-*a* and/or AFDM within the impaired segment of Dunkleberg Creek. This is followed by the quantification of the most significant human caused sources of nutrients. **Figure 6-15** presents the approximate locations of data pertinent to the source assessment in the southern portion of the Dunkelberg Creek sub-watershed. The sub-watershed includes a portion of the Clark Fork River mainstem and numerous 1st order streams that drain directly to the Clark Fork River. **Figure 6-15** includes only that portion of the sub-watershed that contributes flows to impaired reaches of the Dunkleberg Creek AU[2]. The AU begins between the USFS boundary and Bert Weaver/Dunkleberg Creek road juncture.

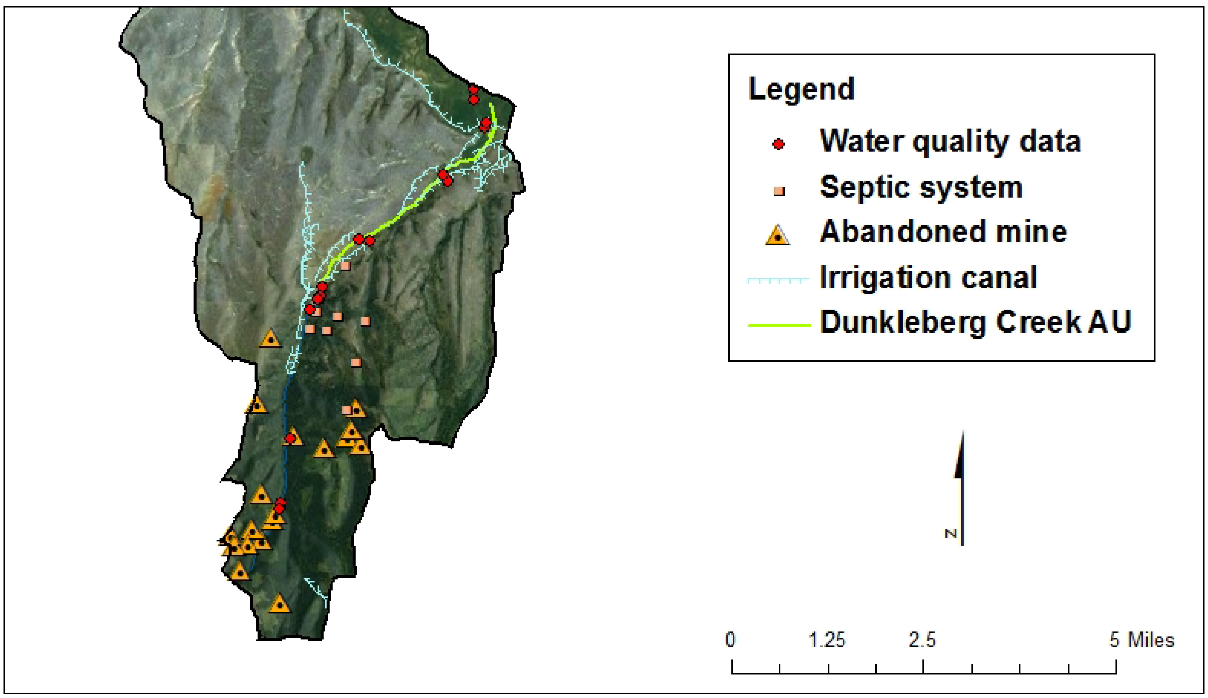

Figure 6-15. Southern Portion of the Dunkleberg Creek Sub-Watershed with Water Quality Sampling Locations

[2] In **Figure 6-15**, the AU does not intersect several of the red sampling locations near the mouth. This error was identified during TMDL development and a request was made for an edit to the NHD layer maintained by the USGS. DEQ AUs mirror the NHD layer. An edit to the NHD and subsequently to the AU should be made by the issue date of the 2016 303(d) list.

Total Nitrogen

DEQ collected water quality samples from Dunkleberg Creek during the growing season over the 2007–11 time period (**Section 6.4.3.2**, **Table 6-6**). Out of a total of 18 samples, only 2 exceeded the TN target concentration. Both exceedances were in the lower portion of the watershed and were collected in July 2007. **Figure 6-16** presents summary statistics for TN concentrations at sampling sites in Dunkleberg Creek. In the following figure, the Dunkleberg-Meadows-Turnbull Ditch and an unnamed ditch both mix with Dunkleberg Creek before being re-diverted. These ditches have the potential to bring nutrient loads from outside the Dunkelberg Creek sub-watershed. TN concentrations measured in both ditches were less than the TN targets for Dunkleberg Creek.

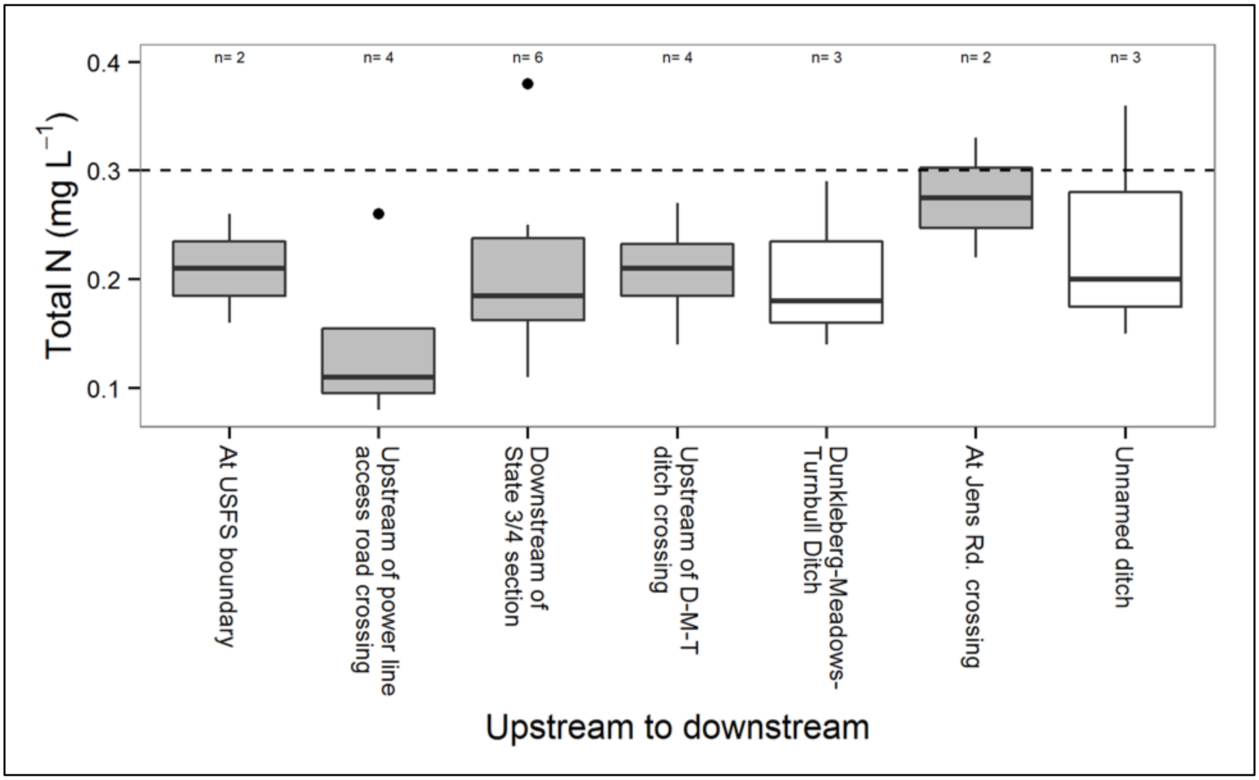

Figure 6-16. Boxplot of TN Concentrations in Dunkleberg Creek (2007–11) (Gray Boxes Are Mainstem Samples, White Boxes Are Tributaries, Dashed Line Is Target)

In **Figure 6-17**, sample data from the AU was plotted as a ratio to the TN target.
Exceedances of the TN target are plotted in **Figure 6-18**. Reductions needed to achieve the TMDL range from 9% to 21% with a median reduction of 15.1%.

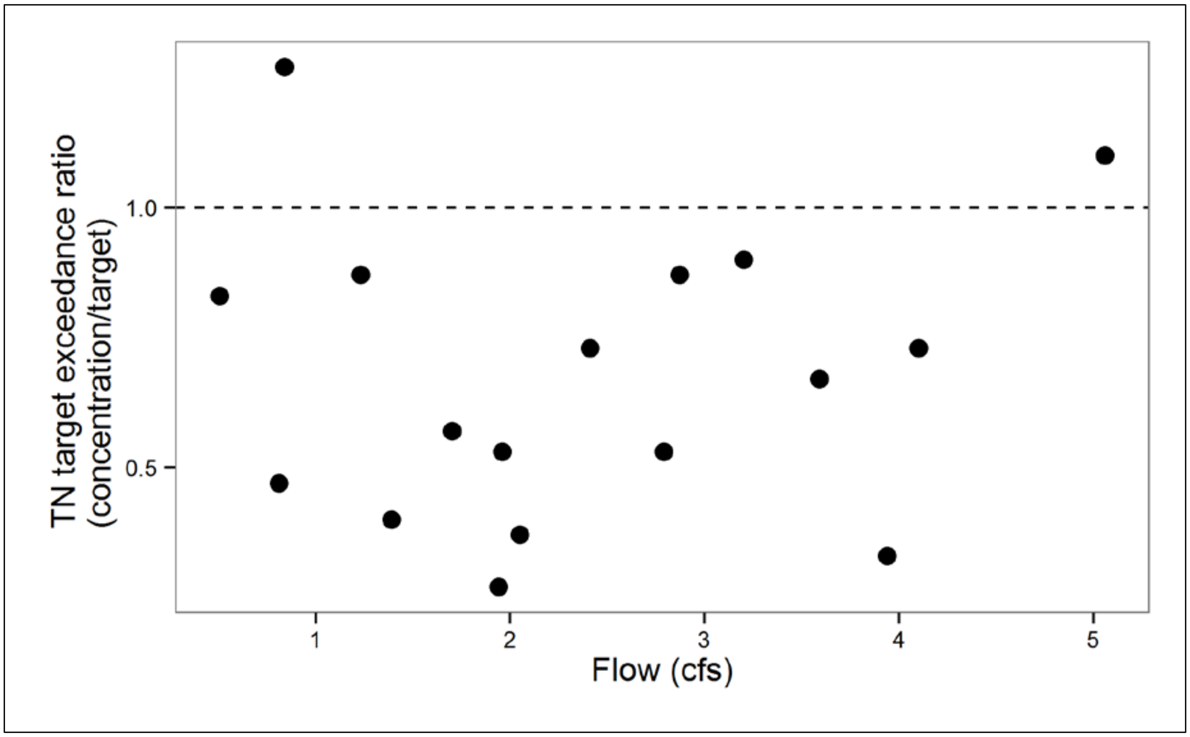

Figure 6-17. TN Target Exceedance Ratio in Dunkleberg Creek (2007–11) (>1 Indicates Exceedance)

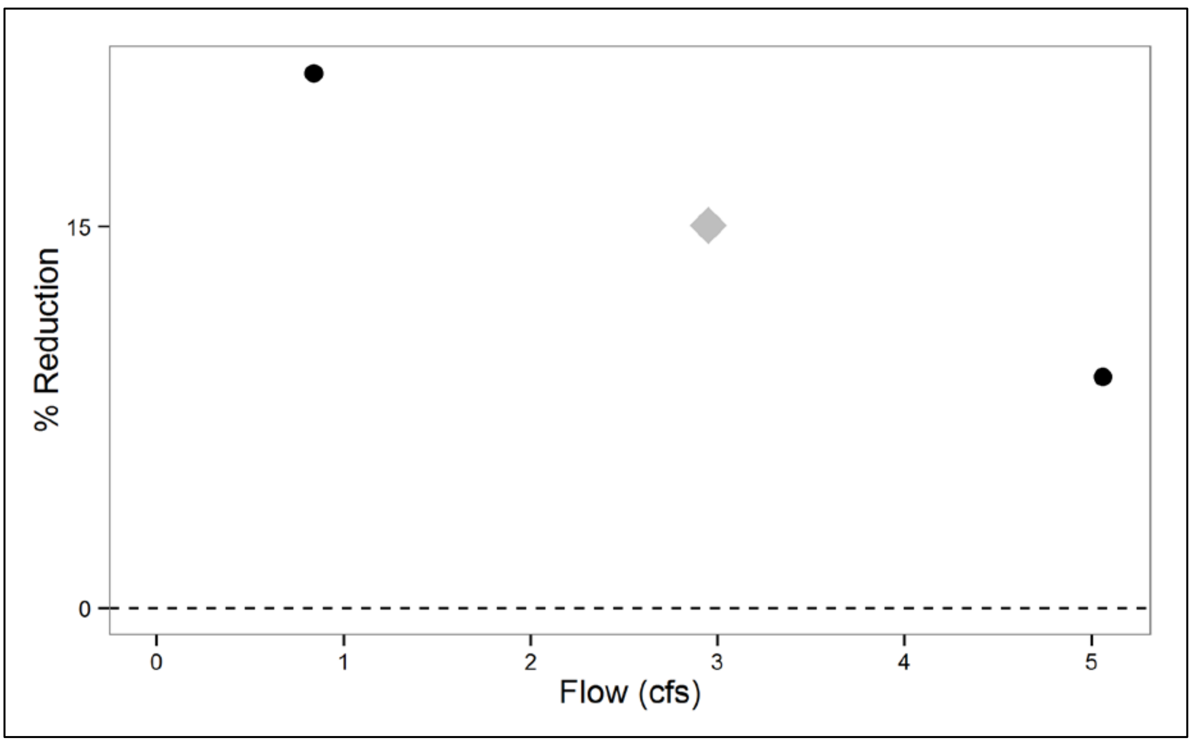

Figure 6-18. Scatterplot of Mainstem Observations and Respective Percent Reductions Necessary to Achieve the TN TMDL in Dunkleberg Creek (the Gray Diamond Is the Median (50th percentile) Observation of Samples that Exceeded the TN TMDL (2007–11))

Total Phosphorus

DEQ collected water quality samples from Dunkleberg Creek during the growing season over the 2007–11 time period (**Section 6.4.3.2**, **Table 6-6**). Out of a total of 18 samples, 13 exceeded the TP target concentration. For TP data, no exceedances of the water quality target were observed upstream of the power line road access crossing (**Figure 6-19**). However, at most sampling stations on Dunkleberg Creek, TP concentrations were well above the TP target of 0.03 mg/L. In addition, samples collected from 2 irrigation canals that intercept Dunkleberg Creek were also greater than the target. There were no exceedances of chl-*a* targets in the AU, but this may be related to the fine material stream substrate that may preclude aquatic growth.

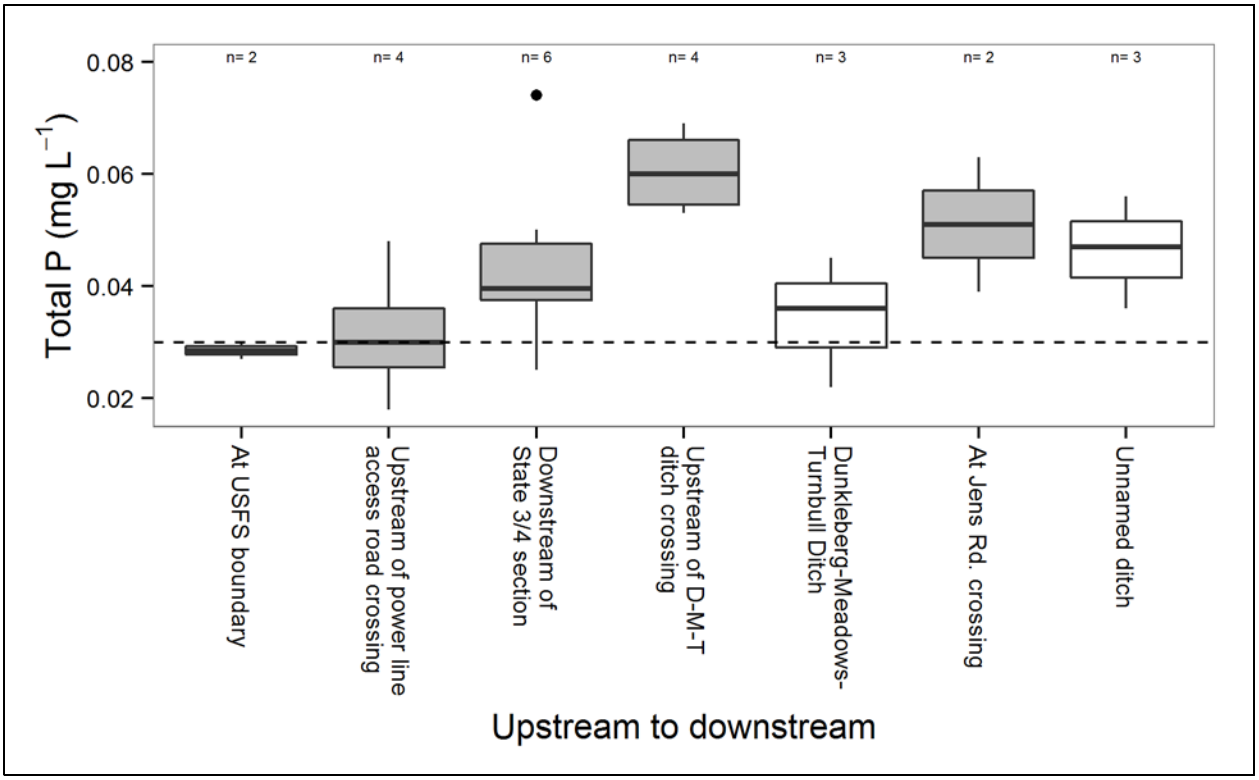

Figure 6-19. Boxplot of TP Concentrations in Dunkleberg Creek (2007–11) (Gray Boxes Are Mainstem Samples, White Boxes Are Irrigation Ditches, Dashed Line Is Target)

Target exceedance ratios were plotted for all Dunkleberg Creek samples. Exceedances ranged from 1 to 2 times the target value and at a range of flows from ~1 cfs to 14 cfs (**Figure 6-20**). Exceedances of the TP target are plotted in **Figure 6-21**. Reductions needed to achieve the TMDL range from 6% to 59% with a median reduction of 38.8%.

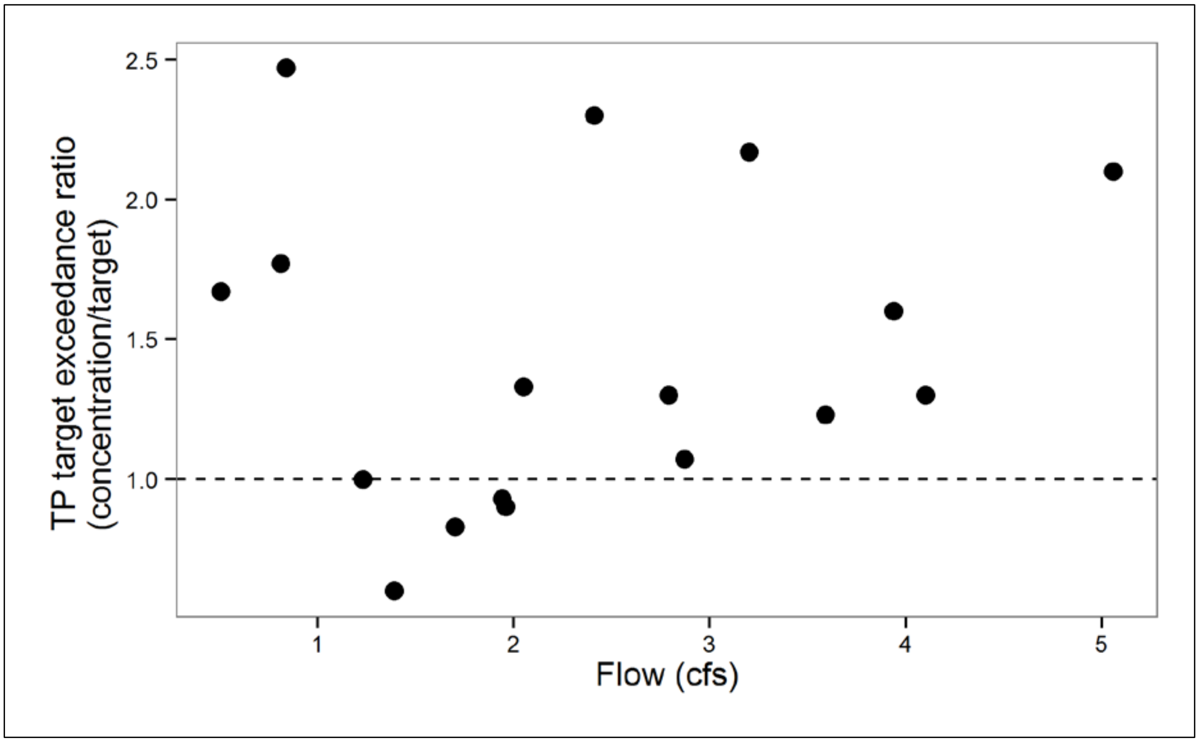

Figure 6-20. TP Target Exceedance Ratio for Dunkleberg Creek (2007–11) (>1 Indicates Exceedance)

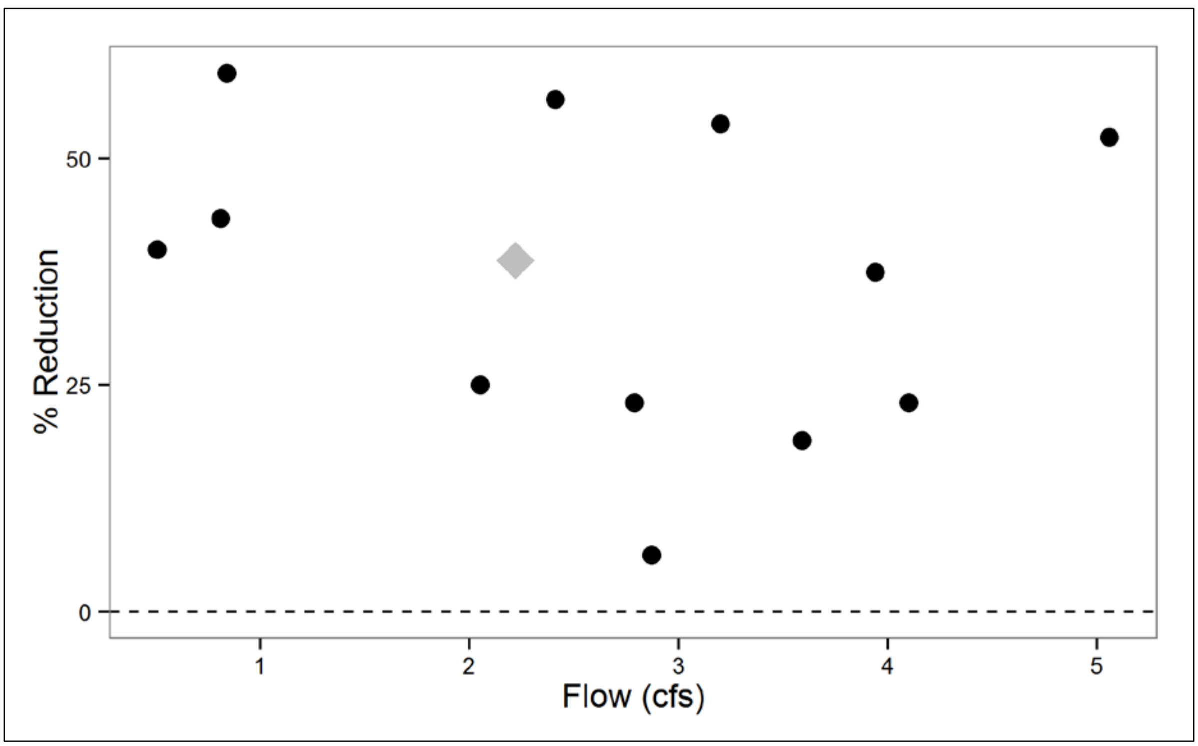

Figure 6-21. Scatterplot of Mainstem Observations and Respective Percent Reductions Necessary to Achieve the TP TMDL (the Gray Diamond Is the Median (50th percentile) Observation of Samples that Exceeded the TP TMDL (2007–11))

6.6.2.2 Assessment of Loading by Source Categories

As referenced in **Section 6.4.3**, field investigations and monitoring by the Tri-State Water Quality council in 2003 observed high dissolved phosphorous concentrations in lower Dunkleberg Creek (McDowell and Watkins, 2004). TP ranged from 0.06 to 0.07 mg/L at the lowest sampling site with the dissolved fraction comprising 40–80% of TP. The authors theorized that these concentrations may be natural and related to an unknown geologic source. An adjacent drainage, Gold Creek, was also included in this project and was the focus of several graduate theses from the University of Montana. In an area with significant anthropogenic sources of TP, data was not robust enough to differentiate between background and anthropogenic load fractions. Once all reasonable soil, land and water conservation practices have been implemented in the sub-watershed, further investigation is warranted to establish the background condition based on reference sites within the Dunkleberg and/or the Gold Creek/Pikes Peak Creek sub-watersheds.

Agriculture

The primary land use and most significant nutrient source in the Dunkleberg Creek sub-watershed is agriculture which includes some irrigated hay/alfalfa in the lowest portion of the drainage. Grazing allotments comprise 4,022 acres on USFS and DNRC administered lands in the drainage with a current maximum of 415 permitted AUMs (**Table 6-27**). Grazing appears to be the main land use on public and private lands in the drainage contributing flow to Dunkleberg Creek.

Both TN and TP water quality data exceeded target concentrations downstream of the forest boundary.

Irrigation networks do have the potential to transport nutrient loads to the Dunkleberg Creek sub-watershed from adjoining sub-watersheds via irrigation ditches. In the headwaters, an irrigation ditch conveys waters from the Goldberg Reservoir (total reservoir area = 8 acres) to Dunkleberg Creek. Goldberg Reservoir is located in the headwaters of Gold Creek. Although the irrigation canal was not sampled, significant nutrient load transfers from the Gold Creek basin into Dunkleberg Creek appears unlikely given the water quality in the headwaters of the Gold Creek drainage and the lack of target exceedances in water quality samples collected upstream of the forest boundary in Dunkleberg Creek.

There are several inter-sub-watershed transfers of irrigation water to the Dunkleberg Creek sub-watershed with the two largest being the Dunkleberg-Meadows-Turnbull Ditch (also called the #21 ditch (Confluence, Inc., 2008)) and an unnamed ditch. The Dunkleberg-Meadows-Turnbull Ditch originates at a point of diversion on the Clark Fork River approximately 2.3 miles east of the Dunkleberg Creek channel. The unnamed ditch originates within a center pivot south of Dunkleberg Road, ¾ miles east of the channel. This unnamed ditch appears to be a channel carrying irrigation return flows back to Dunkleberg Creek. From aerial photographs, it appears that both these canals intersect the Dunkleberg Creek channel. This analysis assumed that loading/dilution processes occur at these crossings.

For TP, water quality collected from these two ditches was found to be equal to or greater than the nutrient targets (**Table 6-46**). For TN, water quality in the ditches was less than the target concentration. Water lost to groundwater as the ditches cross the drainage, or where flows are diverted for use within the drainage may ultimately contribute to the existing Dunkleberg Creek TN and TP nutrient loads.

Table 6-46. Nutrient Water Quality Data for Irrigation Canals in the Dunkleberg Creek Sub-Watershed

Canal/Ditch Name	No. of Samples[a]	Mean Flow (cfs)	Mean TN (mg/L)	Mean TP (mg/L)
Dunkleberg-Meadows-Turnbull Ditch	3	5.8	0.20	0.03
Unnamed ditch	3	5.5	0.24	0.05

[a] Data collected in July and August 2010

Mining
There are 21 abandoned mines in the headwaters of Dunkleberg Creek. Nearly all were lode mines producing precious metals including gold, silver or copper as well as lead and zinc. The most significant mine in the district was the Forest Rose which has not been operated on a large scale since the late 1940s. Remediation work on 4 acres of metal-mining impacted land along Dunkelberg Creek by DEQ was completed at the Forest Rose Mine site in 2013 (Montana Department of Environmental Quality, Mine Waste Cleanup Bureau, 2013). The Forest Rose mine site is located outside the AU in the upstream of the forest boundary. Given that TN and TP water quality is meeting or below target concentrations above the forest boundary, these abandoned mine sites appear to be having no discernible impacts on nutrient water quality. Water quality sampling from seeps at the Forest Rose site did not yield water quality exceedances for nitrate-N (Madison et al., 1998). Two abandoned mines in the upper reaches of Dunkleberg Creek are DEQ priority mine sites: Jackson Park and Forest Rose. However, as all water quality exceedances in Dunkleberg Creek were downstream of the forest boundary, abandoned mines do not appear to be impairing nutrient water quality in Dunkleberg Creek.

Silviculture (includes timber harvest)
An analysis of aerial imagery from the sub-watershed that drains to the AU suggest there have been some timber harvests completed on private inholdings in recent years. Most of the forested land is administered by the BDNF and records indicate that recent forest practices have only included some thinning/road work along the various forest roads in the these sub-watersheds. Minimal impact on instream nutrient loads is expected from such practices.

Subsurface Wastewater Disposal and Treatment
According to DEQ records, there are eight individual septic systems in the southern portion of the Dunkleberg Creek sub-watershed which could impact the stream. Most of these systems are located outside the main floodway. Septic effluent is considered a very minor contributor to the Dunkleberg Creek TN and TP daily loads.

Summary
The source assessment for Dunkleberg Creek suggests that the most important source of nutrients in the sub-watershed is from grazing practices. The irrigation conveyance infrastructure may be transporting a portion of the observed Dunkleberg Creek nutrient loads from outside the watershed, namely from diversion points on the Clark Fork River with possible influence from nutrient sources in the intervening distance between point of diversion and place of use.

6.6.2.3 TN TMDL, Allocations, and Current Loading

The TMDL for TN is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the TN TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TN TMDL for Dunkleberg Creek uses **Equation 1**, with the median measured flow from all sites during 2007–11 sampling (2.05 cfs):

***Equation 1**: TMDL* **= (0.30 mg/L) (2.05 cfs) (5.4) = 3.32 lbs/day**

Equation 4 is the basis for the natural background LA for TN. To continue with the example at a flow of 2.05 cfs, this allocation is as follows:

***Equation 4**:* **LA_{NB} = (0.095 mg/L) (2.05 cfs) (5.4) = 1.05 lbs/day**

Using **Equation 5**, the combined human-caused TN LA at 2.05 cfs can be calculated:
***Equation 5**:* **LA_{H} = 3.32 lbs/day – 1.05 lbs/day = 2.27 lbs/day**

An example total existing load is calculated as follows using **Equation 6,** the 80th percentile of TN values measured from Dunkleberg Creek from 2007 to 2011 (0.26 mg/L) and the median measured flow of 2.05 cfs:

***Equation 6**: Total Existing Load* **= (0.26 mg/L) (2.05 cfs) (5.4) = 2.88 lbs/day**

The portion of the existing load attributed to human sources is 1.83 lbs/day, which is determined by subtracting out the 1.05 lbs/day background load. This 1.83 lbs/day value represents the load measured within the stream after potential nutrient uptake.

Table 6-47 contains the results for the example TN TMDL, LAs, and current loading. In addition, it contains an example percent reduction to human-caused LA required to meet the water quality target for TN. At the median growing season flow of 2.05 cfs and the 80th percentile of measured TN values, the current loading in Dunkleberg Creek is less than the TMDL. Under these example conditions no reduction is necessary as the TMDL is being met. Inter-sub-watershed transfers of irrigation flows do not appear to be causing or contributing to a TN impairment. As shown in **Figure 6-16**, two samples exceed the target values and thus would result in exceeding the TMDL under the specific flow conditions represented by those two samples. **Figure 6-17** shows that load reductions between 9% and 21% are necessary to achieve the TMDL.

Table 6-47. Dunkleberg Creek TN Example TMDL, LAs, Current Loading, and Reductions

Source Category	Allocation and TMDL (lbs/day)[a]	Existing Load (lbs/day)[a]	Percent Reduction
Natural Background	1.05	1.05	0%
Human-caused (primarily irrigated agriculture)	2.27	1.83	0%
	TMDL = 3.32	**Total = 2.88**	**Total = 0%**

[a] Based on a median growing season flow of 2.05 cfs

6.6.2.4 TP TMDL, Allocations, and Current Loading

The TMDL for TP is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the TP TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TP TMDL for Dunkleberg Creek uses **Equation 1**, with the median measured flow from all sites during 2007–11 sampling (2.05 cfs):

TMDL **= (0.03 mg/L) (2.05 cfs) (5.4) = 0.33 lbs/day**

Equation 4 is the basis for the natural background LA for TP. To continue with the example at a flow of 2.05 cfs, this allocation is as follows:

***LA_{NB}* = (0.01 mg/L) (2.05 cfs) (5.4) = 0.11 lbs/day**

Using **Equation 5**, the combined septic and other human-caused TP LA at 2.05 cfs can be calculated:

***LA_{H}* = 0.33 lbs/day – 0.11 lbs/day = 0.22 lbs/day**

An example total existing load is calculated as follows using **Equation 6**, the 80th percentile of TP values measured from Dunkleberg Creek from 2007 to 2011 (0.060 mg/L) and the median measured flow of 2.05 cfs:

***Total Existing Load* = (0.060 mg/L) (2.05 cfs) (5.4) = 0.66 lbs/day**

The portion of the existing load attributed to human sources is 0.55 lbs/day, which is determined by subtracting out the 0.11 lbs/day background load from the existing load. This 0.55 lbs/day value represents the load measured within the stream after potential nutrient uptake.

Table 6-48 contains the results for the example TP TMDL, LAs, and current loading. In addition, it contains an example percent reduction to the human-caused LA required to meet the water quality target for TP. The percent reduction to natural background is assumed to be 0%. At the median growing season flow of 2.05 cfs and the 80th percentile of measured TP values, the current loading in Dunkleberg Creek is greater than the TMDL. Under these example conditions, a 60% reduction of human-caused sources and an overall 50% reduction of TP in Dunkleberg Creek would result in the TMDL being met. The source assessment of the Dunkleberg Creek watershed indicates that livestock grazing and irrigated agriculture are the most likely sources of TP; load reductions should focus on limiting and controlling TP loading from these sources. Meeting LAs for Dunkleberg Creek may be achieved through a variety of water quality planning and implementation actions and is addressed **Section 7.0**. Inter-sub-watershed transfers of irrigation flows do complicate the loading dynamics.

Table 6-48. Dunkleberg Creek TP Example TMDL, LAs, Current Loading, and Reductions

Source Category	Allocation and TMDL (lbs/day)[a]	Existing Load (lbs/day)[a]	Percent Reduction
Natural Background	0.11	0.11	0%
Human-caused (primarily livestock grazing/irrigated ag.)	0.22	0.55	60%
	TMDL = 0.33	**Total = 0.66**	**Total = 50%**

[a] Based on a median growing season flow of 2.05 cfs

6.6.3 Gold Creek (MT76G005_092)

6.6.3.1 Assessment of Water Quality Results

The source assessment for Gold Creek consists of an evaluation of TP concentrations and exceedances of chl-*a* and/or AFDM within the impaired segment of Gold Creek. This is followed by the quantification of the most significant human caused sources of nutrients. It should be noted that FWP lists Gold Creek as being chronically dewatered (dewatering is a significant issue in most years) from downstream of the forest boundary to the mouth (Clark Fork River). The lower reaches of two Gold Creek tributaries are also listed as chronically dewatered: Crevice Creek and Blum Creek.

Figure 6-22 displays the watershed bounds of the Gold Creek and Pikes Peak Creek sub-watersheds. Pikes Peak Creek into Gold Creek downstream of the forest boundary and is included in the source assessment as a potential source of TP loads to the AU.

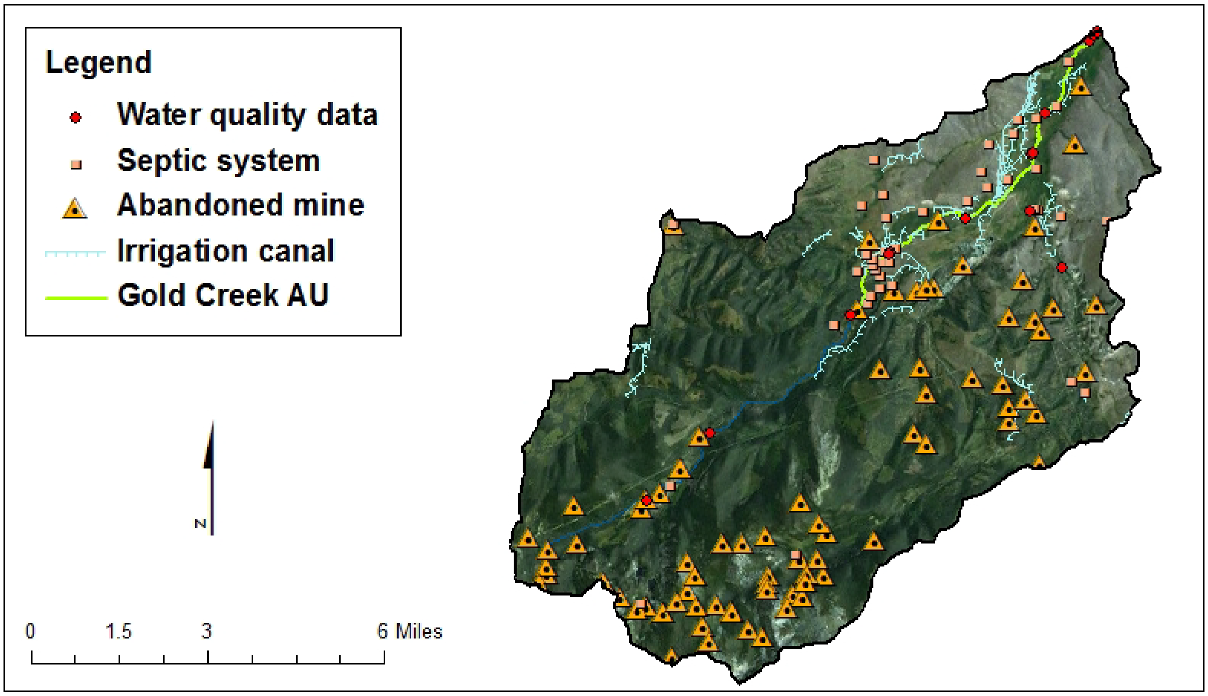

Figure 6-22. Gold Creek and Pikes Peak Creek Sub-Watersheds with Water Quality Sampling Locations

Total Phosphorus

DEQ collected water quality samples for TP from Gold Creek during the growing season over the 2007–10 time period (**Section 6.4.3.3**, **Table 6-8**). Out of a total of 27 samples, 10 exceeded the TP target concentration of 0.03 mg/L. **Figure 6-23** presents summary statistics for TP concentrations at sampling sites in Gold Creek and includes samples collected from Pioneer Gulch and Pikes Peak Creek, which are tributaries to Gold Creek. The AU begins just downstream of where Lone Tree Hill Road crosses Gold Creek. There were no exceedances of chl-*a* targets in the AU.

TP concentrations are less than the target concentration (0.03 mg/L) for all samples collected upstream of the forest boundary; indicating that TP loading from this portion of the sub-watershed is minimal and within expected natural background concentrations. A very observable increase in TP concentrations occurs between the Wall City sampling location and downstream of Pikes Peak Creek confluence. In this reach, several tributaries flow into Gold Creek including: Blum Creek, Griffin Creek and Pikes Peak Creek. Blum Creek and Griffin Creek enter from the west and Pikes Peak Creek flows from the east. In addition, inflow from groundwater recharge and irrigation returns may also be cause for the increase in TP concentrations (McDowell and Watkins, 2004).

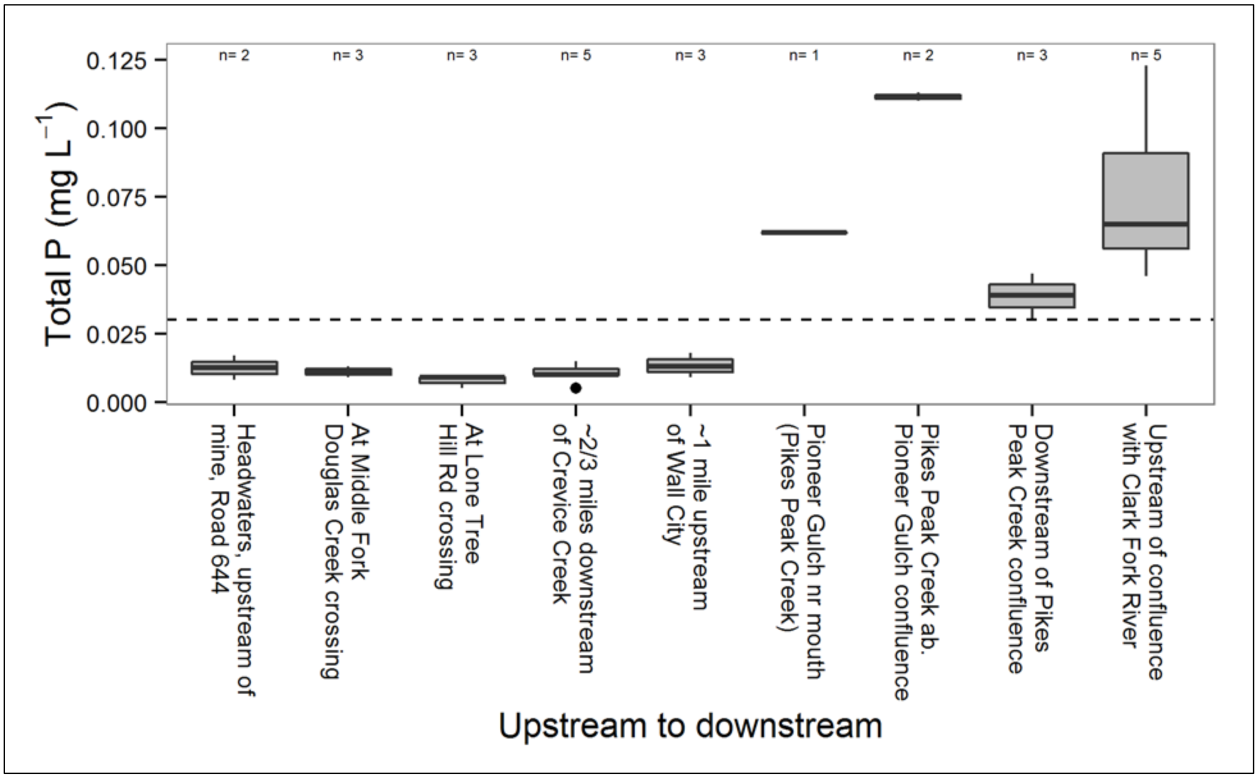

Figure 6-23. Boxplot of TP Concentrations in Gold Creek (2007–10) (Gray Boxes Are Mainstem Samples, White Boxes Are Tributaries, Dashed Line Is Target)

In **Figure 6-24**, sample data from the AU was plotted as a ratio to the TP target.
Exceedances of the TP target are plotted in **Figure 6-25**. Reductions needed to achieve the TP TMDL range from 23% to 76% with a median reduction of 46.4%.

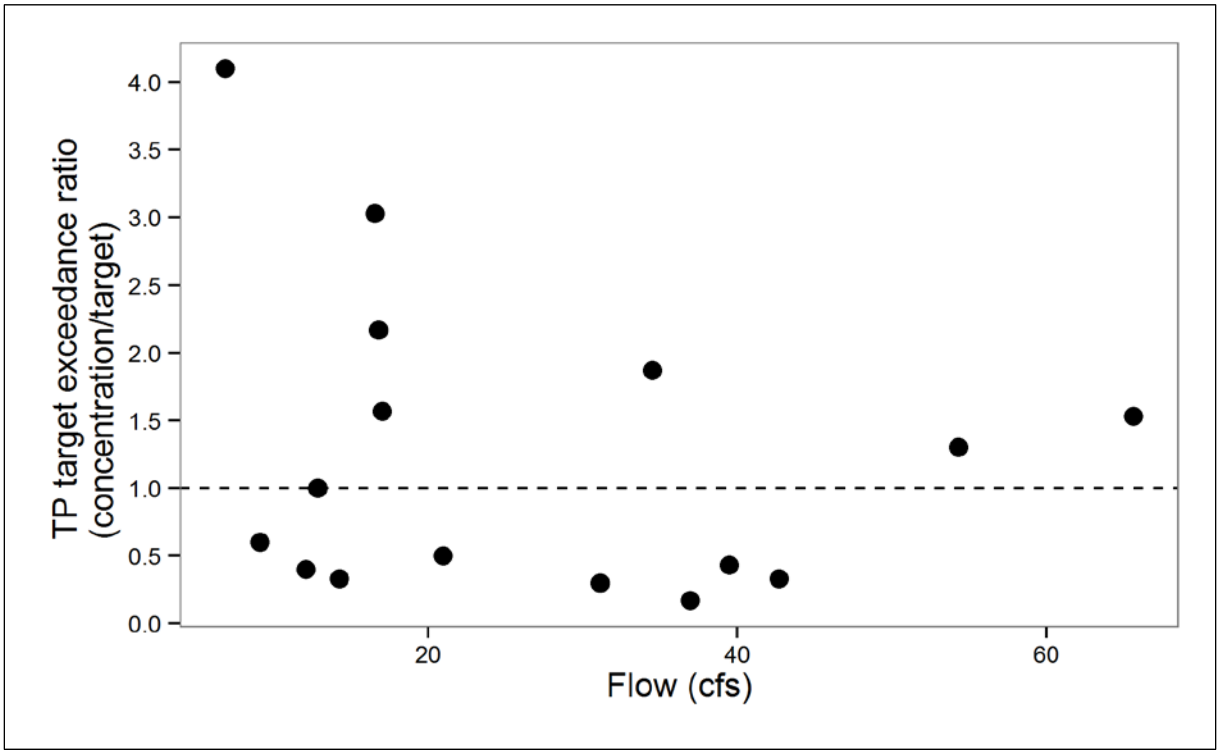

Figure 6-24. TN Target Exceedance Ratio in Gold Creek (2007–10) (>1 Indicates Exceedance)

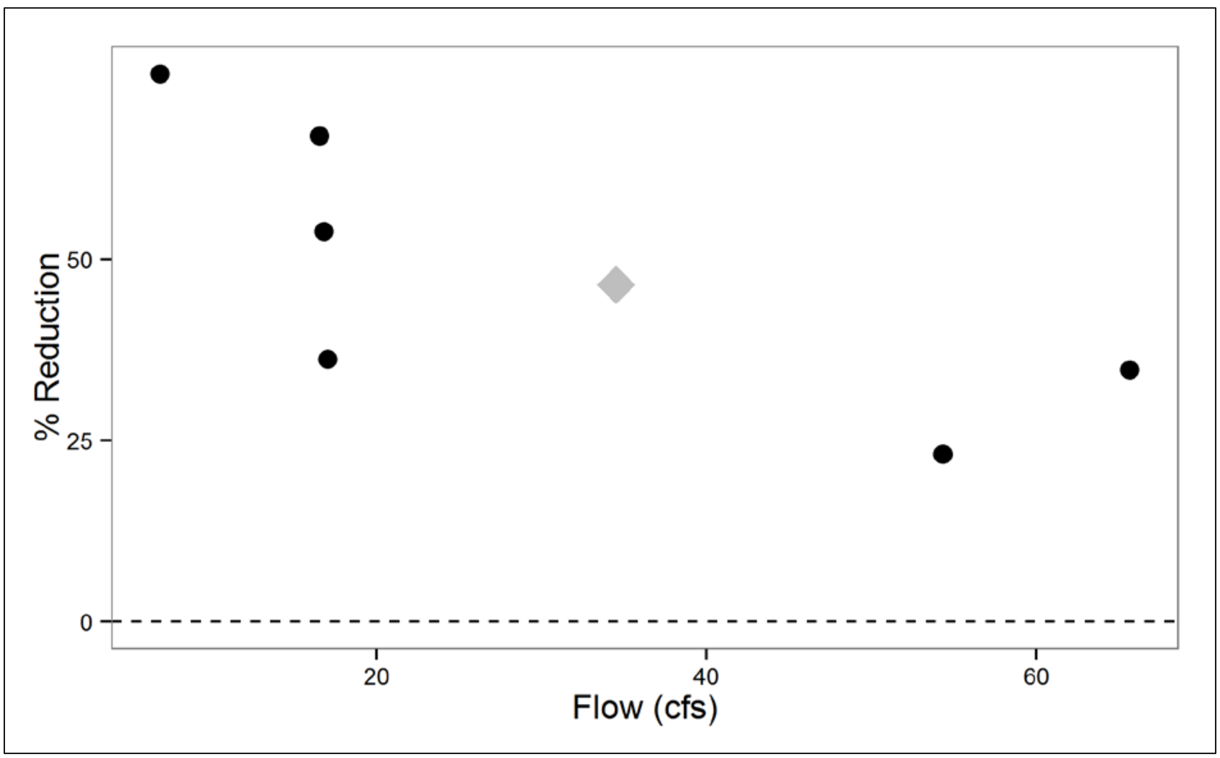

Figure 6-25. Scatterplot of Mainstem Observations and Respective Percent Reductions Necessary to Achieve the TN TMDL in Gold Creek (the Gray Diamond Is the Median (50th percentile) Observation of Samples that Exceeded the TN TMDL (2007–10)

6.6.3.2 Assessment of Loading by Source Categories

There have been several water quality investigations in the Gold Creek basin which have examined nutrient dynamics and potential sources, including Carey (1991), Krier (2004), the Tri-State Water Quality Council (McDowell and Watkins, 2004), and the WRC (KirK Environmental, LLC, 2004). Carey's work was the most comprehensive and concluded that, during irrigation season the hydrology of the lower system is dominated by groundwater originating as springs in the headwaters of several tributaries (Blum Creek, Griffin Creek, Pikes Peak Creek drainages). Carey and Krier used Soluble Reactive Phosphorus (SRP)/TP ratios to identify groundwater as being the dominant phosphorus source in Gold Creek during low flow periods. However, the authors also theorized that the fine sediment in Blum Creek and Griffin Creek were phosphorus rich and existing land uses led to sediment deposition in these channels and subsequent transportation to the mainstem. Irrigation practices were also identified as potentially exacerbating a natural condition of elevated phosphorus in Gold Creek tributaries.

There was insufficient data in an area with significant anthropogenic sources of TP to differentiate between background and anthropogenic load fractions. Once all reasonable soil, land and water conservation practices have been implemented in the sub-watershed, further investigation is warranted to establish the background condition based on reference sites within the Dunkleberg and/or the Gold Creek/Pikes Peak Creek sub-watersheds.

Genetically pure westslope cutthroat trout were documented by FWP in Blum Creek. At both 2009 FWP sample locations on Blum Creek, deep pools were lacking and fine sediment accumulation was observed (Lindstrom, 2011). In 2007, westslope cutthroat trout were the dominant fish species observed at three sampled reaches on Gold Creek upstream of the Pikes Peak Creek confluence (Lindstrom et al., 2008). Only at a reach near the mouth (River Mile 0.3) were westslope cutthroat trout outnumbered by brown trout. Fish habitat in Gold Creek was most limited by an absence of deep pools. Fine sediment accumulation was not observed in Gold Creek mainstem sites. In Crevice Creek, fine sediment accumulation was observed at both sites and fish populations were comprised entirely of westslope cutthroat trout (Lindstrom et al., 2008).

Agriculture

The primary land use and most significant nutrient source in the Gold Creek and Pikes Peak Creek sub-watersheds is agriculture which includes some irrigated hay/alfalfa downstream of the forest boundary. There are also small acreages of irrigated small grains. Including the Pikes Peak Creek sub-watershed, grazing allotments comprise 24,604 acres on USFS and BLM administered lands in the drainage with a current maximum of 2,162 permitted AUMs (**Table 6-27**). This area is 58% of the total area draining to Gold Creek. However, elevated concentrations of nutrients were not observed upstream of the forest boundary in Gold Creek, although elevated TP concentrations were observed in Pikes Peak Creek.

Irrigation is extensive downstream of the forest boundary and several of the west side tributaries to Gold Creek, including Griffin Creek and Blum Creek are used as natural carriers of irrigation water (Confluence, Inc., 2008). It appears that irrigation diversions of mainstem flows increase the proportion of tributary flow to total instream flow in the lower reaches of Gold Creek. As referenced earlier, possible geologic sources of SRP in the spring-fed tributary systems are the source of elevated TP concentrations in Gold Creek. Irrigation practices may potentially be exacerbating a natural condition of elevated TP in Gold Creek tributaries.

A significant restoration project was completed on the ranch operation nearest the mouth with the Clark Fork River. Between 2008 and 2011, 3 miles of fence were installed along 1.5 miles of Gold Creek to create a riparian pasture, and 7 off-stream water tanks were installed. Two hundred eighty acres of flood/sprinkler irrigation were converted to 248 acres under center pivot irrigation which restored 9 cfs of flow to Gold Creek. Finally, a large corral complex was relocated away from the stream corridor. This project addressed nutrient source loading and flows in the Gold Creek channel. Source assessment concentration and flow data were collected on Gold Creek in 2010 near the mouth, but current conditions would most likely reflect improvement from project implementation. The project was facilitated by the landowners and the Clark Fork Coalition and included numerous state and federal partners as well as local conservation districts.

Mining

There are 84 abandoned mines in the Gold Creek and Pikes Peak Creek sub-watersheds which includes 2 phosphate lode mines in the headwaters. Most of the mining activity was placer mining for gold which occurred in the middle portion of the drainage and was equally concentrated in Gold Creek tributaries such as Pioneer Gulch and Pikes Peak Creek, as well as the Gold Creek mainstem. Mining in the headwaters was mostly lode mining and was concentrated in the Pikes Peak sub-watershed.

Gold Creek was the site of the first discovery of Gold in Montana in 1852. Most of the mining activity in the area occurred in the late 1800s. None of the lode workings in the headwaters produced significant amounts of ore. Nearly all mining activity in the Gold Creek and Pikes Peak creek sub-watersheds had ceased by the end of World War II. The exception is the Masters Mine in the headwaters. However, past mining activity has resulted in extensive placer deposits in Gold, Little Gold, Pioneer, and Pikes Peak Creeks which may contribute to phosphorus loading in the Gold Creek mainstem.

Water quality sampling from seeps at the Sunlight/Copper Queen Mine site did not yield water quality exceedances for nitrate-N (Madison et al., 1998). As water quality exceedances of TP are limited to the lower reaches on Gold Creek, mining is considered a relatively small source of phosphorus. The only potential exception to this is potential re-suspension of sediment from placer mining operations during spring runoff.

Silviculture (includes timber harvest)

An analysis of aerial imagery from the Gold Creek and Pikes Peak Creek sub-watersheds suggest there have been some timber harvests completed on private inholdings in recent years. Most of the forested land is administered by the BDNF and records indicate that recent forest practices have only included some thinning/road work along the various forest roads in the sub-watersheds. Minimal impact on instream nutrient loads is expected from such practices, and silviculture is considered a negligible source of nutrients in the Gold Creek/Pikes Peak Creek watersheds.

Subsurface Wastewater Disposal and Treatment

According to DEQ, there are 42 septic systems in the Gold Creek and Pikes Peak Creek sub-watersheds. Nearly all are concentrated in the lower portion of the Gold Creek drainage, but are considered a minor source of nutrients to Gold Creek given their relative distance to the stream and location outside the floodway in most instances.

Summary

The source assessment for Gold Creek suggests that the most important source of human-caused phosphorus in the sub-watershed is from grazing and cropping on irrigated lands. However, as stated previously, there may be naturally elevated TP concentrations in the watershed that are difficult to discern given the range of human-caused sources of phosphorus.

6.6.3.3 TP TMDL, Allocations, and Current Loading

The TMDL for TP is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the TP TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TP TMDL for Gold Creek uses **Equation 1**, with the median measured flow from all sites during 2007–11 sampling (19.0 cfs):

***Equation 1*: *TMDL* = (0.03 mg/L) (19.0 cfs) (5.4) = 3.08 lbs/day**

Equation 4 is the basis for the natural background LA for TP. To continue with the example at a flow of 19.0 cfs, this allocation is as follows:

***Equation 4*: LA_{NB} = (0.01 mg/L) (19.0 cfs) (5.4) = 1.03 lbs/day**

Using **Equation 5**, the combined septic and other human-caused TP LA at 19.0 cfs can be calculated:

***Equation 5*: LA_{H} = 3.08 lbs/day – 1.03 lbs/day = 2.05 lbs/day**

An example total existing load is calculated as follows using **Equation 6**, the 80th percentile of TP values measured from Gold Creek from 2007 to 2011 (0.056 mg/L) and the median measured flow of 19.0 cfs:

***Equation 6*: *Total Existing Load* = (0.056 mg/L) (19.0 cfs) (5.4) = 5.75 lbs/day**

The portion of the existing load attributed to human sources is 4.72 lbs/day, which is determined by subtracting out the 1.03 lbs/day background load from the existing load. This 4.72 lbs/day value represents the load measured within the stream after potential nutrient uptake.

Table 6-49 contains the results for the example TP TMDL, LAs, and current loading. In addition, it contains an example percent reduction to the human-caused LA required to meet the water quality target for TP. The percent reduction to natural background is assumed to be 0%. At the median growing season flow of 19.0 cfs and the 80th percentile of measured TP values, the current loading in Gold Creek is greater than the TMDL. Under these example conditions, a 57% reduction of human-caused sources and an overall 46% reduction of TP in Gold Creek would result in the TMDL being met. The source assessment of the Gold Creek watershed indicates that livestock grazing and irrigated agriculture is the most likely source of anthropogenically derived TP; load reductions should focus on limiting and controlling TP loading from these sources. Meeting LAs for Gold Creek may be achieved through a variety of water quality planning and implementation actions and is addressed **Section 7.0**. Inter-sub-watershed transfers of irrigation flows complicate the loading dynamics.

Table 6-49. Gold Creek TP Example TMDL, LAs, Current Loading, and Reductions

Source Category	Allocation and TMDL (lbs/day)[a]	Existing Load (lbs/day)[a]	Percent Reduction
Natural Background	1.03	1.03	0%
Human-caused (primarily livestock grazing/irrigated ag.)	2.05	4.72	57%
	TMDL = 3.08	**Total = 5.75**	**Total = 46%**

[a] Based on a median growing season flow of 19.0 cfs

6.6.4 Hoover Creek, upper (MT76G005_081)

6.6.4.1 Assessment of Water Quality Results

The source assessment for upper Hoover Creek consists of an evaluation of TP concentrations and exceedances of chl-*a* and/or AFDM within the impaired segment of upper Hoover Creek. This is followed by the quantification of the most significant human caused sources of nutrients. **Figure 6-26** presents the approximate locations of data pertinent to the source assessment for Hoover Creek, upstream of Miller Lake. Miller Lake is a dammed impoundment located where Swamp Creek and upper Hoover Creek converge. The upper Hoover Creek AU encompasses Hoover Creek from headwaters to Miller Lake. It should be noted that a sediment TMDL for upper Hoover Creek was completed in 2010 (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2010).

Miller Dam is a 25-ft-high earthen dam built in 1962 with a maximum capacity of 196 acre-feet and a normal capacity of 62 acre-feet. The dam is located on property owned by Stimson Lumber Company with water rights owned by a lower Hoover Creek landowner, and was classified as low hazard by the Army Corps of Engineers in 1979. The dam is a top release with a drop inlet structure.

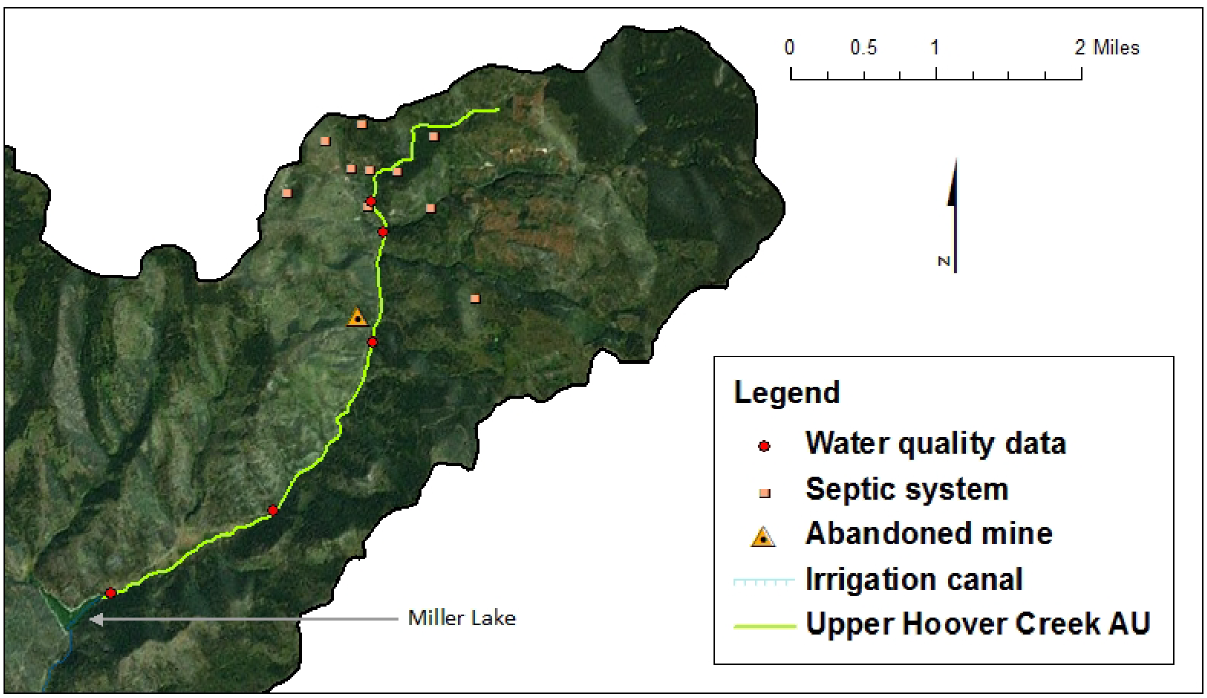

Figure 6-26. Upper Hoover Creek Drainage within the Hoover Creek Sub-Watershed with Water Quality Sampling Locations

Water quality data also includes two AFDM samples which grossly exceeded the target (<35 g/m^2) collected in this AU in 2010.

DEQ collected water quality samples from upper Hoover Creek during the growing season in 2010 (**Section 6.4.3.4, Table 6-10**). In-stream TP concentrations exceeded the target concentration of 0.03 mg/L at all sampling locations in the AU (**Figure 6-27**).

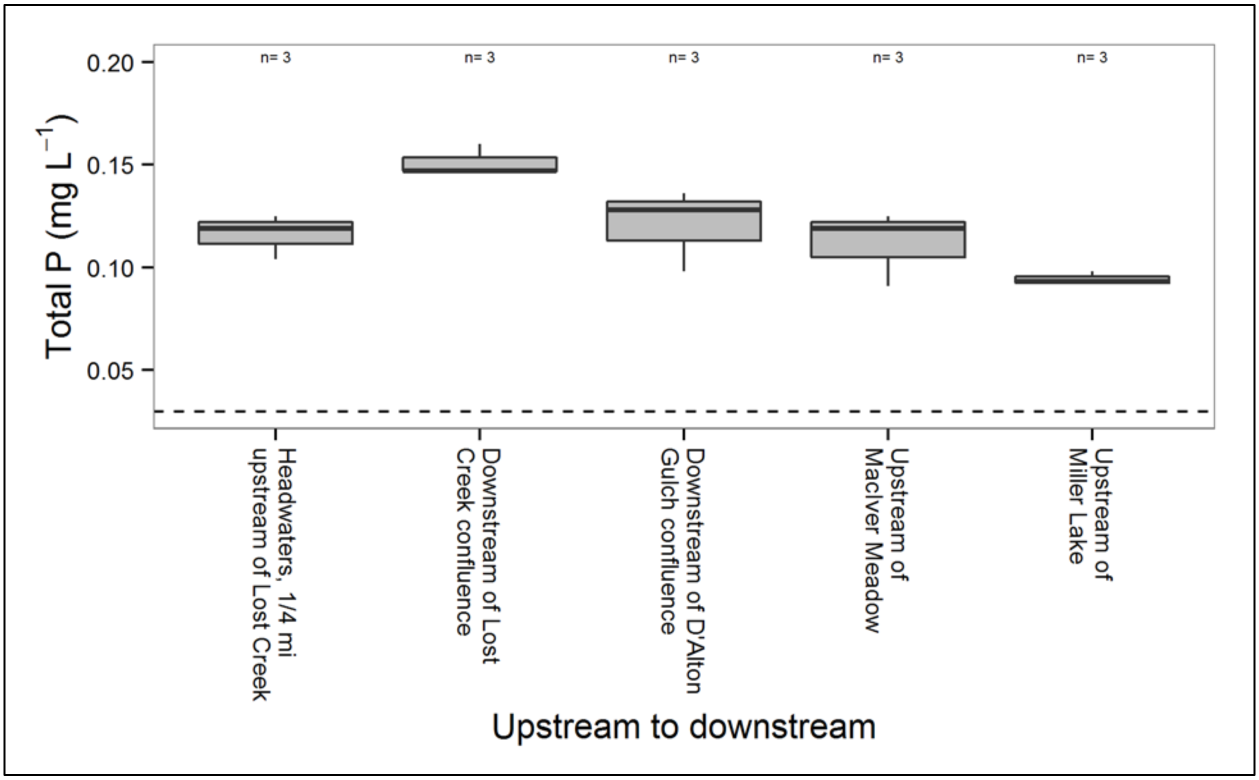

Figure 6-27. Boxplot of TP Concentrations in Upper Hoover Creek (2010) (Dashed Line Is Target)

In **Figure 6-28**, sample data from the AU was plotted as a ratio to the TP target. Exceedances ranged from 2.2 to 4 times the target concentration. Exceedances of the TP target are plotted in **Figure 6-29**. Reductions needed to achieve the TP TMDL range from 56% to 75%, with a median reduction of 66%.

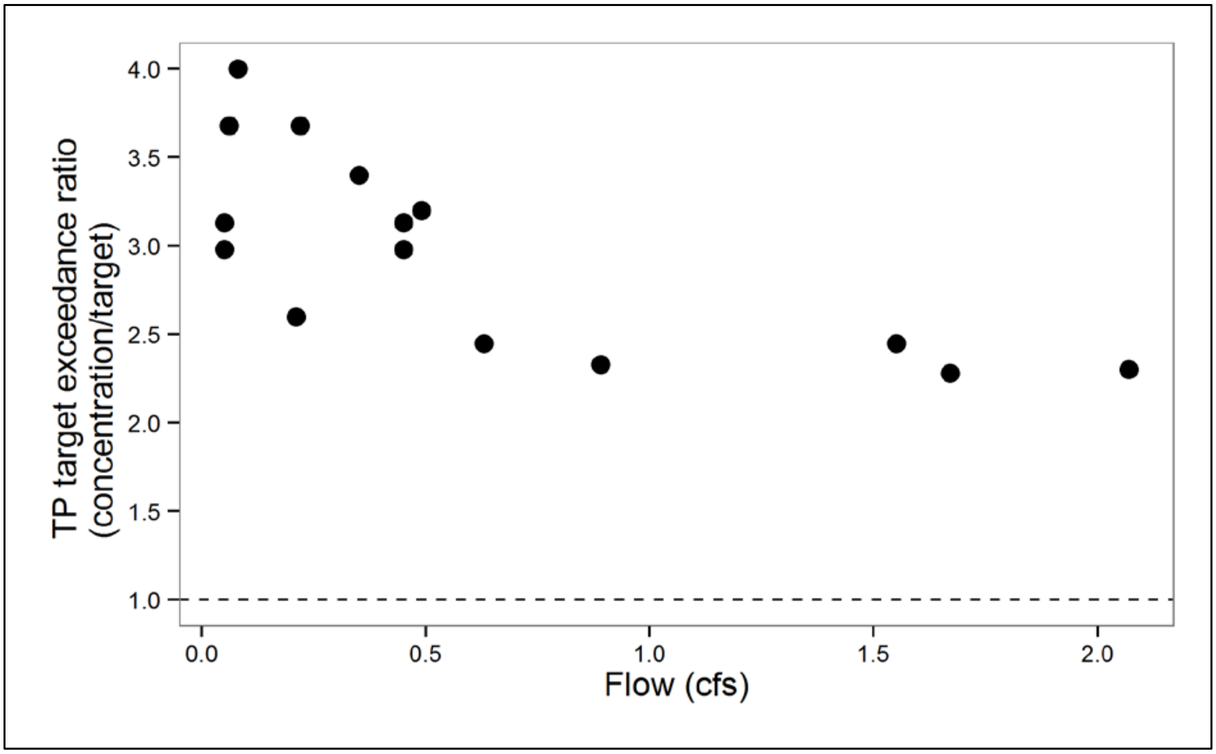

Figure 6-28. TP Target Exceedance Ratio in Upper Hoover Creek (2010) (>1 Indicates Exceedance)

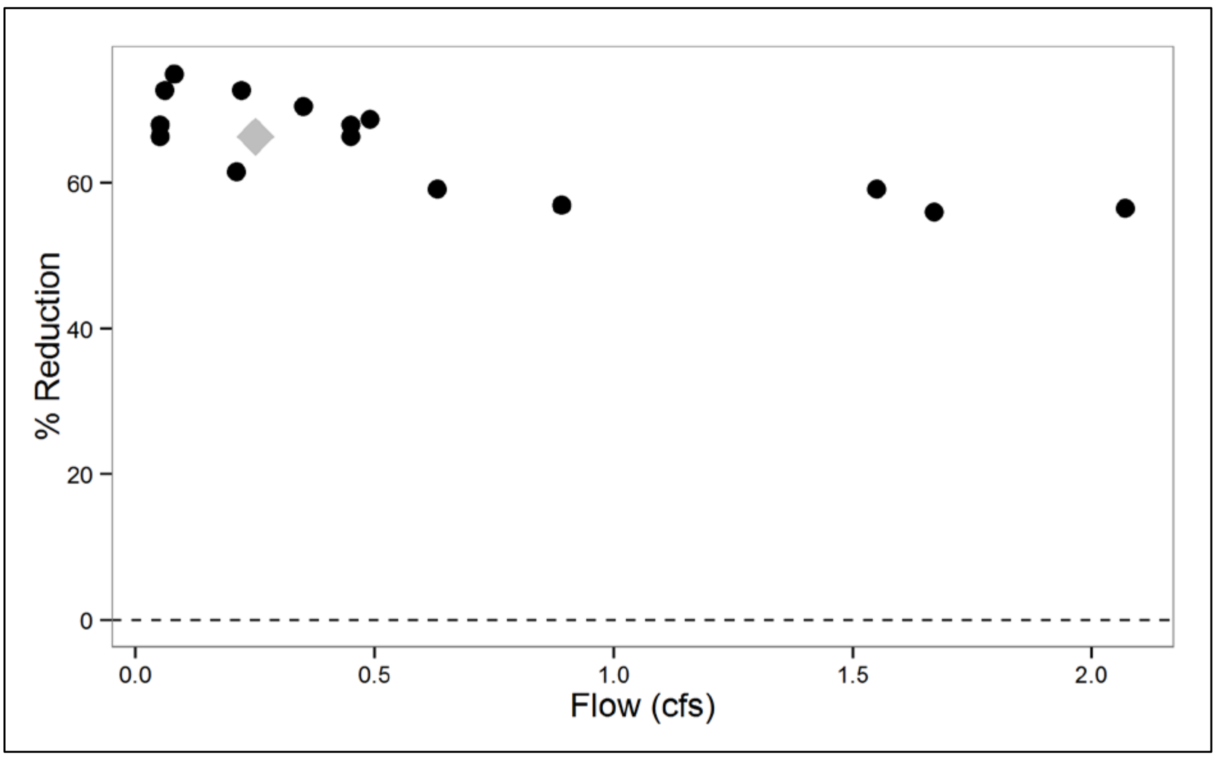

Figure 6-29. Scatterplot of Mainstem Observations and Respective Percent Reductions Necessary to Achieve the TP TMDL in Upper Hoover Creek (the Gray Diamond Is the Median (50th percentile) Observation of Samples that Exceeded the TP TMDL (2010))

6.6.4.2 Assessment of Loading by Source Categories

Agriculture

Agricultural land uses are limited to grazing impacts from cattle. There are no federal grazing allotments in the upper Hoover Creek drainage, but DNRC grazing allotments include approximately 500 acres, with a current maximum of 95 AUMs. This estimate includes only those lands which drain to the Hoover Creek upstream of Miller Lake and is based on the data in **Table 6-27**. There was no surface water irrigation noted in the upper drainage in 2008 (Confluence, Inc., 2008). Site visit notes during data collection noted significant cattle grazing impacts in the stream corridor at some of the most upstream sample locations.

Mining

There is one abandoned mine listed in the upper drainage, which is listed as a phosphate mine. It is located between the Lost Creek confluence and D'Alton Gulch. TP concentrations decreased in this reach (**Figure 6-26**). This abandoned mine site appears to be having no discernible impact on TP concentrations in upper Hoover Creek.

Silviculture (includes timber harvest)

Extensive timber harvest operations have occurred in the upper Hoover Creek drainage on private lands owned by individuals and a lumber company (**Figure 6-30**). Harvesting began in the late 1970s and early 1980s by Champion Timberlands and involved 80–90% removal of standing volume from a tract over a 5- to 10-year span with multiple entries. Additional private lands were harvested extensively in the late 1980s. DNRC harvested two state sections in 1986 and 1987. Plum Creek purchased the Champion Timberlands tracts in the early 1990s and completed some minor harvesting but sold their lands to Stimson Lumber, which continued harvesting in the drainage until the company sold their mill in Bonner (Staedler, F., personal communication 2013). Historic and recent logging has significantly reduced forest cover and created many miles of logging networks throughout the drainage. Erosion of sediment from roads and skid trails to Hoover Creek is quite likely introducing phosphorus to the AU. Given the volcanic parent material for soils in the drainage, soils are not only at a greater risk of erosion, but are also likely phosphorus-rich compared with other sub-watersheds in the Upper Clark Fork Phase 2 TPA. TSS data is limited for this segment, but suggests that there may be some suspended sediment loading to upper Hoover Creek from Lost Creek and D'Alton Gulch, two small tributaries to upper Hoover Creek where past timber harvesting has occurred.

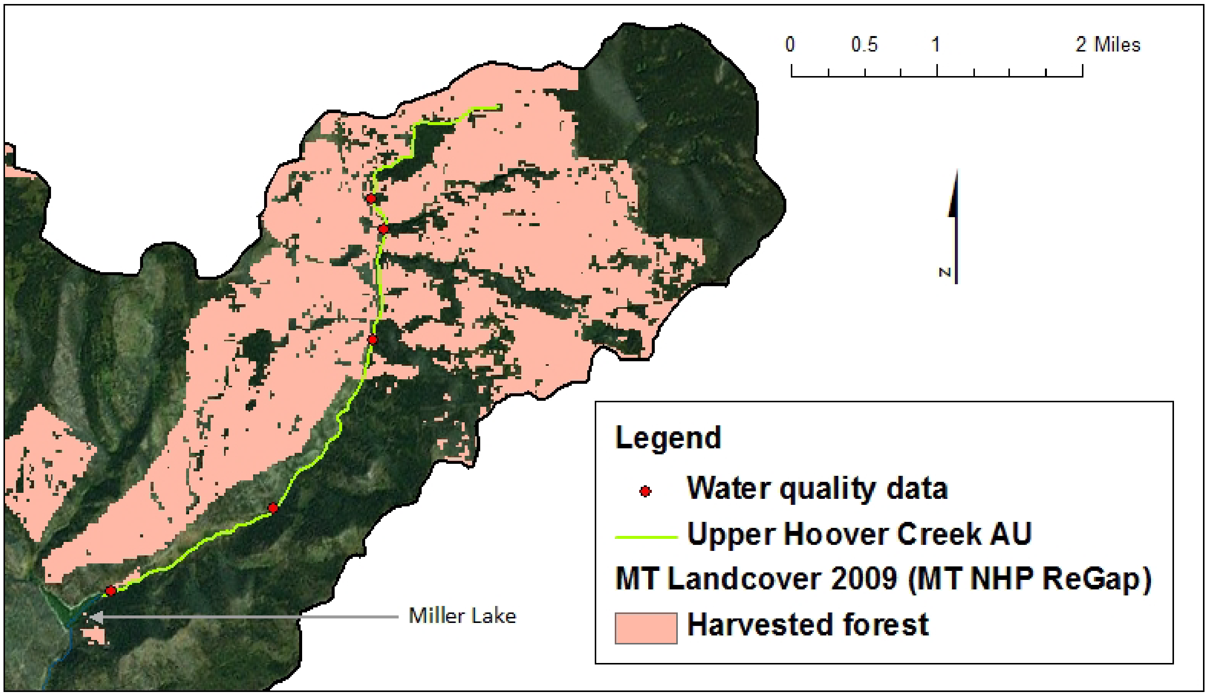

Figure 6-30. Extent of Recent (2005–09) Timber Harvest Operations in the Upper Hoover Creek Drainage

Riparian assessments conducted by FWP in the upper Hoover Creek drainage observed good riparian health with good channel stability and decent shading of the stream (Liermann et al., 2009). Near the headwaters, fine sediment accumulation was notable and thought to be correlated with the forest road network. Culverts in the vicinity were found to be undersized/perched and not conducive for either fish or debris passage (Liermann et al., 2009).

Subsurface Wastewater Disposal and Treatment

According to DEQ records, there are 10 individual septic systems in the upper Hoover Creek drainage which could impact the stream. Most of these systems are located outside the main floodway. Septic effluent is considered a very minor contributor to the upper Hoover Creek TP daily loads.

Summary

The source assessment for upper Hoover Creek suggests that the most important source of human-caused phosphorus in the sub-watershed is the result of sedimentation from past timber harvest operations. However, as stated previously, there may be naturally elevated TP concentrations in the watershed that are difficult to discern given the range of human-caused sources of phosphorus.

6.6.4.3 TP TMDL, Allocations, and Current Loading

The TMDL for TP is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the TP TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TP TMDL for upper Hoover Creek uses **Equation 1,** with the median measured flow from all sites during 2010 sampling (0.45 cfs):

***Equation 1**: TMDL* **= (0.03 mg/L) (0.45 cfs) (5.4) = 0.07 lbs/day**

Equation 4 is the basis for the natural background LA for TP. To continue with the example at a flow of 0.45 cfs, this allocation is as follows:

Equation 4**:** LA_{NB} **= (0.01 mg/L) (0.45 cfs) (5.4) = 0.02 lbs/day**

Using **Equation 5**, the combined septic and other human-caused TP LA at 0.45 cfs can be calculated:

Equation 5**:** LA_{H} **= 0.07 lbs/day – 0.02 lbs/day = 0.05 lbs/day**

An example total existing load is calculated as follows using **Equation 6**, the 80th percentile of TP values measured from upper Hoover Creek from 2010 (0.138 mg/L) and the median measured flow of 0.45 cfs:

Equation 6: Total Existing Load **= (0.138 mg/L) (0.45 cfs) (5.4) = 0.34 lbs/day**

The portion of the existing load attributed to human sources is 0.32 lbs/day, which is determined by subtracting out the 0.02 lbs/day background load from the existing load. This 0.32 lbs/day value represents the load measured within the stream after potential nutrient uptake.

Table 6-50 contains the results for the example TP TMDL, LAs, and current loading. In addition, it contains an example percent reduction to the human-caused LA required to meet the water quality target for TP. The percent reduction to natural background is assumed to be 0%. At the median growing season flow of 0.45 cfs and the 80th percentile of measured TP values, the current loading in upper Hoover Creek is greater than the TMDL. Under these example conditions, an 84% reduction of human-caused sources and an overall 79% reduction of TP in upper Hoover Creek would result in the TMDL being met. The source assessment of the upper Hoover Creek watershed indicates that livestock grazing and timber harvesting is the most likely source of TP; load reductions should focus on limiting and controlling TP loading from these sources. Erosion from road networks and associated phosphorus loading is a likely TP source in the upper sub-watershed. Meeting LAs for upper Hoover Creek may be achieved through a variety of water quality planning and implementation actions and is addressed **Section 7.0**.

Table 6-50. Upper Hoover Creek TP Example TMDL, LAs, Current Loading, and Reductions

Source Category	Allocation and TMDL (lbs/day)[a]	Existing Load (lbs/day)[a]	Percent Reduction
Natural Background	0.02	0.02	0%
Human-caused (primarily livestock grazing/irrigated ag.)	0.05	0.32	84%
	TMDL = 0.07	**Total = 0.34**	**Total = 79%**

[a] Based on a median growing season flow of 0.45 cfs

6.6.5 Hoover Creek, lower (MT76G005_082)

6.6.5.1 Assessment of Water Quality Results

The source assessment for lower Hoover Creek consists of an evaluation of TN and TP concentrations and exceedances of chl-*a* and/or AFDM within the impaired segment. This is followed by the quantification of the most significant human caused sources of nutrients.

FWP lists Hoover Creek as being chronically dewatered (dewatering is a significant issue in most years) from Miller Lake to the mouth (Clark Fork River) (**Figure 6-31**). It should be noted that a sediment TMDL for lower Hoover Creek was completed in 2010 (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2010).

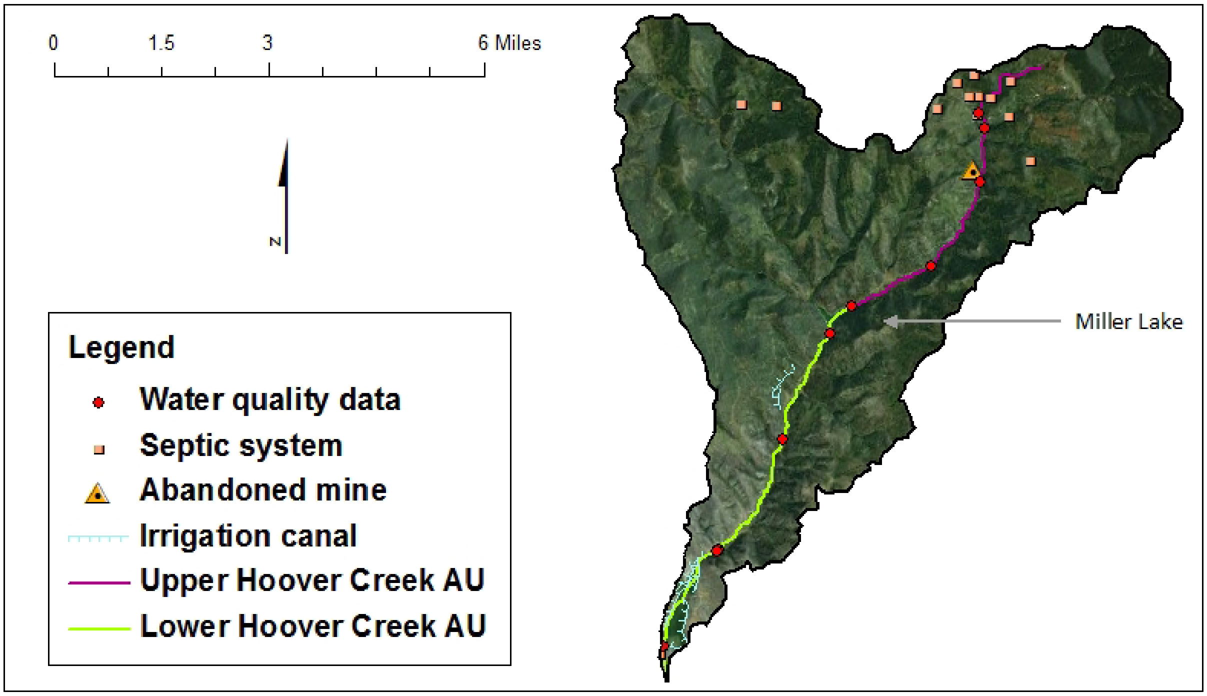

Figure 6-31. Hoover Creek Sub-Watershed with Water Quality Sampling Locations and Identified AU

Total Nitrogen

DEQ collected water quality samples from both AUs on Hoover Creek during the growing season over the 2007–11 time period (**Section 6.4.3.4, Table 6-10; Section 6.4.3.5**, **Table 6-12**). In **Figure 6-32**, TN concentrations only exceeded the target concentration of 0.300 mg/L at sample locations downstream of Miller Lake. There were no exceedances of the TN target in the upper Hoover Creek AU. TN concentrations fall steadily through lower Hoover Creek before rising at the most downstream station, located downstream of a large irrigated hay meadow.

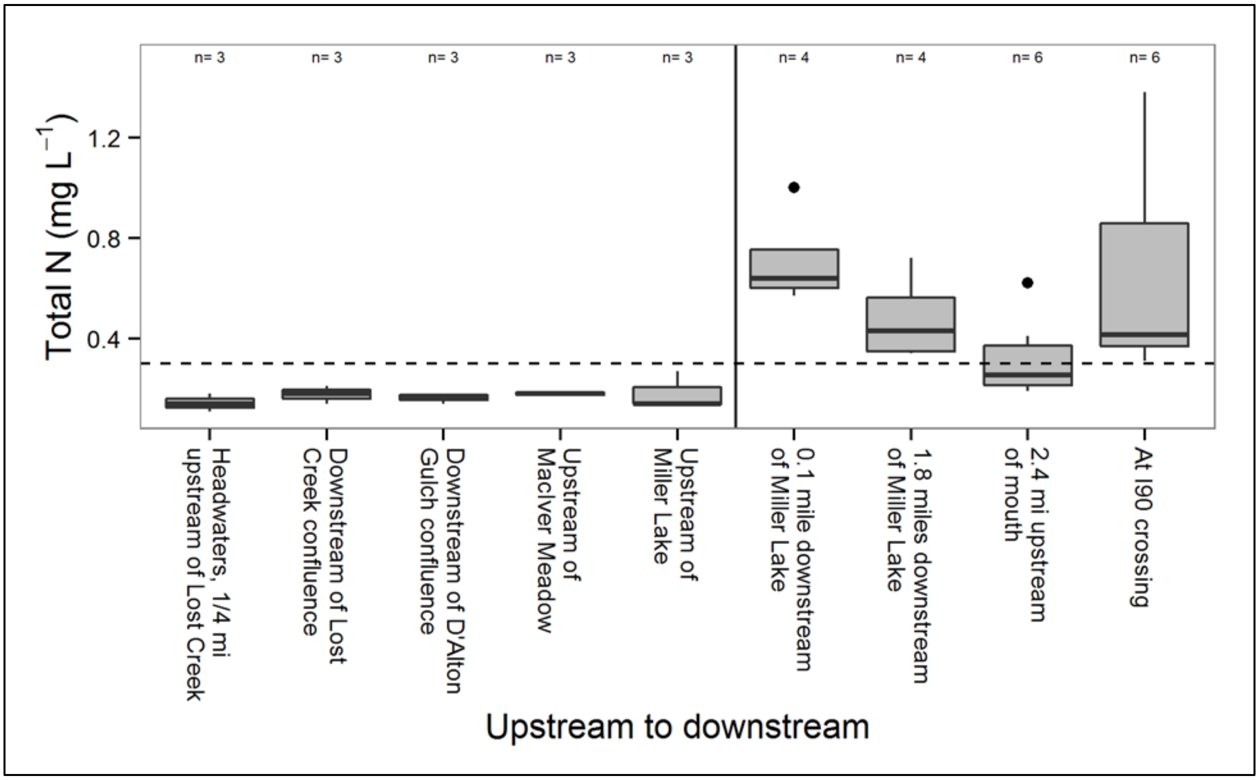

Figure 6-32. Boxplot of TN Concentrations in Upper and Lower Hoover Creek (2007–11); Miller Lake Divides Hoover Creek into Upper and Lower AUs (Dashed Line Is Target)

In **Figure 6-33**, sample data from the AU was plotted as a ratio to the TN target. Exceedances ranged from 1 to >5 times the target concentration of 0.300 mg/L. Exceedances of the TN target are plotted in **Figure 6-34**. Reductions needed to achieve the TN TMDL range from 16% to 81% with a median reduction of 52%. Water quality data in the following figures is limited to those samples collected on the lower Hoover Creek AU.

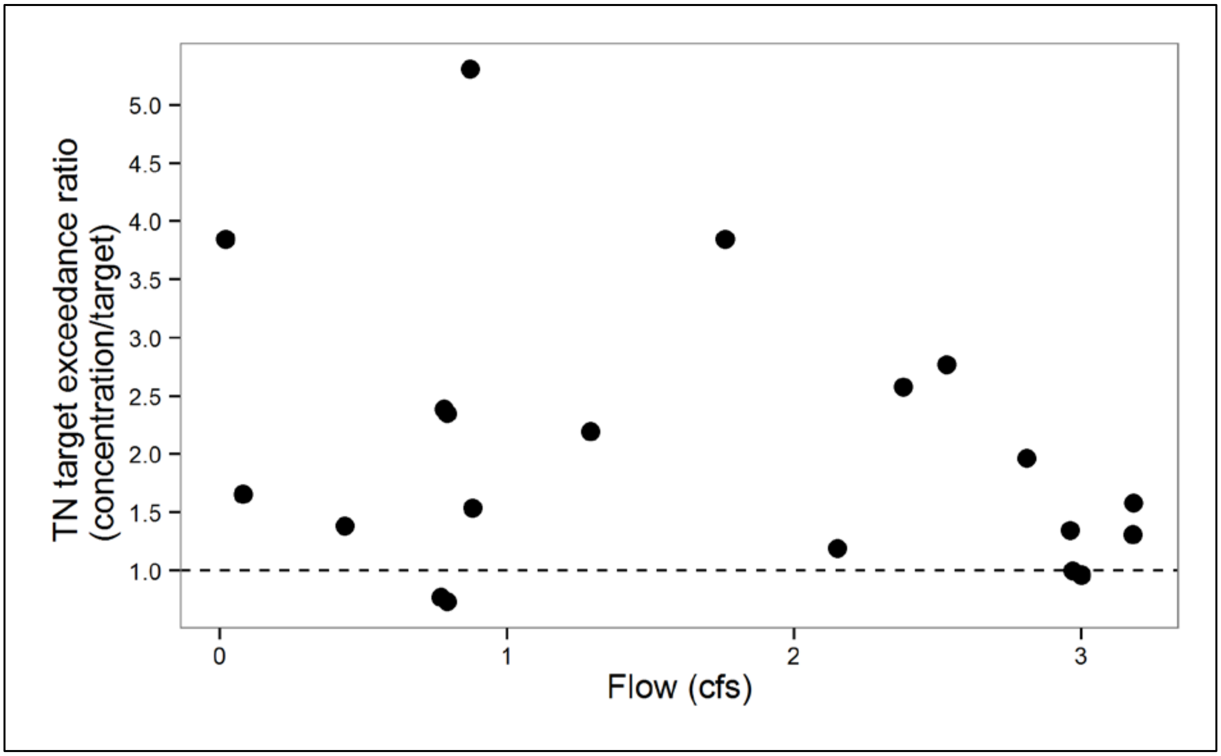

Figure 6-33. TN Target Exceedance Ratio in Lower Hoover Creek (2007–11) (>1 Indicates Exceedance)

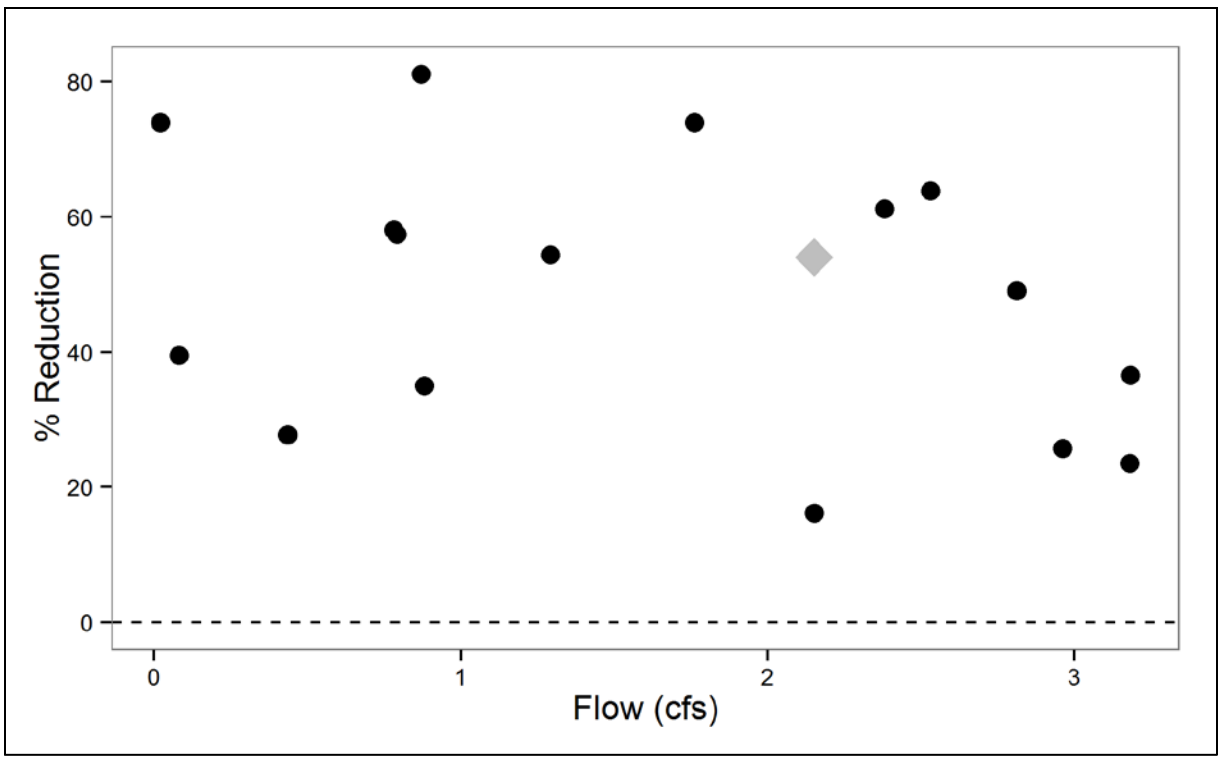

Figure 6-34. Scatterplot of Mainstem Observations and Respective Percent Reductions Necessary to Achieve the TN TMDL in Lower Hoover Creek (the Gray Diamond Is the Median (50th percentile) Observation of Samples that Exceeded the TN TMDL (2007–11))

Total Phosphorus
DEQ collected water quality samples from both AUs on Hoover Creek during the growing season over the 2007–11 time period (**Section 6.4.3.4, Table 6-10; Section 6.4.3.5**, **Table 6-12**). In examining the TP concentration data for Hoover Creek, all data collected on both the upper and lower AUs of Hoover Creek exceeded the water quality target (0.03 mg/L) (**Figure 6-35**).

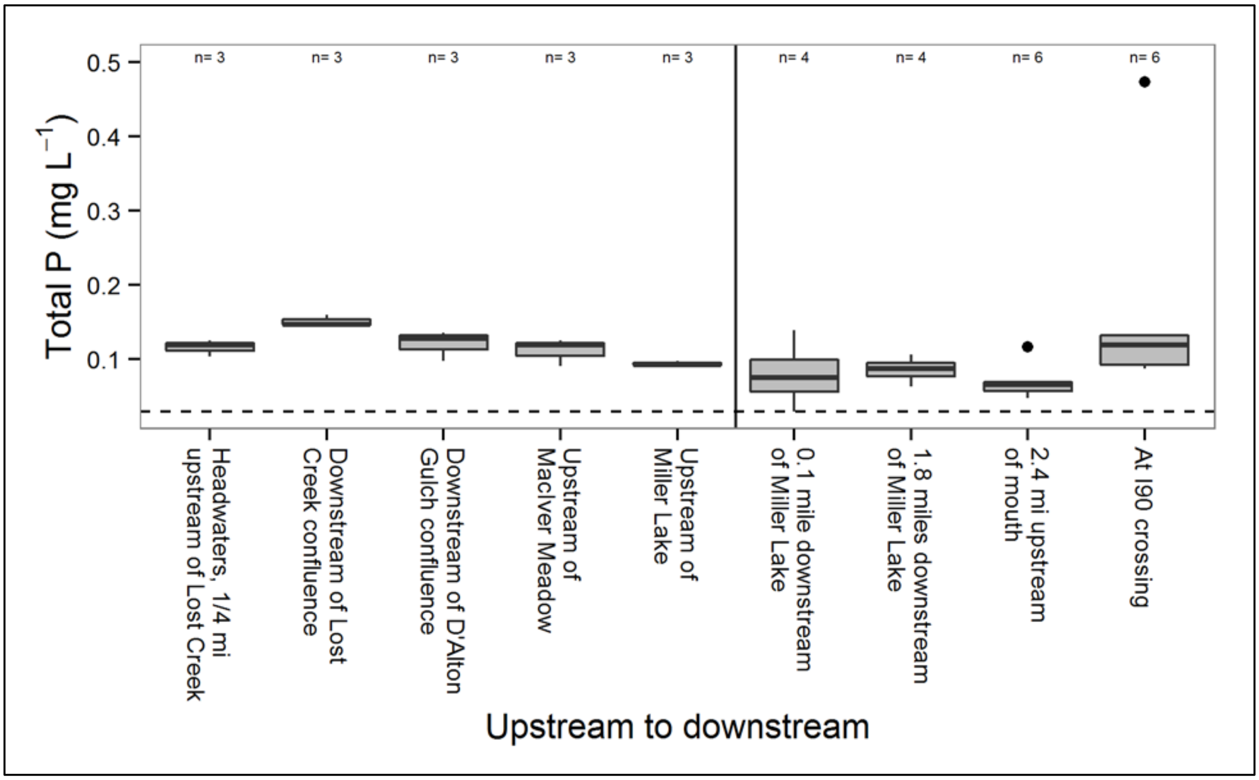

Figure 6-35. Boxplot of TP Concentrations in Hoover Creek (2007–11); Miller Lake Divides Hoover Creek into Upper and Lower AUs (Dashed Line Is Target)

In **Figure 6-36**, sample data from the AU was plotted as a ratio to the TP target. Excluding one outlier, which was nearly 12 times the TP target, exceedances ranged from 1 to >3 times the target concentration of 0.030 mg/L. Exceedances of the TP target are plotted in **Figure 6-37**. Reductions needed to achieve the TP TMDL range from 17% to 92%, with a median reduction of 54%. Water quality data in the following figures is limited to those samples collected on the lower Hoover Creek AU.

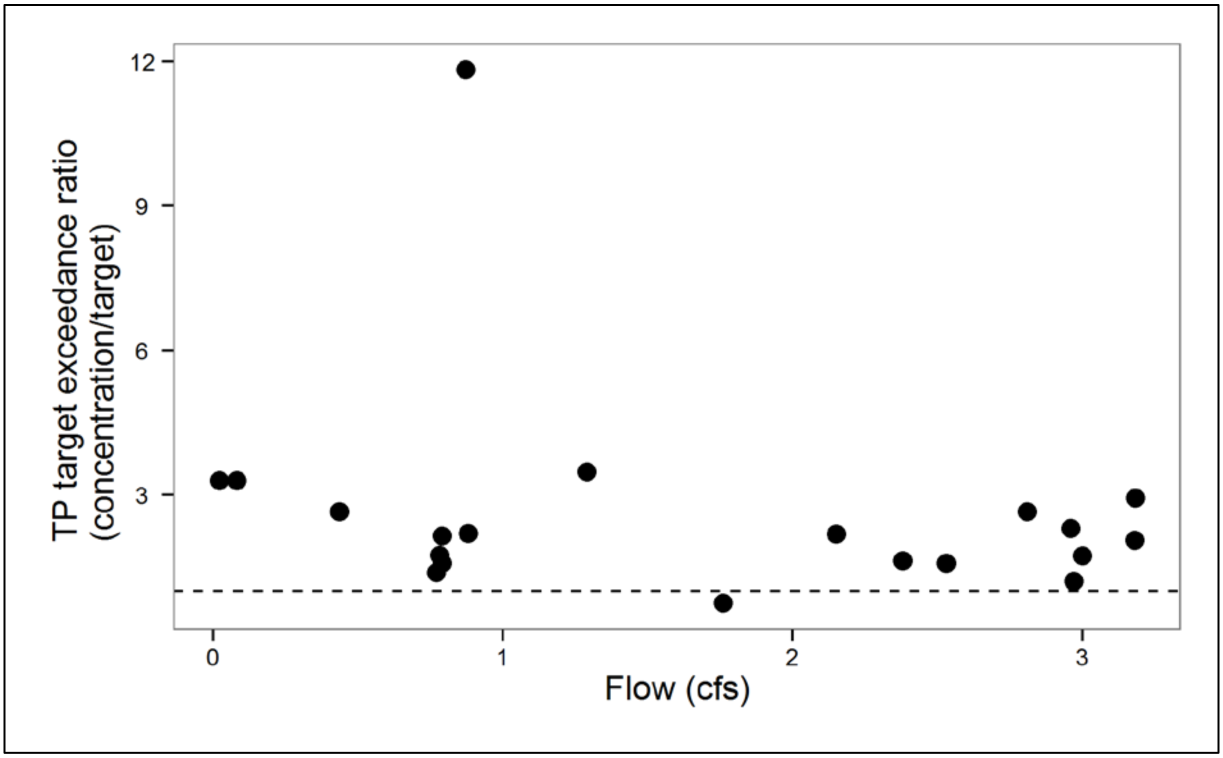

Figure 6-36. TP Target Exceedance Ratio for Lower Hoover Creek (2007–11) (>1 Indicates Exceedance)

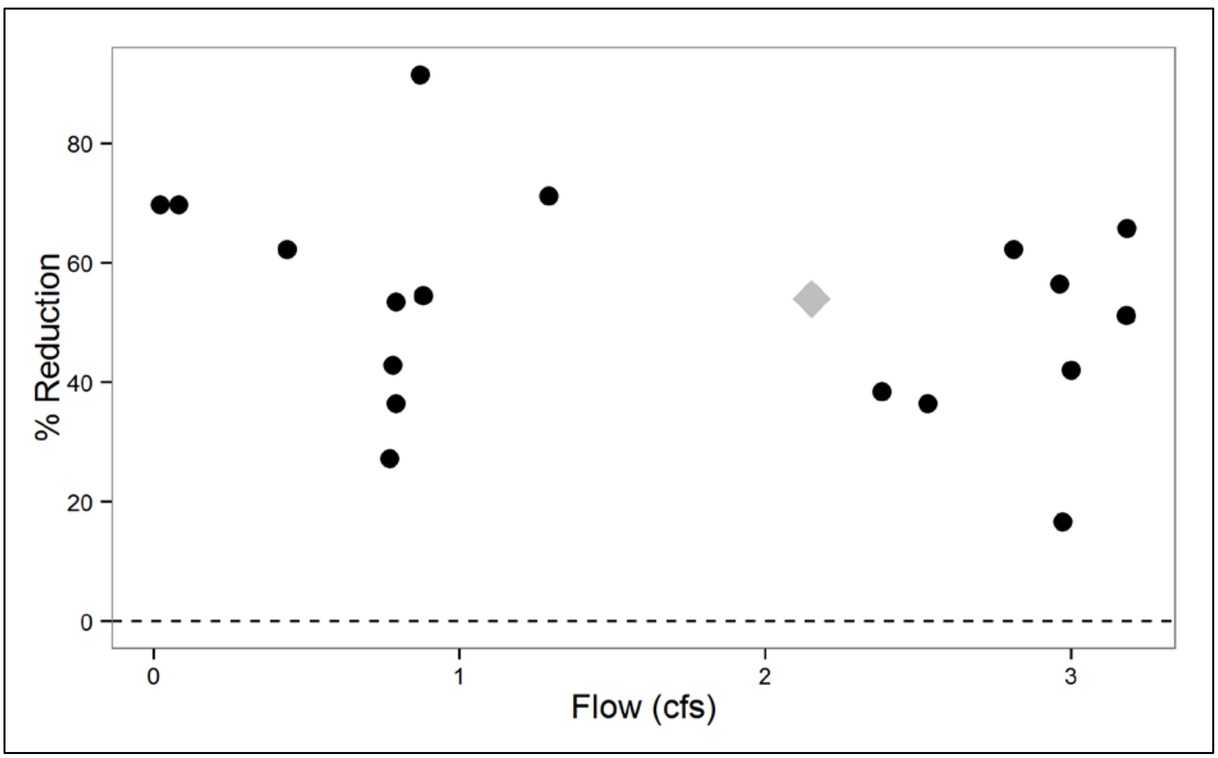

Figure 6-37. Scatterplot of Mainstem Observations and Respective Percent Reductions Necessary to Achieve the TP TMDL in Lower Hoover Creek (the Gray Diamond Is the Median (50th percentile) Observation of Samples that Exceeded the TP TMDL (2007–11))

6.6.5.2 Assessment of Loading by Source Categories

The influence of Miller Lake on nutrient concentration in Hoover Creek is not clear, particularly for TN. TP concentrations are elevated upstream of Miller Lake; a pattern which holds through the lower drainage. For TN, the impairment begins immediately downstream of Miller Lake. Given the relative size (~25 acres) and draw (top, drop hole) of the impoundment, it is not thought to be releasing elevated TN concentrations as a function of the dam. One explanation is that livestock grazing pressure/watering access is much more significant downstream of the dam, which may explain the sudden increase in TN.

There were no chl-*a* or AFDM exceedances of targets in the lower Hoover Creek.

Agriculture

Grazing allotments comprise 2,804 acres on DNRC administered lands in the drainage with a current maximum of 358 permitted AUMs (**Table 6-27**). Irrigated agriculture is limited in the lower Hoover Creek drainage, with irrigated parcels found between the canyon and the mouth (Clark Fork River). Diverted water is used to grow hay/alfalfa. Livestock grazing is a significant land use in the AU and is likely a more important nutrient source than irrigated agriculture.

There was a dammed impoundment 3 miles upstream of the mouth of Hoover Creek which was breached in the mid-2000s and no longer impounds Hoover Creek flows.

An irrigation ditch, which originates on the Clark Fork River, captures Hoover Creek entirely approximately 0.1 mile upstream of the mouth (Liermann et al., 2009). The diversion appears to pass limited flows down Hoover Creek. The Hoover Creek sub-watershed ends near this ditch diversion, where Hoover Creek enters the Clark Fork River floodplain. FWP identified channelization and downcutting in the Hoover Creek channel both upstream and downstream of I90. Lack of deep pools, fine sediment accumulation, and browsing pressure on riparian health and robustness were observed in reaches upstream of I90 (Liermann et al., 2009).

Mining

Not a source based on assessment of Upper Hoover Creek (**Section 6.6.4.2**).

Silviculture (includes timber harvest)

A potentially significant source of TP based on assessment of Upper Hoover Creek (**Section 6.6.4.2**). There have been no recent timber harvest/forest operations in the Hoover Creek watershed downstream of Miller Lake, however, timber harvesting operations have occurred in the Swamp Creek drainage (western tributary that flows into Miller Lake) on a smaller scale during the same timeframe as described for upper Hoover Creek.

Subsurface Wastewater Disposal and Treatment

According to DEQ records, there are 13 individual septic systems in the Hoover Creek sub-watershed. Most of these systems are located outside the main floodway. Septic effluent is considered a very minor contributor to the lower Hoover Creek TN and TP daily loads.

Summary

The source assessment for lower Hoover Creek suggests that the most important source of human-caused nutrients in the sub-watershed is from grazing and impacts from past timber harvest operations. The elevated TP concentrations in lower Hoover Creek are likely tied to timber harvest operations upstream of Miller Lake. The source assessment suggests that the high TN concentrations in the lower watershed are most likely linked to grazing land uses. However, as stated previously, there may be naturally elevated TP concentrations in the watershed that are difficult to discern given the range of human-caused sources of phosphorus.

6.6.5.3 TN TMDL, Allocations, and Current Loading

The TMDL for TN is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the TN TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TN TMDL for lower Hoover Creek uses **Equation 1**, with the median measured flow from all sites during 2007–11 sampling (1.53 cfs):

***Equation 1**: TMDL* **= (0.300 mg/L) (1.53 cfs) (5.4) = 2.48 lbs/day**

Equation 4 is the basis for the natural background LA for TN. To continue with the example at a flow of 1.53 cfs, this allocation is as follows:

***Equation 4**:* **LA_{NB} = (0.095 mg/L) (1.53 cfs) (5.4) = 0.78 lbs/day**

Using **Equation 5**, the combined septic and other human-caused TN LA at 1.53 cfs can be calculated:

***Equation 5**:* **LA_{H} = 2.48 lbs/day – 0.78 lbs/day = 1.70 lbs/day**

An example total existing load is calculated as follows using **Equation 6**, the 80th percentile of TN values measured from lower Hoover Creek from 2007 to 2011 (0.680 mg/L) and the median measured flow of 1.53 cfs:

***Equation 6**: Total Existing Load* **= (0.680 mg/L) (1.53 cfs) (5.4) = 5.62 lbs/day**

The portion of the existing load attributed to human sources is 4.84 lbs/day, which is determined by subtracting out the 0.78 lbs/day background load from the existing load. This 4.84 lbs/day value represents the load measured within the stream after potential nutrient uptake.

Table 6-51 contains the results for the example TN TMDL, LAs, and current loading. In addition, it contains an example percent reduction to the human-caused LA required to meet the water quality target for TN. The percent reduction to natural background is assumed to be 0%. At the median growing season flow of 1.53 cfs and the 80th percentile of measured TN values, the current loading in lower Hoover Creek is greater than the TMDL. Under these example conditions, a 65% reduction of human-caused sources and an overall 56% reduction of TN in lower Hoover Creek would result in the TMDL being met. The source assessment of the lower Hoover Creek watershed indicates that livestock grazing and irrigated agriculture are the most likely sources of TN; load reductions should focus on limiting and controlling TN loading from these sources. Meeting LAs for lower Hoover Creek may be achieved through a variety of water quality planning and implementation actions and is addressed **Section 7.0**.

Table 6-51. Lower Hoover Creek TN Example TMDL, LAs, Current Loading, and Reductions

Source Category	Allocation and TMDL (lbs/day)[a]	Existing Load (lbs/day)[a]	Percent Reduction
Natural Background	0.78	0.78	0%
Human-caused (livestock grazing/irrigated agriculture)	1.70	4.84	65%
	TMDL = 2.48	**Total = 5.62**	**Total = 56%**

[a] Based on a median growing season flow of 1.53 cfs

6.6.5.4 TP TMDL, Allocations, and Current Loading

The TMDL for TP is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the TP TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TP TMDL for lower Hoover Creek uses **Equation 1,** with the median measured flow from all sites during 2007–11 sampling (1.53 cfs):

***Equation 1**: TMDL* **= (0.03 mg/L) (1.53 cfs) (5.4) = 0.25 lbs/day**

Equation 4 is the basis for the natural background LA for TP. To continue with the example at a flow of 1.53 cfs, this allocation is as follows:

***Equation 4**:* LA_{NB} **= (0.01 mg/L) (1.53 cfs) (5.4) = 0.08 lbs/day**

Using **Equation 5**, the combined septic and other human-caused TP LA at 1.53 cfs can be calculated:

***Equation 5**:* LA_{H} **= 0.25 lbs/day – 0.08 lbs/day = 0.17 lbs/day**

An example total existing load is calculated as follows using **Equation 6**, the 80th percentile of TP values measured from lower Hoover Creek from 2007 to 2011 (0.120 mg/L) and the median measured flow of 1.53 cfs:

***Equation 6**: Total Existing Load* **= (0.120 mg/L) (1.53 cfs) (5.4) = 0.99 lbs/day**

The portion of the existing load attributed to human sources is 0.91 lbs/day, which is determined by subtracting out the 0.08 lbs/day background load from the existing load. This 0.91 lbs/day value represents the load measured within the stream after potential nutrient uptake.

Table 6-52 contains the results for the example TP TMDL, LAs, and current loading. In addition, it contains an example percent reduction to the human-caused LA required to meet the water quality target for TP. The percent reduction to natural background is assumed to be 0%. At the median growing season flow of 1.53 cfs and the 80th percentile of measured TP values, the current loading in lower Hoover Creek is greater than the TMDL. Under these example conditions, an 81% reduction of human-caused sources and an overall 75% reduction of TP in lower Hoover Creek would result in the TMDL being met. The source assessment of the Hoover Creek watershed indicates that livestock grazing and timber harvesting is the most likely source of TP; load reductions should focus on limiting and controlling TP loading from these sources. Erosion from road networks and associated phosphorus loading is a likely TP source in the upper sub-watershed. Meeting LAs for Hoover Creek may be achieved through a variety of water quality planning and implementation actions and is addressed **Section 7.0**.

Table 6-52. Lower Hoover Creek TP Example TMDL, LAs, Current Loading, and Reductions

Source Category	Allocation and TMDL (lbs/day)[a]	Existing Load (lbs/day)[a]	Percent Reduction
Natural Background	0.08	0.08	0%
Human-caused (livestock grazing/timber harvesting)	0.17	0.91	81%
	TMDL = 0.25	**Total = 0.99**	**Total = 75%**

[a] Based on a median growing season flow of 1.53 cfs

6.6.6 Lost Creek (MT76G002_072)

6.6.6.1 Assessment of Water Quality Results

The source assessment for Lost Creek consists of an evaluation of TN and exceedances of chl-*a* and/or AFDM within the impaired segment of Lost Creek. This is followed by the quantification of the most significant human caused sources of nutrients. It should be noted that FWP lists Lost Creek as being chronically dewatered (dewatering is a significant issue in most years) from the Lost Creek State Park to the mouth (Clark Fork River). **Figure 6-38** presents the approximate locations of data pertinent to the source assessment in the sub-watershed.

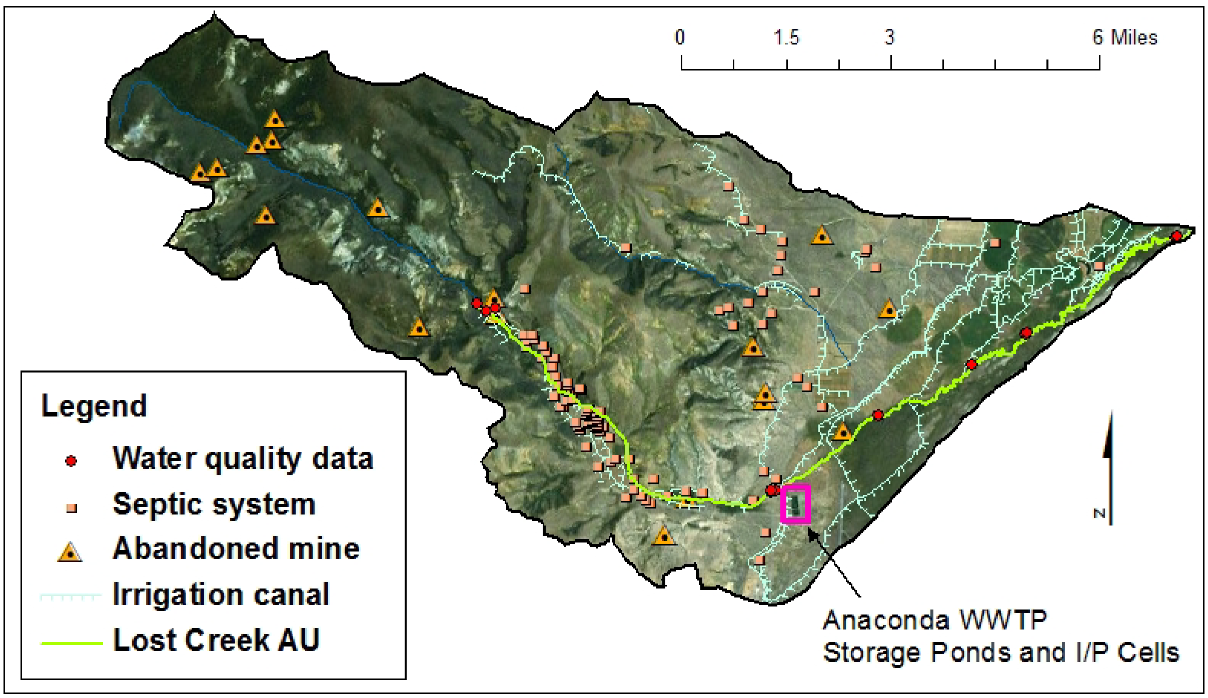

Figure 6-38. Lost Creek Sub-Watershed with Water Quality Sampling Locations

Total Nitrogen

DEQ collected water quality samples from Lost Creek during the growing season (July 1 to September 30) over the 2007–11 time period (**Section 6.4.3.6**, **Table 6-14**). Data is grouped by location and plotted in the **Figure 6-38.** With a single exception for a sample collected near the south boundary of Lost Creek State Park, TN only exceeded the water quality target of 0.300 mg/L at sites downstream of the Galen Road crossing and downgradient of the Anaconda WWTP facility.

Figure 6-39 includes TN concentration distributions for samples collected in the Lost Creek channel. Chl-*a* targets were exceeded in samples collected at both ARCO property sample locations downgradient from Galen Road. In **Figure 6-39**, the Anaconda WWTP HIP facility is located in between the sample location at the Galen Road bridge and the ARCO property (T15N, R10W, S16).

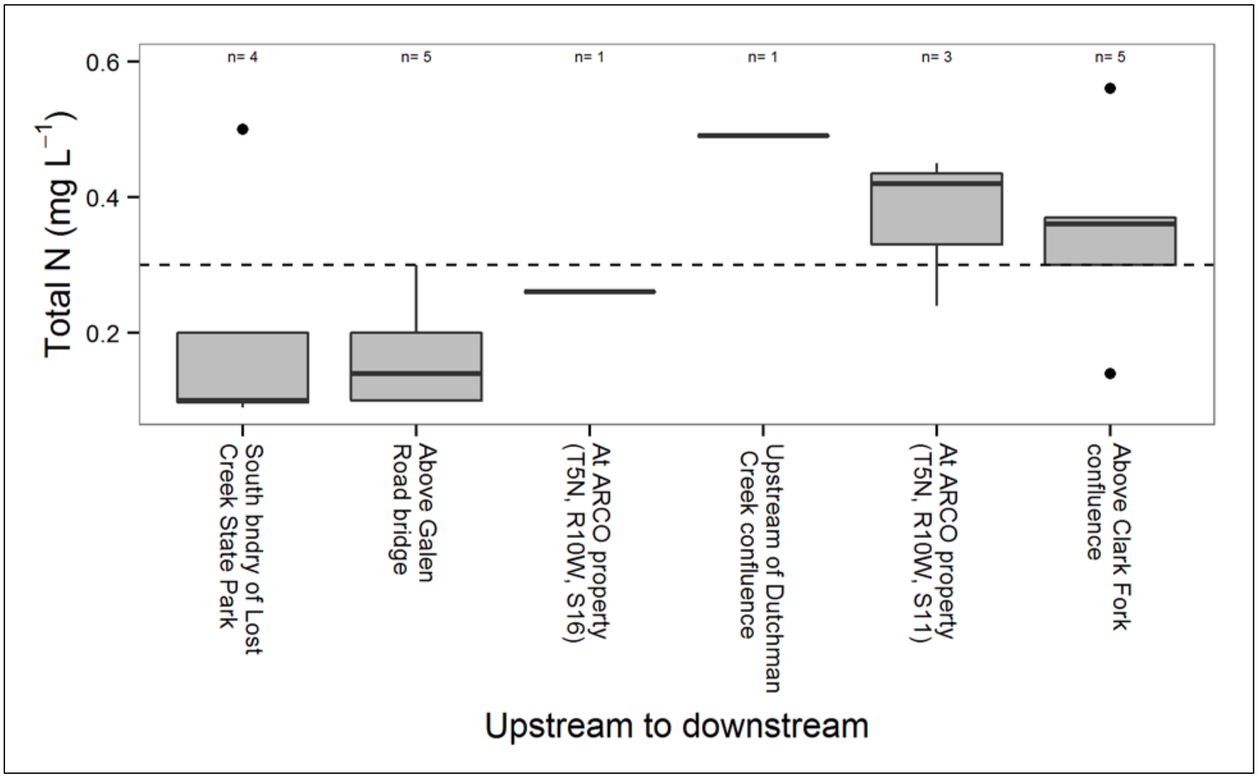

Figure 6-39. Boxplot of TN Concentrations in Lost Creek (2007–11) (Dashed Line Is Target)

In **Figure 6-40**, sample data from the AU was plotted as a ratio to the TN target. Exceedances of the TN target occurred at a variety of flows from <<1 cfs to 19 cfs. As noted previously, with a single exception, all exceedances of the target were observed in the lower portion of the sub-watershed downstream of the Galen Road crossing.

Exceedances of the TN target are plotted in **Figure 6-41**. TN load reductions necessary to achieve the TMDL range from 17% to 46% with a median reduction of 33.3%.

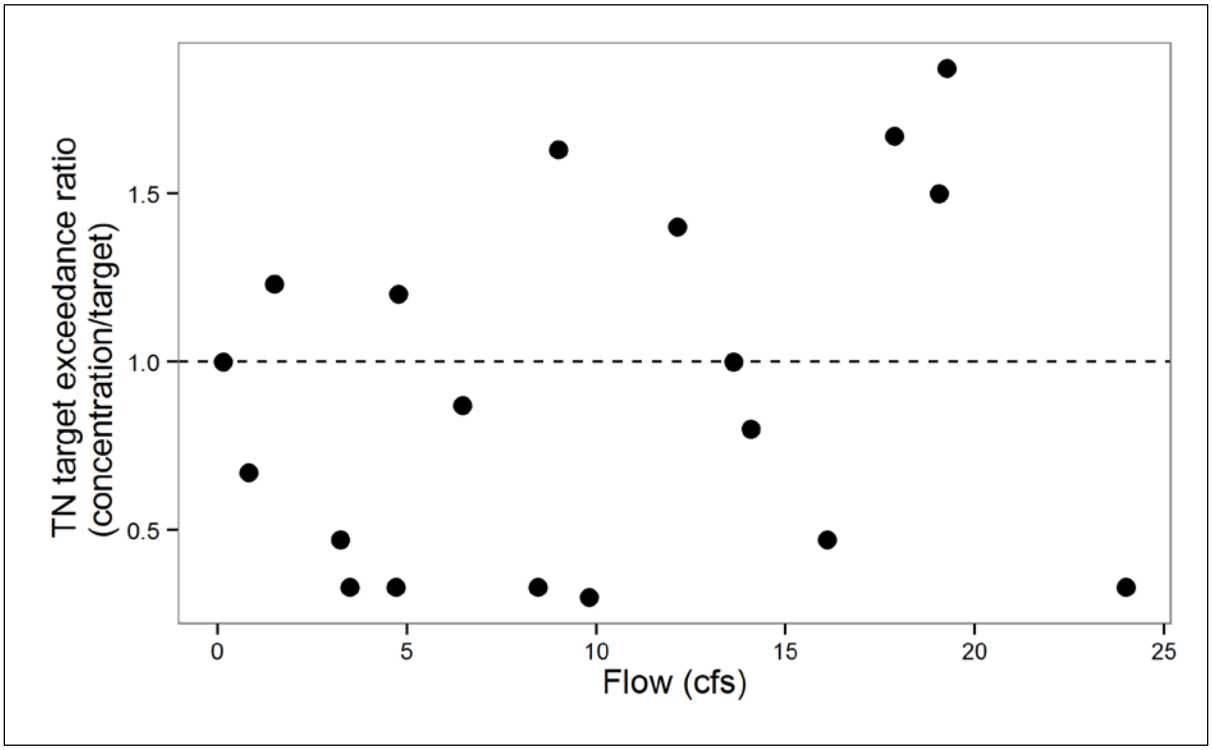

Figure 6-40. TN Target Exceedance Ratio in Lost Creek (2007–11) (>1 Indicates Exceedance)

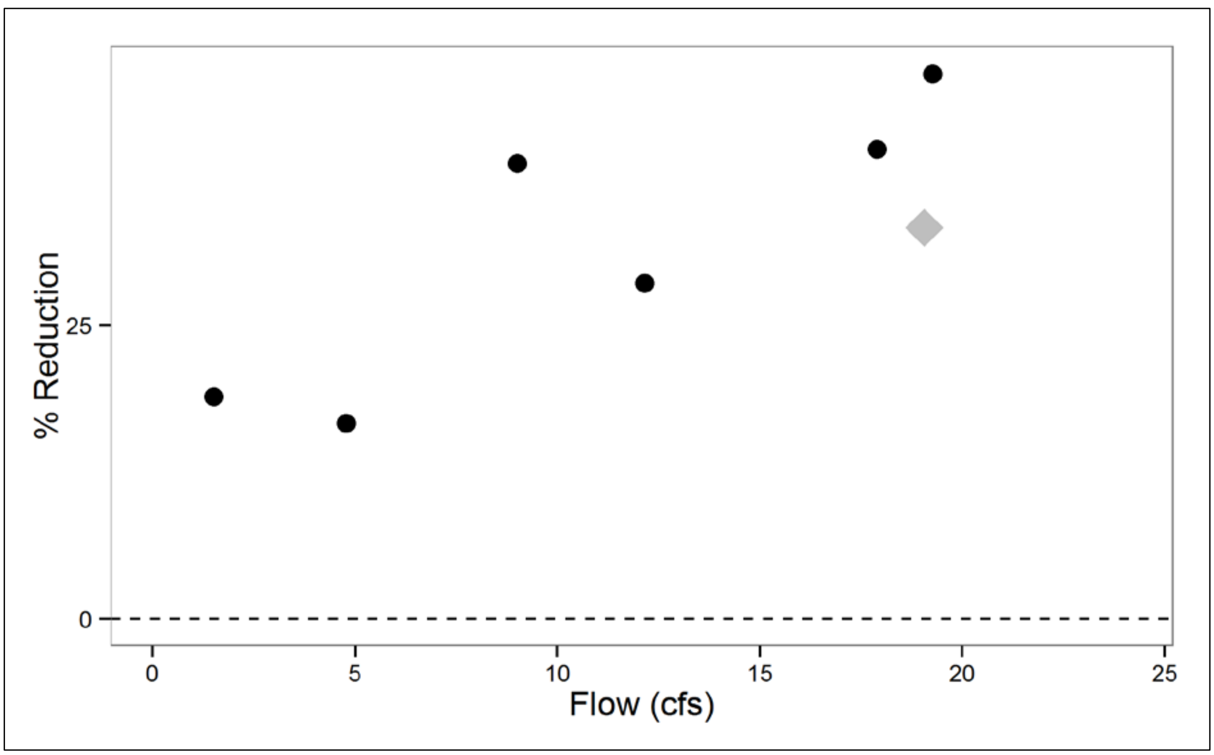

Figure 6-41. Scatterplot of Mainstem Observations and Respective Percent Reductions Necessary to Achieve the TN TMDL in Lost Creek (the Gray Diamond Is the Median (50th percentile) Observation of Samples that Exceeded the TN TMDL (2007–11))

6.6.6.2 Assessment of Loading by Source Categories

Agriculture
The primary land use downstream of the Lost Creek State Park is agriculture. Agricultural land uses include rangeland, pasture, and irrigated hayland, with cow/calf operations comprising the primary agricultural resource in the sub-watershed. Grazing allotments comprise 2,090 acres on USFS and DNRC administered lands in the drainage with a current maximum of 49 permitted AUMs (**Table 6-27**).

In 1998, Lost Creek was identified by the now non-operational Tri-State Water Quality Council as being the largest TN load contributor among all tributaries to the Upper Clark Fork River upstream of Deer Lodge, and was the number one priority among non-point nutrient sources in the Upper Clark Fork River Basin (Saffel and Mostad, 2011).

Partly in response to the Tri-State Water Quality Council's recommendations, the USGS Section 104 Program (Water Resources Research Act of 1984) funded a research project on Lost Creek in 1999 through the University of Montana. Graduate student James Harris, advised by Dr. Vicki Watson, completed a baseline study which identified the main nutrient sources on Lost Creek. Nutrient sources included cattle grazing impacts, irrigation return flows, loss of riparian function from cattle, and the Anaconda wastewater facility on Galen Road (Harris and Watson, 2000).

From 2000 to 2005, extensive restoration work was completed on Lost Creek to address nutrient and sediment sources identified by Harris (2000). Most of the major landowners in the lower segment of Lost Creek downstream of Galen Road agreed to direct involvement in the work which included removal of fish passage barriers, more than 15 miles of riparian fencing, channel realignment, off-stream watering sources for cattle operations, and riparian restoration and wetland creation. In addition, a large AFO (2,500 cattle) was relocated away from the stream corridor as part of this work (Saffel and Mostad, 2011). Project goals included restoring Lost Creek's water quality, aquatic habitat and riparian conditions to a natural, self-sustaining channel. Restoration success was documented by a FWP fish population assessment on Lost Creek in 2008 (Liermann et al., 2009). FWP noted the previously severely channelized area now appeared stable and had continued to maintain good connection to its extensive floodplain. Beaver activity was extensive near the mouth of Lost Creek (Liermann et al., 2009).

Agriculture is still the primary land use in the lower drainage and is likely still contributing TN loads to Lost Creek via irrigation return flows and some cattle grazing impacts. It should be noted that much of the irrigation in the lower drainage is efficient center pivot delivery. In addition, restoration work in the early 2000s significantly decreased impacts from on-stream watering and riparian grazing by cow-calf operations (Saffel and Mostad, 2011). Although, the existing number of livestock that use this area is not known, livestock impacts were significantly reduced via off-stream watering and riparian fencing in the mid-2000s prior to the data collection used in the Lost Creek analysis (2007–11).

Surface water irrigation is extensive in the Lost Creek watershed particularly in the lower drainage near the mouth with the Clark Fork River. The Gardiner Ditch carries water from the Warm Springs Creek south drainage through the Lost Creek watershed and into the Modesty Creek sub-watershed. While canals do appear to run through the wetland complex east of the Galen Road and intersect the Lost Creek channel, several of these were confirmed to be abandoned and a few are actually drains which discharge to the creek. There is potential that these drains transport nutrient loads to the Lost Creek channel. With the exception of potential canal loss from the Gardiner Ditch, it is assumed that no TN loads are transported into the basin via irrigation diversion. Limited water quality data collected from the Gardiner Ditch south of Lost Creek in the Lost Creek sub-watershed had TN concentrations greater than the target concentration of 0.30 mg/L (**Table 6-53**). Gardiner Ditch crosses Lost Creek between the Galen Road bridge and the Anaconda WWTP HIP facility location. While it appears that Gardiner Ditch flows are not diverted for irrigation use in the Lost Creek sub-watershed, canal losses via seepage may contribute some TN loading to Lost Creek (Confluence, Inc., 2008).

Table 6-53. Nutrient Water Quality Data for Gardiner Ditch in the Lost Creek Sub-Watershed

Canal/Ditch Name	No. of Samples[a]	Mean Flow (cfs)	Mean TN (mg/L)	Mean TP (mg/L)
Gardiner Ditch	2	13.3	0.47	0.007

[a] Data collected in July and September 2010

Mining

There are 18 abandoned mines in the Lost Creek watershed. With several located near the stream, potential impacts from past mining activities are possible. However, water quality data collected in the vicinity of mine locations do not indicate that these sites are having an appreciable effect on instream nutrient water quality in Lost Creek. An analysis of mining impacts on lands administered by the BDNF in the Upper Clark Fork identified the Lost Creek drainage as having little precious metal production (Madison et al., 1998).

Silviculture (includes timber harvest)

While no timber harvest operation have been conducted on USFS lands in Lost Creek in recent years, a small roads project was conducted on Microwave Road (aka Hoodoo Road) in 2013. This may have briefly increased sediment loading in Lost Creek but is assumed to not have affected nutrient loading.

Subsurface Wastewater Disposal and Treatment

According to DEQ records, there are 95 individual septic systems in the Lost Creek watershed. Upstream of the Galen Road crossing, the valley constricts and homes are sited fairly close to the stream channel. The highest densities of septic systems in the Lost Creek watershed are located in this reach downstream of Lost Creek State Park. Water quality data collected upstream of Galen Road suggest an increasing TN load in the stream as suggested by the increase in TN concentrations of about 0.1 mg/l in **Figure 6-38** between Lost Creek State Park and Galen Road. Note that in this reach TN concentrations remain below target values. The most likely source of this loading is septic effluent as agricultural land use is fairly limited in this reach.

Included in this category is the Anaconda WWTP facility on Galen Road. Coarse loading estimates from the facility to the stream channel are outlined in **Section 6.5.1.1** (Subsurface Wastewater Treatment and Disposal; Anaconda WWTP (unpermitted)).

Summary

The source assessment for Lost Creek suggests that the most important source of human-caused nitrogen in the watershed is from subsurface wastewater treatment and disposal. Many of the individual septic systems are within close proximity to the stream channel in the narrow canyon between the Lost Creek State Park and Galen Road and the Anaconda WWTP HIP facility on Galen Road has also been identified as being part of this load.

6.6.6.3 TN TMDL, Allocations, and Current Loading

The TMDL for TN is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the TN TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TN TMDL for Lost Creek uses **Equation 1**, with the median measured flow from all sites during 2007–11 sampling (9.00 cfs):

***Equation 1*: *TMDL* = (0.30 mg/L) (9.00 cfs) (5.4) = 14.58 lbs/day**

Equation 4 is the basis for the natural background LA for TN. To continue with the example at a flow of 9.00 cfs, this allocation is as follows:

***Equation 4*: LA_{NB} = (0.095 mg/L) (9.00 cfs) (5.4) = 4.62 lbs/day**

Using **Equation 5**, the combined human-caused TN LA at 9.00 cfs can be calculated:

Equation 5: LA_H = 14.58 lbs/day – 4.62 lbs/day = 9.96 lbs/day

An example total existing load is calculated as follows using **Equation 6,** the 80th percentile of TN values measured from Lost Creek from all sampling stations (2007–11) (0.432 mg/L) and the median measured flow of 9.00 cfs:

***Equation 6*: *Total Existing Load* = (0.432 mg/L) (9.00 cfs) (5.4) = 21.00 lbs/day**

The portion of the existing load attributed to human sources is 16.38 lbs/day, which is determined by subtracting out the 4.62 lbs/day background load. This 16.38 lbs/day value represents the load measured within the stream after potential nutrient uptake.

Table 6-54 contains the results for the example TN TMDL, LAs, and current loading. In addition, it contains an example percent reduction to human-caused LA required to meet the water quality target for TN. At the median growing season flow of 9.00 cfs and the 80th percentile of measured TN values, the current loading in Lost Creek is greater than the TMDL. Under these example conditions, a 39% reduction of human-caused sources and an overall 31% reduction of TN in Lost Creek would result in the TMDL being met. The source assessment of the Lost Creek watershed indicates that irrigated agriculture and subsurface wastewater treatment and disposal are the most likely sources of TN in Lost Creek. Load reductions should focus on limiting and controlling TN loading from these sources. Meeting LAs for Lost Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 7.0**. Inter-sub-watershed transfers of irrigation flows do potentially complicate the loading dynamics.

Table 6-54. Lost Creek TN Example TMDL, LAs, Current Loading, and Reductions

Source Category	Allocation and TMDL (lbs/day)[a]	Existing Load (lbs/day)[a]	Percent Reduction
Natural Background	4.62	4.62	0%
Human-caused (irrigated agriculture, wastewater)	9.96	16.38	39%
	TMDL = 14.58	**Total = 21.00**	**Total = 31%**

[1] Based on a median growing season flow of 9.00 cfs

The TN TMDL for Lost Creek addresses the existing NO_3+NO_2 impairment (**Table 6-26**).

6.6.7 Peterson Creek, upper (MT76G002_131)

6.6.7.1 Assessment of Water Quality Results

The source assessment for upper Peterson Creek consists of an evaluation of TN and TP concentrations and exceedances of chl-*a* and/or AFDM within the impaired segment from the headwaters to the Jack Creek confluence. This is followed by the quantification of the most significant human caused sources of nutrients. **Figure 6-42** presents the approximate locations of data pertinent to the source assessment for Peterson Creek upstream of the Jack Creek confluence. It should be noted that a sediment TMDL for upper Peterson Creek was completed in 2010 (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2010).

FWP lists Peterson Creek as being chronically dewatered (dewatering is a significant issue in most years) from the confluence of an unnamed spring creek to the Jack Creek confluence.

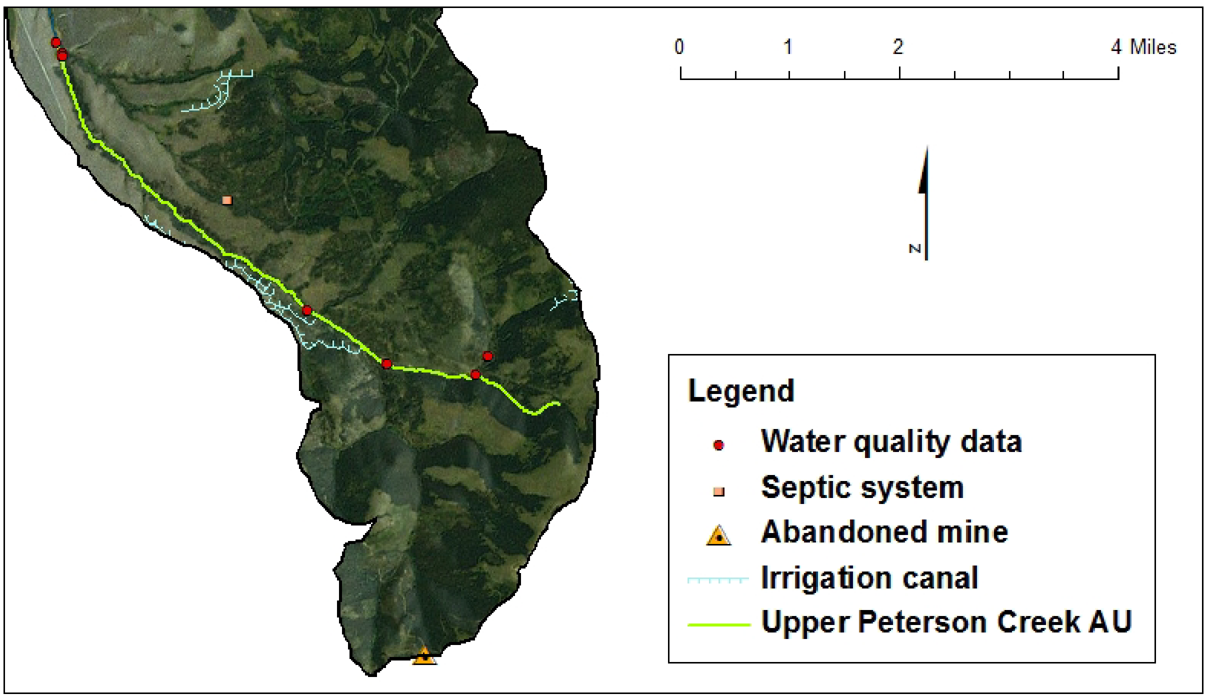

Figure 6-42. Upper Peterson Creek Drainage within the Peterson Creek Sub-Watershed with Water Quality Sampling Locations

Total Nitrogen

DEQ collected water quality samples for TN from Peterson Creek upstream of the Jack Creek confluence during the growing season over the 2007–10 time period (**Section 6.4.3.7**, **Table 6-16**). Out of a total of 16 samples collected from the mainstem, only 1 exceeded the TN target concentration (0.300 mg/L). **Figure 6-43** presents summary statistics for TN concentrations at sampling sites in Peterson Creek upstream of the Jack Creek confluence, and includes samples from a headwater tributary.

In **Figure 6-44**, sample data from the AU was plotted as a ratio to the TN target. TN concentrations were less than the target in all samples except for one collected just upstream of the Jack Creek confluence on 8/24/2011.

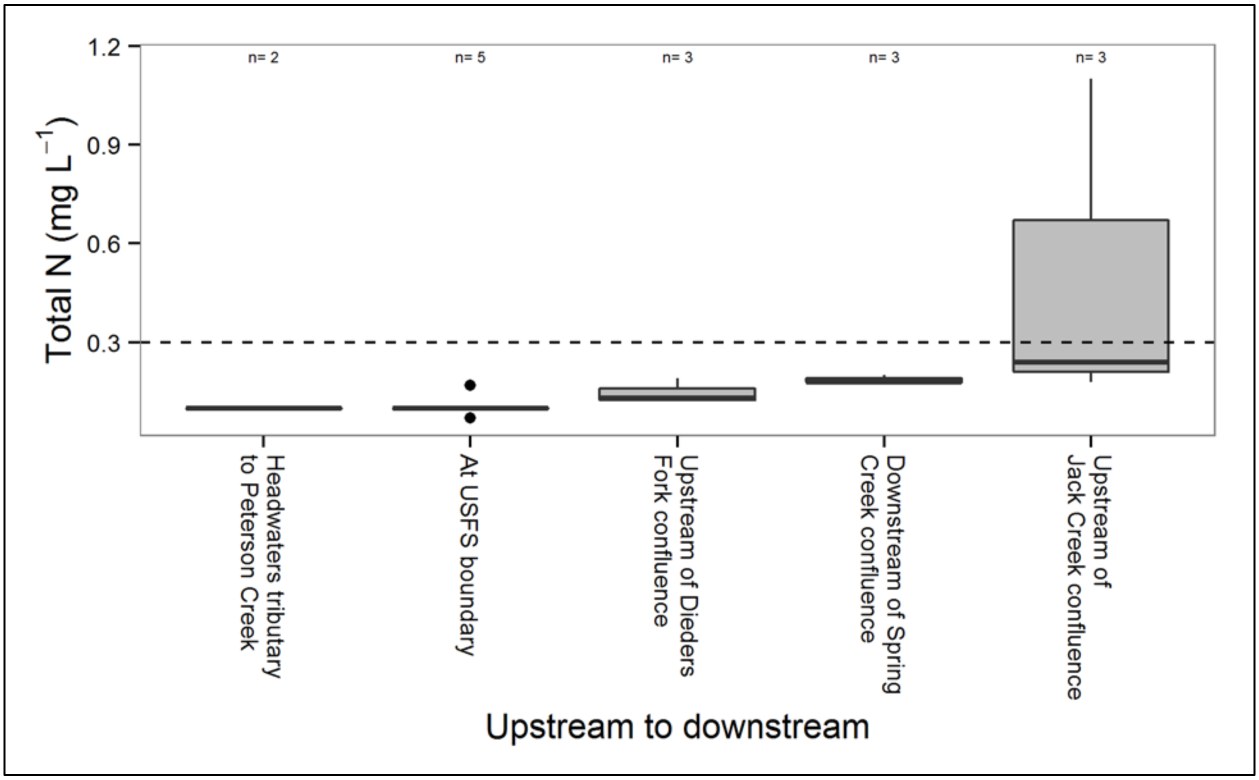

Figure 6-43. Boxplot of TN Concentrations in Upper Peterson Creek (2007–10) (Dashed Line Is Target)

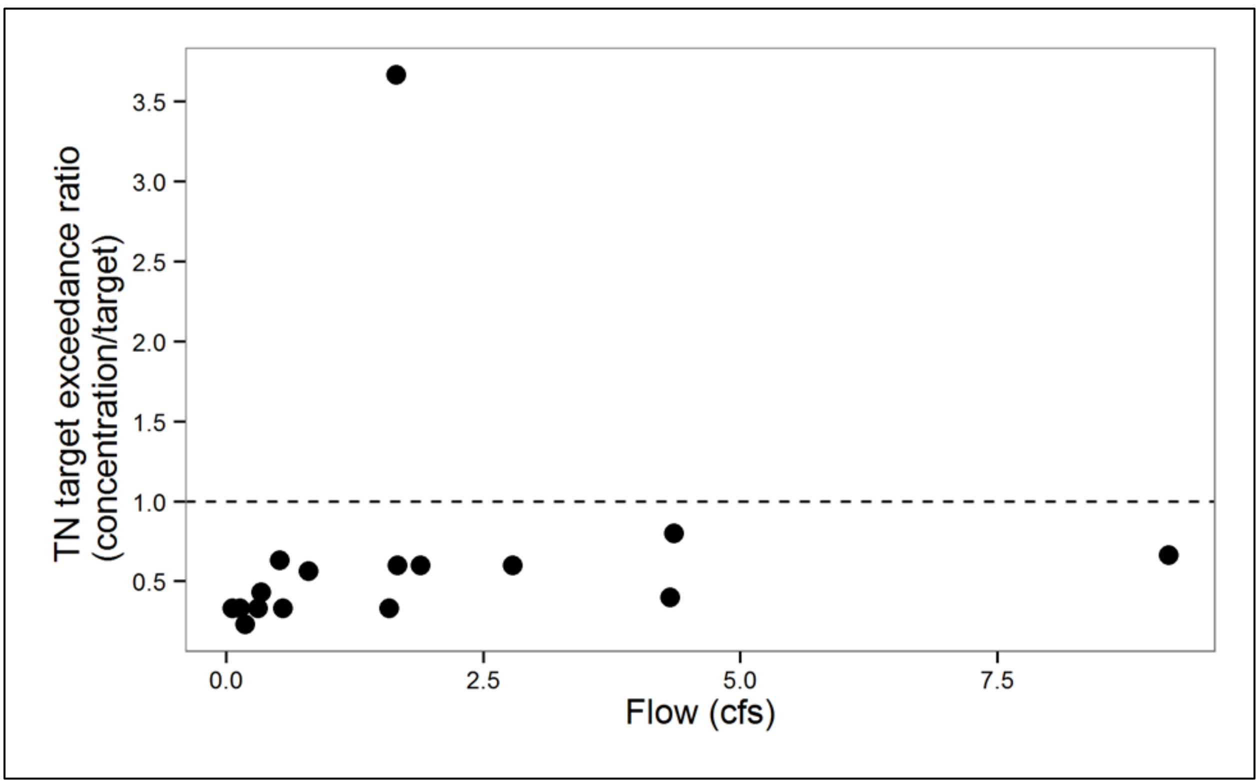

Figure 6-44. TN Target Exceedance Ratio in Upper Peterson Creek (2007–10) (>1 Indicates Exceedance)

The TN concentration of the lone exceedance was 1.1 mg/L TN. Using this sample point, a 73% reduction is needed to achieve the TMDL.

Total Phosphorus

DEQ collected water quality samples for TP from Peterson Creek upstream of the Jack Creek confluence during the growing season over the 2007–10 time period (**Section 6.4.3.7**, **Table 6-16**). Out of a total of 16 samples collected from the mainstem, 7 exceeded the TP target concentration (0.03 mg/L). **Figure 6-45** presents summary statistics for TP concentrations at sampling sites in Peterson Creek upstream of the Jack Creek confluence and includes samples from a headwaters tributary.

Exceedances of the TP target were first observed immediately upstream of the Dieders Fork confluence and all water quality samples downstream of this point exceeded the TP target concentration as well.

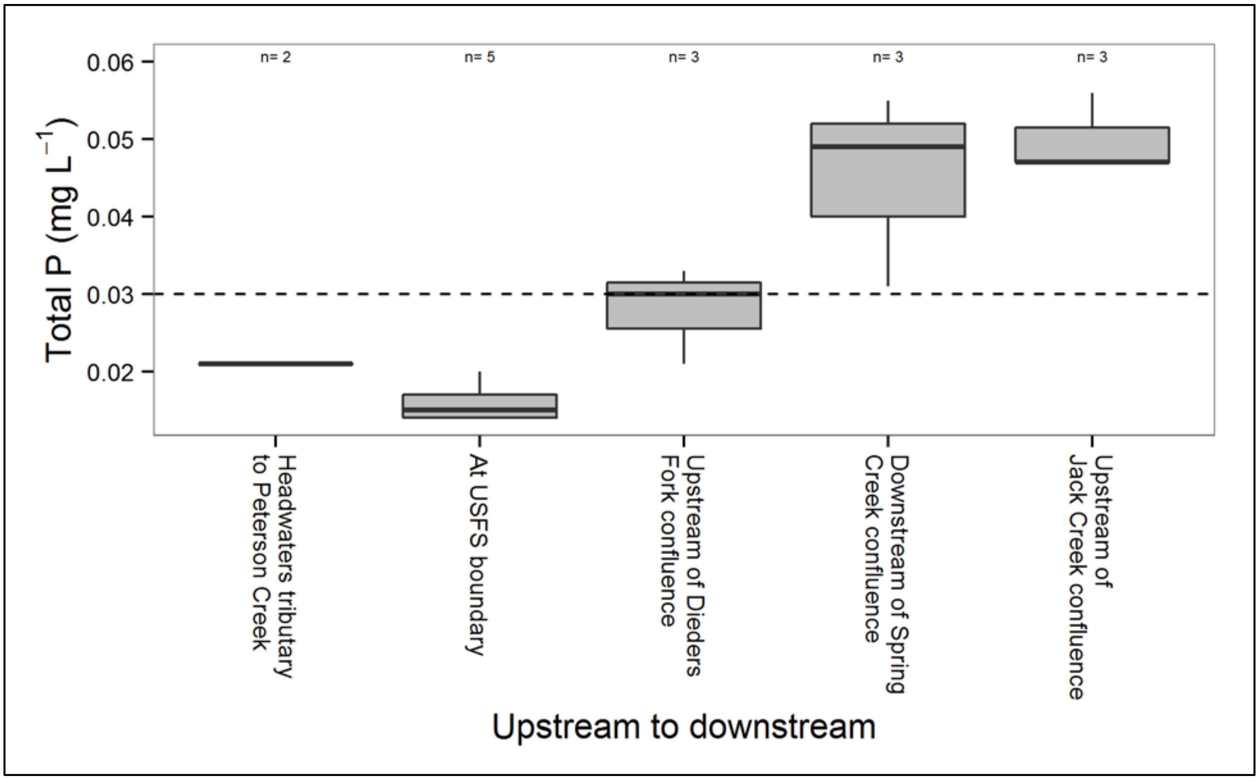

Figure 6-45. Boxplot of TP Concentrations in Upper Peterson Creek (2007–10) (Dashed Line Is Target)

In **Figure 6-46**, sample data from the AU was plotted as a ratio to the TP target. Exceedances of the TP target occurred at a variety of flows from <<1 cfs to 9 cfs. No exceedances of the target concentration were observed in samples collected near the headwaters and all exceedances were <2 times the target concentration.

Exceedances of the TP target are plotted in **Figure 6-47**. TP load reductions necessary to achieve the TMDL range from 3% to 46% with a median reduction of 36%.

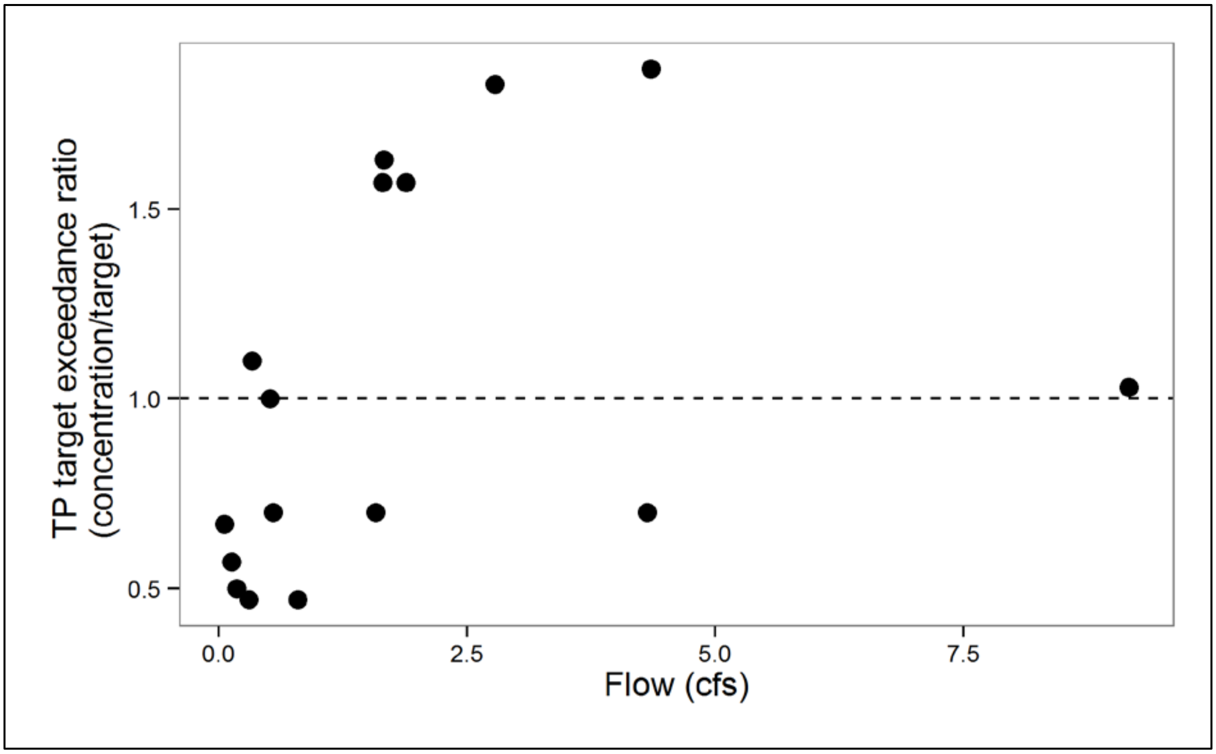

Figure 6-46. TP Target Exceedance Ratio in Upper Peterson Creek (2007–10) (>1 Indicates Exceedance)

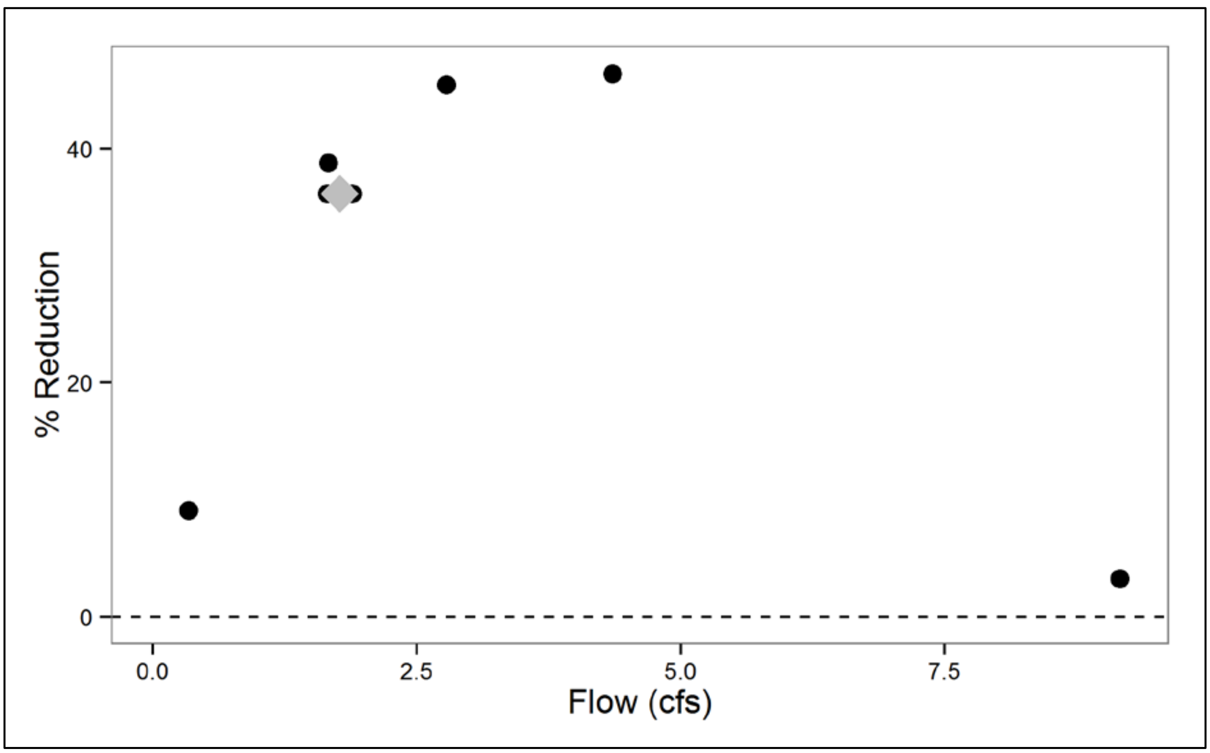

Figure 6-47. Scatterplot of Mainstem Observations and Respective Percent Reductions Necessary to Achieve the TP TMDL in Upper Peterson Creek (the Gray Diamond Is the Median (50th percentile) Observation of Samples that Exceeded the TP TMDL (2007–10))

6.6.7.2 Assessment of Loading by Source Categories

There was a chl-*a* exceedance at the uppermost mainstem sample location and an AFDM exceedance at the site immediately upstream of the Dieders Fork confluence.

There have been a few water-quality investigations in the Peterson Creek drainage. Peterson Creek was one of several streams along the east side of the Deer Lodge valley that was included in a baseline investigation in 2003 (KirK Environmental, LLC, 2003). In addition, FWP also conducted an assessment of fish populations and riparian habitat in Peterson Creek in 2008 (Liermann et al., 2009).

The 2003 baseline investigation, which was limited in nutrient sampling on Peterson Creek, observed TN and TP concentrations which exceeded the nutrient targets used in this document and found that phosphorus concentrations tended to increase from upstream to downstream while nitrogen stayed fairly static (KirK Environmental, LLC, 2003). As with the KirK Environmental, LLC investigation, beaver ponds were frequently observed by the FWP sampling crew in the upper portions of Peterson Creek (Liermann et al., 2009). Beavers were found to be well established upstream of the Jack Creek confluence and it was also noted that excessive riparian grazing was an issue through most of the sub-watershed.

Agriculture

The primary land use in the basin is livestock grazing, with some limited irrigated hay/alfalfa production along the channel. Grazing allotments comprise 5,508 acres on USFS and DNRC administered lands in the drainage upstream of the Jack Creek confluence, with a current maximum of 466 permitted AUMs. This is based on the data in **Table 6-27**. Grazing permits on USFS lands are generally for the summer period while DNRC leases are year-round. However, DNRC leased lands are almost entirely confined to the portion of the drainage downstream of the Jack Creek confluence in the lower AU.

There are several irrigation diversions between Dieders Fork and Jack Creek that can divert flows into adjacent sub-watersheds to the south (Confluence, Inc., 2008). In the headwaters, the Schurch ditch could transport water into Peterson Creek from the Boulder River-Rock Creek sub-watershed, although it is not known if it is still in use.

Restoration work has been performed in Peterson Creek by the WRC in recent years. On private and DNRC administered lands near the confluence of Jack Creek and Peterson Creek, two miles of riparian fencing was installed in 2010 and five summer stock watering tanks which included three miles of pipe was installed in 2012. Between 2010 and 2012, the WRC did reported no significant changes to the riparian community but attributed this to possible observer bias and a lack of sufficient time between riparian assessments (Watershed Restoration Coalition, 2013).

Mining

There is one abandoned mine in the upper drainage in the headwaters of Dieders Fork. An old lode mine, the site does not appear to have an appreciable effect on nutrient water quality in Peterson Creek. However, placer mining and tailings have been noted along the Peterson Creek channel in the upper drainage. Copper, iron, and lead TMDLs were written for upper Peterson Creek as part of a previous TMDL (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2010). The effects of the placer tailings may more easily contribute to sediment loading during high-flow events and contribute to instream phosphorus loading but this is not known.

Silviculture (includes timber harvest)
There have been limited forest operations on USFS administered lands in the upper Peterson Creek sub-watershed within the last several years. Some roadwork has been performed near the Divide, with salvage logging occurring at the Orofino Campground which is >1.5 miles from Peterson Creek. Aerial imagery does suggest there has been some logging activity on private lands in the Peterson Creek sub-watershed as well. Based on instream water quality and distance to the stream from known harvest operations, silviculture is considered a negligible source of nutrients to Peterson Creek.

Subsurface Wastewater Disposal and Treatment
According to DEQ records, upstream of the Jack Creek confluence with Peterson Creek, there is only a single septic system. This constitutes a very minor source of nutrients and is likely having no discernible impacts on instream nutrient concentrations given its distance from the stream.

Summary
The source assessment for upper Peterson Creek suggests that the most important source of human-caused nutrients in the sub-watershed upstream of Jack Creek is grazing. This is primary land use which has the potential to deliver TN and TP to the stream channel. However, as stated previously, in **Section 6.4.2.2**, there may be naturally elevated TP concentrations in the watershed that are difficult to discern given the range of human-caused sources of phosphorus.

6.6.7.3 TN TMDL, Allocations, and Current Loading
The TMDL for TN is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the TN TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TN TMDL for upper Peterson Creek uses **Equation 1**, with the median measured flow from all sites from the 2007–10 sampling (1.23 cfs):

***Equation 1*: *TMDL* = (0.300 mg/L) (1.23 cfs) (5.4) = 1.99 lbs/day**

Equation 4 is the basis for the natural background LA for TN. To continue with the example at a flow of 1.23 cfs, this allocation is as follows:

***Equation 4*: LA_{NB} = (0.095 mg/L) (1.23 cfs) (5.4) = 0.63 lbs/day**

Using **Equation 5**, the combined septic and other human-caused TN LA at 1.23 cfs can be calculated:

***Equation 5*: LA_H = 1.99 lbs/day – 0.63 lbs/day = 1.36 lbs/day**

An example total existing load is calculated as follows using **Equation 6**, the 80th percentile of TN values measured from upper Peterson Creek from 2007 to 2010 (0.194 mg/L) and the median measured flow of 1.23 cfs:

***Equation 6*: *Total Existing Load* = (0.194 mg/L) (1.23 cfs) (5.4) = 1.29 lbs/day**

The portion of the existing load attributed to human sources is 0.66 lbs/day, which is determined by subtracting out the 0.63 lbs/day background load from the existing load. This 0.66 lbs/day value represents the load measured within the stream after potential nutrient uptake.

Table 6-55 contains the results for the example TN TMDL, LAs, and current loading. In addition, it contains an example percent reduction to the human-caused LA required to meet the water quality target for TN. The percent reduction to natural background is assumed to be 0%. At the median growing season flow of 1.23 cfs and the 80th percentile of measured TN values, the current loading in upper Peterson Creek is less than the TMDL. Under these example conditions, the TN TMDL is currently being met. However, the single TN exceedance was 1.1 mg/L TN. Using this sample point, a 73% reduction is needed to achieve the TMDL. The source assessment of the upper Peterson Creek watershed indicates that livestock grazing is the most likely source of TN.

Table 6-55. Upper Peterson Creek TN Example TMDL, LAs, Current Loading, and Reductions

Source Category	Allocation and TMDL (lbs/day)[a]	Existing Load (lbs/day)[a]	Percent Reduction
Natural Background	0.63	0.63	0%
Human-caused (livestock grazing)	1.36	0.66	0%
	TMDL 1.99	**Total = 1.29**	**Total = 0%**

[a] Based on a median growing season flow of 1.23 cfs

The TN TMDL for upper Peterson Creek addresses the existing TKN impairment (**Table 6-26**).

6.6.7.4 TP TMDL, Allocations, and Current Loading

The TMDL for TP is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the TP TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TP TMDL for upper Peterson Creek uses **Equation 1**, with the median measured flow from all sites during 2007–10 sampling (1.23 cfs):

***Equation 1**: TMDL* **= (0.03 mg/L) (1.23 cfs) (5.4) = 0.20 lbs/day**

Equation 4 is the basis for the natural background LA for TP. To continue with the example at a flow of 1.23 cfs, this allocation is as follows:

***Equation 4**:* LA_{NB} **= (0.01 mg/L) (1.23 cfs) (5.4) = 0.07 lbs/day**

Using **Equation 5**, the combined septic and other human-caused TP LA at 1.23 cfs can be calculated:

***Equation 5**:* LA_{H} **= 0.20 lbs/day – 0.07 lbs/day = 0.13 lbs/day**

An example total existing load is calculated as follows using **Equation 6**, the 80th percentile of TP values measured from upper Peterson Creek from 2007 to 2010 (0.048 mg/L) and the median measured flow of 1.23 cfs:

***Equation 6**: Total Existing Load* **= (0.048 mg/L) (1.23 cfs) (5.4) = 0.32 lbs/day**

The portion of the existing load attributed to human sources is 0.25 lbs/day, which is determined by subtracting out the 0.07 lbs/day background load from the existing load. This 0.25 lbs/day value represents the load measured within the stream after potential nutrient uptake.

Table 6-56 contains the results for the example TP TMDL, LAs, and current loading. In addition, it contains an example percent reduction to the human-caused LA required to meet the water quality target for TP. The percent reduction to natural background is assumed to be 0%. At the median growing season flow of 1.23 cfs and the 80th percentile of measured TP values, the current loading in upper Peterson Creek is greater than the TMDL. Under these example conditions, a 48% reduction of human-caused sources and an overall 38% reduction of TP in upper Peterson Creek would result in the TMDL being met. The source assessment of the upper Peterson Creek watershed indicates that livestock grazing is the most likely source of TP; load reductions should focus on limiting and controlling TP loading from these sources. Meeting LAs for upper Peterson Creek may be achieved through a variety of water quality planning and implementation actions and is addressed **Section 7.0**. Inter-sub-watershed transfers of irrigation flows may possibly complicate the loading dynamics.

Table 6-56. Upper Peterson Creek TP Example TMDL, LAs, Current Loading, and Reductions

Source Category	Allocation and TMDL (lbs/day)[a]	Existing Load (lbs/day)[a]	Percent Reduction
Natural Background	0.07	0.07	0%
Human-caused (livestock grazing)	0.13	0.25	48%
	TMDL = 0.20	**Total = 0.32**	**Total = 38%**

[a] Based on a median growing season flow of 1.23 cfs

6.6.8 Peterson Creek, lower (MT76G002_132)

6.6.8.1 Assessment of Water Quality Results

The source assessment for lower Peterson Creek consists of an evaluation of TN and TP concentrations and exceedances of chl-*a* and/or AFDM within the impaired segment from the Jack Creek confluence to the mouth (Clark Fork River) and of available data for the upper segment. This is followed by the quantification of the most significant human caused sources of nutrients. **Figure 6-48** presents the approximate locations of data pertinent to the source assessment for the Peterson Creek sub-watershed. It should be noted that sediment, metals and temperature TMDLs for Peterson Creek were completed in 2010 (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2010).

FWP lists Peterson Creek as being chronically dewatered (dewatering is a significant issue in most years) from the confluence of an unnamed spring creek to the Jack Creek confluence and from the Jack Creek confluence to the mouth (Clark Fork River).

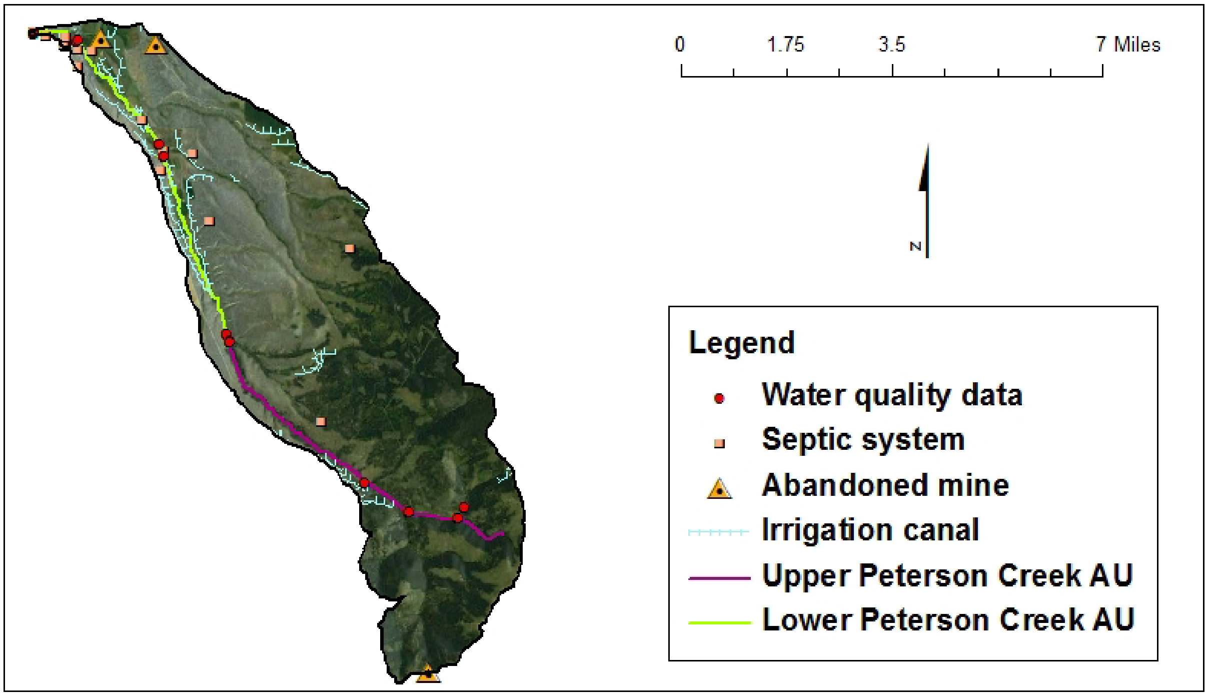

Figure 6-48. Peterson Creek Sub-Watershed with Water Quality Sampling Locations

Total Nitrogen

DEQ collected water quality samples from both AUs on Peterson Creek during the growing season over the 2007–11 time period (**Section 6.4.3.7**, **Table 6-16**; **Section 6.4.3.8**, **Table 6-18**). Out of a total of 24 samples collected from the mainstem, 21 exceeded the TN target concentration (0.300 mg/L). In **Figure 6-49**, TN concentrations first exceed the target concentration of 0.300 mg/L immediately upstream of the Jack Creek confluence and steadily increase down to the mouth (Clark Fork River).

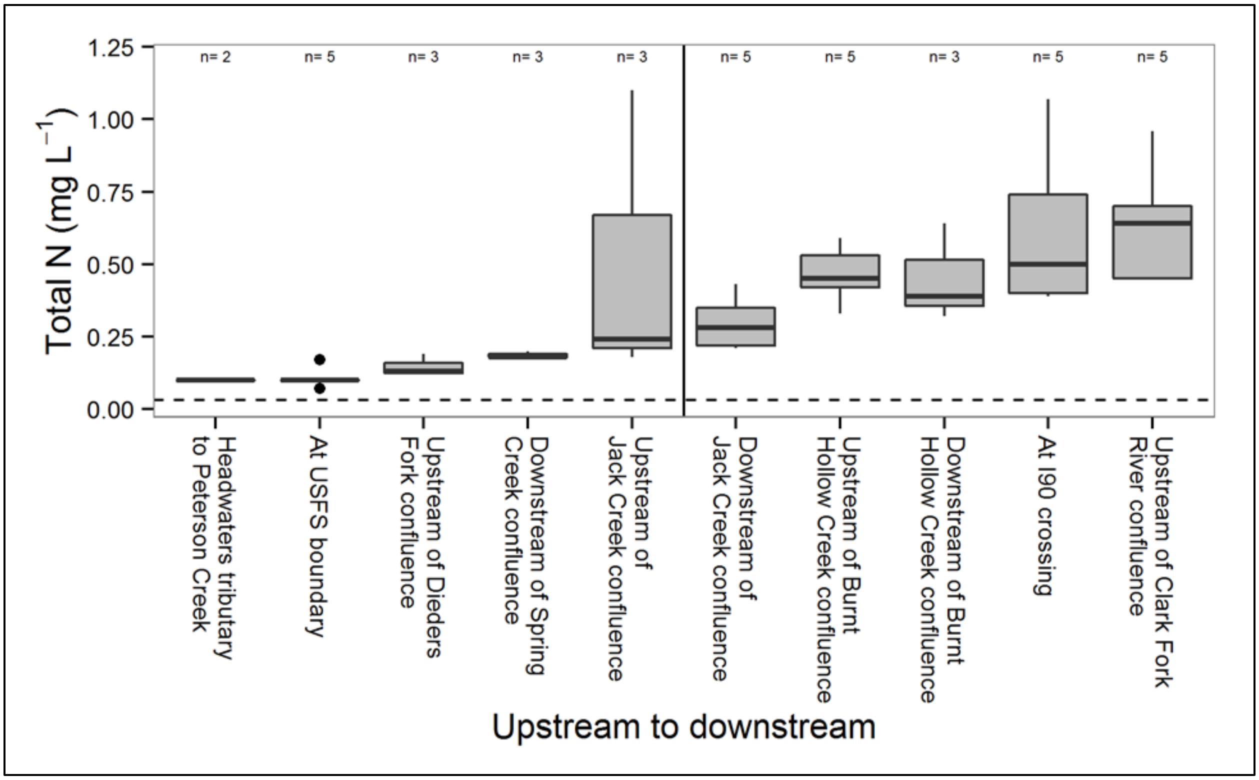

Figure 6-49. Boxplot of TN Concentrations in Upper and Lower Peterson Creek (2007–11) (Dashed Line Is Target)

In **Figure 6-50**, sample data from the AU was plotted as a ratio to the TN target. Exceedances of the TN target occurred at a variety of flows from <<1 cfs to 3 cfs. No exceedances of the target concentration were observed in samples collected near the headwaters, but exceedances downstream of the Jack Creek confluence were as high as 3.5 times the target concentration.

Exceedances of the TN target are plotted in **Figure 6-51**. TN load reductions necessary to achieve the TMDL range from 7% to 76% with a median reduction of 42%.

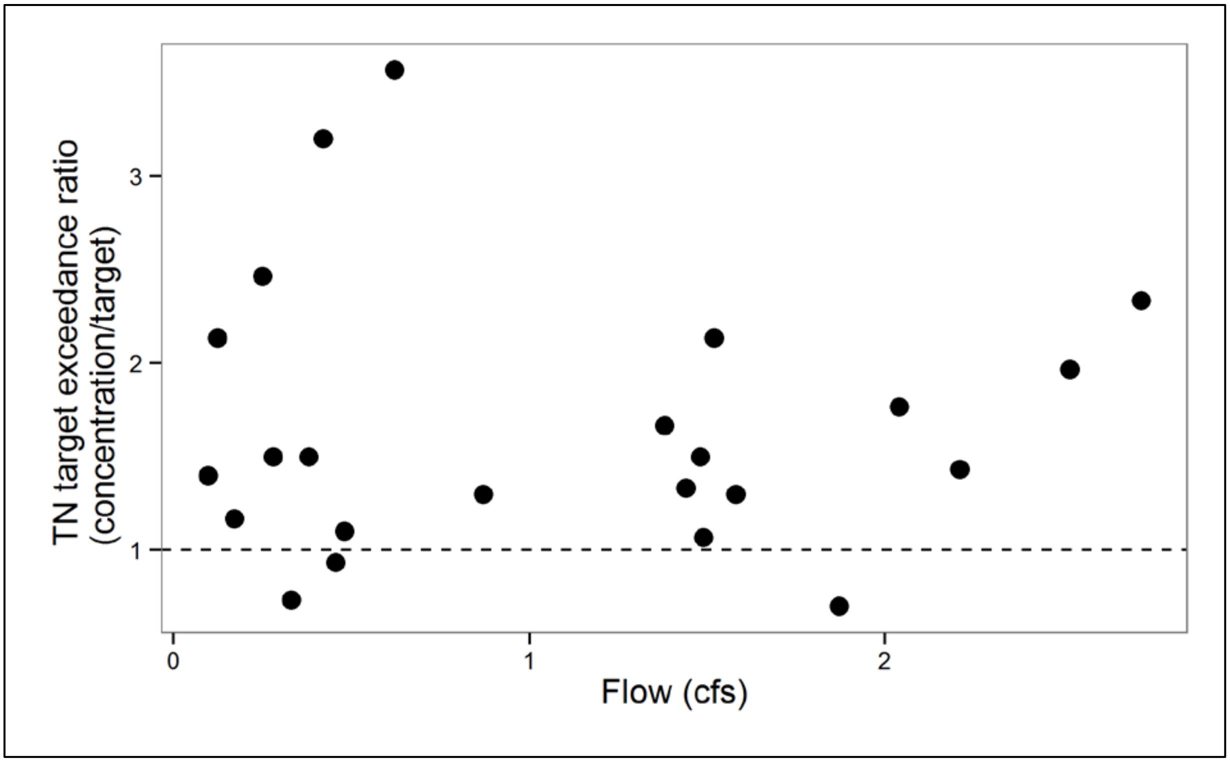

Figure 6-50. TN Target Exceedance Ratio in Lower Peterson Creek (2007–11) (>1 Indicates Exceedance)

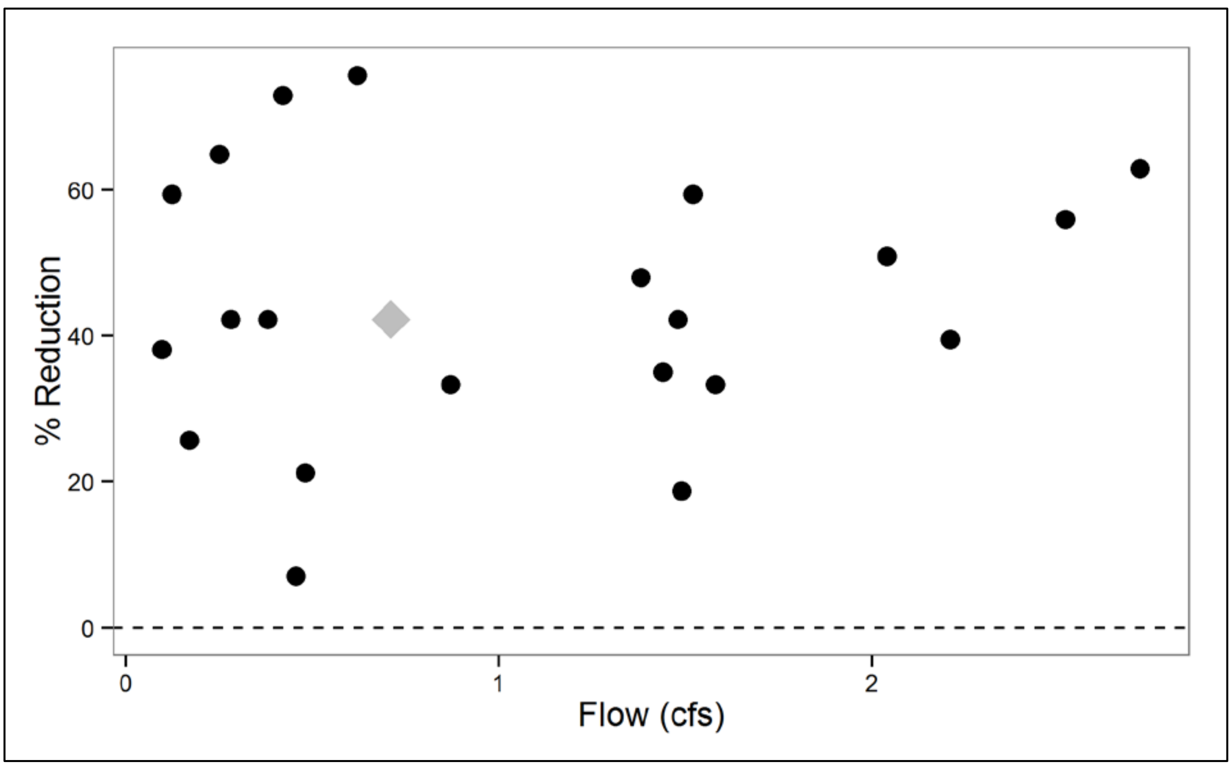

Figure 6-51. Scatterplot of Mainstem Observations and Respective Percent Reductions Necessary to Achieve the TN TMDL in Lower Peterson Creek (the Gray Diamond Is the Median (50th percentile) Observation of Samples that Exceeded the TN TMDL (2007–11))

Total Phosphorus
DEQ collected water quality samples from both AUs on Peterson Creek during the growing season over the 2007–11 time period (**Section 6.4.3.7**, **Table 6-16**; **Section 6.4.3.8**, **Table 6-18**). Out of a total of 23 samples collected from the mainstem, 23 exceeded the TP target concentration (0.030 mg/L). In **Figure 6-52**, TP concentrations first exceed the target concentration of 0.030 mg/L immediately upstream of the Dieders Fork confluence and all water quality samples downstream of this point exceeded the TP target concentration as well.

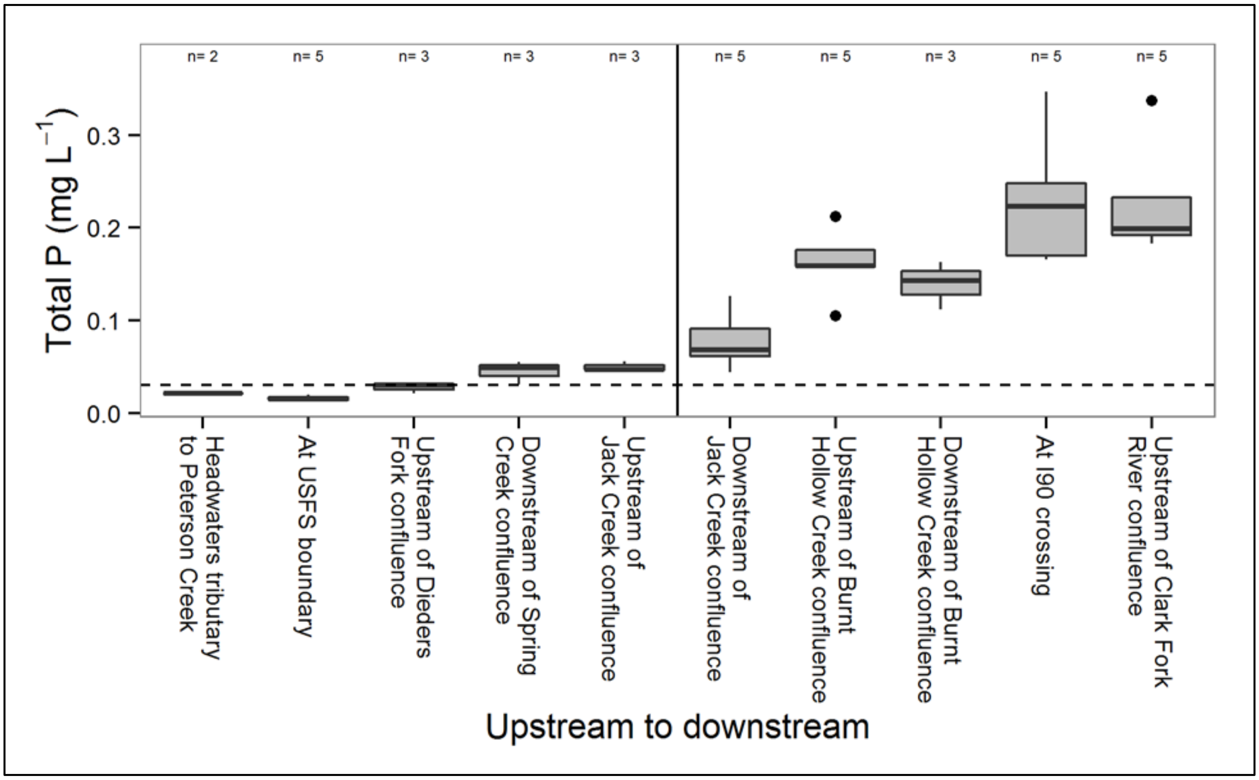

Figure 6-52. Boxplot of TP Concentrations in Upper and Lower Peterson Creek (2007–11) (Dashed Line Is Target)

In **Figure 6-53**, sample data from the AU was plotted as a ratio to the TN target. Exceedances of the TP target occurred at a variety of flows from <<1 cfs to 3 cfs. No exceedances of the target concentration were observed in samples collected near the headwaters, but exceedances downstream of the Jack Creek confluence were as high as 11.6 times the target concentration.

Exceedances of the TP target are plotted in **Figure 6-54**. TP load reductions necessary to achieve the TMDL range from 9% to 88% with a median reduction of 76%.

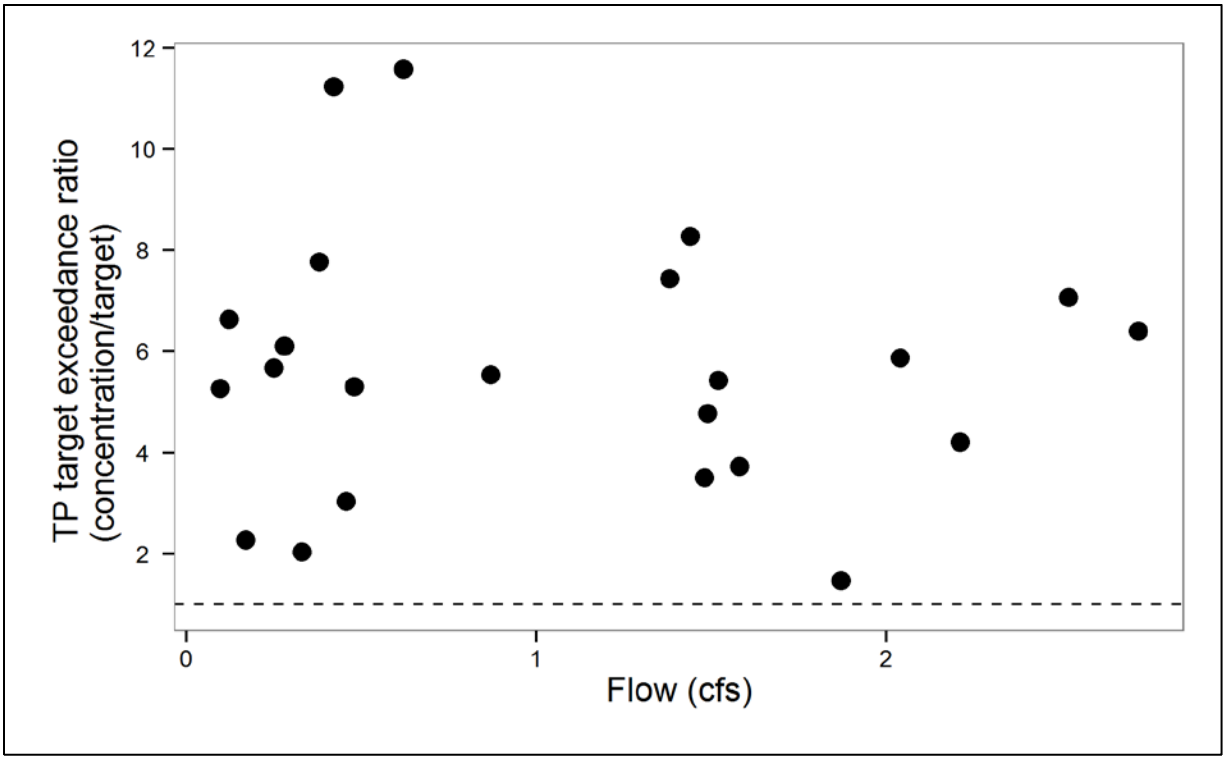

Figure 6-53. TP Target Exceedance Ratio in Lower Peterson Creek (2007–11) (>1 Indicates Exceedance)

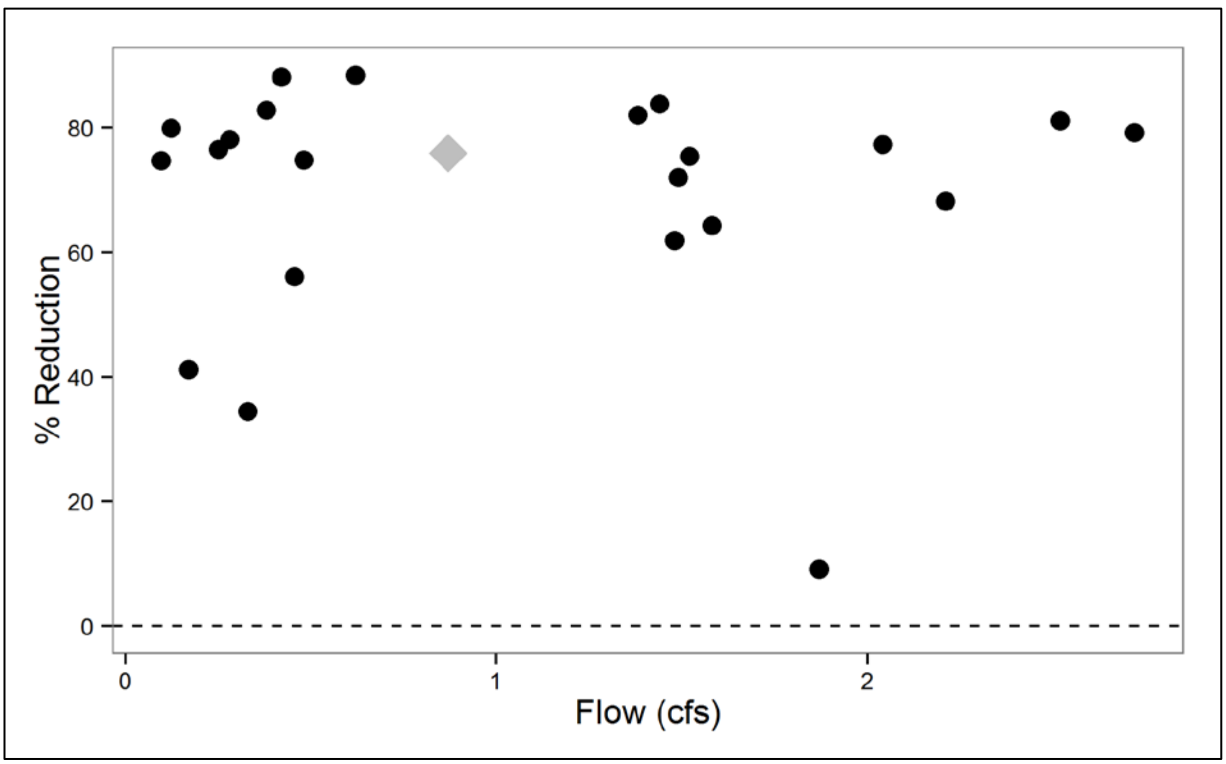

Figure 6-54. Scatterplot of Mainstem Observations and Respective Percent Reductions Necessary to Achieve the TP TMDL in Lower Peterson Creek (the Gray Diamond Is the Median (50th percentile) Observation of Samples that Exceeded the TP TMDL (2007–11))

6.6.8.2 Assessment of Loading by Source Categories

There have been a few water-quality investigations in the Peterson Creek sub-watershed. A summary of these investigations and their findings is found at the beginning of **Section 6.6.7.2**.

Agriculture

The primary land use in the basin is livestock grazing, with some limited irrigated hay/alfalfa production along the channel. For the entire Peterson Creek sub-watershed, grazing allotments comprise 7,207 acres on USFS and DNRC administered lands with a current maximum of 843 permitted AUMs (**Table 6-27**); of this total, 1,699 acres and 377 AUMs are in the lower watershed downstream of Jack Creek. Grazing permits on USFS lands are generally for the summer period, while DNRC leases are year-round. DNRC leased lands are almost entirely confined to the portion of the drainage downstream of the Jack Creek confluence in the lower AU. This summary does not include grazing pressure on private lands which comprise most of the lower Peterson Creek drainage.

Between the sample locations downstream of Burnt Fork Creek and the I90 crossing, an un-named stream enters from the east. According to an irrigation network study completed in 2008, there are several irrigation ditches in this small drainage that may divert water from Reese Anderson Creek in the Cottonwood Creek sub-watershed to the Peterson Creek sub-watershed (Confluence, Inc., 2008).

As stated in the source assessment for upper Peterson Creek, restoration work has been performed on Peterson Creek by the WRC in recent years. On private and DNRC administered lands near at the confluence of Jack Creek and Peterson Creek, two miles of riparian fencing was installed in 2010 and five summer stock watering tanks which included three miles of pipe was installed in 2012. Between 2010 and 2012, the WRC did reported no significant changes to the riparian community but attributed this to possible observer bias and a lack of sufficient time between riparian assessments (Watershed Restoration Coalition, 2013). This project area spans the boundary between the upper and lower Peterson Creek assessment units and likely positively affected water quality in both segments.

Mining

There are two abandoned mines in the lowermost portion of the drainage which do not appear to be having a discernible effect on instream water quality given their distance from the stream at the head of dry gulches. However, the effects of the placer tailings noted in the stream channel along the entire length of Peterson Creek may more easily contribute to sediment loading during high-flow events and contribute to instream phosphorus loading but this is not known.

Silviculture (includes timber harvest)

Not a source based on assessment of Upper Peterson Creek (**Section 6.6.7.2**)

Subsurface Wastewater Disposal and Treatment

According to DEQ records, there are 14 septic systems in the lower Peterson Creek sub-watershed. Most of the systems are well away from the stream corridor with a relatively small cluster of septic systems near I90. While these certainly constitute a portion of the nutrient load to Peterson Creek, they are likely having a negligible influence on instream nutrient concentrations. Peterson Creek joins the Clark Fork River on the southern outskirts of the city of Deer Lodge. A portion of the urban watershed drains to Peterson Creek, but the homes in this area are sewered to the Deer Lodge WWTP with few exceptions.

Summary

The source assessment for lower Peterson Creek suggests that the most important source of human-caused nutrients in the sub-watershed downstream of Jack Creek is grazing. This is primary land use which has the potential to deliver TN and TP to the stream channel. However, as stated previously, in **Section 6.4.2.2**, there may be naturally elevated TP concentrations in the watershed that are difficult to discern given the range of human-caused sources of phosphorus.

6.6.8.3 TN TMDL, Allocations, and Current Loading

The TMDL for TN is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the TN TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TN TMDL for lower Peterson Creek uses **Equation 1**, with the median measured flow from all sites during 2007–11 sampling (0.87 cfs):

***Equation 1*: *TMDL* = (0.300 mg/L) (0.87 cfs) (5.4) = 1.41 lbs/day**

Equation 4 is the basis for the natural background LA for TN. To continue with the example at a flow of 0.87 cfs, this allocation is as follows:

***Equation 4*: LA_{NB} = (0.095 mg/L) (0.87 cfs) (5.4) = 0.45 lbs/day**

Using **Equation 5**, the combined septic and other human-caused TN LA at 0.87 cfs can be calculated:

***Equation 5*: LA_{H} = 1.41 lbs/day – 0.45 lbs/day = 0.96 lbs/day**

An example total existing load is calculated as follows using **Equation 6**, the 80th percentile of TN values measured from lower Peterson Creek from 2007 to 2011 (0.640 mg/L) and the median measured flow of 0.87 cfs:

***Equation 6*: *Total Existing Load* = (0.640 mg/L) (0.87 cfs) (5.4) = 3.01 lbs/day**

The portion of the existing load attributed to human sources is 2.56 lbs/day, which is determined by subtracting out the 0.45 lbs/day background load from the existing load. This 2.56 lbs/day value represents the load measured within the stream after potential nutrient uptake.

Table 6-57 contains the results for the example TN TMDL, LAs, and current loading. In addition, it contains an example percent reduction to the human-caused LA required to meet the water quality target for TN. The percent reduction to natural background is assumed to be 0%. At the median growing season flow of 0.87 cfs and the 80th percentile of measured TN values, the current loading in lower Peterson Creek is greater than the TMDL. Under these example conditions, the TN load needs to be reduced 53% overall and human-caused loading needs to be reduced 63% in order to achieve the TN TMDL. The source assessment for the Peterson Creek watershed indicates that livestock grazing and irrigated agriculture is the most likely source of TN.

Table 6-57. Lower Peterson Creek TN Example TMDL, LAs, Current Loading, and Reductions

Source Category	Allocation and TMDL (lbs/day)[a]	Existing Load (lbs/day)[a]	Percent Reduction
Natural Background	0.45	0.45	0%
Human-caused (livestock grazing/irrigated agriculture)	0.96	2.56	63%
	TMDL 1.41	**Total = 3.01**	**Total = 53%**

[a] Based on a median growing season flow of 0.87 cfs

6.6.8.4 TP TMDL, Allocations, and Current Loading

The TMDL for TP is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the TP TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TP TMDL for lower Peterson Creek uses **Equation 1**, with the median measured flow from all sites during 2007–11 sampling (0.87 cfs):

***Equation 1**: TMDL* **= (0.03 mg/L) (0.87 cfs) (5.4) = 0.14 lbs/day**

Equation 4 is the basis for the natural background LA for TP. To continue with the example at a flow of 0.87 cfs, this allocation is as follows:

***Equation 4**:* LA_{NB} **= (0.01 mg/L) (0.87 cfs) (5.4) = 0.05 lbs/day**

Using **Equation 5**, the combined septic and other human-caused TP LA at 0.87 cfs can be calculated:

***Equation 5**:* LA_{H} **= 0.14 lbs/day – 0.05 lbs/day = 0.09 lbs/day**

An example total existing load is calculated as follows using **Equation 6**, the 80th percentile of TP values measured from lower Peterson Creek from 2007 to 2011 (0.219 mg/L) and the median measured flow of 0.87 cfs:

***Equation 6**: Total Existing Load* **= (0.219 mg/L) (0.87 cfs) (5.4) = 1.03 lbs/day**

The portion of the existing load attributed to human sources is 0.98 lbs/day, which is determined by subtracting out the 0.05 lbs/day background load from the existing load. This 0.98 lbs/day value represents the load measured within the stream after potential nutrient uptake.

Table 6-58 contains the results for the example TP TMDL, LAs, and current loading. In addition, it contains an example percent reduction to the human-caused LA required to meet the water quality target for TP. The percent reduction to natural background is assumed to be 0%. At the median growing season flow of 0.87 cfs and the 80th percentile of measured TP values, the current loading in lower Peterson Creek is greater than the TMDL. Under these example conditions, a 91% reduction of human-caused sources and an overall 86% reduction of TP in lower Peterson Creek would result in the TMDL being met. The source assessment of the lower Peterson Creek watershed indicates that livestock grazing is the most likely source of TP; load reductions should focus on limiting and controlling TP loading from these sources. Meeting LAs for lower Peterson Creek may be achieved through a variety of water quality planning and implementation actions and is addressed **Section 7.0**. Inter-sub-watershed transfers of irrigation flows may possibly complicate the loading dynamics.

Table 6-58. Lower Peterson Creek TP Example TMDL, LAs, Current Loading, and Reductions

Source Category	Allocation and TMDL (lbs/day)[a]	Existing Load (lbs/day)[a]	Percent Reduction
Natural Background	0.05	0.05	0%
Human-caused (livestock grazing)	0.09	0.98	91%
	TMDL = 0.14	**Total = 1.03**	**Total = 86%**

[a] Based on a median growing season flow of 0.87 cfs

6.6.9 Silver Bow Creek (MT76G003_020)

6.6.9.1 Assessment of Water Quality Results

Silver Bow Creek is one the most well-sampled and well-studied streams in the State of Montana. Given the large volume of data and publications available for the watershed, this section is organized differently than the other nutrient impaired stream segments in the Upper Clark Fork Phase 2 TPA.

The source assessment for Silver Bow Creek consists of an evaluation of instream TN and TP concentrations as well as load estimates from point source dischargers based on DMR and ancillary data. The source assessment also examines potential nutrient loading from tributaries to Silver Bow Creek. This is followed by the quantification of the most significant human caused sources of nutrients. Point source load estimates were calculated in **Section 6.5.1.2**. The source assessment also includes estimated nutrient loads from respective subareas within the Silver Bow Creek watershed based on bracket sampling of incoming tributaries to Silver Bow Creek. A more general, watershed-wide source assessment by nonpoint source (e.g., agriculture, mining) follows. WLAs are then presented per point source discharge in the watershed. Lastly, the TN and TP example TMDLs are presented.

It is important to note the studies specific to Silver Bow Creek have documented diel cycling of nutrients in the upper portion of the stream in and around the Summit Valley (Gammons et al., 2011; Nimick et al., 2011). This does not grossly affect nutrient loading dynamics but can influence the relative concentrations of water chemistry parameters depending on the time of day samples were collected. Although acknowledged here, the sample dataset was not altered to account for possible effects of diel cycling.

In **Figure 6-55**, water quality sampling locations collected by the Remediation Division of DEQ in addition to relevant source assessment data is displayed. Although the Silver Bow Creek AU includes where the creek flows through the Warm Springs Ponds, the ponds are excluded in state statute as a state waterbody and are not assessed in this document. In addition, at present, flows from the Mill and Willow Creek sub-watersheds do not reach Silver Bow Creek at what was the natural confluence but are routed around Warm Springs Ponds and discharge to the Silver Bow Creek channel upstream of the Warm Springs Creek confluence. The Warms Spring Creek and Silver Bow Creek confluence marks the start of the Clark Fork River. However, relative loading from the Mill and Willow Creek sub-watersheds to Silver Bow Creek downstream of the ponds was determined for the TN and TP TMDLs. DEQ Remediation data collection comprised 13 different locations and included 1 site on Blacktail Creek at Father Sheehan Park. Sampling bracketed several of the tributaries that enter Silver Bow Creek including Sand Creek, Browns Gulch and German Gulch. The most downstream data collection point (at Opportunity) is upstream of the Warm Springs Ponds.

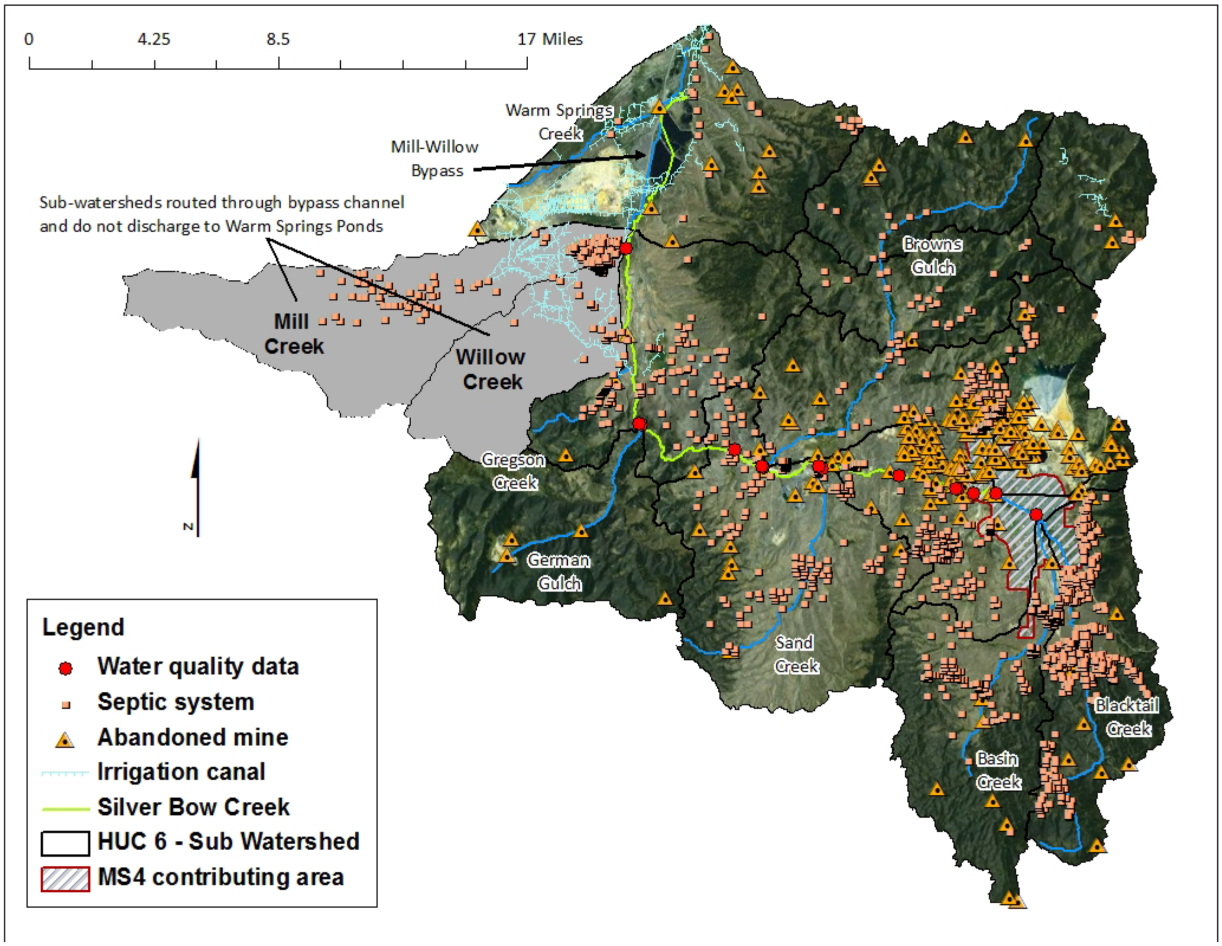

Figure 6-55. Silver Bow Creek Watershed with Water Quality Sampling Locations

Total Nitrogen

DEQ (Remediation Division) collected water quality samples from Silver Bow Creek during the growing season over the 2007–12 time period; however, water samples were analyzed for TKN from 2007-2009 and for TN from 2010-2012 (**Section 6.4.3.9**, **Table 6-20**). Although data was collected prior to 2007 in Silver Bow Creek, this analysis will use only data analyzed for TN by DEQ Remediation Division since 2010 as it best represents existing in-stream loading dynamics with the target parameter. **Figure 6-56** presents summary statistics for TN concentrations at sampling sites in Silver Bow Creek.

TN concentrations were in excess of the target for all samples (*n*= 35) on Blacktail Creek and Silver Bow Creek. In the following figure, Blacktail Creek at Father Sheehan Park is a tributary to the Silver Bow Creek AU. The most significant change in in-stream TN concentrations occurs between the 3rd and 4th sampling stations. This reach includes the CERCLA discharges from MPTP and the LAO, the Ranchland Packing facility and the BSB WWTP discharge.

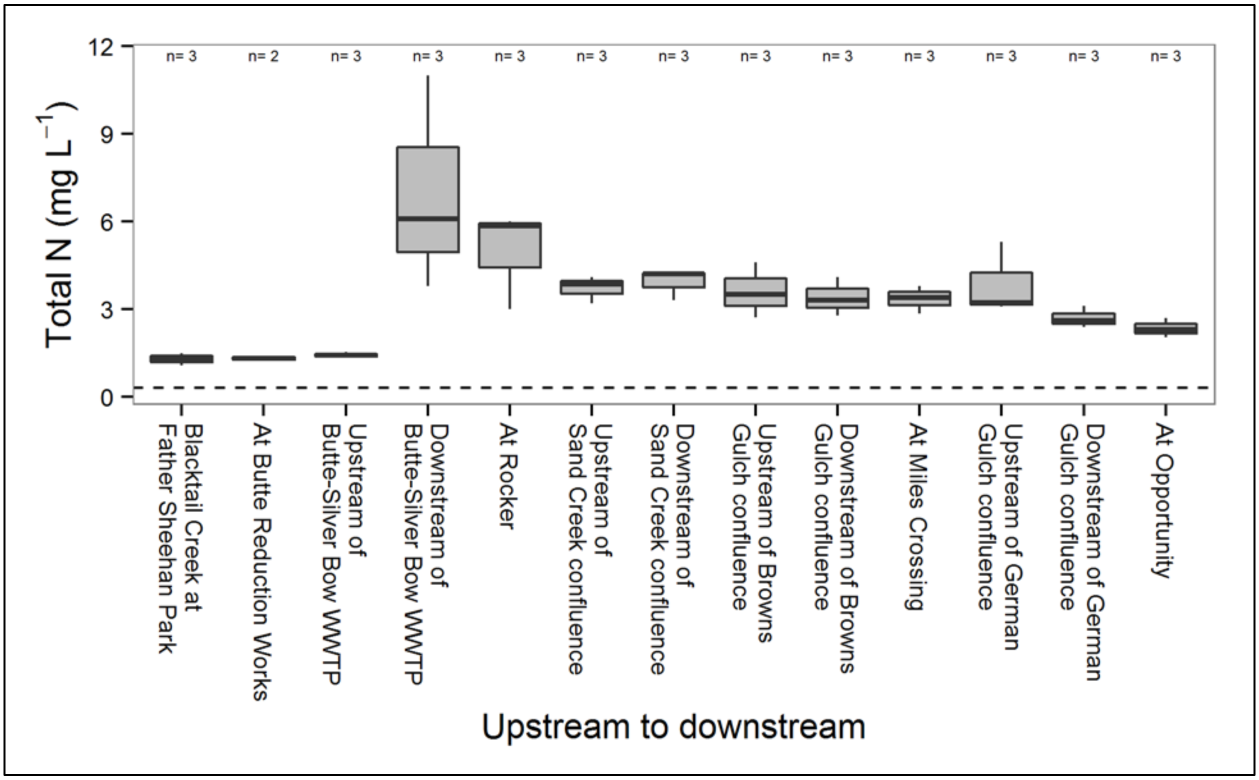

Figure 6-56. Boxplot of TN Concentrations in Silver Bow Creek (2010–12) (Dashed Line Is Target)

In **Figure 6-57**, sample data from the AU was plotted as a ratio to the TN target. Exceedances ranged from 4 to 36 times the target concentration of 0.300 mg/L. Exceedances of the TN target are plotted in **Figure 6-58**. Reductions needed to achieve the TN TMDL range from 75% to 97% with a median reduction of 91%. Water quality data in the following figures is limited to those samples collected in Silver Bow Creek upstream of Warm Spring Ponds.

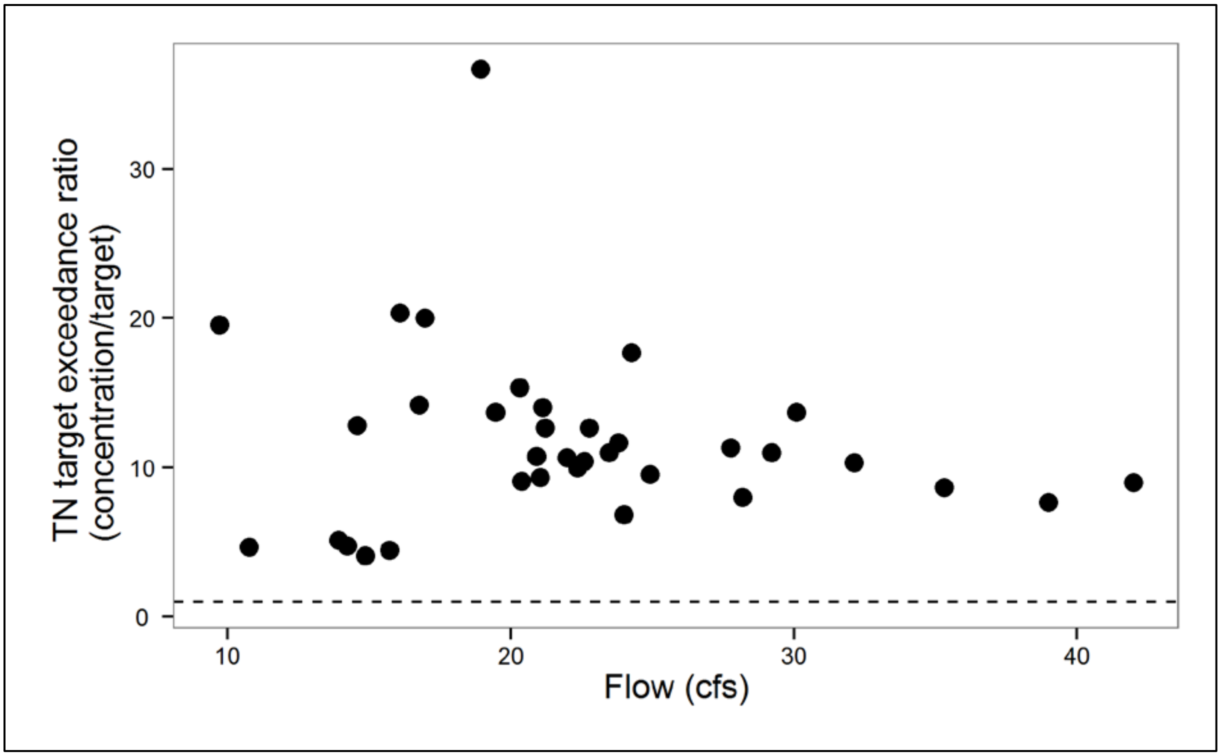

Figure 6-57. TN Target Exceedance Ratio in Silver Bow Creek (2010–12) (>1 Indicates Exceedance)

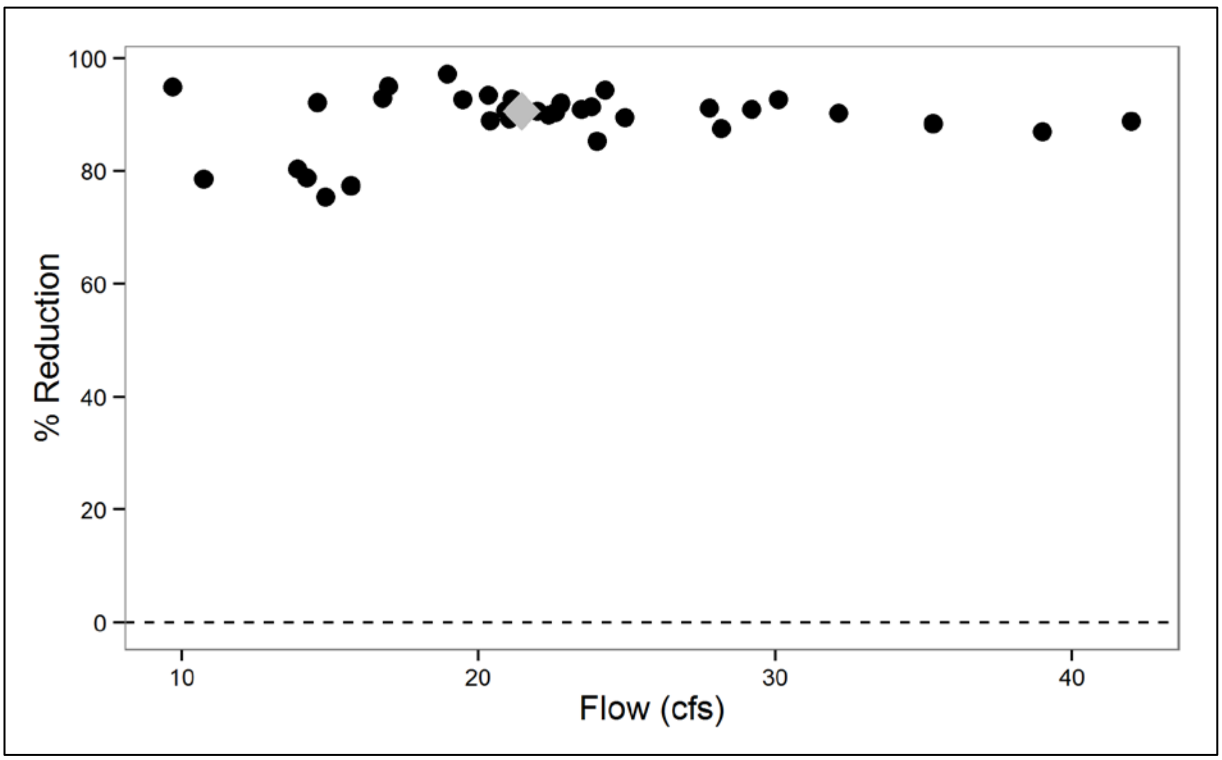

Figure 6-58. Scatterplot of Mainstem Observations and Respective Percent Reductions Necessary to Achieve the TN TMDL in Silver Bow Creek (the Gray Diamond Is the Median (50th percentile) Observation of Samples that Exceeded the TN TMDL (2010–12))

Total Phosphorus

DEQ (Remediation Division) collected water quality samples from Silver Bow Creek during the growing season over the 2007–12 time period (**Section 6.4.3.9**, **Table 6-20**). Although data was collected prior to 2007 in Silver Bow Creek, this analysis will use only data collected by DEQ Remediation Division since 2007 as it best represents existing in-stream loading dynamics. **Figure 6-59** presents summary statistics for TP concentrations at sampling sites in Silver Bow Creek.

TP concentrations were in excess of the target for all samples (*n*= 68) on Blacktail Creek and Silver Bow Creek. In the following figure, Blacktail Creek at Father Sheehan Park is a tributary to the Silver Bow Creek AU. The most significant change in in-stream TP concentrations occurs between the 3rd and 4th sampling stations. This reach includes the Ranchland Packing facility and the BSB WWTP discharge.

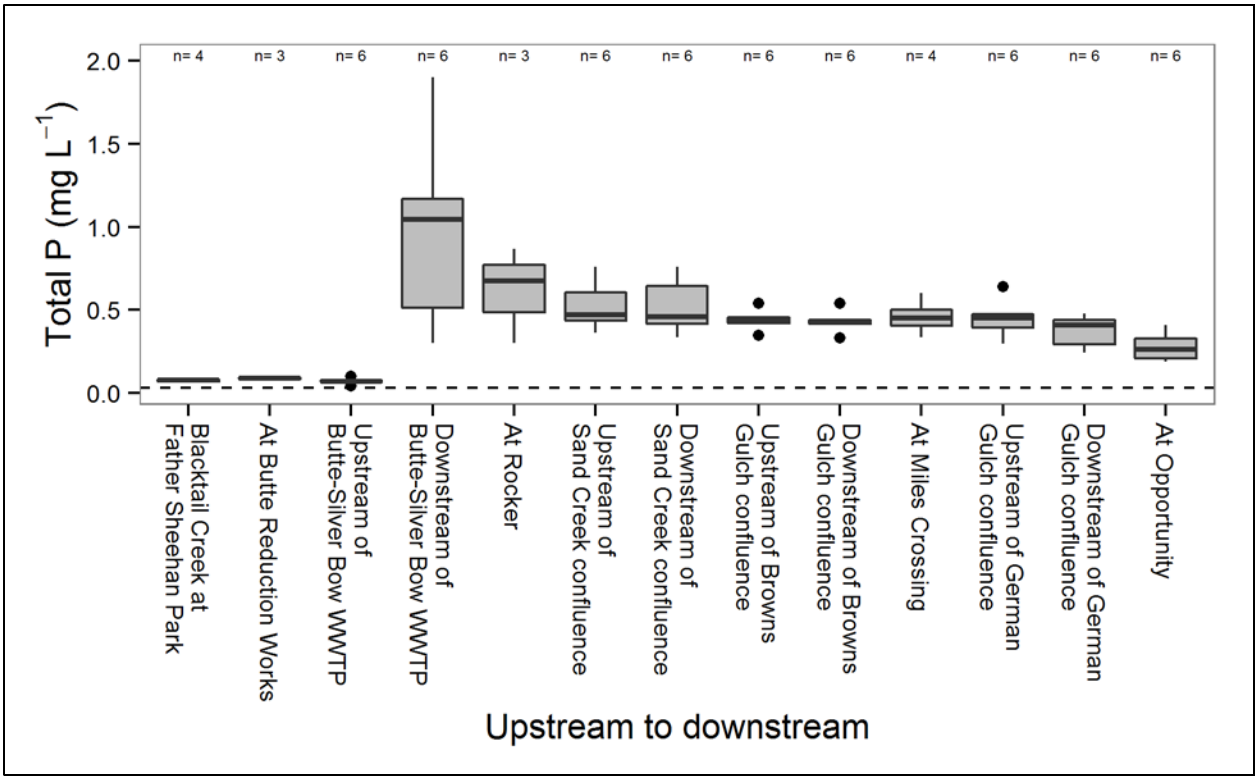

Figure 6-59. Boxplot of TP Concentrations in Silver Bow Creek (2007–12) (Dashed Line Is Target)

In **Figure 6-60**, sample data from the AU was plotted as a ratio to the TP target. Exceedances ranged from 1 to 63 times the target concentration of 0.030 mg/L. Exceedances of the TP target are plotted in **Figure 6-61**. Reductions needed to achieve the TP TMDL range from 30% to 98% with a median reduction of 93%. Water quality data in the following figures is limited to those samples collected in Silver Bow Creek upstream of Warm Spring Ponds.

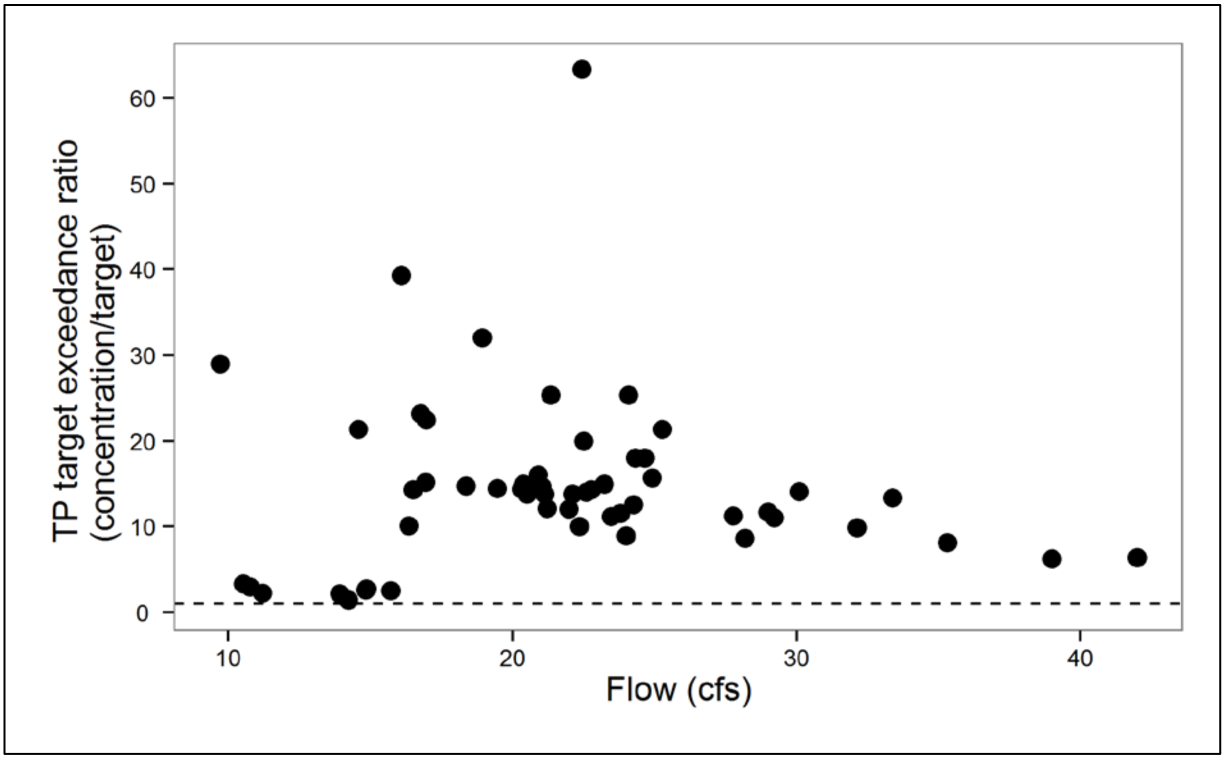

Figure 6-60. TP Target Exceedance Ratio in Silver Bow Creek (2007–12) (>1 Indicates Exceedance)

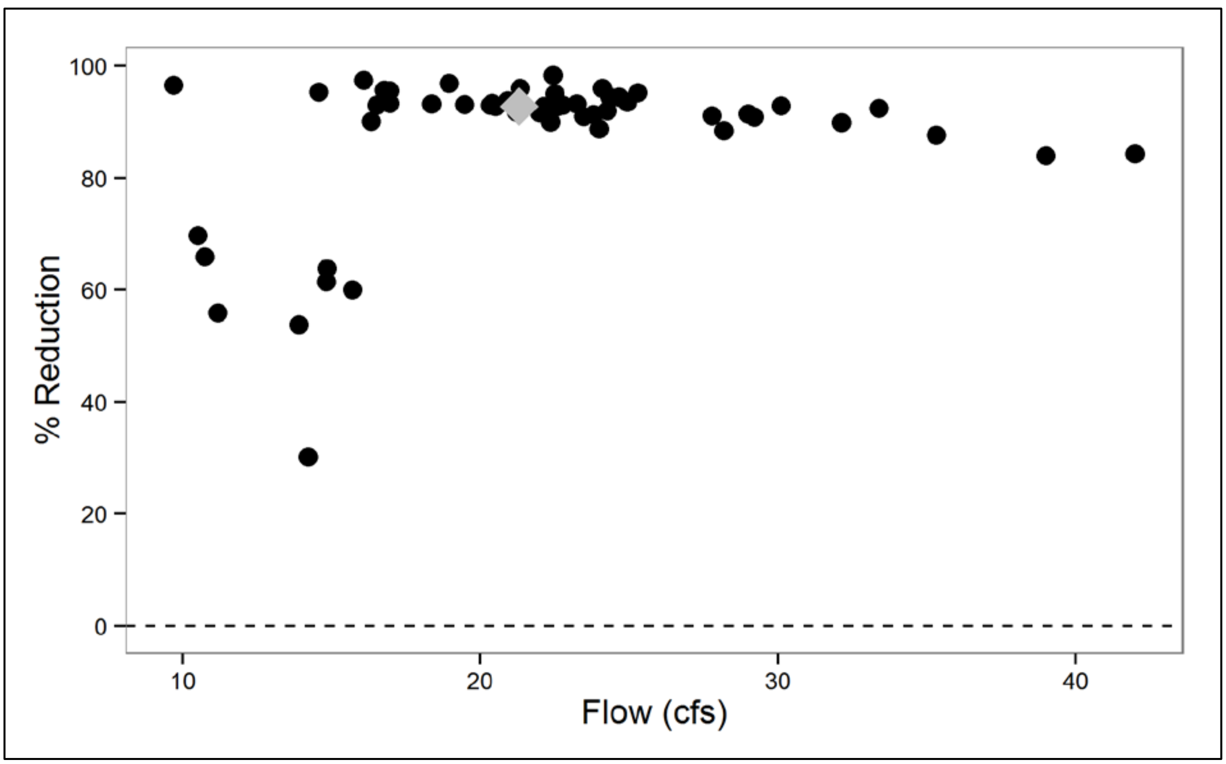

Figure 6-61. Scatterplot of Mainstem Observations and Respective Percent Reductions Necessary to Achieve the TP TMDL in Silver Bow Creek (the Gray Diamond Is the Median (50th percentile) Observation of Samples that Exceeded the TP TMDL (2007–12))

6.6.9.2 Assessment of Loading by Source Waters

Given the plethora of data available within the Silver Bow Creek watershed in addition to its relative size and number of point sources, the nutrient source assessment was divided between an assessment of nonpoint source loading to Silver Bow Creek via tributary inputs and nonpoint source loading to the channel itself. This will be combined with point source load estimates calculated in **Section 6.5.1.2**. All load estimates integrate natural plus human loads. The TN and TP TMDLs then pull out the natural load based on the example flow.

There are five major tributaries to Silver Bow Creek upstream of Warm Springs Ponds: (1) Blacktail Creek (with Basin Creek), (2) Sand Creek, (3) Browns Gulch, (4) German Gulch, and (5) Gregson Creek. An additional tributary, the Mill-Willow Bypass flows into Silver Bow Creek downstream of Warm Springs Ponds.

Blacktail Creek/Summit Valley

The city of Butte, Montana, is located in the northern part of the Summit Valley. The Summit valley is a north-south intermontane valley in the upper part of the Silver Bow Creek watershed and is bounded on all sides by mountains formed of granite. Historic Butte is situated on the uplands in the northern part of the valley and overlooks the valley floor which is an alluvial plain that is ~5 miles long and ~3 miles wide. The valley is drained by 2 north-flowing streams: Basin Creek and Blacktail Creek. Basin Creek joins Blacktail Creek approximately 2 miles upstream of the Blacktail Creek and MSD confluence which marks the start of Silver Bow Creek. Silver Bow Creek flows westward and exits from the northwest portion of Summit Valley.

A groundwater investigation by the MBMG documented the vulnerability of groundwater aquifers developed in fractured bedrock to nitrate-N contamination from individual septic systems (Carstarphen et al., 2004). Data was collected over a period of 2.5 years in and around Warne Heights, a subdivision 4 miles south of Butte in the foothills of the Highland Mountains. Nitrate concentrations ranged from 0.9 to 11.6 mg/L and were widely distributed in the study area. Groundwater nitrate-N concentrations were significantly higher beneath subdivisions than underneath adjacent, undeveloped lands. N and O isotope analyses were suggestive of septic sources. Results highlighted the vulnerability of fractured bedrock aquifers to surface conditions despite the depth to water of 70 to 300 ft (Carstarphen et al., 2004).

As an expansion of the 2004 study, nitrate concentrations in groundwater and surface water in the Summit Valley was investigated by MBMG (LaFave, 2008). The study observed that anomalously high concentrations of nitrate occur in the groundwater and surface water in the Summit Valley compared with other parts of the Clark Fork drainage basin. A data set of 239 samples showed that nitrate concentrations exceeded the 10 mg/L health standard for nitrate-N in 13% of samples and an additional 51% exceeded 2 mg/L suggesting some land-use impact. Concentrations were slightly higher under sewered urban/residential than under unsewered and were highest in the sewered residential area on the east side of Butte. N and O isotope analyses of wells completed in different land uses and hydrogeologic settings revealed that all the samples were isotopically similar and suggested an animal waste or human sewage source for all sites (LaFave, 2008). The lone exception was a sample collected from a monitoring well at the MPTP CERCLA site on Silver Bow Creek which was indicative of a fertilizer or possibly an explosive source that could be linked to a long-running powder works (LaVelle Powder) that operated upgradient of the MPTP.

From the 2008 study, baseflow samples from Blacktail and Silver Bow Creeks included elevated nitrate concentrations upstream from the WWTP. In the Summit Valley, ground-water contamination is the most probable nitrate source to the streams above the WWTP. The sampling results from the Summit Valley show that along a 4- to 6-mile reach upstream of the BSB WWTP discharge to Silver Bow Creek, nitrate concentrations are well above that of other streams in the Upper Clark Fork basin.

In addition, a graduate student at Montana Tech in Butte examined the geochemistry of nutrients in Silver Bow Creek (Plumb, 2009). In her research, Plumb collected synoptic samples for nutrient analysis at 10–15 monitoring stations every 4–6 weeks from May 2006 to August 2007. Results observed elevated nitrogen and phosphorus concentrations and loads in Silver Bow Creek as it leaves the Summit Valley even when compared to national reference conditions for 'developed basins'. N and O isotope analyses of Silver Bow Creek samples indicated human and animal waste as the likely sources of nitrogen.

Hydrology

Between the lower portion of Blacktail Creek and the upper segment of Silver Bow Creek upstream of the WWTP outfall, there is an area of significant groundwater recharge. There are 2 active USGS stream gages in the Summit Valley. Gage 12323240 is located on Blacktail Creek immediately upstream of the MSD confluence where Silver Bow Creek begins. Stream gage 12323250 is located on Silver Bow Creek immediately downstream of the BSB WWTP discharge to Silver Bow Creek. The distance between the gages is 1.8 miles. For the period of record 1989–2009, Blacktail Creek at Butte (12323240) had a mean summer period (July 1 to September 30) discharge of 10.1 cfs. For the Silver Bow Creek below Butte (12323250), the mean summer period discharge is 19.7 cfs for the period of record (1984–2009). Eliminating inflows from the Butte WWTP (5.12 cfs), the LAO discharge (2.58 cfs), and the MPTP discharge (0.72 cfs), the estimated daily groundwater net inflow in this reach is 1.14 cfs.

Monitoring data from Blacktail Creek also indicate significant groundwater inflows between Father Sheehan Park and the Blacktail Creek/MSD confluence. The distance between these sampling points is 1.6 miles. Data collected on Blacktail Creek from 2007 to 2009 during the summer period found an average increase of 3.29 cfs moving downstream between the 2 points. Two intermittent streams do enter Blacktail Creek in this reach: Sand Creek and Grove Gulch Creek but these systems are frequently dry during the summer period (July 1 to September 30).

Estimated Nutrient Loads

As opposed to tributary data that was analyzed for median discharges and concentration to estimate loads, instream data collected from Blacktail Creek and Silver Bow Creek upstream of the BSB WWTP discharge was used to estimate the total groundwater/surface water load from the Summit Valley and Blacktail Creek. Using DEQ Remediation Division data collected during the summer period (July 1 to September 30) from 2009 to 2011, synoptic events determined the average nutrient loads from the Summit Valley/Blacktail Creek drainage to Silver Bow Creek are 84.03 lbs/day TN and 6.00 lbs/day TP (**Table 6-59**). These loads do not include the CERCLA discharges from LAO and the MPTP site but do include potential impacts from the Ranchland Packing Facility at the downstream end of the reach.

Table 6-59. Blacktail Creek/Summit Valley Average Nutrient Concentrations and Flow to Silver Bow Creek

	TN (mg/L)	TP (mg/L)	Discharge (cfs)
Mean	1.05	0.075	14.82

From DEQ Remediation September data, 2009–11

Summary

In addition to the studies outlined previously, the vulnerability of surficial groundwater aquifers to contamination from on-site sewage treatment and disposal has been well documented (Botz, 1969; Boettcher and Juvan, 1970; Straw W.T., 1980). The Summit Valley is contributing a large TN and TP load to Silver Bow Creek via Blacktail Creek and groundwater recharge during the summer period. N and O isotopic analyses support the conclusion that the nitrogen source is most likely leaking sanitary sewers, illicit stormwater sewer connections, and septic effluent.

Sand Creek

DEQ Remediation Division data collection efforts sampled water quality and measured discharge in Silver Bow Creek immediately upstream and downstream of the Sand Creek confluence. In total, 5 of these bracket sampling events were completed during the month of September in 2006 and from 2009 to 2012. Sand Creek contributed flow to Silver Bow Creek in 3 of 5 events (60%). Mean water quality and flow statistics from these positive flow events are in **Table 6-60**.

Table 6-60. Sand Creek Average Nutrient Concentrations and Flow to Silver Bow Creek

	TN (mg/L)	TP (mg/L)	Discharge (cfs)
Mean	5.72	0.620	1.77

From DEQ Remediation September data, 2010–12

In years where Sand Creek does reach Silver Bow Creek, Sand Creek delivers nutrient loads to the Silver Bow Creek. Based on the mean values from **Table 6-60**, the average TN load is 54.67 lbs/day and the average TP load is 5.93 lbs/day. This is a large load for a relatively small tributary and the nutrient concentrations, particularly for TN, are quite elevated. Near the confluence of Sand Creek and Silver Bow Creek is the BSB WWTP sod farm. However, dominant groundwater flow paths do not suggest that this facility is a significant source of the TN in Sand Creek. Evidence of this is that, when flowing, Sand Creek dilutes chloride concentrations in Silver Bow Creek. It would be anticipated that if applied effluent at the sod farm were entering Sand Creek there would be a significant chloride signature observed in the bracket sampling data for Sand Creek since chloride is a conservative pollutant normally associated with WWTP effluent.

Based on the bracket sampling in Silver Bow Creek, Sand Creek nutrient concentrations are well above target concentrations for TN and TP. Land uses in the Sand Creek drainage are mostly limited to dryland grazing with some clustering of individual septic systems. It is not clear what is causing the elevated nutrient concentrations and additional monitoring and source assessment work is recommended.

Browns Gulch

DEQ Remediation Division data collection efforts sampled Silver Bow Creek immediately upstream and downstream of the Browns Gulch confluence. In total, 6 of these bracket sampling events were completed during the month of September every year from 2007 to 2012. Browns Gulch contributed flow to Silver Bow Creek in 3 of 6 events (50%). Mean water quality and flow statistics from these positive flow events are in **Table 6-61**. Although not currently classified as dewatered by FWP, dewatering of the Browns Gulch channel in the lower reaches has been observed in some years (KirK Environmental, LLC, 2006).

Table 6-61. Browns Gulch Average Nutrient Concentrations and Flow to Silver Bow Creek

	TN (mg/L)	TP (mg/L)	Discharge (cfs)
Mean	3.09	0.32	6.35

From DEQ Remediation September data, 2007, 2010–12

However, in years where Browns Gulch does reach Silver Bow Creek it delivers a large TN and TP load. Based on the mean values from **Table 6-61**, the average TN load is 105.96 lbs/day and the average TP load is 10.97 lbs/day. The Browns Gulch load may include loading from the Ramsay WWTP lagoons which, impeded by a railroad embankment to the south, may flow more westerly and join the Browns Gulch channel upstream of the Silver Bow Creek confluence. However, this likely represents a very minor load to the system (**Section 6.5.1.1**; see Subsurface Wastewater Treatment and Disposal).

Based on the bracket sampling in Silver Bow Creek, Browns Gulch nutrient concentrations are greater than target concentrations for TN and TP. Source assessments suggest that irrigated agriculture and, possibly, individual septic systems are causing the elevated nutrient concentrations. Any loading from the Ramsay WWTP to Browns Gulch would have to be considered negligible given the distance from the WWTP lagoons and the relative load from the facility being discharged to groundwater. However, as stated previously in **Section 6.4.2.2**, there may be naturally elevated TP concentrations in the watershed that are difficult to discern given the range of human-caused sources of phosphorus.

German Gulch

DEQ Remediation Division data collection efforts sampled German Gulch at the mouth. At this site, a sample was collected during the month of September every year from 2007 to 2012. Mean statistics of these samples are in **Table 6-62**. German Gulch contributed flow to Silver Bow Creek in 6 of 6 events (100%).

Table 6-62. German Gulch Mean Nutrient Concentrations and Flow to Silver Bow Creek

	TN (mg/L)	TP (mg/L)	Discharge (cfs)
Mean	0.09	0.029	9.93

From DEQ Remediation September data, 2007–12

German Gulch water quality data had 0 exceedances of TN (n=3) and 1 exceedance of TP (n=6) and most often provides dilution to Silver Bow Creek nutrient concentrations. Based on the mean values from **Table 6-62**, German Gulch delivers loads of 4.83 lbs/day TN and 1.56 lbs/day TP to Silver Bow Creek. German Gulch is not a source of nutrient loads in excess of Middle Rockies target concentrations.

Gregson Creek

Gregson Creek is the only perennial stream that enters Silver Bow Creek between German Gulch and Opportunity. All other tributaries to Silver Bow Creek in this reach drain rangeland and forest and are identified in the NHD as intermittent. Gregson Creek includes some irrigated agriculture and the Fairmont Hot Springs Resort complex. Fairmont Hot Springs Resort includes a golf course and an unpermitted WWTP (**Section 6.5.1.1**; see Subsurface Wastewater Treatment and Disposal).

DEQ Remediation Division data collection included four sampling events where both flow and water quality was measured in Silver Bow Creek at a site immediately downstream of German Gulch and at a site near Opportunity. In three of four events, flows increased between sampling locations. Of these three events, TN loads increased in two events and TP loads decreased in all events. For the two events where TN loads increased, inorganic N comprised ≈75% of the observed TN concentration. In the event where TN did not increase, the flow change between points was +1.40 cfs. This could be an error in measurement or groundwater inflow.

As Gregson Creek was not specifically bracketed by sampling efforts, this analysis does assume that all nutrient loading in the intervening reach is attributable to Gregson Creek. However, it is the only perennial stream in a reach where groundwater recharge may be relatively insignificant.

Based on the mean values from **Table 6-63**, Gregson Creek delivers loads of 60.90 lbs/day TN and 1.02 lbs/day TP to Silver Bow Creek.

Table 6-63. Gregson Gulch Mean Nutrient Concentrations and Flow to Silver Bow Creek

	TN (mg/L)	TP (mg/L)	Discharge (cfs)
Mean	1.79	0.030[a]	6.30

Estimated from DEQ Remediation September data, 2007–12 collected downstream of German Gulch and at Opportunity

[a] Assumed to be at the target concentration based on Silver Bow Creek data

The limited data collected in Silver Bow Creek downstream of Durant Canyon suggest that Gregson Creek is not a large source of phosphorus to Silver Bow Creek. Additional monitoring of Gregson Creek is warranted to verify this assumption. It does appear that Gregson Creek is a source of TN to Silver Bow Creek, perhaps related to the application of WWTP effluent on irrigated acreage which also serves as winter feeding grounds for cattle. Based on the assessment of the Fairmont Hot Springs WWTP in **Section 6.5.1.1**, groundwater discharges of nutrients from the facility are very small for both TN and TP.

Mill-Willow Bypass

Nutrient water quality data collected in the last 10 years is limited for the Mill-Willow Bypass near its confluence with Silver Bow Creek downstream of the Warm Spring Ponds. Recent data is limited to 3 growing season (July 1 to September 30) samples collected immediately upstream of the Mill-Willow Bypass and Silver Bow Creek confluence (where Silver Bow Creek flows out of Warm Springs Pond 2) in 2005. However, there were extensive data collection efforts at this same location from 1998 to 2002; TKN was collected in these samples versus Total (Persulfate) Nitrogen. TKN is the sum of organic N, ammonia, and ammonium whereas TN is the sum of TKN and nitrate-nitrite. As nitrate-nitrite data was not collected in 2005, an estimated TN concentration cannot be calculated (**Table 6-64**).

Table 6-64. Mill-Willow Bypass Mean Nutrient Concentrations and Flow to Silver Bow Creek

	Number of Samples	TKN (mg/L)	TN (mg/L)[a]	TP (mg/L)	Discharge (cfs)
1998–2002 Mean	13	0.22	0.24	0.019	50.72
2005 Mean	3	0.20	NA[b]	0.017	NM[c]

[a] Calculated by DEQ

[b] No nitrate-nitrite data was collected in 2005

[c] Flow was not measured in 2005

Examining the 1998–2002 data, the 80th percentile of TN was 0.31 mg/L and for TP it was 0.026 mg/L. Analysis of the two datasets suggests that at present, the Mill-Willow Bypass is contributing nutrient concentrations less than target concentrations of 0.300 mg/L TN and 0.03 mg/L TP with some possible exceptions for TN.

Based on the 1998–2002 mean values for TN and TP from **Table 6-64**, Mill-Willow Bypass delivers loads of 65.73 lbs/day TN and 5.20 lbs/day TP to Silver Bow Creek.

It should be noted that TN and TP TMDLs for Willow Creek are contained in this document. In addition, 28 metals TMDLs were completed for Mill Creek, Willow Creek and the Mill-Willow Bypass as well as 2 sediment TMDLs on upper and lower Willow Creek in a previous TMDL document (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2010). The estimated TN and TP loads for the Mill-Willow bypass are much higher than those estimated for lower Willow Creek in **Section 6.6.11**. This is due to the much increased flow downstream of the Mill Creek and Willow Creek confluence. The data in **Table 6-64** also suggest that Mill Creek joins Willow Creek at nutrient concentrations at or less than the target concentrations as compared with nutrient concentrations observed in lower Willow Creek (see **Figures 6-71** and **6-75**).

Data collection from the Mill-Willow Bypass near the mouth (Silver Bow Creek) determined that it is at or very close to nutrient concentration targets for TN and TP with some possible exceedances of TN. Sources of TN are most likely linked with grazing and irrigated agriculture as well as individual septic systems in the Willow Creek sub-watershed.

Loading from Subareas of Watershed not Covered Elsewhere
Nutrient loading from most of the Silver Bow Creek watershed has been covered in the point source and tributary analysis with the exception of a few discrete subareas of the watershed including: Subarea (1) BSB WWTP discharge to Sand Creek confluence, Subarea (2) Browns Gulch confluence to German Gulch confluence and Subarea (3) that portion of watershed that drains to Silver Bow Creek between Opportunity and the Clark Fork River including the Warm Spring Ponds.

While there are numerous abandoned mines in Subarea (1) and some livestock grazing in all 3 subareas, Subarea (2) has the most potential to deliver nutrient loads to Silver Bow Creek via subsurface wastewater disposal and treatment. According to DEQ records, there are 57 individual septic systems in this subarea. However, in both subareas (1) and (2), synoptic sampling data is highly variable in changes in concentration and flow. This may be due to the fact that the available dataset is exclusively from September sampling events at the end of the growing season. It is believed that the large fluctuations in nutrient loading may be due to senescence effects where nutrients bound in organic growth are released back into the water column. Given the lack of perennial streams and large nutrient sources in these identified areas, the TMDL assumes that TN and TP additions are at or less than the target concentrations. The average positive flow event discharge is used to assign a load from these areas in a composite LA to (1), (2) and (3). The average positive flow event had an observed change in instream flow of 3.0 cfs (**Table 6-65**). It is assumed that the TN existing load is 4.86 lbs/day and the TP existing load is 0.49 lbs/day.

Table 6-65. Other Subareas Not Covered Previously Mean Nutrient Concentrations and Flow to Silver Bow Creek

	TN (mg/L)	TP (mg/L)	Discharge (cfs)
Mean	0.300[a]	0.030[a]	3.0

From DEQ Remediation September data, 2007–12
[a] Assumed to be at the target concentration

6.6.9.3 Activities Contributing to Nutrient Loading Within Source Areas
The following outlines nonpoint nutrient sources for the entire Silver Bow Creek watershed.

Agriculture
In the Silver Bow Creek watershed, irrigated agriculture is limited to areas near the mouth of Browns Gulch, the BSB WWTP sod farm on Sand Creek, and irrigated hay/alfalfa on Gregson Creek and in the lower Mill and Willow Creek drainages. There is livestock grazing in upland and forested portions of the watershed particularly in the Browns Gulch drainage and Blacktail and Basin Creek sub-watersheds. Grazing allotments comprise 95,969 acres on USFS and DNRC administered lands in the drainage with a current maximum of 6174 permitted AUMs (**Table 6-27**).

Mining
CERCLA Superfund OUs encompass the primary abandoned mines impacts on nutrient loading. In total, there are 255 abandoned mines in the Silver Bow Creek watershed with the highest density (*n*=89) in and around the Summit Valley and upstream of the Sand Creek confluence. It is not thought that these constitute a direct source of nutrients to Silver Bow Creek as a whole. However, the extensive workings in and around Butte are believed to provide preferential flow of nutrient enriched groundwater (from septic systems and leaking sanitary and stormwater sewers) to surface water discharges and to groundwater capture remediation OUs (LAO, MPTP). Included in the count of 255 are 67 abandoned mines in catchments that currently discharge to the Berkeley Pit. Especially for the Summit Valley, impacts from abandoned mines are difficult to separate from other nonpoint source contributions. Potential nutrient loading from abandoned mines in the Summit Valley are captured in the LA to Blacktail Creek/Summit Valley. Fertilizer use in remediated portions in the SSTOU may also comprise a portion of the nonpoint sources of nutrient to Silver Bow Creek.

There are 3 abandoned mine sites in the headwaters of Silver Bow Creek upstream of Butte which are on the DEQ priority abandoned mines list: the Rising Sun, Mary Emcee/Cliniton are in the Elk Park district and the Highland mine is in the Basin mining district.

<u>Rhodia Silver Bow Elemental Phosphorus Production Plant</u>
The Rhodia Silver Bow Elemental Phosphorus Production Plant is a RCRA site. Ownership of the site changed five times from when the facility first started producing elemental phosphorus in 1950 to when production ceased in 1997 (Barr Engineering Company, 2012). In the late 1960s, the plant was granted a permit to discharge storm water runoff, uncontaminated cooling water, and septic system water through a concrete discharge pipe to Silver Bow Creek. Direct discharge to Silver Bow Creek ceased in 1975 with final upgrades to facility infrastructure and septic system. The pipe system was removed in 2004 and 2005.

Following facility closure in 1997, most of the facility was decontaminated and demolished in 1998–1999 (Barr Engineering Company, 2012). Structures remaining on site include a 100-ft clarifier, two office buildings, and several other miscellaneous buildings and silos. Water quality sampling in Sheep Gulch north of the former tailings ponds at the facility observed a 98% reduction in TP between 1997 and 2008. A 98% reduction was also observed for the same time period at a surface water sampling station on Sheep Gulch where the channel exits the Rhodia property. TP concentrations were highest upstream of the Rhodia site where the REC Advanced Silicon Materials facility discharges to Sheep Gulch (see **Section 6.5.1.2**).

Water quality sampling in Silver Bow Creek and Sheep Gulch in 2008 determined that "Since Silver Bow Creek is the receiving body for both surface water discharges and groundwater from the Rhodia site, these data show that the surface water discharges from Sheep Gulch and groundwater from the Rhodia plant do not cause significant increases in concentrations in Silver Bow Creek" (Barr Engineering Company, 2012).

Based on this assessment, the Rhodia site is considered part of the composite LA from nonpoint sources to Silver Bow Creek.

Silviculture (includes timber harvest)
Based on records from the BDNF, there have been recent forest operations in portions of the Silver Bow Creek watershed. These actions include timber operations in Basin Creek (608 acres), Blacktail Creek (240 acres), Browns Gulch (222 acres), and German Gulch (22 acres). With the exception of harvests in the Blacktail Creek sub-watershed, these operations were mostly limited to salvage and trailhead work and are not anticipated to have resulted in water quality problems given the relatively small acreages and type of treatment. The Blacktail Creek harvest operation was near the headwaters of Blacktail Creek; given the location, size and distance from the impacted stream it is assumed that this operation also had negligible effects on downstream water quality.

Subsurface Wastewater Disposal and Treatment
According to DEQ records, there are 1,628 individual septic systems in the Silver Bow Creek watershed. This compilation assumed that there are no septic systems within the MS4 contributing area (**Figure 6-53**). The highest concentrations of these are in the Mill Creek sub-watershed around the town of Opportunity, the Grove Gulch area southwest of Butte, the Walkerville area north of Butte and in the Blacktail Creek sub-watershed south of Butte which has the highest density of any sub-watershed in the Silver Bow Creek drainage. Many of these areas were directly addressed in the tributary analysis such as the case with Blacktail Creek/Summit Valley analysis. It is recognized that given the number and density of septic systems in some portions of the watershed, that septic systems are likely contributing more than a nominal nutrient load to Silver Bow Creek as has been well documented in several MBMG publications (Carstarphen et al., 2004; LaFave, 2008).

In addition to septic systems, there are several other permitted and unpermitted facilities that are part of the nutrient sources in the Silver Bow Creek watershed. These include Fairmont Hot Springs WWTP on Gregson Creek, Ranchland Packing in Butte, Ramsay WWTP, and the sod farm operated by BSB WWTP. Potentiometric maps suggest that the groundwater moves from the sod farm in a northwesterly direction towards the Silver Bow Creek channel. With the exception of the sod farm, these nonpoint sources are discussed in more detail in **Section 6.5.1.1** under subsurface wastewater treatment and disposal. The sod farm is discussed in **Section 6.5.1.2** as part of the review of the BSB WWTP permit (MT0022012).

Summary
The source assessment for Silver Bow Creek suggests that the most important sources of human-caused nutrients are point source discharges from WWTPs and urban land uses in the Summit Valley including subsurface wastewater treatment and disposal. These comprise the largest TN and TP loads to Silver Bow Creek.

6.6.9.4 Wasteload Allocation (WLA) Approach
WLAs were developed for 6 MPDES permitted and for 2 CERCLA discharges to Silver Bow Creek including:

- Montana Resources (MT0000191)

- BSB MS4 Storm Water System (MTR04002)
- BSB WWTP (MT0022012)
- Town of Rocker WWTP (MT0022012)
- Montana Livestock Auction (MTG010166)
- REC Advanced Silicon Materials (MT0030350)

WLAs are presented in order from upstream to downstream per their respective discharge location to Silver Bow Creek (**Figure 6-3**).

Montana Resources (MT0000191)
Montana Resources is authorized to discharge wastewater to Silver Bow Creek via the MSD under MPDES permit number MT0000191. Although unused the permit does identify one authorized outfall, Outfall 004, for intermittent discharge to the Silver Bow Creek via the Butte MSD. The treatment process at the HSB consists of a two-stage high density sludge lime precipitation water treatment process. Currently, the effluent water is used as process water at the Montana Resources facility and is not discharged to Silver Bow Creek.

Silver Bow Creek is impaired for TN and TP. Per Montana State Law (ARM 17.30.637(2)), no wastes may be discharged such that the wastes, either alone or in combination with other wastes, will violate, or can reasonably be expected to violate, any of the standards. For permitted dischargers, this requirement is satisfied when the discharge concentration is less than or equal to an applicable numeric water quality standard if the reach immediately upstream where the discharge occurs is already exceeding the standard. If the reach immediately upstream of the Sheep Gulch confluence is determined to be unimpaired for TN and/or TP, the WLA will be modified based on a mass-balance approach if there is sufficient assimilative capacity in the receiving water.

The TMDL target values provide a numeric translation of the applicable narrative standard found in ARM 17.30.637(1)(e). The draft numeric nutrient criteria provide the basis for the TMDL targets (**Section 6.4.2**). Based on recent Blacktail Creek data, there is currently no assimilative capacity where the MSD joins Blacktail Creek to create Silver Bow Creek. To ensure the Montana Resources discharge does not cause or contribute to a violation of water quality standards, the WLA is based on a discharge concentration equal to the nutrient target concentrations for both TN and TP multiplied by the Montana Resources discharge flow. Therefore, the resulting nutrient WLAs are based on the following equations:

Equation 7: TN WLA = TMDL TN Target Concentration X Discharge Flow = (0.300 mg/l) (Discharge Flow) x Conversion Factor

Equation 8: TP WLA = TMDL TP Target Concentration X Discharge Flow = (0.030 mg/l) (Discharge Flow) x Conversion Factor

For both **Equations 7** and **8**, the target concentrations are lower than current limits of technology for treatment of wastewater effluent. Therefore, a staged approach for WLA implementation is developed below.

At all Montana Resources discharge flows, the maximum TN concentrations of 0.300 mg/l and the maximum TP concentration of 0.030 mg/l must be met to satisfy the **Equation 7** and **Equation 8** WLA conditions. For all Montana Resource discharge flows, Montana Resources TN and TP loads will not cause or contribute to impairment as long as the discharge concentration is equal to or less than the TMDL target concentrations shown in **Equations 7** and **8**.

Mixing Zone Allowance

If water quality in Blacktail Creek in the reach immediately upstream of the MSD confluence improves to the point where either the TP or TN water quality target or adopted numeric nutrient standard is met, then the TN and/or TP WLA may be modified as assimilative capacity has been created in the receiving water. This increase would be based on a mass-balance calculation that ensures that water quality standards and/or TMDL targets are met at the end of the mixing zone during July through September under 14Q5 flow conditions. For a given stream, 14Q5 refers to the 14 day low flow with a recurrence interval of 5 years.

A mixing zone would be calculated the same regardless of whether or not numeric nutrient standards are adopted into rule. The 75^{th} percentile of the available upstream water quality data will be used to determine assimilative capacity of TN and TP.

Staged Implementation of Nutrient WLAs

The TMDL targets represent concentrations below the current limits of treatment technology for TN and TP. MPDES permits provides a regulatory mechanism for implementing the TMDL via the variance process, to address affordability issues and concerns about the limits of treatment technology. The variance (75-5-313 MCA) allows Montana to implement numeric nutrient criteria in a staged manner thus allowing time enough to address all point and nonpoint sources of nutrient pollution and allow for advancements in treatment technology and associated affordability.

The WLAs for TN and TP for Montana Resources at Outfall 004 defined in this TMDL allows staged implementation consistent with the variance process. There are two staged implementation scenarios based on whether the variance process has been adopted at the time a MPDES permit is renewed:

<u>Scenario 1: Numeric Nutrient Standards Adopted into Rule</u>

When Montana Resources renews its MPDES permit for Outfall 004, it can apply for a variance as part of a staged implementation approach for one or both nutrient WLAs. The variance will be implemented as defined within Montana State Law (75-5-313, MCA) and the rule as adopted.

<u>Scenario 2: Numeric Nutrient Standards Not Adopted into Rule</u>

- **Staged WLAs for TN (no numeric TN standard)**
  No action is necessary until the next permit renewal scheduled for 2017. The WLA for TN in the 2017 permit will be based on the discharge flow at that time multiplied by the lower of the two following concentrations: (1) the design performance at the facility or (2) the long-term DMR average TN concentration after the most recent upgrade(s). The WLA for TN in the 2022 permit will be based on the discharge flow at that time multiplied by the then current limit of technology for TN. Regarding future permit cycles starting in 2017, the TN limit of technology will be defined by DEQ in conjunction with the Nutrient Work Group. In 2022, if the plant is not capable of meeting the limit of technology for TN, then a specific plan to optimize TN treatment capabilities will be required for the 2022 permit renewal outlining specific measures and plant management protocols that will result in the lowest TN concentration feasible at the facility. This concentration will be the basis for calculating the TN WLA using the discharge flow in 2022. The process outlined here for the 2022 permit cycle will be applied for all subsequent permits.

Staged implementation will no longer be necessary once (1) Montana Resources is able to meet the WLA value defined by **Equation 7** (i.e. discharge concentrations less than or equal to 0.300 mg/l), or (2) Silver Bow Creek gains assimilative capacity and Montana Resources meets the mixing zone allowance requirements for TN treatment (defined above).

- **Staged WLAs for TP (no numeric TP standard)**
  No action is necessary until the next permit renewal scheduled for 2017. The WLA for TP in the 2017 permit will be based on the discharge flow at that time multiplied by the lower of the two following concentrations: (1) the design performance at the facility or (2) the long-term DMR average TP concentration after the most recent upgrade(s). The WLA for TP in the 2022 permit will be based on the discharge flow at that time multiplied by the then current limit of technology for TP. Regarding future permit cycles starting in 2017, the TP limit of technology will be defined by DEQ in conjunction with the Nutrient Work Group. In 2022, if the plant is not capable of meeting the limit of technology for TP, then a specific plan to optimize TP treatment capabilities will be required for the 2022 permit renewal outlining specific measures and plant management protocols that will result in the lowest TP concentration feasible at the facility. This concentration will be the basis for calculating the TP WLA using the discharge flow in 2022. The process outlined here for the 2022 permit cycle will be applied for all subsequent permits.

  Staged implementation will no longer be necessary once (1) Montana Resources is able to meet the WLA value defined by **Equation 7** (i.e. discharge concentrations less than or equal to 0.030 mg/l), or (2) Silver Bow Creek gains assimilative capacity and Montana Resources meets the mixing zone allowance requirements for TP treatment (defined above).

Under Scenario 2, a timeline of how DEQ anticipates the staged implementation of the Montana Resources WLA to occur (**Figure 6-62**).

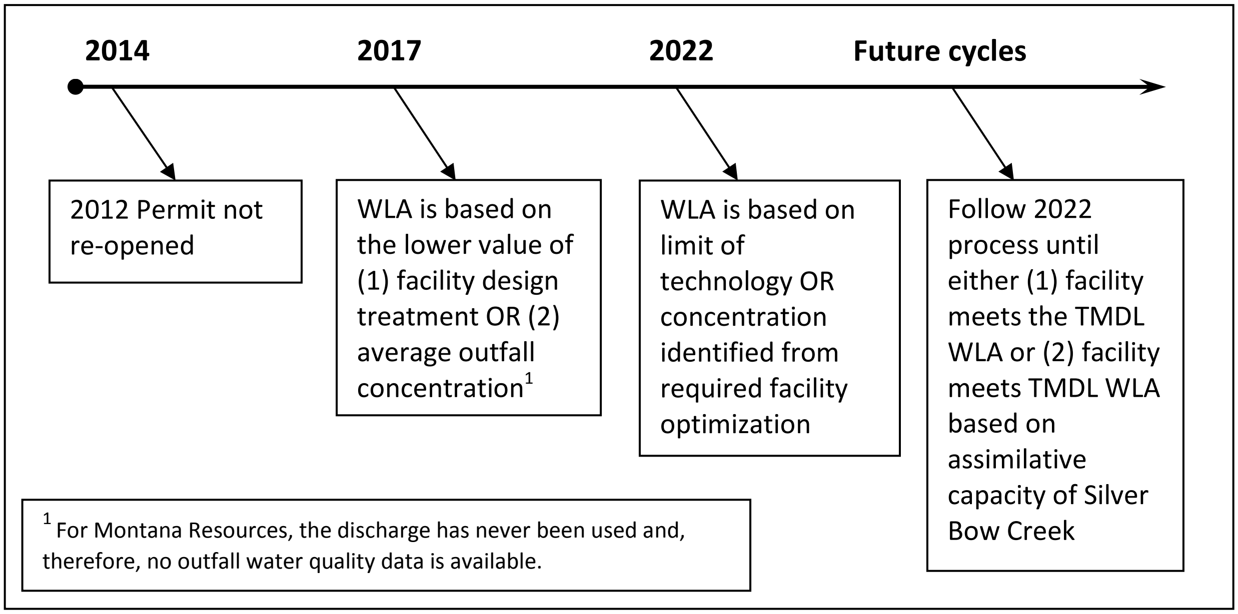

Figure 6-62. DEQ Anticipated Timeline of the Staged Implementation of the Montana Resources WLA

The Montana Resources permit was recently renewed in 2012, and the next renewal (after EPA approval of this TMDL) is scheduled for 2017. The existing permit does not need to be reopened before 2017 to integrate the WLAs defined in this document.

During staged implementation, the TN and TP WLAs can be alternatively expressed as concentrations (versus loads) so that a concentration-based approach can be used for MPDES permit development using the staged implementation provided above. If a concentration based approach is not used for MPDES permit integration, then the WLA should be based on the staged implementation concentrations multiplied by the facility discharge flow at that time (versus the design flow). This could create a loading cap until the next permit cycle when the WLA can be recalculated using an updated facility average discharge flow.

Nutrient Trading

Montana has developed a nutrient trading program to allow point source dischargers to use trading as a cost-effective method of achieving the state's numeric criteria for nutrients. Trading is a market-based approach in which a point source permittee purchases pollutant reduction credits from another point source or a nonpoint source in the applicable trading region. These credits are used to offset the source's pollutant discharge obligations. Nothing in this TMDL document prevents nutrient trading as long as it is consistent with Montana's nutrient trading program. The nutrient trading policy is outlined in department circular DEQ-13 (Montana Department of Environmental Quality, 2012a).

Butte-Silver Bow MS4 Storm Water System (MTR040002) WLA

Per Part III.A. of the General Permit (MTR040000), the BSB MS4 SWMP must address the pollutants of concern for which the receiving waterbodies are included on the state's 303(d) list. This discussion must specifically address BMPs that will address the pollutants of concern.

Per EPA requirements at the federal level, National Pollutant Discharge Elimination System-regulated stormwater discharges (MS4-permitted discharges) must be addressed by the WLA of a TMDL (40 CFR 130.2(h) & (i).). EPA requires a numeric WLA but allows a state permitting authority to apply BMPs to satisfy the WLA of a TMDL. TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure.

At the state level, ARM 17.30.1111(5) requires MS4 permittees to develop, implement, and enforce a SWMP to reduce the discharge of pollutants to the maximum extent practicable.

ARM 17.30.1111(5)(a) also states, "For the purposes of this rule, narrative effluent limitations requiring the implementation of BMPs are the most appropriate form of effluent limitations when designed to satisfy technology requirements (including reductions of pollutants to the maximum extent practicable) and to protect water quality. Implementation of BMPs consistent with the provisions of the SWMP required pursuant to this rule and the provisions of the permit shall constitute compliance with the standard of reducing pollutants to the 'maximum extent practicable.'"

The MS4 will be assigned a WLA of zero (0) lbs/day TN and TP when the stormwater system is not activated. As required by the general permit, an illicit discharge detection and elimination (IDDE) program is necessary to achieve this WLA, which requires the permittees to regularly update the storm sewer system map, showing the location and number of all outfalls. Storm Water Ordinance 10-13, adopted by the city-county of BSB, establishes legal authority to prohibit illicit discharges in the MS4. These measures will achieve the WLA when the system should not be producing flow. The IDDE program is critical for reducing chronic exceedances of water quality targets in the receiving waterbodies. According to annual reporting from the MS4, in recent years BSB has had success with IDDE with the lining of the Buffalo Gulch main and in other sections of the MS4 on Butte Hill as improvements and repairs have been made to the MS4.

As discussed in the TMDL targets **Section 6.4**, there are two primary methods for evaluating target compliance based on nutrient concentrations. These include the exact binomial and student t-tests. Normally both tests are satisfied by setting the TMDL such that loading levels satisfy the target concentration values. This approach works in most watersheds in Montana because the BMPs required to meet the nutrient TMDLs during low flows are either somewhat independent of flow (e.g., septic systems) or will also limit elevated nutrient loading during stormwater events (e.g., grazing management). For streams that receive significant stormwater flows from MS4 permitted areas, an additional percent-load reduction WLA is developed for the MS4 to ensure compliance with the t-test and provide a MOS to help ensure compliance with the additional biology targets.

During and after precipitation, loading from the MS4 to the receiving waterbodies will be reduced by implementing ARM's (17.30.1111) "maximum extent practicable" and by monitoring stormwater BMPs within the MS4 boundaries. In addition to an active SWMP, these measures should achieve reductions in nutrient loads to the receiving waterbodies. Based on literature pollutant removal efficiencies, the maximum-extent-practicable level of treatment varies among BMPs for TN and TP. The International Storm Water Best Management Practices Database, published in 2010 for nutrients, lists retention ponds (59% decrease in concentration (DIC)), wetland basins (33% DIC), media filters (47% DIC), and wetland channels (22% DIC) as the BMPs that consistently reduced TP concentrations in stormwater. For TN, bioretention (12% DIC), retention ponds (27% DIC), and filter strips (13% DIC) BMPs consistently reduced TN concentrations in stormwater. For nitrogen, BMPs must target the type of nitrogen, since organic nitrogen is reduced differently than inorganic forms. Limited data from the BSB MS4 indicate that organic nitrogen comprises a larger proportion of TN than inorganic forms.

In order to maintain loading from the MS4 following implementation of the control measures, minimizing loading from new development, or redevelopment, projects greater than 1 acre will be important. Low-impact development BMPs minimize direct runoff to streams and use onsite or regional retention and infiltration to effectively remove direct discharge of stormwater to streams. The permit requires that projects that fit the above parameters infiltrate, evapotranspire, or capture for reuse the runoff generated from the first 0.5 inch of rainfall from a 24-hour storm preceded by 48 hours of no measurable precipitation. This process was to be in place by January 1, 2012.

DEQ expects that by following the six minimum control measures outlined in the general permit, with particular attention to IDDE and stormwater BMPs, TN and TP loads to the receiving waterbodies will be reduced by 33% and 50%, respectively. These percent reductions are based on audit information of the BSB MS4 program and system and reductions possible from the available, applicable stormwater BMPs identified by EPA that specifically target TN and TP as were outlined in **Section 6.5.1.2** (see Butte-Silver Bow MS4 (MTR0000191)).

Even when the MS4 meets the percent reduction WLA requirement, Silver Bow Creek could occasionally have concentrations above the target concentrations presented in **Section 6.4.2** because of stormwater flows and pollutant concentrations. This is not an issue for compliance with targets and water quality standards since these short duration occurrences will be less than 20% of the summer growing season (July 1 to September 30) and will be randomly spaced throughout that period. Where target exceedances do exist, but are less than 20%, it is desirable to have a somewhat random spacing of such exceedances similar to what would be anticipated from BSB MS4 stormwater system (Suplee et al., 2008).

Ultimately, when the MS4 is activated, load reductions are based on the successful implementation of a SWMP. Therefore, since the system should not be actively discharging during typical summer low flow conditions, both the existing load and WLA are defined as 0 (zero) lbs/day for TN and TP.

During storm events, implementation of additional stormwater BMPs in the Butte MS4 as well as an aggressive IDDE program is expected to reduce TN loads by 33% and TP loads by 50%. This relies on the assumption that much of the phosphorus being discharged by the Butte MS4 is sediment bound. Reduction of TN loads is thought to be more closely tied to IDDE and maintenance of the stormwater and sanitary sewer infrastructure. Although the HD installation in Butte in 2011–2013 was an effective means of reducing TP in targeted sub-basins, for the entire Butte MS4 TP loads were only reduced by an estimated 4.8% with the installation of the HDs.

Butte-Silver Bow Wastewater Treatment Plant (MT0022012) WLA

The BSB WWTP discharges directly into Silver Bow Creek, which is impaired for TN and TP. Per Montana State Law (ARM 17.30.637(2)), no wastes may be discharged such that the wastes, either alone or in combination with other wastes, will violate, or can reasonably be expected to violate, any of the standards. For a WWTP and other permitted dischargers, this requirement is satisfied when the discharge concentration is less than or equal to an applicable numeric water quality standard if the reach immediately upstream where the discharge occurs is already exceeding the standard. If the reach immediately upstream of the WWTP discharge is determined to be unimpaired for TN and/or TP, the WLA will be modified based on a mass-balance approach if there is sufficient assimilative capacity in the receiving water.

The TMDL target values provide a numeric translation of the applicable narrative standard found in ARM 17.30.637(1)(e). The draft numeric nutrient criteria provide the basis for the TMDL targets (**Section 6.4.2**). The reach of Silver Bow Creek immediately upstream of the BSB WWTP discharge is impaired for both TN and TP based on application of the TMDL targets and instream water chemistry data. To ensure the BSB WWTP discharge does not cause or contribute to a violation of water quality standards, the WLA is based on a discharge concentration equal to the nutrient target concentrations for both TN and TP multiplied by the WWTP discharge flow. Therefore, the resulting nutrient WLAs are based on the following equations:

Equation 7: TN WLA = TMDL TN Target Concentration X Discharge Flow = (0.300 mg/l) (Discharge Flow) x Conversion Factor

Equation 8: TP WLA = TMDL TP Target Concentration X Discharge Flow = (0.030 mg/l) (Discharge Flow) x Conversion Factor

For both **Equation 7** and **8**, the target concentrations are lower than current limits of technology for treatment of wastewater effluent. Therefore, a staged approach for WLA implementation is developed below.

The WLAs for TN and TP are represented in **Figure 6-63**, which identifies the allowable load to Silver Bow Creek based on the discharge rate from the WWTP. For reference, the summer period long-term mean discharge from the WWTP is 5.25 cfs (3.39 mgd) and the design capacity for the existing facility is 13.25 cfs (8.55 mgd).

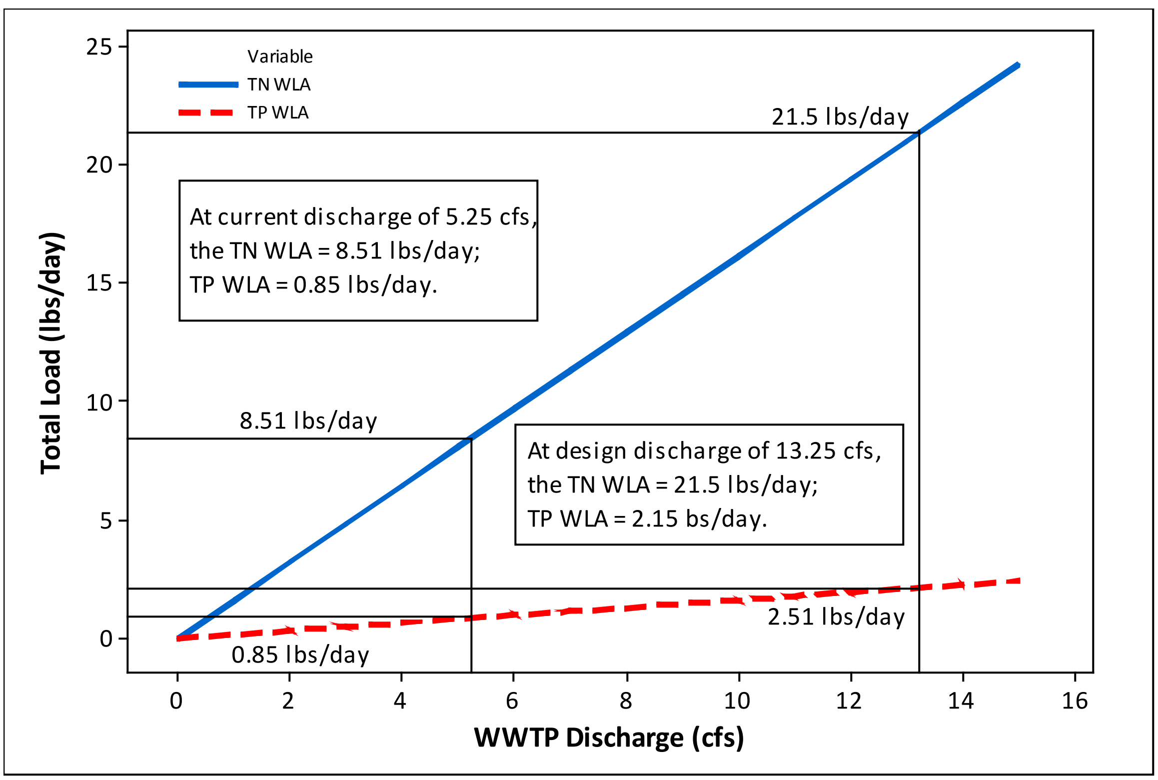

Figure 6-63. WLA for TN and TP for the BSB WWTP

At the design capacity discharge flow of 13.25 cfs, the TN WLA equates to 21.5 lbs/day per **Equation 7** (discharge concentration of 0.300 mg/l), and the TP WLA equates to 2.51 lbs/day per **Equation 8** (discharge concentration of 0.030 mg/l). When WWTP discharge flows are lower than the design flow, the maximum TN concentrations of 0.300 mg/l and the maximum TP concentration of 0.030 mg/l must be met to satisfy the **Equation 7** and **Equation 8** WLA conditions, resulting in lower WLAs. For example, at existing WWTP discharge flows of 5.25 cfs, the TN WLA equates to 8.51 lbs/day, and the TP WLA equates to 0.85 lbs/day. For all WWTP discharge flows, WWTP TN and TP loads will not cause or contribute to impairment as long as the discharge concentration is equal to or less than the TMDL target concentrations shown in **Equation 7** and **Equation 8**.

Mixing Zone Allowance

If water quality in Silver Bow Creek in the reach immediately upstream of the BSB WWTP discharge location improves to the point where either the TP or TN water quality target or adopted numeric nutrient standard is met, then the TN and/or TP WLA may be modified as assimilative capacity has been created in the receiving water. This increase would be based on a mass-balance calculation that ensures that water quality standards and/or TMDL targets are met at the end of the mixing zone during July through September under 14Q5 flow conditions. For a given stream, 14Q5 refers to the 14 day low flow with a recurrence interval of 5 years.

A mixing zone would be calculated the same regardless of whether or not numeric nutrient standards are adopted into rule. The 75th percentile of the available upstream water quality data will be used to determine assimilative capacity of TN and TP.

Staged Implementation of Nutrient WLAs

The TMDL targets represent concentrations below the current limits of treatment technology for TN and TP. MPDES permits provides a regulatory mechanism for implementing the TMDL via the variance process, to address affordability issues and concerns about the limits of treatment technology. The variance (75-5-313 MCA) allows Montana to implement numeric nutrient criteria in a staged manner thus allowing time enough to address all point and nonpoint sources of nutrient pollution and allow for advancements in treatment technology and associated affordability.

The WLAs for TN and TP for the BSB WWTP defined in this TMDL allows staged implementation consistent with the variance process. There are two staged implementation scenarios based on whether the variance process has been adopted at the time a MPDES permit is renewed:

<u>Scenario 1: Numeric Nutrient Standards Adopted into Rule</u>

When BSB renews its MPDES permit for the WWTP, it can apply for a variance as part of a staged implementation approach for one or both nutrient WLAs. The variance will be implemented as defined within Montana State Law (75-5-313, MCA) and the rule as adopted.

<u>Scenario 2: Numeric Nutrient Standards Not Adopted into Rule</u>

- **Staged WLAs for TN (no numeric TN standard)**

  No action is necessary until the next permit renewal scheduled for 2017. The WLA for TN in the 2017 permit will be based on the WWTP discharge flow at that time multiplied by the lower of the two following concentrations: (1) the design performance at the facility or (2) the long-term DMR average TN concentration after the most recent upgrade(s). The WLA for TN in the 2022 permit will be based on the WWTP discharge flow at that time multiplied by the then current limit of technology for TN. Regarding future permit cycles starting in 2017, the TN limit of technology will be defined by DEQ in conjunction with the Nutrient Work Group. In 2022, if the plant is not capable of meeting the limit of technology for TN, then a specific plan to optimize TN treatment capabilities will be required for the 2022 permit renewal outlining specific measures and plant management protocols that will result in the lowest TN concentration feasible at the facility. This concentration will be the basis for calculating the TN WLA using the WWTP discharge flow in 2022. The process outlined here for the 2022 permit cycle will be applied for all subsequent permits.

Staged implementation will no longer be necessary once (1) the WWTP is able to meet the WLA value defined by **Equation 7** (i.e. discharge concentrations less than or equal to 0.300 mg/l), or (2) Silver Bow Creek gains assimilative capacity and the WWTP meets the mixing zone allowance requirements for TN treatment (defined above).

- **Staged WLAs for TP (no numeric TP standard)**
  No action is necessary until the next permit renewal scheduled for 2017. The WLA for TP in the 2017 permit will be based on the WWTP discharge flow at that time multiplied by the lower of the two following concentrations: (1) the design performance at the facility or (2) the long-term DMR average TP concentration after the most recent upgrade(s). The WLA for TP in the 2022 permit will be based on the WWTP discharge flow at that time multiplied by the then current limit of technology for TP. Regarding future permit cycles starting in 2017, the TP limit of technology will be defined by DEQ in conjunction with the Nutrient Work Group. In 2022, if the plant is not capable of meeting the limit of technology for TP, then a specific plan to optimize TP treatment capabilities will be required for the 2022 permit renewal outlining specific measures and plant management protocols that will result in the lowest TP concentration feasible at the facility. This concentration will be the basis for calculating the TP WLA using the WWTP discharge flow in 2022. The process outlined here for the 2022 permit cycle will be applied for all subsequent permits.

  Staged implementation will no longer be necessary once (1) the WWTP is able to meet the WLA value defined by **Equation 8** (i.e., discharge concentrations less than or equal to 0.030 mg/l), or (2) Silver Bow Creek gains assimilative capacity and the WWTP meets the mixing zone allowance requirements for TP treatment (defined above).

Under Scenario 2, a timeline of how DEQ anticipates the staged implementation of the BSB WWTP WLA to occur (**Figure 6-64**).

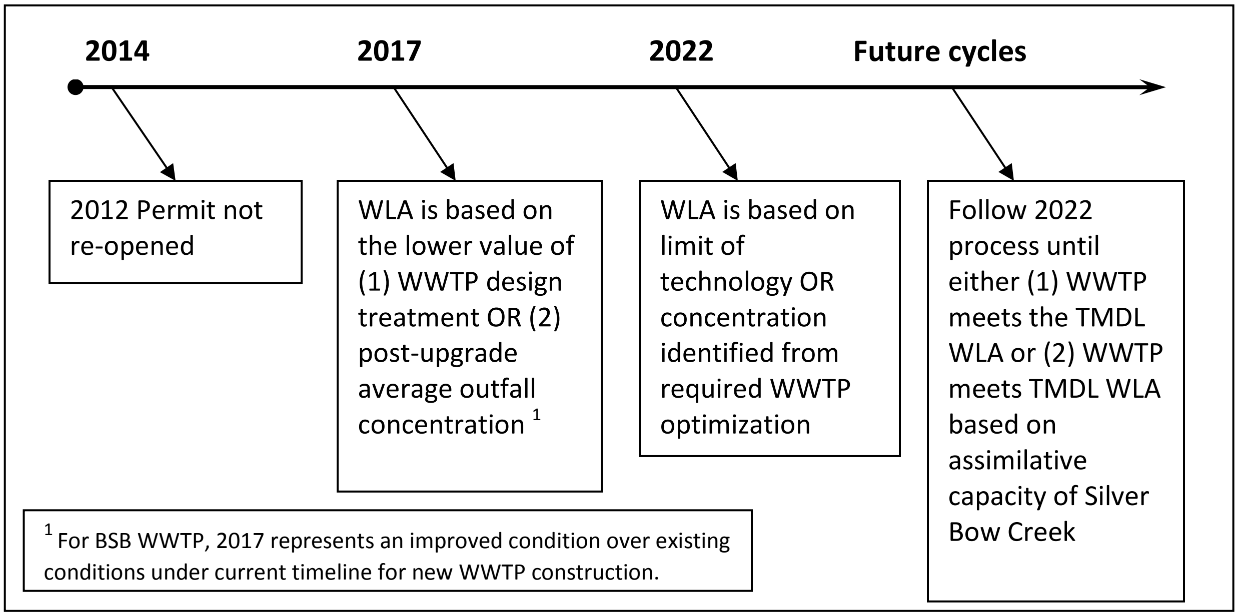

Figure 6-64. DEQ Anticipated Timeline of the Staged Implementation of the BSB WWTP WLA

The BSB WWTP permit was recently renewed in 2012, and the next renewal (after EPA approval of this TMDL) is scheduled for 2017. The existing permit does not need to be reopened before 2017 to integrate the WLAs defined in this document.

During staged implementation, the TN and TP WLAs can be alternatively expressed as concentrations (versus loads) so that a concentration-based approach can be used for MPDES permit development using the staged implementation provided above. If a concentration based approach is not used for MPDES permit integration, then the WLA should be based on the staged implementation concentrations multiplied by the WWTP discharge flow at that time (versus the design flow). This could create a loading cap until the next permit cycle when the WLA can be recalculated using an updated WWTP average discharge flow.

Nutrient Trading

Montana has developed a nutrient trading program to allow point source dischargers to use trading as a cost-effective method of achieving the state's numeric criteria for nutrients. Trading is a market-based approach in which a point source permittee purchases pollutant reduction credits from another point source or a nonpoint source in the applicable trading region. These credits are used to offset the source's pollutant discharge obligations. Nothing in this TMDL document prevents nutrient trading as long as it is consistent with Montana's nutrient trading program. The nutrient trading policy is outlined in department circular DEQ-13 (Montana Department of Environmental Quality, 2012a).

Town of Rocker WWTP (MT0022012) WLA

The Rocker WWTP discharges directly into Silver Bow Creek, which is impaired for TN and TP. Per Montana State Law (ARM 17.30.637(2)), no wastes may be discharged such that the wastes, either alone or in combination with other wastes, will violate, or can reasonably be expected to violate, any of the standards. For a WWTP and other permitted dischargers, this requirement is satisfied when the discharge concentration is less than or equal to an applicable numeric water quality standard if the reach immediately upstream where the discharge occurs is already exceeding the standard. If the reach immediately upstream of the WWTP discharge is determined to be unimpaired for TN and/or TP, the WLA will be modified based on a mass-balance approach if there is sufficient assimilative capacity in the receiving water.

The TMDL target values provide a numeric translation of the applicable narrative standard found in ARM 17.30.637(1)(e). The draft numeric nutrient criteria provide the basis for the TMDL targets (**Section 6.4.2**). The reach of Silver Bow Creek immediately upstream of the Rocker WWTP discharge is impaired for both TN and TP based on application of the TMDL targets and instream water chemistry data. To ensure the Rocker WWTP discharge does not cause or contribute to a violation of water quality standards, the WLA is based on a discharge concentration equal to the nutrient target concentrations for both TN and TP multiplied by the WWTP discharge flow. Therefore, the resulting nutrient WLAs are based on the following equations:

Equation 7: TN WLA = TMDL TN Target Concentration X Discharge Flow = (0.300 mg/l) (Discharge Flow) x Conversion Factor

Equation 8: TP WLA = TMDL TP Target Concentration X Discharge Flow = (0.030 mg/l) (Discharge Flow) x Conversion Factor

For both **Equation 7** and **8**, the target concentrations are lower than current limits of technology for treatment of wastewater effluent. Therefore, a staged approach for WLA implementation is developed below.

The WLAs for TN and TP are represented in **Figure 6-65**, which identifies the allowable load to Silver Bow Creek based on the discharge rate from the WWTP. For reference, the summer period long-term mean discharge from the WWTP is 0.041 cfs (0.03 mgd) and the design capacity for the facility is 0.0775 cfs (0.05 mgd) for the activated sludge plant.

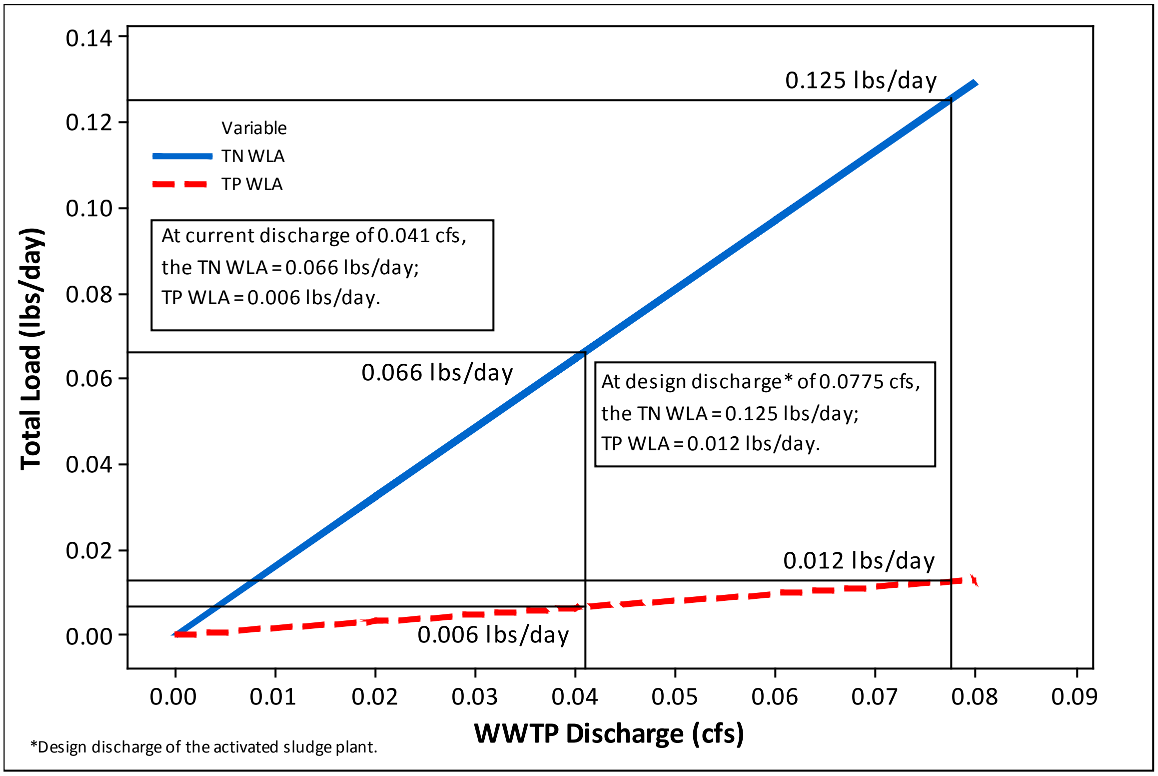

Figure 6-65. WLA for TN and TP for the Rocker WWTP

At the design capacity discharge flow of 0.0775 cfs, the TN WLA equates to 0.125 lbs/day per **Equation 7** (discharge concentration of 0.300 mg/l), and the TP WLA equates to 0.012 lbs/day per **Equation 8** (discharge concentration of 0.030 mg/l). When WWTP discharge flows are lower than the design flow, the maximum TN concentrations of 0.300 mg/l and the maximum TP concentration of 0.030 mg/l must be met to satisfy the **Equation 7** and **Equation 8** WLA conditions, resulting in lower WLAs. For example, at existing WWTP discharge flows of 0.041 cfs, the TN WLA equates to 0.066 lbs/day, and the TP WLA equates to 0.06 lbs/day. For all WWTP discharge flows, WWTP TN and TP loads will not cause or contribute to impairment as long as the discharge concentration is equal to or less than the TMDL target concentrations shown in **Equations 7** and **8**.

Mixing Zone Allowance

If water quality in Silver Bow Creek in the reach immediately upstream of the Rocker WWTP discharge location improves to the point where either the TP or TN water quality target or adopted numeric nutrient standard is met, then the TN and/or TP WLA may be modified as assimilative capacity has been created in the receiving water. This increase would be based on a mass-balance calculation that ensures that water quality standards and/or TMDL targets are met at the end of the mixing zone during July through September under 14Q5 flow conditions. For a given stream, 14Q5 refers to the 14 day low flow with a recurrence interval of 5 years.

A mixing zone would be calculated the same regardless of whether or not numeric nutrient standards are adopted into rule. The 75th percentile of the available upstream water quality data will be used to determine assimilative capacity of TN and TP.

Staged Implementation of Nutrient WLAs
The TMDL targets represent concentrations below the current limits of treatment technology for TN and TP. MPDES permits provides a regulatory mechanism for implementing the TMDL via the variance process, to address affordability issues and concerns about the limits of treatment technology. The variance (75-5-313 MCA) allows Montana to implement numeric nutrient criteria in a staged manner thus allowing time enough to address all point and nonpoint sources of nutrient pollution and allow for advancements in treatment technology and associated affordability.

The WLAs for TN and TP for the Rocker WWTP defined in this TMDL allows staged implementation consistent with the variance process. There are two staged implementation scenarios based on whether the variance process has been adopted at the time a MPDES permit is renewed:

Scenario 1: Numeric Nutrient Standards Adopted into Rule
When Rocker renews its MPDES permit for the WWTP, it can apply for a variance as part of a staged implementation approach for one or both nutrient WLAs. The variance will be implemented as defined within Montana State Law (75-5-313, MCA) and the rule as adopted.

Scenario 2: Numeric Nutrient Standards Not Adopted into Rule

- **Staged WLAs for TN (no numeric TN standard)**
  No action is necessary until the next permit renewal scheduled for 2018. The WLA for TN in the 2018 permit will be based on the WWTP discharge flow at that time multiplied by the lower of the two following concentrations: (1) the design performance at the facility or (2) the long-term DMR average TN concentration after the most recent upgrade(s). The WLA for TN in the 2023 permit will be based on the WWTP discharge flow at that time multiplied by the then current limit of technology for TN. Regarding future permit cycles starting in 2018, the TN limit of technology will be defined by DEQ in conjunction with the Nutrient Work Group. In 2023, if the plant is not capable of meeting the limit of technology for TN, then a specific plan to optimize TN treatment capabilities will be required for the 2023 permit renewal outlining specific measures and plant management protocols that will result in the lowest TN concentration feasible at the facility. This concentration will be the basis for calculating the TN WLA using the WWTP discharge flow in 2023. The process outlined here for the 2023 permit cycle will be applied for all subsequent permits.

  Staged implementation will no longer be necessary once (1) the WWTP is able to meet the WLA value defined by **Equation 7** (i.e., discharge concentrations less than or equal to 0.300 mg/l), or (2) Silver Bow Creek gains assimilative capacity and the WWTP meets the mixing zone allowance requirements for TN treatment (defined above).

- **Staged WLAs for TP (no numeric TP standard)**
  No action is necessary until the next permit renewal scheduled for 2018. The WLA for TP in the 2018 permit will be based on the WWTP discharge flow at that time multiplied by the lower of the two following concentrations: (1) the design performance at the facility or (2) the long-term DMR average TP concentration after the most recent upgrade(s). The WLA for TP in the 2023 permit will be based on the WWTP discharge flow at that time multiplied by the then current limit of technology for TP. Regarding future permit cycles starting in 2018, the TP limit of technology will be defined by DEQ in conjunction with the Nutrient Work Group. In 2023, if the plant is not capable of meeting the limit of technology for TP, then a specific plan to optimize TP treatment capabilities will be required for the 2023 permit renewal outlining specific measures

and plant management protocols that will result in the lowest TP concentration feasible at the facility. This concentration will be the basis for calculating the TP WLA using the WWTP discharge flow in 2023. The process outlined here for the 2023 permit cycle will be applied for all subsequent permits.

Staged implementation will no longer be necessary once (1) the WWTP is able to meet the WLA value defined by **Equation 8** (i.e. discharge concentrations less than or equal to 0.030 mg/l), or (2) Silver Bow Creek gains assimilative capacity and the WWTP meets the mixing zone allowance requirements for TP treatment (defined above).

Under Scenario 2, a timeline of how DEQ anticipates the staged implementation of the Rocker WWTP WLA to occur (**Figure 6-66**).

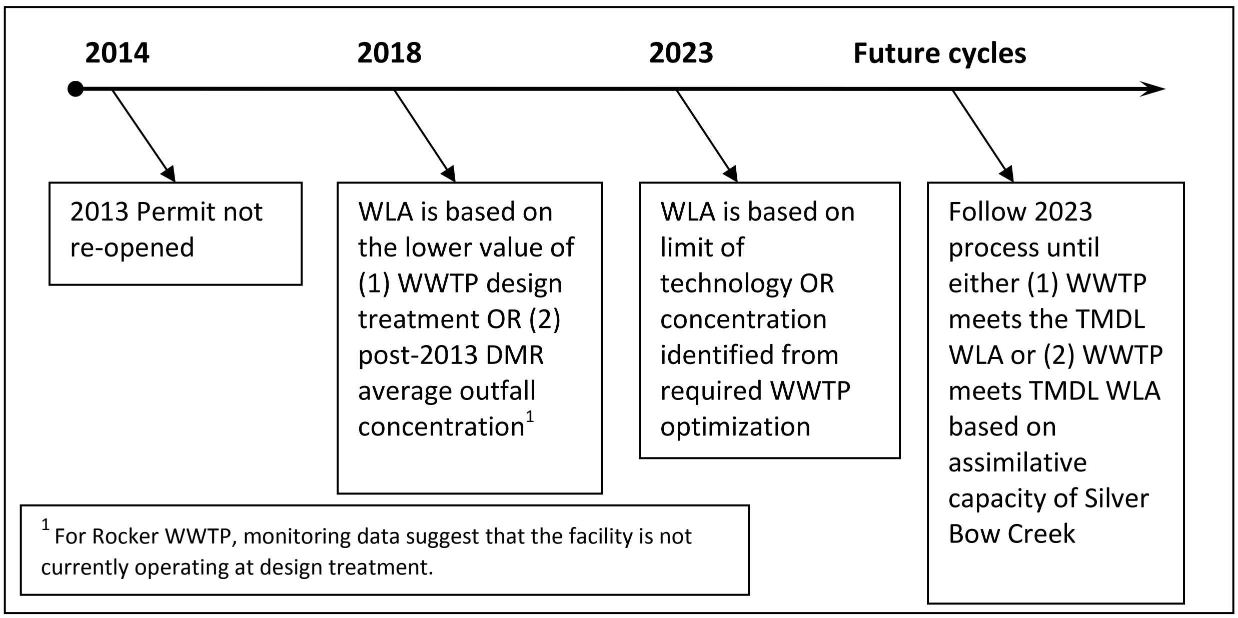

Figure 6-66. DEQ Anticipated Timeline of the Staged Implementation of the Rocker WWTP WLA

The Rocker WWTP permit was recently renewed in 2013, and the next renewal (after EPA approval of this TMDL) is scheduled for 2018. The existing permit does not need to be reopened before 2017 to integrate the WLAs defined in this document.

During staged implementation, the TN and TP WLAs can be alternatively expressed as concentrations (versus loads) so that a concentration-based approach can be used for MPDES permit development using the staged implementation provided above. If a concentration based approach is not used for MPDES permit integration, then the WLA should be based on the staged implementation concentrations multiplied by the WWTP discharge flow at that time (versus the design flow). This could create a loading cap until the next permit cycle when the WLA can be recalculated using an updated WWTP average discharge flow.

Nutrient Trading

Montana has developed a nutrient trading program to allow point source dischargers to use trading as a cost-effective method of achieving the state's numeric criteria for nutrients. Trading is a market-based approach in which a point source permittee purchases pollutant reduction credits from another point source or a nonpoint source in the applicable trading region. These credits are used to offset the source's pollutant discharge obligations. Nothing in this TMDL document prevents nutrient trading as long as it is consistent with Montana's nutrient trading program. The nutrient trading policy is outlined in department circular DEQ-13 (Montana Department of Environmental Quality, 2012a).

Montana Livestock Auction (MTG010166)
The Montana Livestock Auction operates under a CAFO General Permit. Given the discharge history at MTG010166, the estimated existing load from the facility to Silver Bow Creek is 0.0 lbs TN/day and 0.0 lbs TP/day.

Compliance with the CAFO General Permit, and the associated DEQ approved AR2 constitute the meeting of all TMDL requirements for nutrients for this facility. Under the conditions of the permits, all pollutants are to be contained on site during any and all storm events less than a 25-year, 24 hour rain event. Therefore the TMDL is 0 lbs/day for TN and TP for this source, under typical rainfall events (less than 25-year storm event). For any rainfall events equivalent to a 25-year, 24 hour duration or greater, full compliance with permit requirements assumes the pollutant load that may enter the receiving waterbody is acceptable. Given the nature of DEQ's nutrient assessment methodology, these rare conditions of elevated nutrient loading would not cause or contribute to impairment conditions in the receiving stream.

Renewable Energy Corporation Advanced Silicon Materials (MT0030350)
At permitted Outfall 001, REC Advanced Silicon Materials discharges to Sheep Gulch which empties into Silver Bow Creek. Permitted Outfall 003, for which no infrastructure has been completed and which is not used, will follow the same WLA approach outlined below for Outfall 001 should it ever be used to discharge effluent to Silver Bow Creek.

Silver Bow Creek is impaired for TN and TP. Per Montana State Law (ARM 17.30.637(2)), no wastes may be discharged such that the wastes, either alone or in combination with other wastes, will violate, or can reasonably be expected to violate, any of the standards. For permitted dischargers, this requirement is satisfied when the discharge concentration is less than or equal to an applicable numeric water quality standard if the reach immediately upstream where the discharge occurs is already exceeding the standard. If the reach immediately upstream of the Sheep Gulch confluence is determined to be unimpaired for TN and/or TP, the WLA will be modified based on a mass-balance approach if there is sufficient assimilative capacity in the receiving water.

The TMDL target values provide a numeric translation of the applicable narrative standard found in ARM 17.30.637(1)(e). The draft numeric nutrient criteria provide the basis for the TMDL targets (**Section 6.4.2**). The reach of Silver Bow Creek immediately upstream of the Sheep Gulch confluence is impaired for both TN and TP based on application of the TMDL targets and instream water chemistry data. To ensure the REC discharge does not cause or contribute to a violation of water quality standards, the WLA is based on a discharge concentration equal to the nutrient target concentrations for both TN and TP multiplied by the REC discharge flow. Therefore, the resulting nutrient WLAs are based on the following equations:

Equation 7: TN WLA = TMDL TN Target Concentration X Discharge Flow = (0.300 mg/l) (Discharge Flow) x Conversion Factor

Equation 8: TP WLA = TMDL TP Target Concentration X Discharge Flow = (0.030 mg/l) (Discharge Flow) x Conversion Factor

For both **Equations 7** and **8**, the target concentrations are lower than current limits of technology for treatment of wastewater effluent. Therefore, a staged approach for WLA implementation is developed below.

The WLAs for TN and TP are represented in **Figure 6-67**, which identifies the allowable load to Silver Bow Creek based on the discharge rate from REC. For reference, the summer period long-term mean discharge from REC is 1.35 cfs (0.87 mgd).

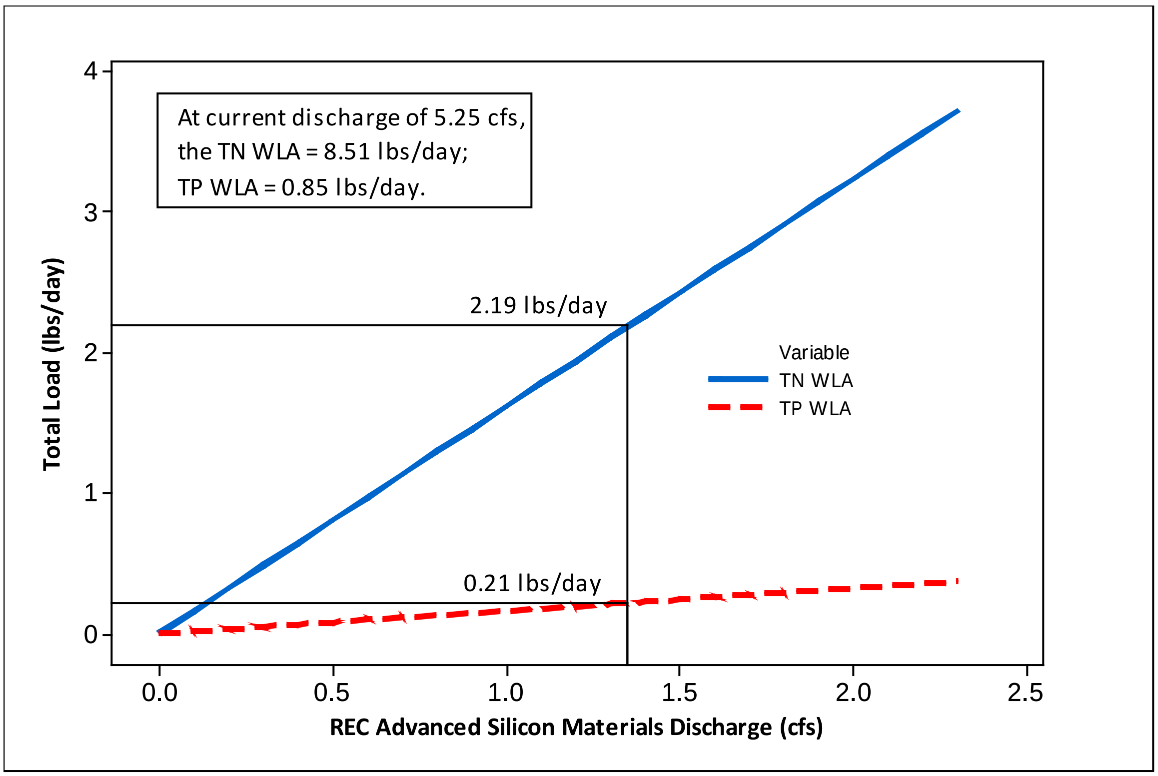

Figure 6-67. WLA for TN and TP for REC Advanced Silicon Materials Outfall 001

At the estimated mean discharge of 1.35 cfs from Outfall 001, the TN WLA equates to 2.19 lbs/day per **Equation 7** (discharge concentration of 0.300 mg/l), and the TP WLA equates to 0.219 lbs/day per **Equation 8** (discharge concentration of 0.030 mg/l). At all REC discharge flows, the maximum TN concentrations of 0.300 mg/l and the maximum TP concentration of 0.030 mg/l must be met to satisfy the **Equation 7** and **Equation 8** WLA conditions. For all REC discharge flows, REC TN and TP loads will not cause or contribute to impairment as long as the discharge concentration is equal to or less than the TMDL target concentrations shown in **Equations 7** and **8**.

Mixing Zone Allowance

If water quality in Silver Bow Creek in the reach immediately upstream of the Sheep Gulch confluence discharge location improves to the point where either the TP or TN water quality target or adopted numeric nutrient standard is met, then the TN and/or TP WLA may be modified as assimilative capacity has been created in the receiving water. This increase would be based on a mass-balance calculation that ensures that water quality standards and/or TMDL targets are met at the end of the mixing zone during July through September under 14Q5 flow conditions. For a given stream, 14Q5 refers to the 14 day low flow with a recurrence interval of 5 years.

A mixing zone would be calculated the same regardless of whether or not numeric nutrient standards are adopted into rule. The 75th percentile of the available upstream water quality data will be used to determine assimilative capacity of TN and TP.

Staged Implementation of Nutrient WLAs
The TMDL targets represent concentrations below the current limits of treatment technology for TN and TP. MPDES permits provides a regulatory mechanism for implementing the TMDL via the variance process, to address affordability issues and concerns about the limits of treatment technology. The variance (75-5-313 MCA) allows Montana to implement numeric nutrient criteria in a staged manner thus allowing time enough to address all point and nonpoint sources of nutrient pollution and allow for advancements in treatment technology and associated affordability.

The WLAs for TN and TP for REC Advanced Silicon Materials at Outfall 001 defined in this TMDL allows staged implementation consistent with the variance process. There are two staged implementation scenarios based on whether the variance process has been adopted at the time a MPDES permit is renewed:

<u>Scenario 1: Numeric Nutrient Standards Adopted into Rule</u>
When REC Advanced Silicon Materials renews its MPDES permit for Outfall 001, it can apply for a variance as part of a staged implementation approach for one or both nutrient WLAs. The variance will be implemented as defined within Montana State Law (75-5-313, MCA) and the rule as adopted.

<u>Scenario 2: Numeric Nutrient Standards Not Adopted into Rule</u>

- **Staged WLAs for TN (no numeric TN standard)**
  No action is necessary until the next permit renewal scheduled for 2015. The WLA for TN in the 2015 permit will be based on the WWTP discharge flow at that time multiplied by the lower of the two following concentrations: (1) the design performance at the facility or (2) the long-term DMR average TN concentration after the most recent upgrade(s). The WLA for TN in the 2020 permit will be based on the WWTP discharge flow at that time multiplied by the then current limit of technology for TN. Regarding future permit cycles starting in 2015, the TN limit of technology will be defined by DEQ in conjunction with the Nutrient Work Group. In 2020, if the plant is not capable of meeting the limit of technology for TN, then a specific plan to optimize TN treatment capabilities will be required for the 2020 permit renewal outlining specific measures and plant management protocols that will result in the lowest TN concentration feasible at the facility. This concentration will be the basis for calculating the TN WLA using the WWTP discharge flow in 2020. The process outlined here for the 2020 permit cycle will be applied for all subsequent permits.

  Staged implementation will no longer be necessary once (1) the WWTP is able to meet the WLA value defined by **Equation 7** (i.e., discharge concentrations less than or equal to 0.300 mg/l), or (2) Silver Bow Creek gains assimilative capacity and the WWTP meets the mixing zone allowance requirements for TN treatment (defined above).

- **Staged WLAs for TP (no numeric TP standard)**
  No action is necessary until the next permit renewal scheduled for 2015. The WLA for TP in the 2015 permit will be based on the WWTP discharge flow at that time multiplied by the lower of the two following concentrations: (1) the design performance at the facility or (2) the long-term DMR average TP concentration after the most recent upgrade(s). The WLA for TP in the 2020 permit will be based on the WWTP discharge flow at that time multiplied by the then current limit of technology for TP. Regarding future permit cycles starting in 2015, the TP limit of technology will be defined by DEQ in conjunction with the Nutrient Work Group. In 2020, if the plant is not capable of meeting the limit of technology for TP, then a specific plan to optimize TP treatment capabilities will be required for the 2020 permit renewal outlining specific measures and plant management protocols that will result in the lowest TP concentration feasible at the facility. This concentration will be the basis for calculating the TP WLA using the WWTP discharge flow in 2022. The process outlined here for the 2020 permit cycle will be applied for all subsequent permits.

  Staged implementation will no longer be necessary once (1) the WWTP is able to meet the WLA value defined by **Equation 8** (i.e., discharge concentrations less than or equal to 0.030 mg/l), or (2) Silver Bow Creek gains assimilative capacity and the WWTP meets the mixing zone allowance requirements for TP treatment (defined above).

Under Scenario 2, a timeline of how DEQ anticipates the staged implementation of the REC Advanced Silicon Materials WLA to occur (**Figure 6-68**).

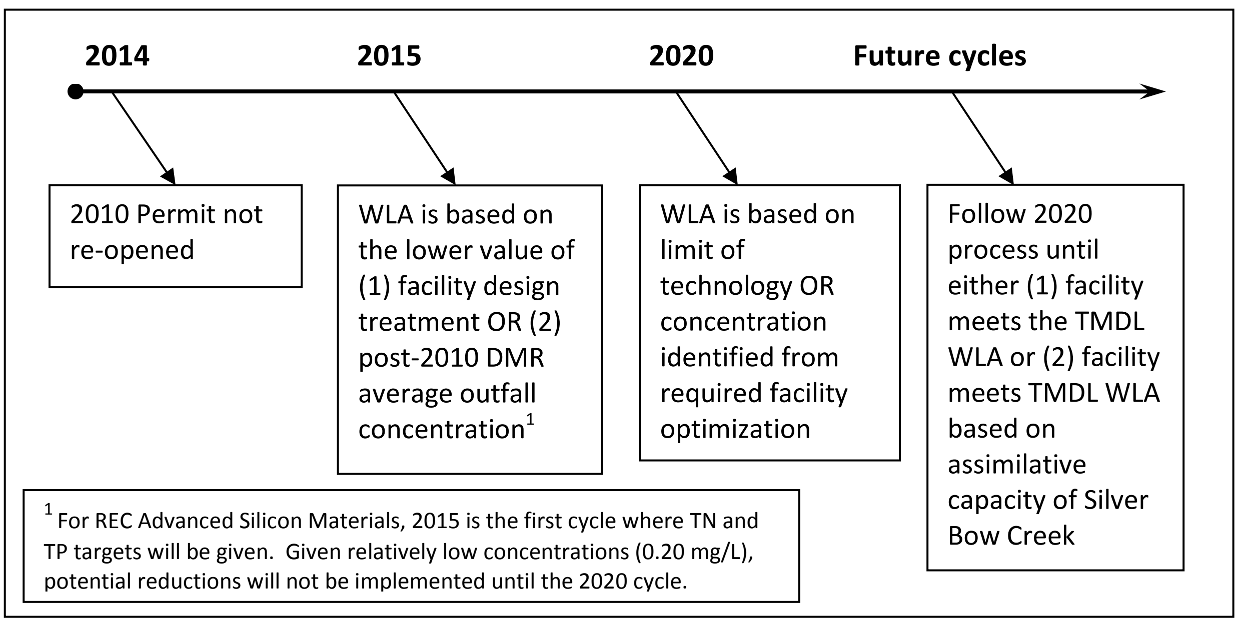

Figure 6-68. DEQ Anticipated Timeline of the Staged Implementation of the REC Advanced Silicon Materials WLA

The REC Advanced Silicon Materials permit was recently renewed in 2010, and the next renewal (after EPA approval of this TMDL) is scheduled for 2015. The existing permit does not need to be reopened before 2015 to integrate the WLAs defined in this document.

During staged implementation, the TN and TP WLAs can be alternatively expressed as concentrations (versus loads) so that a concentration-based approach can be used for MPDES permit development using the staged implementation provided above. If a concentration based approach is not used for MPDES permit integration, then the WLA should be based on the staged implementation concentrations multiplied by the facility discharge flow at that time (versus the design flow). This could create a loading cap until the next permit cycle when the WLA can be recalculated using an updated facility average discharge flow.

Nutrient Trading

Montana has developed a nutrient trading program to allow point source dischargers to use trading as a cost-effective method of achieving the state's numeric criteria for nutrients. Trading is a market-based approach in which a point source permittee purchases pollutant reduction credits from another point source or a nonpoint source in the applicable trading region. These credits are used to offset the source's pollutant discharge obligations. Nothing in this TMDL document prevents nutrient trading as long as it is consistent with Montana's nutrient trading program. The nutrient trading policy is outlined in department circular DEQ-13 (Montana Department of Environmental Quality, 2012a).

Permitted Outfall 002

As covered under the permit, Outfall 002 is a stormwater discharge which requires the permittee to develop and implement a SWPPP. The purpose of the SWPPP is to identify sources of pollution to storm water and to select BMPs to eliminate or minimize pollutant discharges at the source and/or to remove pollutants contained in the storm water runoff. The facility must implement the provisions of the SWPPP required under this part as a condition of the permit. This applies to stormwater generated from precipitation that is both commingled and independent of process wastewater generated by the facility prior to the regulated point source discharge. The stormwater system is given a WLA of 0 lbs/day TN and TP when not active. It is assumed that following the stormwater permit requirements including the SWPPP will not result in nutrient impairing the receiving waterbodies.

Superfund Sites Regulated Under CERCLA

<u>CERCLA discharge from Montana Pole and Treating Plant</u>

As stated in **Section 6.5.1.2**, the likely source of nitrates in the groundwater for MPTP is the former Lavelle Powder explosive factory that is upgradient of the MPTP site. The former Lavelle Powder explosives factory is not part of the MPTP site. Nitrate was not identified as a contaminant of concern for MPTP, and a source of nitrates has not been identified at the MPTP site. The MPTP site does not add any additional nitrates to the pumped groundwater before discharging to Silver Bow Creek. Upon completion of the CERCLA remedy, the discharge from the MPTP site to Silver Bow Creek will end.

The CERCLA discharge from MPTP to Silver Bow Creek does not fall under MPDES requirements. Therefore, although a WLA will be assigned the MPTP discharge, there is currently no permitting mechanism by which to enforce the WLA. Nevertheless, the same approach used to develop WLAs for MPDES permitted discharges is also used for this CERCLA discharge.

To ensure the MPTP discharge does not cause or contribute to an impairment of water quality standards, the WLA is based on a discharge concentration equal to the nutrient target concentrations for both TN and TP multiplied by the MPTP discharge flow. Therefore, the resulting nutrient WLAs are based on the following equations:

Equation 7: TN WLA = TMDL TN Target Concentration X Discharge Flow = (0.300 mg/l) (Discharge Flow) x Conversion Factor

Equation 8: TP WLA = TMDL TP Target Concentration X Discharge Flow = (0.030 mg/l) (Discharge Flow) x Conversion Factor

For the MPTP discharge, the maximum TN concentrations of 0.300 mg/l and the maximum TP concentration of 0.030 mg/l would have to be met to satisfy the **Equation 7** and **Equation 8** WLA conditions. For example, at the anticipated long-term average discharge flow of 0.72 cfs, the TN WLA equates to 1.16 lbs/day, and the TP WLA equates to 0.11 lbs/day. For all MPTP discharge flows, MPTP TN and TP loads will not cause or contribute to impairment as long as the discharge concentration is equal to or less than the TMDL target concentrations shown in **Equation 7** and **Equation 8**. Because the discharge from MPTP will end once the final remedy is completed, this source of nitrogen to Silver Bow Creek (which is from a source upgradient of the MPTP), will be addressed.

CERCLA discharge from Lower Area One (unpermitted)

For LAO, the likely sources of nitrates are from septic effluent and leaking storm and sanitary sewer lines. Additionally, seepage from the Ranchland Packing storage ponds may be entering the LAO ponds system although Ranchland Packing was included in the Summit valley/Blacktail Creek LA. Further, the former Lavelle Powder explosives factory is upgradient of the LAO capture system, and may be contributing nitrates to LAO. Nitrates were not identified as a contaminant of concern at BPSOU, and a source of nitrates has not been identified as part of BPSOU. LAO does not add any additional sources of nitrogen to the Butte Treatment Lagoon before discharging to Silver Bow Creek.

Although water quality data does not suggest that the LAO discharge is discharging at concentrations greater than the target concentration of 0.03 mg/L TP, as the LAO is a point source to Silver Bow Creek, a WLA was developed and is outlined here.

The CERCLA discharge from LAO to Silver Bow Creek does not fall under MPDES requirements. Therefore, although a WLA will be assigned the LAO discharge, there is currently no permitting mechanism by which to enforce the WLA. Nevertheless, the same approach used to develop WLAs for MPDES permitted discharges is also used for this CERCLA discharge.

To ensure the LAO discharge does not cause or contribute to a violation of water quality standards, the WLA is based on a discharge concentration equal to the nutrient target concentrations for both TN and TP multiplied by the LAO discharge flow. Therefore, the resulting nutrient WLAs are based on the following equations:

Equation 7: TN WLA = TMDL TN Target Concentration X Discharge Flow = (0.300 mg/l) (Discharge Flow) x Conversion Factor

Equation 8: TP WLA = TMDL TP Target Concentration X Discharge Flow = (0.030 mg/l) (Discharge Flow) x Conversion Factor

For the LAO discharge, the maximum TN concentrations of 0.300 mg/l and the maximum TP concentration of 0.030 mg/l would have to be met to satisfy the **Equation 7** and **Equation 8** WLA conditions. For example, at the existing LAO discharge flows of 2.52 cfs, the TN WLA equates to 4.08 lbs/day, and the TP WLA equates to 0.40 lbs/day. For all LAO discharge flows, LAO TN and TP loads will not cause or contribute to impairment as long as the discharge concentration is equal to or less than the TMDL target concentrations shown in **Equation 7** and **Equation 8**.

6.6.9.5 TN TMDL, Allocations, and Current Loading

The TMDL for TN is based on the estimated mean existing loads from the identified point sources and sub-watershed outlets reported in **Section 6.5.1.2** and **Section 6.6.9.2**. All reductions are based on meeting the in-stream target concentration of 0.300 mg/L TN (**Table 6-66**).

The TMDL for TN is based on **Equation 1** and the TMDL allocations are based on **Equation 3**. The value of the TN TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TN TMDL for Silver Bow Creek uses **Equation 1** with the median measured flow from all sites during 2007–12 sampling (102.77 cfs):

***Equation 1*: *TMDL* = (0.300 mg/L) (102.77 cfs) (5.4) = 166.49 lbs/day**

Equation 4 is the basis for the natural background LA for TN. To continue with the example at a flow of 102.77 cfs, this allocation is as follows:

***Equation 4*: LA_{NB} = (0.095 mg/L) (102.77 cfs) (5.4) = 52.72 lbs/day**

As the natural background load was calculated using **Equation 4**, loads in **Table 6-66** will not reflect the estimated loads identified in **Sections 6.5.1.2** or **6.6.9.2** as those estimates included the natural background load.

Using a form of **Equation 5**, the combined human-caused TN LA to all point (WLA) and nonpoint sources (LA) at 102.77 cfs can be calculated:

***Equation 5*: LA_H + *WLAs* = 166.49 lbs/day – 52.72 lbs/day = 113.77 lbs/day**

An example total existing load is calculated as follows using **Equation 6**, the weighted average TN concentration from estimated loads to Silver Bow Creek via nonpoint and point sources from 2007 to 2012 (1.64 mg/L) and the mean cumulative flow from all inputs of 102.77 cfs:

***Equation 6*: *Total Existing Load* = (1.64mg/L[3]) (102.77 cfs) (5.4) = 911.49 lbs/day**

The portion of the existing load attributed to human sources is 857.41 lbs/day, which is determined by subtracting out the 52.72 lbs/day background load from the existing load. This 857.41 lbs/day value represents the load measured within the mainstem of Silver Bow Creek and represents a cumulative loading to the stream.

Table 6-66 contains the results for the example TN TMDL, LAs (based on **Equation 3**), and current loading. In addition, it contains an example percent reductions required to meet the water quality target for TN. The percent reduction to natural background is assumed to be 0%. At the estimated average growing season flow of 102.77 cfs and the weighted average TN value, the current loading in Silver Bow Creek is greater than the TMDL. Under these example conditions, the TN load needs to be reduced 82%

[3] The weighted mean TN concentration is 1.642434 mg/L after compiling all flows and sources; for simplicity 1.64 mg/L is used in the document.

overall and human-caused loading from point and nonpoint sources needs to be reduced from 0.0% (German Gulch) to 98.9% (Rocker WWTP) in order to achieve the TN TMDL. The source assessment for the Silver Bow Creek watershed indicates WWTP surface water discharges are the most significant source of TN.

The WLAs provided in **Table 6-66** are based on the details provided within **Section 6.5.1.2**. These WLAs remain relatively consistent with varying summer growing season flows in Silver Bow Creek, and instead will vary more as a function of the point source discharge flow multiplied by the TN target concentration (0.30 mg/L). The exceptions to this are the two non-discharge related WLAs (BSB MS4 and Montana Livestock Auction) which have WLAs of 0 lbs/day TN. As stormwater systems, these point sources should not be activated during normal baseflow conditions.

The LAs within **Table 6-66** are based on the tributary or contributing area input flows multiplied by the TN target concentration (0.30 mg/L), proportionally reduced based on the estimated natural background concentration as discussed above. As flows in Silver Bow Creek increase, the TN TMDL will increase and in most situations this will include increased inputs from tributaries and other areas defined below. Under these conditions, most LAs will also increase in a manner where all the LAs and WLAs will add together to equal the Silver Bow Creek TN TMDL under all summer growing season flow conditions.

Table 6-66. Silver Bow Creek TN Example TMDL, LAs, Current Loading, and Reductions

Allocation Type	Source Category	Allocation and TMDL (lbs/day)[a]	Existing Load (lbs/day)[a]	Percent Reduction
WLA	BSB MS4	0.00	0.00	0.0%b
LA	Blacktail Creek - Summit Valley groundwater	16.41	76.43	78.5%
WLA	Montana Resources	0.00c	0.00	0.0%
WLA	MPTP discharge	0.80	27.94	97.1%
WLA	LAO discharge	2.79	10.55	73.5%
WLA	BSB WWTP	5.81	481.24	98.8%
WLA	Rocker WWTP	0.05	3.96	98.9%
LA	Sand Creek (tributary)	1.96	53.76	96.4%
WLA	Montana Livestock Auction	0.00	0.00	0.0%
WLA	REC (via Sheep Gulch)	1.49	1.49	0.0%
LA	Browns Gulch (tributary)	7.03	102.70	93.2%
LA	German Gulch (tributary)	10.99	0.00	0.0%
LA	Gregson Creek (tributary)	6.97	57.66	87.9%
LA	Other SBC catchments	3.32	3.32	0.0%
LA	Mill-Willow Bypass	56.15	39.71	0.0%
LA	Natural background	52.72	52.72	0.0%
		TMDL = 166.49	**Total = 911.49**	**82%**

[a] Based on a mean growing season inflow to Silver Bow Creek of 102.77 cfs
[b] Does include a 33% reduction in TN loads during storm events during the summer period (July 1 – September 30)
[c] The WLA for Montana Resources will be determined based on flow rate from the facility and the TN target concentration (0.300 mg/L TN) should the facility ever begin discharging to Silver Bow Creek via the MSD; as no discharge estimate is was available, the WLA is presented as 0.00 here

The TN TMDL for Silver Bow Creek addresses the existing NO_3+NO_2 impairment (**Table 6-26**).

6.6.9.6 TP TMDL, Allocations, and Current Loading

The TMDL for TP is based on the estimated mean existing loads from the identified point sources and sub-watershed outlets reported in **Section 6.5.1.2** and **Section 6.6.9.2**. All reductions are based on meeting the in-stream target concentration of 0.030 mg/L TN (**Table 6-67**).

The TMDL for TP is based on **Equation 1** and the TMDL allocations are based on **Equation 3**. The value of the TP TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TP TMDL for Silver Bow Creek uses **Equation 1** with the median measured flow from all sites during 2007–12 sampling (102.77 cfs):

***Equation 1*: *TMDL* = (0.030 mg/L) (102.77 cfs) (5.4) = 16.65 lbs/day**

Equation 4 is the basis for the natural background LA for TP. To continue with the example at a flow of 102.77 cfs, this allocation is as follows:

***Equation 4*: LA_{NB} = (0.01 mg/L) (102.77 cfs) (5.4) = 5.55 lbs/day**

Using a form of **Equation 5**, the combined human-caused TP LA to all point (WLA) and nonpoint sources (LA) at 102.77 cfs can be calculated:

***Equation 5*: LA_{H} + *WLAs* = 16.65 lbs/day – 5.55 lbs/day = 11.10 lbs/day**

As the natural background load was calculated using **Equation 4**, loads in **Table 6-67** will not reflect the estimated loads identified in **Sections 6.5.1.2** or **6.6.9.2** as those estimates included the natural background load.

An example total existing load is calculated as follows using **Equation 6**, the weighted average TP concentration from estimated loads to Silver Bow Creek via nonpoint and point sources from 2007 to 2012 (0.15 mg/L) and the mean cumulative flow from all inputs of 102.77 cfs:

***Equation 6*: *Total Existing Load* = (0.15 mg/L[4]) (102.77 cfs) (5.4) = 82.66 lbs/day**

The portion of the existing load attributed to human sources is 77.11 lbs/day, which is determined by subtracting out the 5.55 lbs/day background load from the existing load. This 77.11 lbs/day value represents the load measured within the mainstem of Silver Bow Creek and represents a cumulative loading to the stream.

Table 6-67 contains the results for the example TP TMDL, LAs (based on **Equation 3**), and current loading. In addition, it contains an example percent reductions required to meet the water quality target for TP. The percent reduction to natural background is assumed to be 0%. At the median growing season flow of 102.77 cfs and the weighted average TP value, the current loading in Silver Bow Creek is greater than the TMDL. Under these example conditions, the TP load needs to be reduced 80% overall and human-caused loading from point and nonpoint sources needs to be reduced from 0.0% (German Gulch) to 99.9% (Rocker WWTP) in order to achieve the TP TMDL. The source assessment for the Silver Bow Creek watershed indicates WWTP surface water discharges are the most significant source of TP.

[4] The weighted mean TP concentration is 0.148952 mg/L after compiling all flows and sources; for simplicity 0.15 mg/L is used in the document.

The WLAs provided in **Table 6-67** are based on the details provided within **Section 6.5.1.2**. These WLAs remain relatively consistent with varying summer growing season flows in Silver Bow Creek, and instead will vary more as a function of the point source discharge flow multiplied by the TP target concentration (0.03 mg/L). The exceptions to this are the two non-discharge related WLAs (BSB MS4 and Montana Livestock Auction) which have WLAs of 0 lbs/day TP. As stormwater systems, these point sources should not be activated during normal baseflow conditions.

The LAs within **Table 6-67** are based on the tributary or contributing area input flows multiplied by the TP target concentration (0.03 mg/L), proportionally reduced based on the estimated natural background concentration as discussed above. As flows in Silver Bow Creek increase, the TP TMDL will increase and in most situations this will include increased inputs from tributaries and other areas defined below. Under these conditions, most LAs will also increase in a manner where all the LAs and WLAs will add together to equal the Silver Bow Creek TP TMDL under all summer growing season flow conditions.

Table 6-67. Silver Bow Creek Example TP TMDL, LAs, Current Loading, and Reductions

Allocation Type	Source Category	Allocation and TMDL (lbs/day)[a]	Existing Load (lbs/day)[a]	Percent Reduction
WLA	BSB MS4	0	0	0.0% b
LA	Blacktail Creek - Summit Valley groundwater	1.60	5.20	69.2%
WLA	Montana Resources	0.00c	0.00	0.0%
WLA	MPTP discharge	0.08	0.00	0.0%
WLA	LAO discharge	0.27	0.00	0.0%
WLA	BSB WWTP	0.57	46.49	98.8%
WLA	Rocker WWTP	0.004	3.08	99.9%
LA	Sand Creek (tributary)	0.19	5.83	96.7%
WLA	Montana Livestock Auction	0.00	0.00	0.0%
WLA	REC (via Sheep Gulch)	0.15	1.39	89.5%
LA	Browns Gulch (tributary)	0.69	10.63	93.5%
LA	German Gulch (tributary)	1.07	1.02	0.0%
LA	Gregson Creek (tributary)	0.68	0.68	0.0%
LA	Other SBC catchments	0.32	0.32	0.0%
LA	Mill-Willow Bypass	5.48	2.46	0.0%
LA	Natural background	5.55	5.55	0.0%
		TMDL = 16.65	**Total = 82.66**	**80%**

[a] Based on a mean growing season inflow to Silver Bow Creek of 102.77 cfs
[b] Does include a 50% reduction in TP loads during storm events during the summer period (July 1 – September 30)
[c] The WLA for Montana Resources will be determined based on flow rate from the facility and the TP target concentration (0.030 mg/L TP) should the facility ever begin discharging to Silver Bow Creek via the MSD; as no discharge estimate is was available, the WLA is presented as 0.00 here

6.6.10 Willow Creek, upper (MT76G002_061)

6.6.10.1 Assessment of Water Quality Results

The source assessment for upper Willow Creek consists of an evaluation of TP concentrations and exceedances of chl-*a* and/or AFDM within the upper segment of Willow Creek. This is followed by the quantification of the most significant human caused sources of nutrients. Willow Creek is divided into an upper and lower segment as demarked by T4N R10W S30. **Figure 6-69** presents the approximate locations of data pertinent to the source assessment for Willow Creek upstream of T4N R10W S30. It should be noted that a sediment TMDL for upper Willow Creek was completed in 2010 (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2010).

FWP lists the most downstream ¾ mile of the upper Willow Creek AU as being chronically dewatered (dewatering is a significant issue in most years).

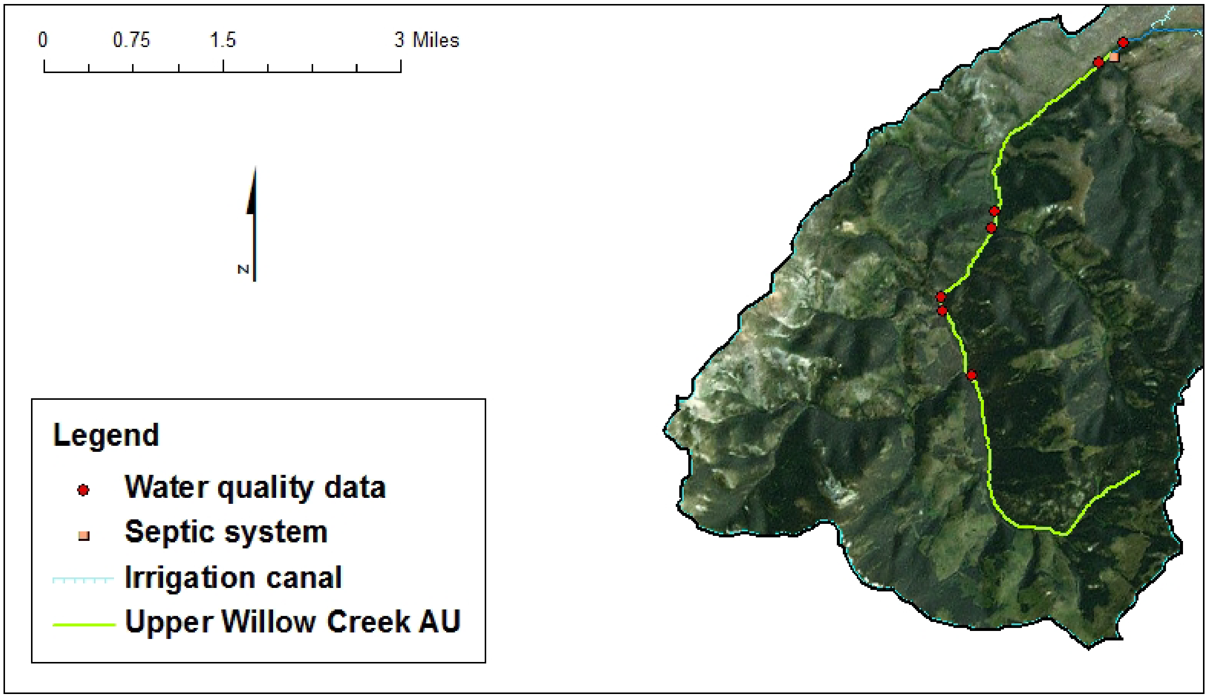

Figure 6-69. Upper Portion of Willow Creek Sub-Watershed with Water Quality Sampling Locations

Total Phosphorus
DEQ collected water quality samples for TP from Willow Creek upstream of T4N R10W S30 during the growing season over the 2004–11 time period (**Section 6.4.3.10**, **Table 6-24**). However for this source assessment, the single sample collected in 2004 was excluded. From 2007 to 2011, out of 19 samples collected from upper Willow Creek, 18 exceeded the TP target concentration (0.030 mg/L). **Figure 6-70** presents summary statistics for TP concentrations at sampling sites in Willow Creek upstream of T4N R10W S30. TP concentrations were in excess of the target at the upper most sample location and rose steadily through the segment. The limited data suggest that there may have been TP loading from the Elk Creek tributary and probable dilution from the Long Canyon Creek tributary.

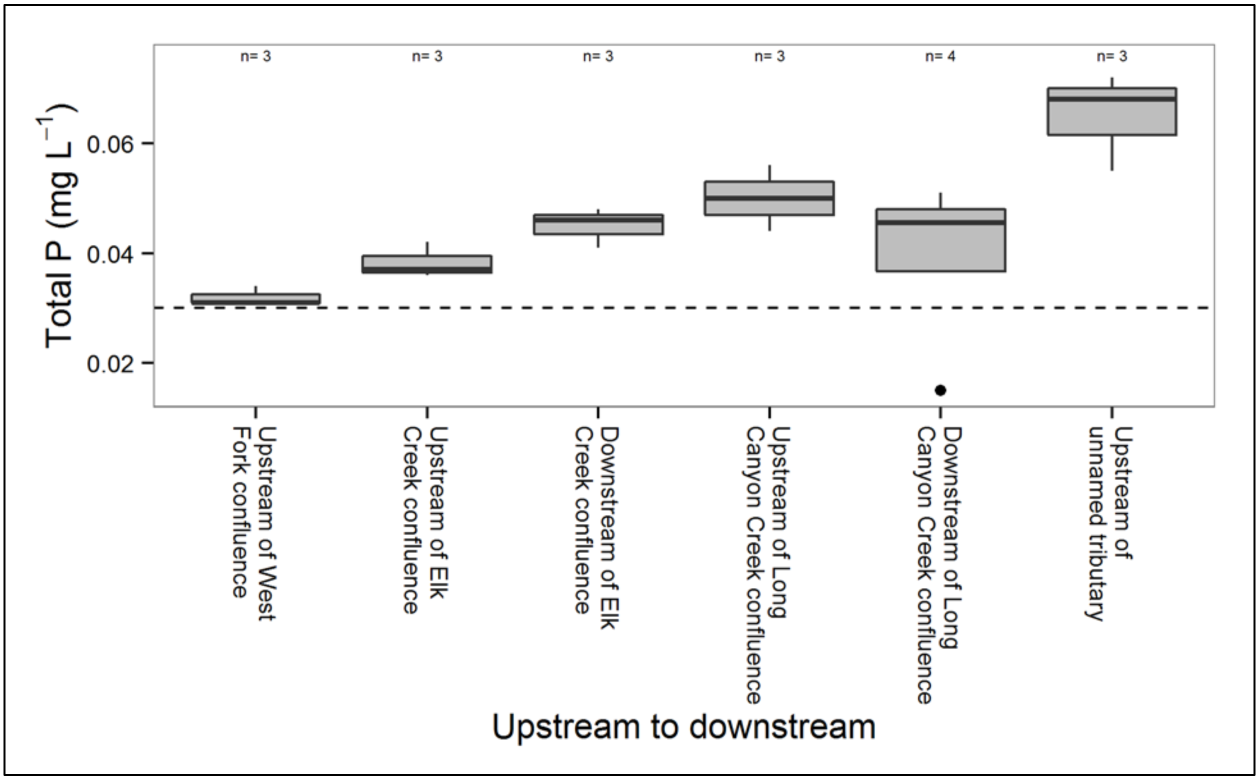

Figure 6-70. TP Target Exceedance Ratio in Upper Willow Creek (2010–11) (Dashed Line Is Target)

In **Figure 6-71**, sample data from the AU was plotted as a ratio to the TP target. Exceedances of the TP target occurred at a variety of flows from 1 cfs to 10 cfs. The only sample that was less than the target concentration occurred at the highest recorded flow in the dataset (12.5 cfs). Exceedances of the target concentration were observed in samples collected near the headwaters all the way downstream to T4N R10W S30. TP exceedances were as high as >2 times the target concentration.

Exceedances of the TP target are plotted in **Figure 6-72**. TP load reductions necessary to achieve the TMDL range from 3% to 58% with a median reduction of 33%.

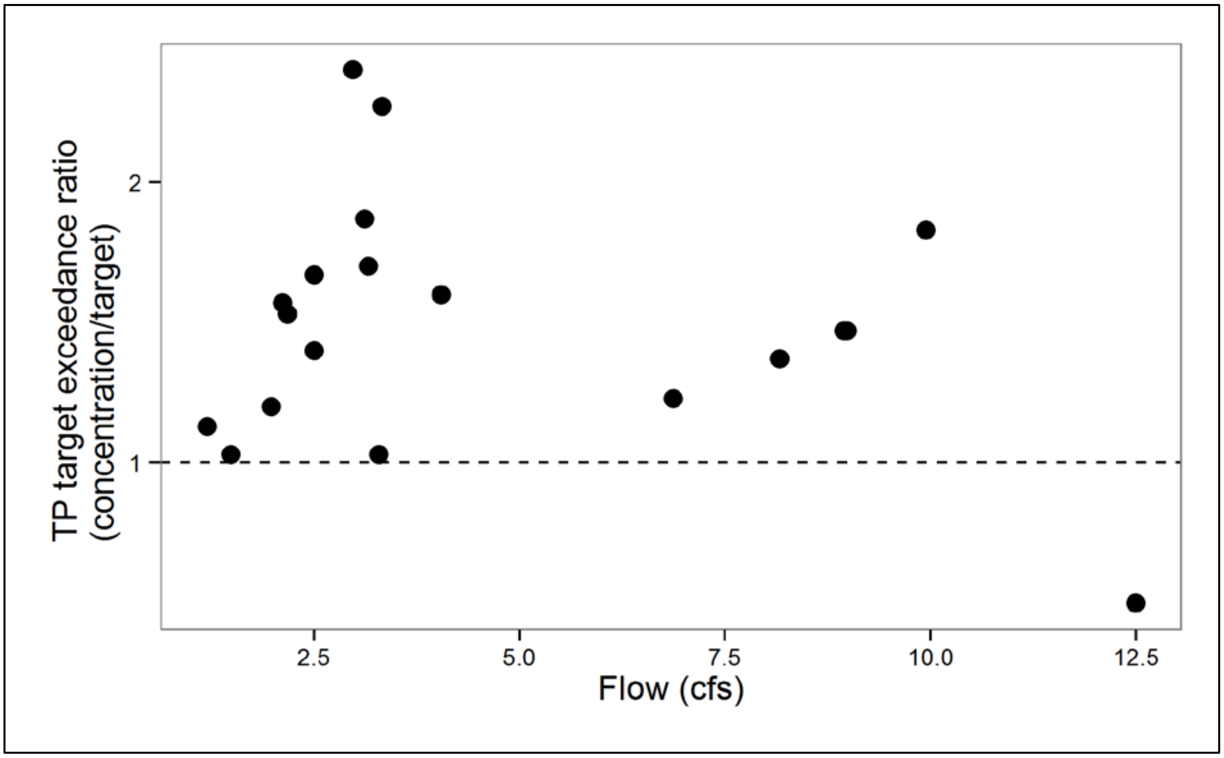

Figure 6-71. TP Target Exceedance Ratio in Upper Willow Creek (2010–11) (>1 Indicates Exceedance)

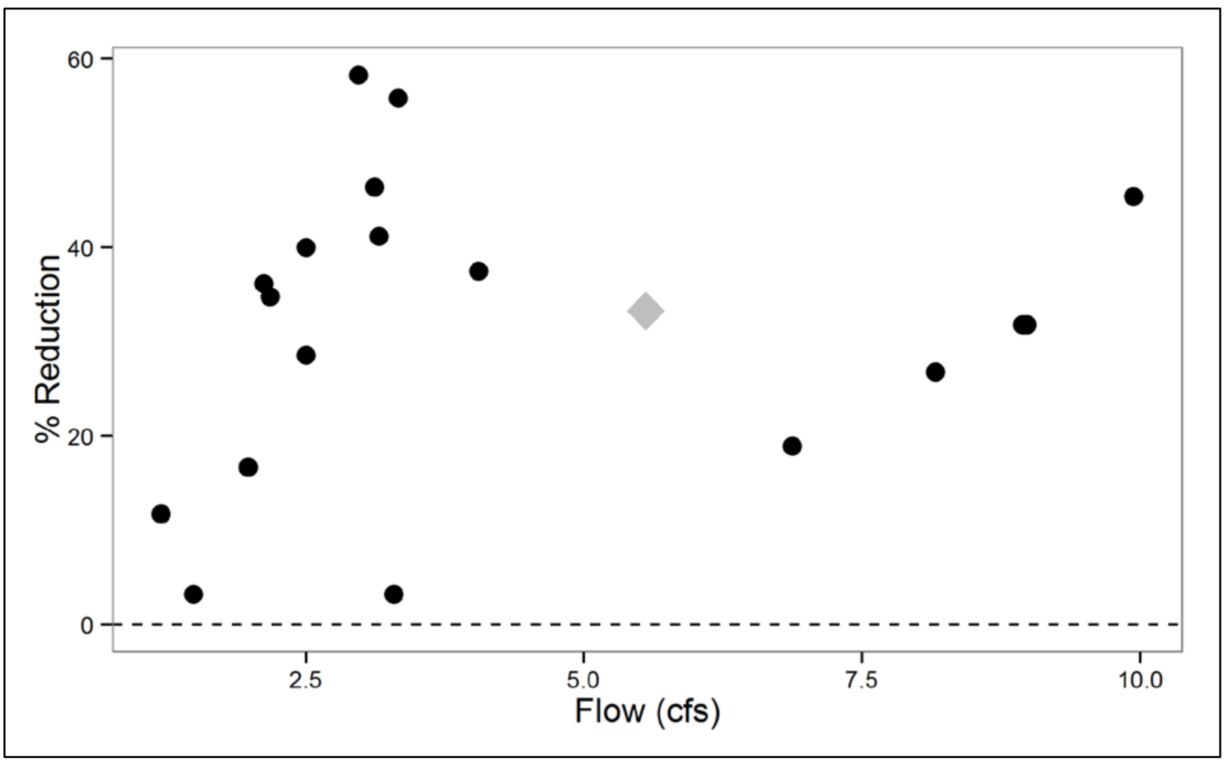

Figure 6-72. Scatterplot of Mainstem Observations and Respective Percent Reductions Necessary to Achieve the TP TMDL in Upper Willow Creek (the Gray Diamond Is the Median (50th percentile) Observation of Samples that Exceeded the TP TMDL (2010–11))

6.6.10.2 Assessment of Loading by Source Categories

Concerning algal growth*,* there was a single AFDM exceedance immediately downstream of the Elk Creek confluence in 2010.

The upper portion of Willow Creek has an interesting history. Originally owned by the Anaconda Company, the watershed was logged for mining industry needs in the 20th Century before being sold to The Nature Conservancy (TNC) when the Anaconda Company was being dissolved. TNC sold the land to the State of Montana but the transaction was paid for, in part, through a timber harvest agreement with Louisiana-Pacific Co., via a 10-year harvest agreement. Although administered by FWP since 1976, a significant volume of timber was harvested by Louisiana-Pacific by the mid-1980s prior to the end of the 10-year agreement. FWP manages its holdings in the Willow Creek sub-watershed as a Wildlife Management Area (WMA) known as the Mt. Haggin WMA. It is one of the largest WMAs in the state.

The watershed falls within the Anaconda Smelter fallout zone where soils are recognized to have partial metals toxicity. The steep slopes in the headwaters combined with aggressive timber harvesting operations in the 20th Century have contributed to bare, poorly vegetated slopes susceptible to erosion as has been documented by EPA and others in the smelter fallout zone around Anaconda (U.S Environmental Protection Agency, 2010; Rennick and Emilsson, 2009). It is likely that the impacts of smelter fallout also hinder plant growth and colonization in some portions of the sub-watershed. As addressed in **Section 6.4.2**, the Willow Creek soils are volcanic in nature, highly erosive, and likely elevated in phosphorus compared with other soil types encountered in the Middle Rockies Level III Ecoregion.

Agriculture

There are no active grazing permits on the DNRC administered section in the upper portion of the sub-watershed. FWP does not allow grazing in the WMA. The only agricultural influence may be in the lowermost section of the AU and would constitute livestock grazing on private lands.

Mining

As mentioned previously, the effects of the smelter fallout zone likely contribute to some slope instability and arrested plant growth in portions of the upper sub-watershed. There are no abandoned mines in the drainage according to DEQ records.

Silviculture

In addition to the significant timber harvest operations that occurred on FWP administered lands in the early 1980s, timber harvest operations also occurred on the DNRC section 6–8 years ago. At this time, DNRC also reconstructed the road through the section and moved it away from the stream corridor (Staedler, F., personal communication 2013).

Subsurface Wastewater Treatment and Disposal

According to DEQ records, there are no septic systems in the upper portion of the Willow Creek sub-watershed.

Summary

The source assessment for upper Willow Creek suggests that the most important source of human-caused phosphorus is sediment-bound phosphorus reaching the stream as a result of timber harvesting operations on highly erosive soils in the Anaconda smelter fallout zone. However, as stated previously, in **Section 6.4.2.2**, there may be naturally elevated TP concentrations in the watershed that are difficult to discern given the range of human-caused sources of phosphorus.

6.6.10.3 TP TMDL, Allocations, and Current Loading

The TMDL for TP is based on **Equation 5** and the TMDL allocations are based on **Equation 2**. The value of the TP TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TP TMDL for upper Willow Creek uses **Equation 1**, with the median measured flow from all sites during 2010–11 sampling (3.16 cfs):

***Equation 1*: *TMDL* = (0.03 mg/L) (3.16 cfs) (5.4) = 0.51 lbs/day**

Equation 4 is the basis for the natural background LA for TP. To continue with the example at a flow of 3.16 cfs, this allocation is as follows:

***Equation 4*: LA_{NB} = (0.01 mg/L) (3.16 cfs) (5.4) = 0.17 lbs/day**

Using **Equation 5**, the combined septic and other human-caused TP LA at 3.16 cfs can be calculated:

***Equation 5*: LA_{H} = 0.51 lbs/day – 0.17 lbs/day = 0.34 lbs/day**

An example total existing load is calculated as follows using **Equation 6**, the 80th percentile of TP values measured from upper Willow Creek from 2007 to 2011 (0.053 mg/L) and the median measured flow of 3.14 cfs:

***Equation 6*: *Total Existing Load* = (0.053 mg/L) (3.16 cfs) (5.4) = 0.90 lbs/day**

The portion of the existing load attributed to human sources is 0.73 lbs/day, which is determined by subtracting out the 0.17 lbs/day background load from the existing load. This 0.73 lbs/day value represents the load measured within the stream after potential nutrient uptake.

Table 6-68 contains the results for the example TP TMDL, LAs, and current loading. In addition, it contains an example percent reduction to the human-caused LA required to meet the water quality target for TP. The percent reduction to natural background is assumed to be 0%. At the median growing season flow of 3.16 cfs and the 80th percentile of measured TP values, the current loading in upper Willow Creek is greater than the TMDL. Under these example conditions, a 53% reduction of human-caused sources and an overall 43% reduction of TP in upper Willow Creek would result in the TMDL being met. The source assessment of the upper Willow Creek watershed indicates that historic logging practices combined with the effects of smelter fallout contribute to sedimentation of Willow Creek and associated phosphorus loading and is the most likely source of TP; load reductions should focus on limiting and controlling TP loading from these sources. Meeting LAs for upper Willow Creek may be achieved through a variety of water quality planning and implementation actions and is addressed **Section 7.0**.

Table 6-68. Upper Willow Creek TP Example TMDL, LAs, Current Loading, and Reductions

Source Category	Allocation and TMDL (lbs/day)[a]	Existing Load (lbs/day)[a]	Percent Reduction
Natural Background	0.17	0.17	0%
Human-caused (historic smelting/logging)	0.34	0.73	53%
	TMDL = 0.51	**Total = 0.90**	**Total = 43%**

[a] Based on a median growing season flow of 3.16 cfs

6.6.11 Willow Creek, lower (MT76G002_062)

6.6.11.1 Assessment of Water Quality Results

The source assessment for lower Willow Creek consists of an evaluation of TN and TP concentrations and exceedances of chl-*a* and/or AFDM within the lower segment of Willow Creek. This is followed by the quantification of the most significant human caused sources of nutrients. Willow Creek is divided into an upper and lower segment as demarked by T4N R10W S30. **Figure 6-73** presents the approximate locations of data pertinent to the source assessment for the Willow Creek sub-watershed. It should be noted that a sediment TMDL for lower Willow Creek was completed in 2010 (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2010).

FWP lists the entire length of lower Willow Creek as being chronically dewatered (dewatering is a significant issue in most years).

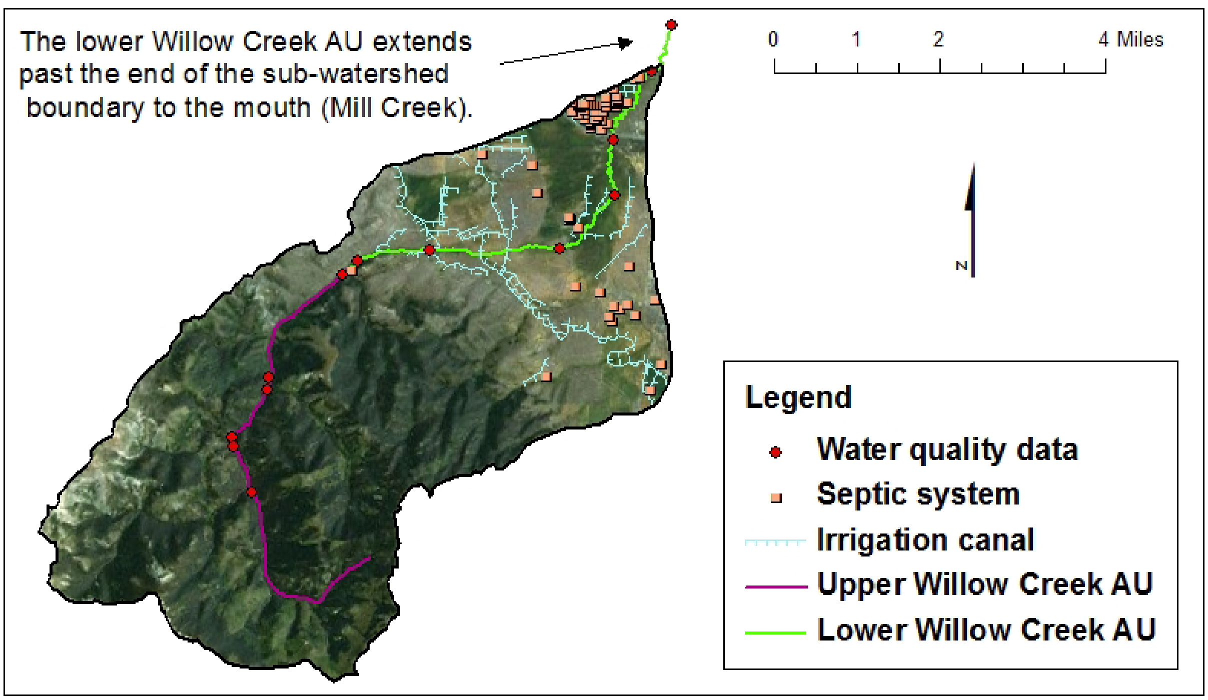

Figure 6-73. Willow Creek Sub-Watershed with Water Quality Sampling Locations and Identified AUs

Total Nitrogen

DEQ collected water quality samples for TN from Willow Creek downstream of T4N R10W S30 to the mouth (Mill Creek) during the growing season over the 2007–11 time period (**Section 6.4.3.11**, **Table 6-26**). From 2007 to 2011, out of 16 samples collected from lower Willow Creek, 7 exceeded the TN target concentration (0.300 mg/L). **Figure 6-74** presents summary statistics for TN concentrations at sampling sites in all of Willow Creek. TN concentrations were in excess of the target at sampling locations between the Crackerville Road and Highway 1, and then again near the mouth with Mill Creek. The limited data suggest that TN sources include irrigated agriculture and the influence of septic systems around the community of Opportunity.

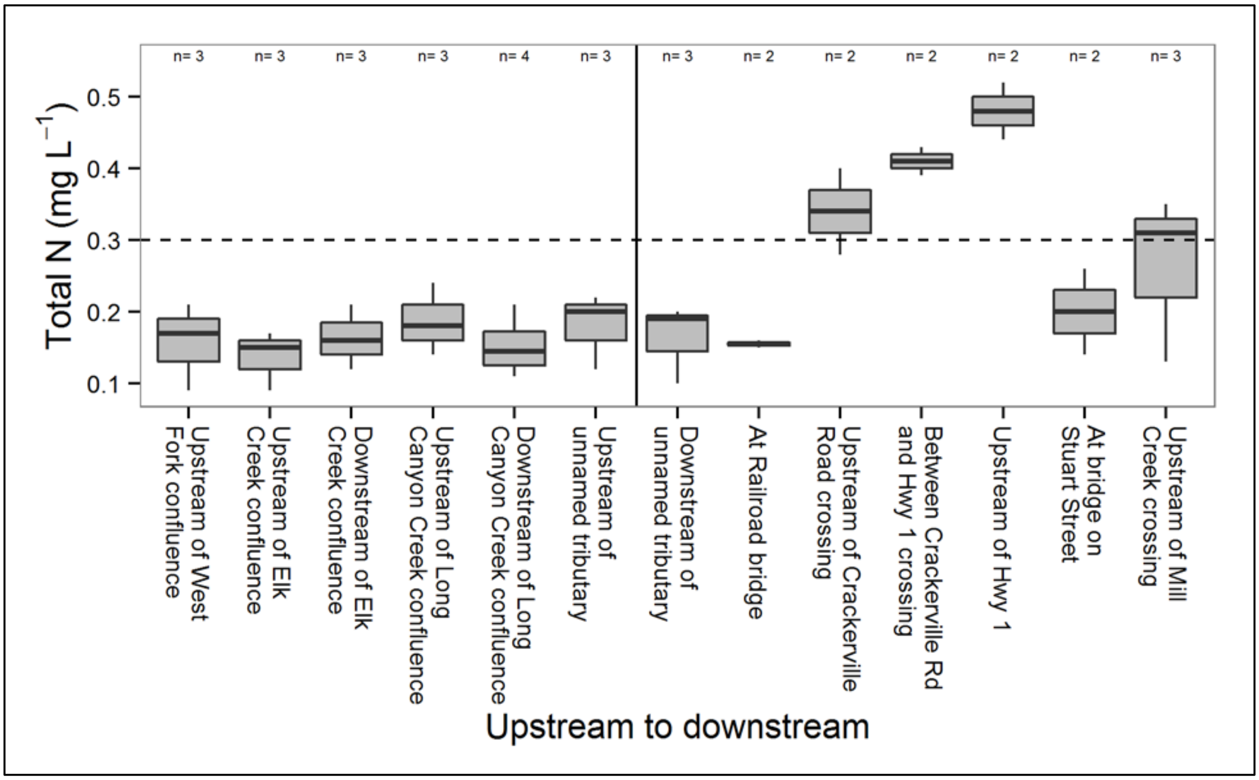

Figure 6-74. Boxplot of TN Concentrations in Willow Creek (2007–11); the Division Line between the Upper and Lower Assessments Units Is Shown (Dashed Line Is Target)

In **Figure 6-75.**, sample data from the AU was plotted as a ratio to the TN target. Exceedances of the TN target occurred at a variety of flows from <1 cfs to 30 cfs. Exceedances of the target concentration were observed in samples collected upstream of the Crackerville Road all the way down to the mouth with Mill Creek with the exception of the Stuart St Bridge sample location. TN exceedances were all <2 times the target concentration.

Exceedances of the TN target are plotted in **Figure 6-76**. TN load reductions necessary to achieve the TMDL range from 3% to 42% with a median reduction of 25%.

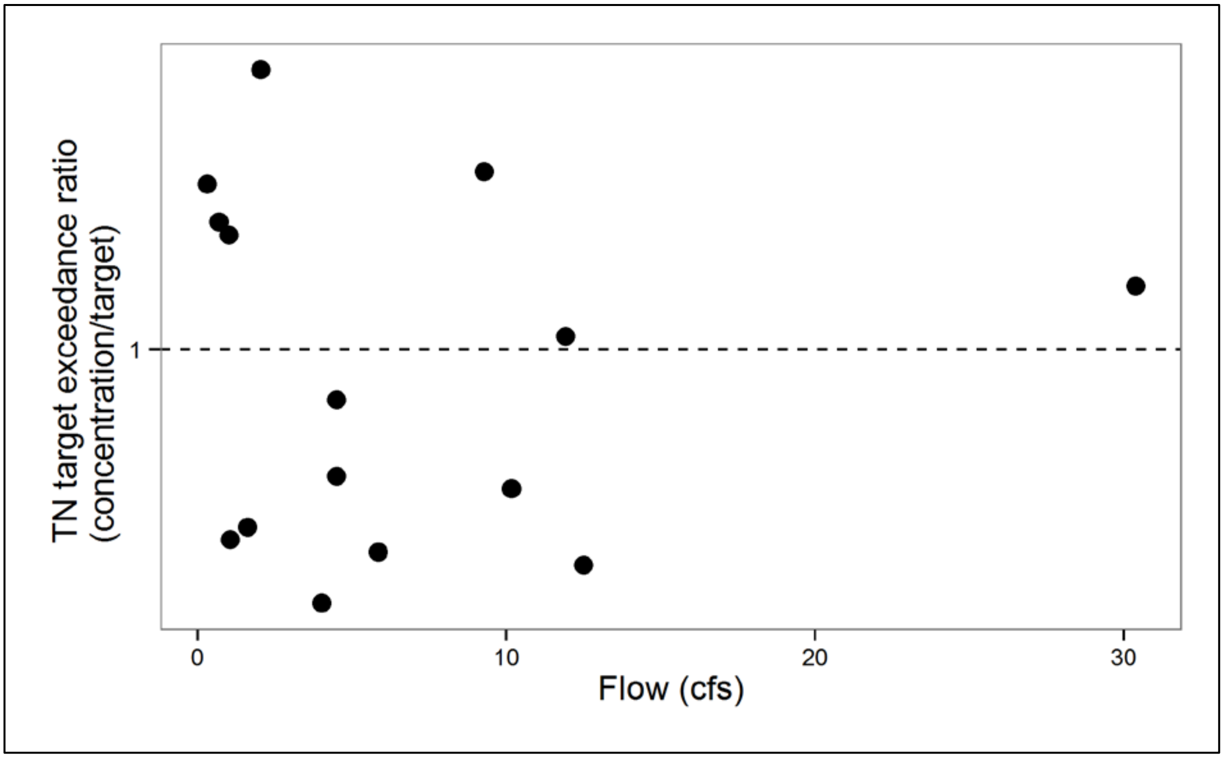

Figure 6-75. TN Target Exceedance Ratio in Lower Willow Creek (2007–11) (>1 Indicates Exceedance)

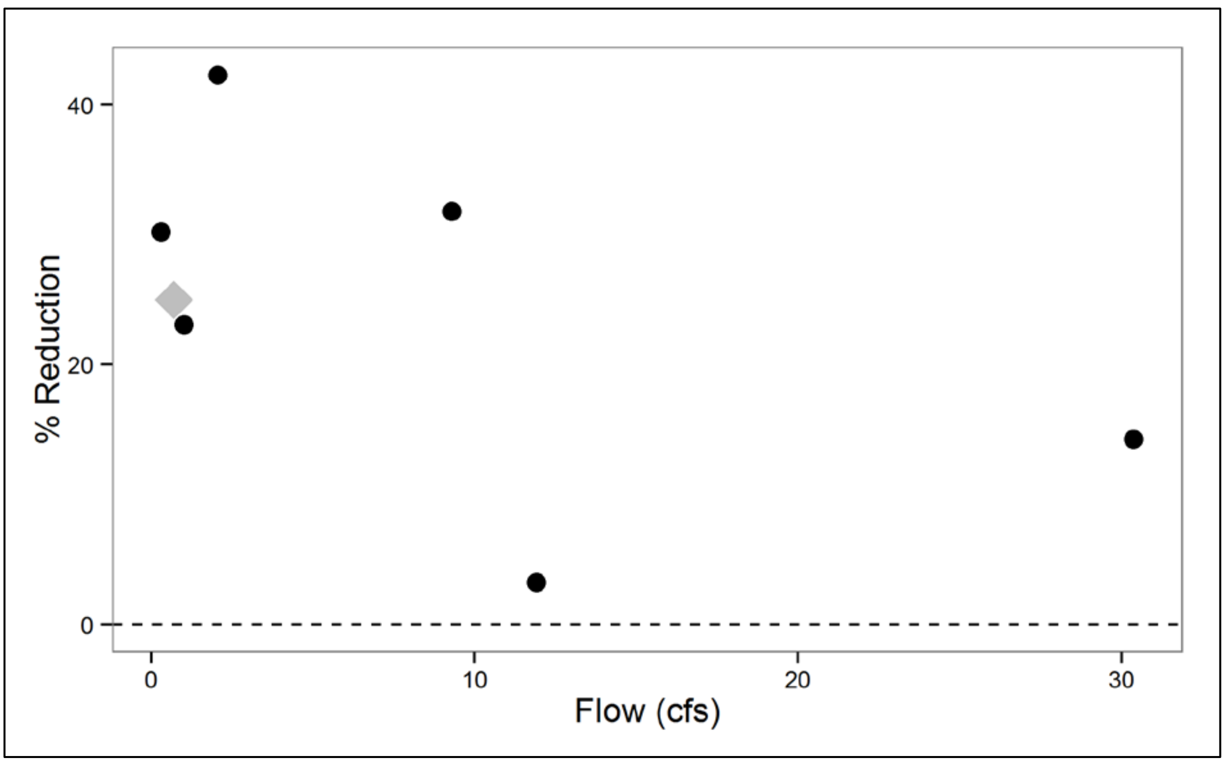

Figure 6-76. Scatterplot of Mainstem Observations and Respective Percent Reductions Necessary to Achieve the TN TMDL in Lower Willow Creek (the Gray Diamond Is the Median (50th percentile) Observation of Samples that Exceeded the TN TMDL (2007–11))

Total Phosphorus
DEQ collected water quality samples for TP from Willow Creek downstream of T4N R10W S30 to the mouth (Mill Creek) during the growing season over the 2004–11 time period (**Section 6.4.3.11**, **Table 6-26**). However for this source assessment, the single sample collected in 2004 was excluded. From 2007 to 2011, out of 16 samples collected from lower Willow Creek, 13 exceeded the TP target concentration (0.030 mg/L). **Figure 6-77** presents summary statistics for TP concentrations at sampling sites in Willow Creek. TP concentrations were in excess of the target at the upper most sample location and rose steadily through the segment before slowly declining through the lower portions of the sub-watershed. The limited data suggest that there may have been additional TP loading from two tributaries, Elk Creek and an unnamed tributary both which join Willow Creek from the southeast followed by potential dilution via groundwater recharge in the lower portions of the sub-watershed.

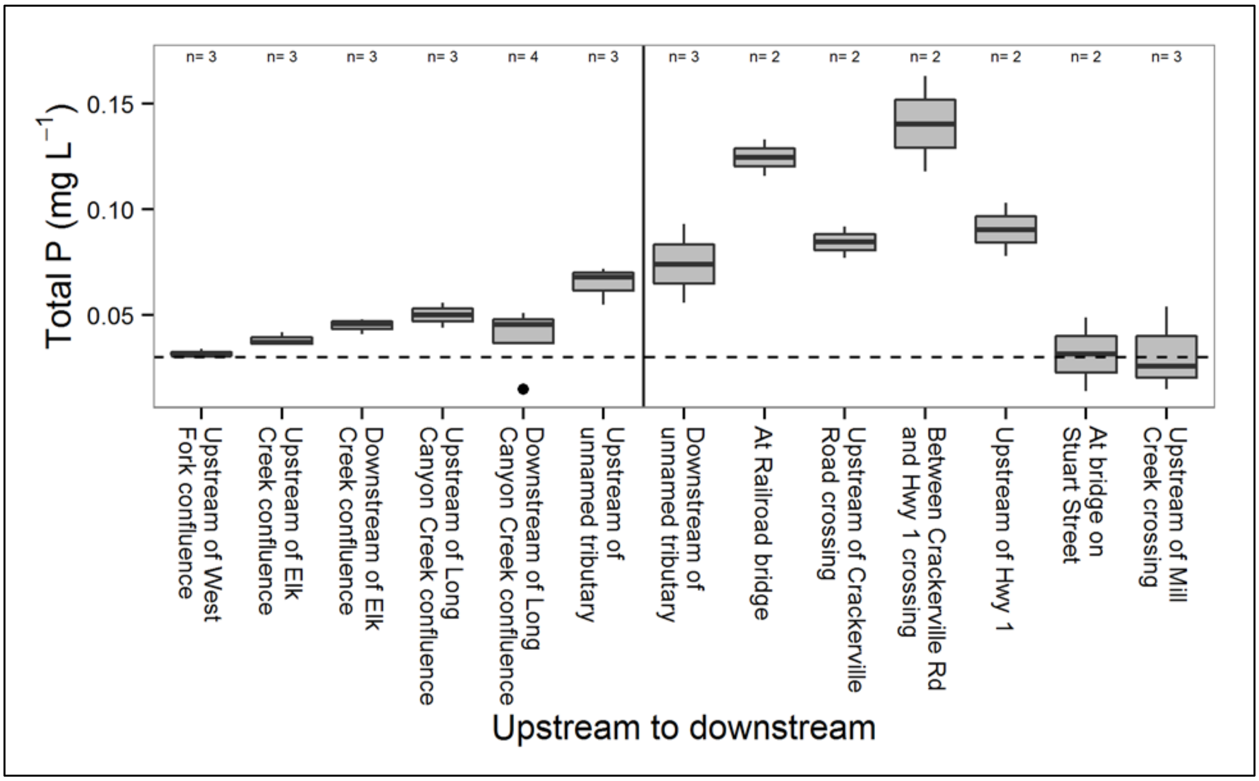

Figure 6-77. Boxplot of TP Concentrations in Willow Creek (2007–11); the Division Line between the Upper and Lower Assessments Units Is Shown (Dashed Line Is Target)

In **Figure 6-78**, sample data from the AU was plotted as a ratio to the TP target. Exceedances of the TP target occurred at a variety of flows from <1 cfs to 75 cfs. Exceedances of the target concentration were observed in samples collected near T4N R10W S30 all the way down to the mouth with Mill Creek. TP exceedances were as high as >5 times the target concentration.

Exceedances of the TP target are plotted in **Figure 6-79**. TP load reductions necessary to achieve the TMDL range from 39% to 82% with a median reduction of 68%.

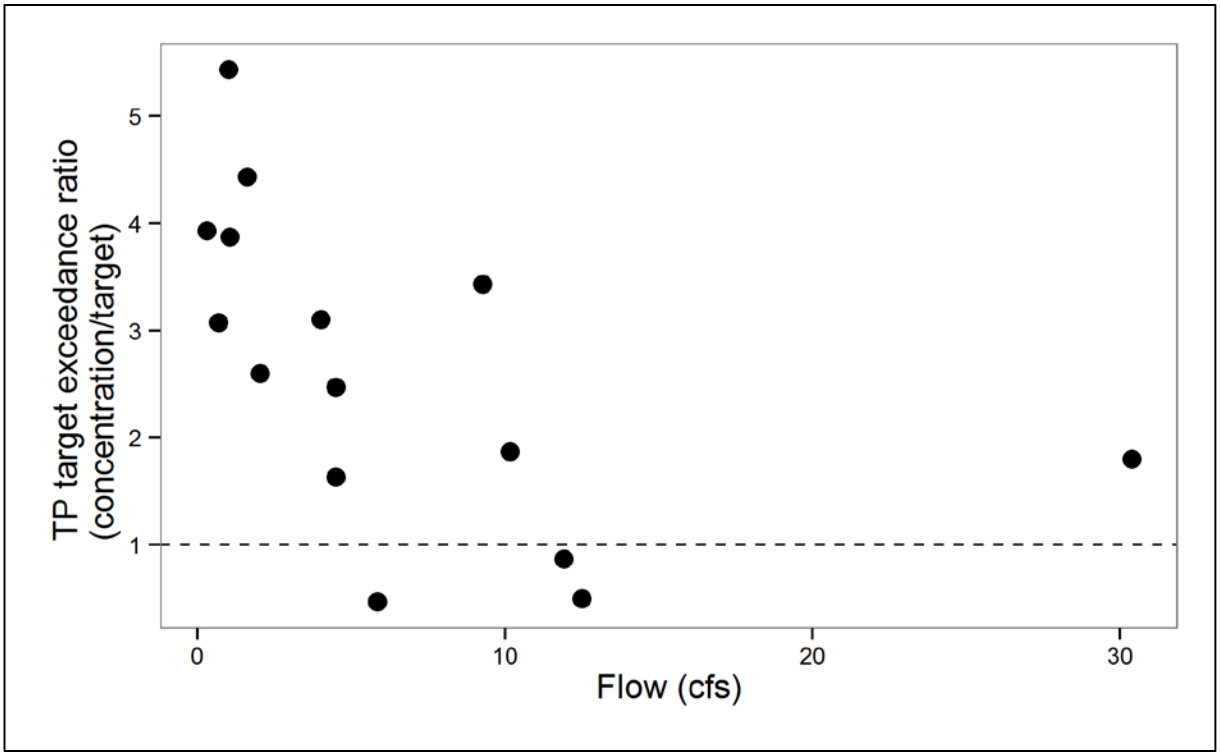

Figure 6-78. TP Target Exceedance Ratio in Lower Willow Creek (2007–11) (>1 Indicates Exceedance)

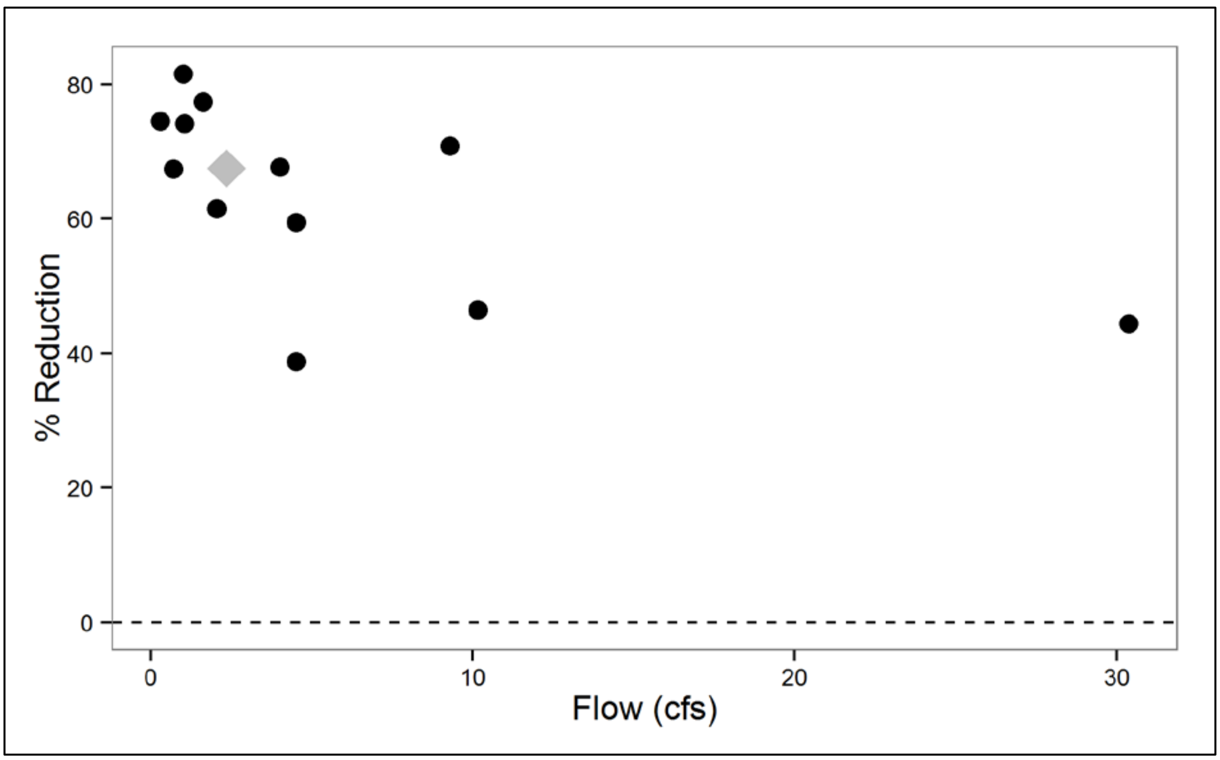

Figure 6-79. Scatterplot of Mainstem Observations and Respective Percent Reductions Necessary to Achieve the TP TMDL in Lower Willow Creek (the Gray Diamond Is the Median (50th percentile) Observation of Samples that Exceeded the TP TMDL (2007–11))

6.6.11.2 Assessment of Loading by Source Categories
Concerning chl-*a*, there were no exceedances in the lower segment.

A summary of the interesting land ownership and use history for the upper Willow Creek watershed is found at the beginning of **Section 6.6.10.2**.

Agriculture
There are no active grazing permits on the DNRC administered section in the upper portion of the sub-watershed. FWP does not allow grazing in the WMA. However, there is significant irrigated hay/alfalfa agriculture and livestock grazing in the lower portions of Willow Creek. A stream-irrigation network study determined that there were 11 points of diversion in the sub-watershed (Confluence, Inc., 2008). There are also several inter-basin water transfers from the Silver Bow Creek watershed (Yellow Ditch) and from the Mill Creek sub-watershed (A.C.M. Ditch and other unnamed ditches) (Confluence, Inc., 2008). The Yellow Ditch actually diverts Silver Bow Creek water through the Willow and Mill Creek sub-watersheds to the Opportunity Ponds. These may potentially contribute TP loads and/or provide dilution to Willow Creek depending on season and current state of the irrigation infrastructure. Aerial imagery suggests there are several areas of groundwater recharge to Willow both upstream and downstream of Opportunity.

Mining
Anaconda smelter fallout zone is a potential source of slope instability leading to stream sedimentation as outlined in **Section 6.6.10.2**.

Silviculture
Past timber harvest operations are potential sources of slope instability leading to stream sedimentation as outlined in **Section 6.6.10.2**.

Subsurface Wastewater Treatment and Disposal
The watershed transitions to largely residential once Willow Creek flows past Highway 1 and flows along the southern and eastern edges of the town of Opportunity. According to DEQ records, there are 68 septic systems in the Willow Creek sub-watershed with the greatest concentration in the town of Opportunity. Although in-stream water quality data showed a decrease in TP concentrations in samples that bracketed Opportunity, these systems are quite likely part of the total TP nutrient load to Willow Creek, in-stream TN concentrations did increase in this same reach. A decrease in TP concentration simply suggests that septic effluent may be reaching Willow Creek at concentrations less than the TP concentration observed at the upstream station but may still be in excess of the target concentration (0.03 mg/L).

Summary
The source assessment for lower Willow Creek suggests that the most important source of human-caused nutrients is grazing and irrigated agriculture as well as impacts from septic systems near the mouth. However, as stated previously, in **Section 6.4.2.2**, there may be naturally elevated TP concentrations in the watershed that are difficult to discern given the range of human-caused sources of phosphorus.

6.6.11.3 TN TMDL, Allocations, and Current Loading

The TMDL for TN is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the TN TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TN TMDL for lower Willow Creek uses **Equation 1**, with the median measured flow from all sites during 2007–11 sampling (4.25 cfs):

***Equation 1*: *TMDL* = (0.30 mg/L) (4.25 cfs) (5.4) = 6.89 lbs/day**

Equation 4 is the basis for the natural background LA for TN. To continue with the example at a flow of 4.25 cfs, this allocation is as follows:

***Equation 4*: LA_{NB} = (0.095 mg/L) (4.25 cfs) (5.4) = 2.18 lbs/day**

Using **Equation 5**, the combined septic and other human-caused TP LA at 4.25 cfs can be calculated:

***Equation 5*: LA_{H} = 6.89 lbs/day – 2.18 lbs/day = 4.71 lbs/day**

An example total existing load is calculated as follows using **Equation 6**, the 80th percentile of TN values measured from lower Willow Creek from 2007 to 2011 (0.400 mg/L) and the median measured flow of 4.25 cfs:

***Equation 6*: *Total Existing Load* = (0.400 mg/L) (4.25 cfs) (5.4) = 9.18 lbs/day**

The portion of the existing load attributed to human sources is 7.00 lbs/day, which is determined by subtracting out the 2.18 lbs/day background load from the existing load. This 7.00 lbs/day value represents the load measured within the stream after potential nutrient uptake.

Table 6-69 contains the results for the example TN TMDL, LAs, and current loading. In addition, it contains an example percent reduction to the human-caused LA required to meet the water quality target for TN. The percent reduction to natural background is assumed to be 0%. At the median growing season flow of 4.25 cfs and the 80th percentile of measured TN values, the current loading in lower Willow Creek is greater than the TMDL. Under these example conditions, a 33% reduction of human-caused sources and an overall 25% reduction of TN in lower Willow Creek would result in the TMDL being met. The source assessment of the Willow Creek watershed indicates that irrigated agriculture and subsurface wastewater treatment and disposal are the most likely sources of TN; load reductions should focus on limiting and controlling TN loading from these sources. Meeting LAs for lower Willow Creek may be achieved through a variety of water quality planning and implementation actions and is addressed **Section 7.0**. Inter-sub-watershed transfers of irrigation flows may possibly complicate the loading dynamics.

Table 6-69. Lower Willow Creek TN Example TMDL, LAs, Current Loading, and Reductions

Source Category	Allocation and TMDL (lbs/day)[a]	Existing Load (lbs/day)[a]	Percent Reduction
Natural Background	2.18	2.18	0%
Human-caused (irrigated ag./subsurface wastewater)	4.71	7.00	33%
	TMDL = 6.89	**Total = 9.18**	**Total = 25%**

[a] Based on a median growing season flow of 4.25 cfs

6.6.11.4 TP TMDL, Allocations, and Current Loading

The TMDL for TP is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the TP TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TP TMDL for lower Willow Creek uses **Equation 1**, with the median measured flow from all sites during 2007–11 sampling (4.25 cfs):

***Equation 1**: TMDL* **= (0.03 mg/L) (4.25 cfs) (5.4) = 0.69 lbs/day**

Equation 4 is the basis for the natural background LA for TP. To continue with the example at a flow of 4.25 cfs, this allocation is as follows:

***Equation 4**:* **LA_{NB} = (0.01 mg/L) (4.25 cfs) (5.4) = 0.23 lbs/day**

Using **Equation 5**, the combined septic and other human-caused TP LA at 4.25 cfs can be calculated:

***Equation 5**:* **LA_{H} = 0.69 lbs/day – 0.23 lbs/day = 0.46 lbs/day**

An example total existing load is calculated as follows using **Equation 6**, the 80th percentile of TP values measured from lower Willow Creek from 2007 to 2011 (0.116 mg/L) and the median measured flow of 4.25 cfs:

***Equation 6**: Total Existing Load* **= (0.116 mg/L) (4.25 cfs) (5.4) = 2.66 lbs/day**

The portion of the existing load attributed to human sources is 2.43 lbs/day, which is determined by subtracting out the 0.23 lbs/day background load from the existing load. This 2.43 lbs/day value represents the load measured within the stream after potential nutrient uptake.

Table 6-70 contains the results for the example TP TMDL, LAs, and current loading. In addition, it contains an example percent reduction to the human-caused LA required to meet the water quality target for TP. The percent reduction to natural background is assumed to be 0%. At the median growing season flow of 4.25 cfs and the 80th percentile of measured TP values, the current loading in lower Willow Creek is greater than the TMDL. Under these example conditions, an 81% reduction of human-caused sources and an overall 74% reduction of TP in lower Willow Creek would result in the TMDL being met. The source assessment of the Willow Creek watershed indicates that historic logging practices combined with the effects of smelter fallout contribute to sedimentation of Willow Creek and associated phosphorus loading is the most likely source of TP in addition to potential loading from agriculture and subsurface wastewater treatment and disposal in the lower drainage; load reductions should focus on limiting and controlling TP loading from these sources. Meeting LAs for lower Willow Creek may be achieved through a variety of water quality planning and implementation actions and is addressed **Section 7.0**. Inter-sub-watershed transfers of irrigation flows may possibly complicate the loading dynamics.

Table 6-70. Lower Willow Creek TP Example TMDL, LAs, Current Loading, and Reductions

Source Category	Allocation and TMDL (lbs/day)a	Existing Load (lbs/day)a	Percent Reduction
Natural Background	0.23	0.23	0%
Human-caused (historic smelting/logging)	0.46	2.43	81%
	TMDL = 0.69	**Total = 2.66**	**Total = 74%**

[a] Based on a median growing season flow of 4.25 cfs

6.7 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 LAs. 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 Upper Clark Fork Phase 2 TPA nutrient TMDL development process.

6.7.1 Seasonality

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 (July 1 to Sept 30), to coincide with seasonal algal growth targets.
- Nutrient data used to determine compliance with targets and to establish allowable loads was collected during the summer-time period to coincide with applicable nutrient targets.

6.7.2 Margin of Safety

An 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:

- Static nutrient target values (e.g., 0.100 mg/L NO_3+NO_2 and 0.025 mg/L TP) were used to calculate allowable loads (TMDLs). Allowable exceedances of nutrient targets were not incorporated into the calculation of allowable loads, thereby adding a MOS to established allocations.
- Target values were developed to err on the conservative side of protecting beneficial uses.
- By considering seasonality (discussed above) and variability in nutrient loading.
- By using an adaptive management approach to evaluate target attainment and allow for refinement of LA, assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development.
- By using a composite LA for human sources because of uncertainty in the source assessment

6.8 Uncertainty and Adaptive Management

Uncertainties in the accuracy of field data, nutrient targets, source assessments, loading calculations, and other considerations are inherent when assessing and evaluating environmental variables for TMDL development. However, 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. Uncertainty is inherent in both the water quality-based and model-based modes of assessing nutrient sources and needed reductions. The main sources of uncertainty are summarized below.

6.8.1 Water Quality Conditions

It was assumed that sampling data for each waterbody segment is representative of conditions in each segment. All segments met the minimum sample size of 12 observations (for previously unlisted AUs). The average sample dataset per AU addressed in **Section 6.4.3** was 20 observations. Water quality exceedances were observed for all nutrient impaired waterbodies where TMDLs were developed.

Future monitoring as discussed in **Section 8.0** should help reduce the uncertainty regarding data representativeness, clarify whether or not nutrient forms that have a TMDL but are meeting targets have a role in causing excess algal growth, improve the understanding of the effectiveness of BMP implementation, and increase the understanding of the loading reductions needed to meet the TMDLs. It was assumed that background concentrations are less than the target values, and based on sample data upstream of known sources and from other, streams within the Upper Clark Fork Phase 2 TPA that are not impaired for nutrients, this appears to be true. However, it is possible that target values are naturally exceeded during certain times or at certain locations in the watershed as was addressed in **Section 6.4.2**. Future monitoring should help reduce uncertainty regarding background nutrients concentrations particularly in sub-watersheds with volcanic surficial geology.

It also recognized that with current and future remediation work in the Silver Bow Creek watershed, water quality conditions are likely not static in that system. Water quality data used in the Silver Bow Creek assessment and TMDL development used data collected from 2007 to 2012. However, it is recommended that data collection efforts continue to capture changing water quality conditions in that system.

7.0 OTHER IDENTIFIED ISSUES OR CONCERNS

7.1 POLLUTANT IMPAIRMENTS

There are many other pollutant impairments in the Upper Clark Fork Phase 2 TPA, some of which are outlined in **Table A-1** in **Appendix A**. In addition to these, numerous other impairments were addressed in the 1998 VNRP for the Clark Fork River (Tri-State Implementation Council, 1998) and in the 2010 TMDL document for the Upper Clark Fork TPA (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2010). The Clark Fork-Silver Bow Metals TMDL document will address many of the impairment listings not addressed in this document or the 2010 document.

7.2 NON-POLLUTANT IMPAIRMENTS

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 Upper Clark Fork Phase 2 TPA may appear on the 303(d) list but may not always require TMDL development for a pollutant, but do have non-pollutant listings such as "chlorophyll-*a*" that could be linked to a nutrient pollutant. Many non-pollutant causes are habitat issues often associated with sediment, but may be associated with nutrient or temperature, 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 (**Table 7-1**). Nevertheless, the issues associated with these streams are still important to consider when working to improve water quality conditions in individual streams, and the Upper Clark Fork Phase 2 TPA as a whole. In some cases, pollutant and non-pollutant 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 non-pollutant listings. Racetrack Creek is the only stream with a non-pollutant listing not addressed with TMDL(s) in this or a previous document (Tri-State Implementation Council, 1998; Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2010).

Table 7-1. Waterbody Segments with Non-Pollutant Listings in the 2014 Water Quality Integrated Report

Waterbody ID	Stream Segment	2014 Probable Causes of Impairment
MT76G001_010	CLARK FORK, Little Blackfoot River to Flint Creek[b]	Alteration in streamside or littoral vegetative covers
		Low flow alterations
		Physical substrate habitat alterations
MT76G001_030	CLARK FORK RIVER, Cottonwood Creek to Little Blackfoot River[b]	Alteration in streamside or littoral vegetative covers
		Low flow alterations
		Physical substrate habitat alterations
MT76G001_040	CLARK FORK RIVER, Warm Springs Creek to Cottonwood Creek[b]	Alteration in streamside or littoral vegetative covers
		Low flow alterations
MT76G005_071	DUNKLEBERG CREEK, headwaters to T9N R12W S2 SW[a, b]	Alteration in streamside or littoral vegetative covers
MT76G005_091	GOLD CREEK, headwaters to National Forest boundary[a, b]	Alteration in streamside or littoral vegetative covers

Table 7-1. Waterbody Segments with Non-Pollutant Listings in the 2014 Water Quality Integrated Report

Waterbody ID	Stream Segment	2014 Probable Causes of Impairment
MT76G002_072	LOST CREEK, the south State Park boundary to mouth (Clark Fork River)[b]	Alteration in streamside or littoral vegetative covers
		Low flow alterations
		Physical substrate habitat alterations
MT76G002_052	MILL CREEK, to section line between Sec 27 and 28, T4N, R11W TO Mill-Willow bypass diversion[a, b]	Alteration in streamside or littoral vegetative covers
		Low flow alterations
MT76G002_080	MODESTY CREEK, headwaters to mouth (Clark Fork River)[a, b]	Low flow alterations
MT76G002_090	RACETRACK CREEK, the national forest boundary to mouth (Clark Fork River)[a]	Alteration in streamside or littoral vegetative covers
		Low flow alterations
MT76G002_011	WARM SPRINGS CREEK, headwaters to Meyers Dam, T5N R12W S25[a]	Physical substrate habitat alterations
MT76G002_012	WARM SPRINGS CREEK, Meyers Dam T5N R12W S25 to mouth (Clark Fork), T6N R9W S6[a, b]	Alteration in streamside or littoral vegetative covers
		Low flow alterations
		Physical substrate habitat alterations

[a] Streams listed for pollution only, with no pollutant listings or no TMDL in this document
[b] Streams addressed by a TMDL in a previous document

Non-pollutant 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. In some cases the pollutant and non-pollutant categories are linked and appear together in the cause listings, however a non-pollutant category may appear independent of a pollutant listing. The following discussion provides some rationale for the application of the identified non-pollutant causes to a waterbody, 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. This may include riparian vegetation removal for a road or utility corridor, effects of streamside mine tailings or placer mining remnants, 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 and elevated sediment loads, in addition to elevated stream temperature from loss of canopy shade.

Physical Substrate Habitat Alterations

Physical substrate habitat alterations generally describe cases where the stream channel has been physically altered or manipulated, such as through the straightening of the channel or from human-influenced channel downcutting, resulting in a reduction of morphological complexity and loss of habitat (riffles and pools) for fish and aquatic life. For example, this may occur when a stream channel has been straightened to accommodate roads, agricultural fields, or through placer mine operations.

Low Flow Alterations

Streams are typically listed for low flow alterations when local water use management leads to base flows that are too low to fully support the beneficial uses designated for that system. This could result in dry channels or extreme low flow conditions harmful to fish and aquatic life.

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

7.2.1 Monitoring and BMPs for Non-Pollutant-Affected Streams

Streams impaired for a non-pollutant 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 are minimal and the linkage between probable cause, non-pollutant listing, and effects to the beneficial uses are not well defined. The monitoring and restoration strategies that follow in **Sections 8.0** and **9.0** are presented to address both pollutant and non-pollutant issues for streams in the Upper Clark Fork Phase 2 TPA with TMDLs in this document.

8.0 WATER QUALITY IMPROVEMENT PLAN

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 nutrients water quality standards in Dempsey, Dunkleberg, Gold, Hoover, Lost, Peterson, Silver Bow and Willow Creeks. The strategy includes general measures for reducing loading from each significant identified pollutant source.

8.1 WATER QUALITY RESTORATION OBJECTIVE

The following is the general water quality objective provided in this TMDL document:

- Provide technical guidance for full recovery of aquatic life beneficial uses to all impaired streams within the Upper Clark Fork Phase 2 TPA by improving nutrients 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.

This TMDL document is a step in restoring water quality in the Upper Clark Fork Phase 2 TPA. A Watershed Restoration Plan (WRP) can provide a framework strategy for water quality restoration and monitoring in the Upper Clark Fork Phase 2 TPA, focusing on how to meet conditions that will likely achieve the TMDLs presented in this document, as well as other water quality issues of interest to local communities and stakeholders. WRPs contain detailed adaptive management plans and identify considerations that should be addressed during TMDL implementation. 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 the nine minimum elements for the WRP:

- Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan. Sources that need to be controlled should be identified at the significant subcategory level, along with estimates of the extent to which they are present in the watershed (e.g., X number of dairy cattle feedlots needing upgrading, including a rough estimate of the number of cattle per facility; Y acres of row crops needing improved nutrient management or sediment control; or Z linear miles of eroded streambank needing remediation).
- An estimate of the load reductions expected from management measures.
- A description of the nonpoint source management measures that will need to be implemented to achieve load reductions in paragraph 2, and a description of the critical areas in which those measures will be needed to implement this plan.

- Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.
- An information and education component used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented.
- Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.
- A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.
- A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.
- A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item 8 immediately above.

In the Upper Clark Fork Phase 2 TPA, a WRP has been completed by the WRC which is based out of Deer Lodge (Watershed Restoration Coalition, 2012). This WRP focused on tributaries to the Upper Clark Fork River and prioritized several sub-watersheds for which TMDLs were developed in this document including Dempsey Creek, Gold Creek, Lost Creek, Peterson Creek and Willow Creek. Other targeted sub-watersheds reflect metals and sediment impairments that were included in a previous TMDL document (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2010).

A WRP is a living, adaptive document and is meant as a guide to watershed groups to identify and achieve restoration of beneficial uses in impaired systems. Future adaptions of the WRP should work to include impaired streams identified in this document in the WRP.

8.2 Implementation of the Plan

The implementation plan discussed in this report is based on an adaptive management approach that includes a monitoring program and feedback loop. Successful implementation requires collaboration among private landowners, land management agencies, and other stakeholders.

8.2.1 DEQ and Stakeholder Roles

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. DEQ will work with participants to use the TMDLs as a basis for developing locally-driven WRPs, administering funding specifically to help pursue water quality improvement and pollution prevention projects, and identifying 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 the WRC, Trout Unlimited, USFS, NRCS, DNRC, BLM, FWP, EPA, and DEQ. Other organizations and non-profits that may provide assistance through technical expertise, funding, educational outreach, or other means include Montana Water Center, University of Montana Watershed Health Clinic, and Montana State University (MSU) Extension Water Quality Program.

8.2.2 Sediment Restoration Approach

Streamside riparian and wetland vegetation restoration and long term riparian area and wetland management are vital restoration practices that must be implemented across the watershed to achieve the sediment TMDLs. Native streamside riparian and wetland vegetation provides root mass which hold streambanks together. Suitable root mass density ultimately slows bank erosion. Riparian and wetland vegetation filters pollutants from upland runoff. Therefore, improving riparian and wetland vegetation will decrease bank erosion by improving streambank stability and will also reduce pollutant delivery from upland sources. Suspended sediment is also deposited more effectively in healthy riparian zones and wetland areas during flooding because water velocities slow in these areas enough for excess sediment to settle out.

Riparian and wetland disturbance has occurred throughout the Upper Clark Fork Phase 2 TPA as a result of many influencing factors. Riparian timber harvest and the conversion of forest and valley bottoms for agriculture, mining, livestock production, and residential development have all had varying degrees of impact, depending on the drainage. Restoration recommendations involve the promotion of riparian and wetland recovery through improved grazing and land management (including the timing and duration of grazing, the development of multi-pasture systems that include riparian pastures, and the development of off-site watering areas), application of timber harvest BMPs, restoration of streams affected by mining activity, and floodplain and streambank stabilization and revegetation efforts where necessary. In general, natural recovery of disturbed systems is preferred however it is acknowledged that existing conditions may not readily allow for unassisted recovery in some areas where disturbance has occurred. Active vegetation planting and bank or stream channel reshaping may increase costs, but may be a reasonable and relatively cost effective restoration approach, depending on the site. When stream channel restoration work is needed because of altered stream channels, cost increases and projects should be assessed on a case by case basis. The implementation of BMPs should aim to prevent the availability, transport, and delivery of a pollutant through the most natural or natural-like means possible. Appropriate BMPs will differ by location and are recommended to be included and prioritized as part of a comprehensive watershed scale plan (e.g., WRP).

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. In addition, routine maintenance and upkeep of unpaved roads is a crucial component to limiting sediment production from roads. 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.

Assistance from resource professionals from various local, state, and federal agencies or non-profit groups should be available in the Upper Clark Fork Phase 2 Creek TPA. In particular, the Deer Lodge Valley and Mile High Conservation Districts and the NRCS are two resources that are valuable aids for assisting with investigating, developing, and implementing measures to improve conditions in the Upper Clark Fork Phase 2 TPA.

8.2.3 Nutrients 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 post-grazing vegetative 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
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 historically been placed 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 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 a 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.

In addition to the agricultural related BMPs, reducing sediment delivery from roads and eroding streambanks is another component of the nutrient reduction restoration plan. Sediment issues in the Upper Clark Fork Phase 2 TPA are addressed in this document for Silver Bow Creek and the Clark Fork River. Upper Clark Fork tributaries impaired by sediment were addressed in a 2010 TMDL document (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2010). It is expected that the sediment related BMPs presented in **Section 9.0** of that plan will also help reduce nutrient loading in impaired tributaries. Sediment TMDLs for Dempsey Creek, upper and lower Hoover Creek, upper and lower Peterson Creek and upper and lower Willow Creek were included in the 2010 TMDL document (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2010).

8.3 Restoration Approaches by Source Category

For each potential source of human-caused pollutant loads in the Upper Clark Fork Phase 2 TPA, general management recommendations are outlined below. Not considering the point source in the Silver Bow Creek watershed, irrigated agriculture and livestock grazing are considered to be the two major nutrient contributors to the Upper Clark Fork Phase 2 TPA. The other sources described in this section may represent a substantial contribution of nutrients locally or when combined. The effect of different sources can change seasonally and be dependent on the magnitude of storm/high flow events. Therefore, restoration activities within the Upper Clark Fork Phase 2 TPA should focus on all major sources for each pollutant category. Restoration should begin with addressing significant sources where large load reductions can be obtained within each source category. The source assessment results in **Sections 6.6.1** and **6.6.11** provide information that should be used to help determine priorities for each major source type in the watershed.

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 implementing appropriate BMPs for new activities and continuing implementation and maintenance of those BMPs currently in place or practice. Restoration might also address current non-pollutant-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 the determination of whether 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 9.0**.

In recognition that noxious weeds are a problem throughout Montana and may be associated with any of the following source categories, noxious weed control should be actively pursued whenever BMPs are being implemented.

8.3.1 Grazing

A riparian grazing management plan 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 Upper Clark Fork Phase 2 TPA 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 re-vegetation are 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 non-pollutant can be obtained in Appendix A of Montana's Nonpoint Source Management Plan (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b) and in (Harmon, 1999).

8.3.2 Small Acreages

The number of small acreages is growing rapidly, and many small acreage owners own horses or cattle. Animals grazing on small acreages can lead to overgrazing and a shortage of grass cover, leaving the soil subject to erosion and runoff to surface waters. General BMP recommendations for small acreage lots with animals include creating drylots, developing a rotational grazing system, and maintaining healthy riparian buffers. Small acreage owners should collaborate with MSU Extension Service, NRCS, conservation districts and agriculture organizations to develop management plans for their lots. Further information may be obtained from the Montana Nonpoint Source Management Plan (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b) or by contacting the MSU extension (http://www.msuextension.org/).

8.3.3 Septic

BMPs for septic systems include regular inspection and cleaning and repair of leaking or otherwise malfunctioning systems. As large acreages are subdivided into smaller lots, the number of septic systems in the watershed increases. Plans for development of lands within the Upper Clark Fork Phase 2 TPA should consider the effects of additional septic systems to watersheds and consider ways of minimizing septic impacts to water quality such as installing Type II systems to decrease nitrogen loading, installing systems further away from streams to allow for more nutrients attenuation, and/or constructing a WWTP to connect multiple wastewater systems.

8.3.4 Animal Feeding Operations

AFOs can pose a number of risks to water quality. To minimize water quality effects from AFOs, the USDA and EPA released the Unified National Strategy for AFOs in 1999 (U.S. Department of Agriculture and U.S. Environmental Protection Agency, 1999). This plan is a written document detailing manure storage and handling systems, surface runoff control measures, mortality management, chemical handling, manure application rates, schedules to meet crop nutrient needs, land management practices, and alternate options for manure disposal. An AFO that meets certain specified criteria is referred to as a CAFO, and in addition may be required to obtain an MPDES permit as a point source. Montana's AFO compliance strategy is based on federal law and has voluntary, as well as regulatory components. If voluntary efforts can eliminate discharges to state waters, no direct regulation is necessary through a permit. Operators of AFOs may take advantage of effective, low cost practices to reduce potential runoff to state waters, which additionally increase property values and operation productivity. Properly installed vegetative filter strips, in conjunction with other practices to reduce wasteloads and runoff volume, are very effective at trapping and detaining sediment and reducing transport of nutrients and pathogens to surface waters, with removal rates approaching 90% (U.S. Department of Agriculture and U.S. Environmental Protection Agency, 1999). Other options may include clean water diversions, roof gutters, berms, sediment traps, fencing, structures for temporary manure storage, shaping, and grading. Animal health and productivity also benefit when clean, alternative water sources are installed to prevent contamination of surface water.

Financial and technical assistance (including comprehensive nutrient management plan development) in achieving voluntary AFO and CAFO compliance may be available from conservation districts and NRCS field offices. Voluntary participation may aide in preventing a more rigid regulatory program from being implemented for Montana livestock operators in the future.

Further information may be obtained from the DEQ website at:
http://deq.mt.gov/wqinfo/mpdes/cafo.mcpx.

Montana's nonpoint source pollution control strategies for addressing AFOs are summarized in the bullets below:

- Work with producers to prevent nonpoint source pollution from AFOs.
- Promote use of State Revolving Fund for implementing AFO BMPs.
- Collaborate with MSU Extension Service, NRCS, and agriculture organizations in providing resources and training in whole farm planning to farmers, ranchers, conservation districts, watershed groups and resource agencies.
- Encourage inspectors to refer farmers and ranchers with potential nonpoint source discharges to DEQ watershed protection staff for assistance with locating funding sources for BMPs that meet their needs. (This is in addition to funds available through NRCS and the Farm Bill).

Develop early intervention of education and outreach programs for small farms and ranches that have potential to discharge nonpoint source pollutants from animal management activities. This includes assistance from the DEQ Permitting and Compliance Division, as well as external entities such as DNRC, local watershed groups, conservation districts, and MSU Extension.

8.3.5 Cropland

The major factors involved in decreasing sediment loads are reducing the amount of erodible soil, reducing the rate of runoff, and intercepting eroding soil before it enters waterbodies. The main BMP recommendation for the Upper Clark Fork Phase 2 TPA is the use of riparian buffers. Buffers reduce the rate of runoff, promote infiltration into the soil (instead of delivering runoff directly to the stream), and intercept sediment. Buffers are most effective when used in conjunction with agricultural BMPs that reduce the availability of erodible soil such as conservation tillage, crop rotation, strip cropping, and precision farming. Buffers along streams should be composed of natural vegetative communities which will also supply shade to reduce instream temperatures. Buffer widths along streams should be at least double the average mature canopy height to assist in providing stream shade. Reducing the amount of fertilizer applied to cropland can also reduce nutrients loading. Additional BMPs and details on the suggested BMPs can be obtained from NRCS and in Appendix A of Montana's Nonpoint Source Management Plan (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b).

8.3.6 Irrigation

Dempsey, Dunkleberg, Gold, lower Hoover, Lost, Peterson and lower Willow Creeks are affected by irrigation primarily in their lower reaches. Flow alteration and dewatering are commonly considered water quantity rather than water quality issues. However, changes to streamflow can have a profound effect on the ability of a stream to attenuate pollutants, especially nutrients, metals and heat. Flow reduction may increase water temperature, allow pollutants to accumulate in stream channels, reduce available habitat for fish and other aquatic life, and may cause the channel to respond by changing in size, morphology, meander pattern, rate of migration, bed elevation, bed material composition, floodplain morphology, and streamside vegetation if flood flows are reduced (Andrews and Nankervis, 1995; Schmidt and Potyondy, 2004). In addition to the BMPs recommended in Appendix A of Montana's Nonpoint Source Management Plan (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b), local coordination and planning are especially important for flow management because State law indicates that legally obtained water rights cannot be divested, impaired, or diminished by Montana's water quality law (MCA 75-5-705).

8.3.7 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. Enhancing and protecting riparian areas and floodplains within the watershed should be a priority of TMDL implementation in the Upper Clark Fork Phase 2 TPA.

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. Passive riparian restoration is preferable, but in areas where stream channels are unnaturally unstable 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 desired to speed up the rate of recovery. 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 should be designed to 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.

8.3.8 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 ft 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.

Buffers of about 50 ft can substantially reduce the amount of sediment and nutrients entering a stream (Lakel et al., 2010; Lee et al., 2003). The SMZ Law protects against excessive erosion within 50 ft of a stream and therefore is an appropriate starting point for helping meet nutrient (especially forms bound to sediments) LAs. Buffers of greater than 50 ft provide additional protection against sediment and nutrients (Mayer et al., 2005; Wegner, 1999). On USFS Lands, 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.

In addition to the BMPs identified above, effects that timber harvest may have on yearly streamflow levels, such as peak flow, should be considered. Timber harvest plans should evaluate the potential for cumulative effects on water yield and peak flow increases and implement BMPs to reduce sediment and nutrients loading.

8.3.9 Mining

Because restoration of mining impacts are typically implemented under state and federal programs, this section will discuss general restoration programs and funding mechanisms that may be applicable to mines as nutrients sources instead of specific BMPs. The need for further characterization of impairment conditions and loading sources is addressed through the monitoring plan in **Section 9.0**. A number of state and federal regulatory programs have been developed over the years to address water quality problems stemming from historic mines, associated disturbances, and metal refining impacts. Some regulatory programs and approaches that may be applicable to the Upper Clark Fork Phase 2 TPA include:

- CERCLA,
- The State of Montana MWCB’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).

8.3.9.1 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 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 many existing or historical land owners can be held liable for remediation costs. Where viable responsible parties 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.

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.

8.3.9.2 Montana DEQ Mine Waste Cleanup Bureau Abandoned Mine Lands (AML) Reclamation Program

The Montana DEQ Mine Waste Cleanup Bureau (MWCB), which is part of the DEQ Remediation Division, is responsible for reclamation of historical mining disturbances associated with abandoned mines in Montana.

The MWCB AML reclamation program is funded through the Surface Mining Control & Reclamation Act of 1977 (SMCRA) with SMCRA funds distributed to states by the federal government. 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 USFS-administered lands, and prior to 1980 for lands administered by the U.S. Bureau of Reclamation. Furthermore, there must be no party (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. There are currently 12 priority abandoned mines in the Upper Clark Fork Phase 2 TPA. For impaired streams in this document, this list includes 2 sites in the Dunkleberg Creek sub-watershed and 3 sites in the Silver Bow Creek watershed upstream of Butte, Montana.

8.3.9.3 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 or CERLCA, are typically addressed through the DEQ State Superfund or CECRA program. The CECRA program maintains a list of facilities potentially requiring remedial 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 11 active sites on the CECRA priority list in the Upper Clark Fork Phase 2 TPA. Nine of these sites are located in and around Butte, Montana. There is one site in Garrison and one site in Deer Lodge.

CECRA also encourages the implementation of voluntary cleanup activities under 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.

8.4 Potential Funding Sources

Funding and prioritization of restoration or water quality improvement projects 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.

8.4.1 Section 319 Nonpoint Source Grant Program

Section 319 grant funds are typically used to implement water quality restoration projects that focus on implementing a WRP. Individual contracts under the yearly award process typically range from $10,000 to $300,000, with a 40% of total project cost match requirement. 319 project funds are awarded to non-profit or governmental entities such as a conservation district, a watershed group, or a county.

8.4.2 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 semiannually in December and June. Projects that may be applicable to the Upper Clark Fork Phase 2 River watershed include restoring streambanks, improving fish passage, and restoring/protecting spawning habitats.

8.4.3 Watershed Planning and Assistance Grants

The Montana DNRC administers Watershed Planning and Assistance Grants to conservation districts and watershed groups that are sponsored by a conservation district. Funding is capped at $11,000 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 is contained in Montana's Nonpoint Source Management Plan (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b) and online at: http://www.epa.gov/nps/funding.html.

8.4.4 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.

8.4.5 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 Montana DNRC that can provide up to $300,000 to address environmental issues. This money can be applied to sites included on the 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 need to be administered through a local government such as a conservation district, city board, or county.

9.0 MONITORING FOR EFFECTIVENESS

The monitoring framework discussed in this section is an important component of watershed restoration, a requirement of TMDL development under Montana's TMDL law, and the foundation of the adaptive management approach. While targets and allocations are calculated using the best available data, the data are only an estimate of a complex ecological system. The MOS 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 local land managers, stakeholder groups, and federal and state agencies to develop more detailed and specific planning efforts regarding monitoring needs; it does not assign monitoring responsibility. 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 Upper Clark Fork Phase 2 TPA 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.

9.1 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 looks like greater reductions in loading or improved performance is necessary to meet targets, then updated TMDL and/or allocations will be developed.
- The road sediment estimates used to develop the sediment allocations for Silver Bow Creek and the Clark Fork River septic and livestock grazing are coarse models that were used to estimate the relative contribution of sediment from paved and unpaved roads to the impaired streams. The models were based on specific sets of assumptions described in **Section 5.8.4** and account for a limited number of variables that can affect sediment loading. As a result there is uncertainty in the accuracy of the values developed. If there is future interest in answering specific questions regarding sediment loading from roads or in calculating more accurate loading estimates, more detailed models will need to be used.

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.

9.2 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, contacts, 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 in one location for the entire watershed.

Loading reductions and BMP effectiveness can be evaluated with water quality samples and comparing them to the targets. In cases where BMPs targeting other probable causes such as sediment are being implemented, BMP effectiveness may be evaluated by documenting the length of streambank repaired and/or taking before and after photos of the project area.

If sufficient implementation progress is made within a watershed, DEQ will conduct a TMDL Implementation Evaluation (TIE). During this process, DEQ compiles recent data, conducts monitoring (if necessary), may be compare data to water quality targets (typically a subset for sediment), summarizes BMP implementation since TMDL development, and evaluates data 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 removed from the 303(d) list. If conditions indicate the TMDL is not being achieved, according to Montana State Law (75-5-703(9)), the evaluation must determine whether:

- 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.

9.3 Future Monitoring Guidance

The objectives for future monitoring in the Upper Clark Fork Phase 2 TPA include: (1) strengthen the spatial understanding of sources for future restoration work, which will also strengthen source assessment analysis for future TMDL review, (2) gather additional data to supplement target analysis, better characterize existing conditions, and improve or refine assumptions made in TMDL development, (3) gather consistent information among agencies and watershed groups that is comparable to targets and allows for common threads in discussion and analysis, (4) expand the understanding of streams throughout the Upper Clark Fork Phase 2 TPA beyond those where TMDL have been developed and address issues if necessary, and (5) track restoration projects as they are implemented and assess their effectiveness.

9.3.1 Strengthening Source Assessment

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.

9.3.1.1 Sediment

In the Upper Clark Fork Phase 2 TPA, the identification of sediment sources was conducted largely through watershed field tours, aerial assessment, the incorporation of GIS information, available data and literature review, with limited field verification and on-the-ground analysis. In many cases, assumptions were made based on overall TPA conditions and extrapolated throughout the watershed. As a result, the level of detail often does not provide specific areas by which to focus restoration efforts, only broad source categories to reduce sediment loads from each of the discussed sub-watersheds.

Strategies for strengthening source assessments for each of the pollutants may include:

- Field surveys of road and road crossing to identify specific contributing road crossings, their associated loads, and prioritize those road segments/crossings of most concern.
- Review of land-use practices specific to sub-watersheds of concern to determine where the greatest potential for improvement and likelihood of sediment reduction can occur for the identified major land-use categories.
- More thorough examinations of changes to bank erosion conditions following Superfund remediation along Silver Bow Creek and the Clark Fork River to better understand the changes in sediment loading post-remediation. Additionally, the development of bank erosion retreat rates specific to Silver Bow Creek and the Clark Fork River TPA would provide a more accurate quantification of sediment loading from bank erosion. Bank retreat rates can be determined by installing bank pins at different positions on the streambank at several transects across a range of landscapes and stability ratings. Bank erosion is documented after high flows and throughout the year for several years to capture retreat rates under a range of flow conditions.

9.3.1.2 Nutrients

Although extensive nutrient data were collected to assist with TMDL development, as conditions change in the respective sub-watersheds with changes in management practices and/or land use, continued monitoring of impaired systems is warranted. When watershed scale monitoring is conducted to assist with future impairment determinations, particular attention should be given to collecting additional nutrient data on impaired streams. Future sampling should also include algal sampling for chl-*a* and AFDM. Additionally, macroinvertebrates are part of a second tier assessment if nutrient and/or algae concentrations do not clearly indicate impairment and therefore should be collected. Data collection that includes water quality, algal, and macroinvertebrate samples ensures that all aspects of nutrients and their effects on aquatic life can be evaluated.

There are several specific data collection efforts that would better delineate some of the nutrient sources addressed in **Section 6.0**. These include:

- Scope and magnitude of inter-basin transfers of irrigation water and associated nutrient (and potentially sediment) loads. This is especially pertinent to those sub-watersheds where inter-basin transfers were identified including: Dempsey Creek, Dunkleberg Creek, Lost Creek, Peterson Creek and Willow Creek.

- Better delineation of potential nutrient loading from currently unpermitted facilities in the TPA including: Fairmont Hot Springs WWTP, Ramsay WWTP and Ranchland Packing in Butte.
- Currently pursuing a groundwater discharge permit, potential loading from the Anaconda WWTP to Lost Creek via groundwater recharge needs to be better understood. This situation needs additional monitoring in Lost Creek upstream and downstream of the facility on Galen Road to determine potential impacts. A conservative tracer associated with wastewater effluent, monitoring may include chloride sampling.
- Potential influence of Miller Lake on nutrient concentrations in Hoover Creek downstream of the reservoir outlet.
- Sampling of CERCLA discharges at LAO and MPTP for TP at detection limits less than the target concentration (0.03 mg/L).
- DEQ is investigating the next steps for delineating potential impacts from the designed TC ponds at Ranchland Packing on nutrient loading to Silver Bow Creek from stormwater discharges and/or groundwater pathways directly to Silver Bow Creek, or, potentially, to Silver Bow Creek via the LAO discharge. There are numerous monitoring wells in the vicinity of Ranchland Packing and LAO, however, additional monitoring wells might be needed to develop a potentiometric surface map to establish groundwater flow direction in tandem with a site assessment and water quality monitoring of surface water and groundwater in the area. While surface water and groundwater data is available, a targeted study plan is needed with involvement from all affected parties.
- Targeted sampling of several Silver Bow Creek tributaries including Basin Creek, Blacktail Creek, Sand Creek, Browns Gulch, and Gregson Creek. Silver Bow Creek instream water quality sampling indicate that these tributaries are likely above Middle Rockies water quality targets for TN and TP. Summer period sampling (July 1 to September 30) is needed to document water quality conditions in these respective streams.

9.3.2 Increase Available Data

While the Upper Clark Fork Phase 2 TPA has been the recipient of significant remediation and restoration activities, data is still often limited depending on the stream and pollutant of interest. Infrequent sampling events at a small number of sampling sites may provide some indication of overall water quality and habitat condition, however regularly scheduled sampling at consistent locations, under a variety of seasonal conditions is the best way to assess overall stream health and monitor change.

9.3.2.1 Sediment

For sediment investigation in the Upper Clark Fork Phase 2 TPA, Silver Bow Creek and the Clark Fork River were stratified into unique reaches based on physical characteristics and anthropogenic influence. A total of 11 sites were sampled in August/September 2011 on Silver Bow Creek and the Clark Fork River upstream of the Flint Creek confluence, however this equates to only a small percentage of the total number of stratified reaches in these streams. TMDLs did incorporate sediment data collected as part of CERCLA remediation efforts on Silver Bow Creek and the Clark Fork River. Sampling additional monitoring locations to represent some of the various reach categories that occur would provide additional data to assess existing conditions, and provide more specific information on a per stream basis as well as the TPA as a whole, by which to assess reach by reach comparisons and the potential influencing factors and resultant outcomes that exist throughout the watershed. This is especially important once remediation work is completed in the Silver Bow Creek and Clark Fork River channels and floodplain.

9.3.2.2 Nutrients
Water quality sampling locations for nutrients were distributed spatially along each AU in order to best delineate nutrient sources. Over multiple sample seasons, sampling locations were refined to better quantify loading sources to the impaired waterbodies. Source refinement will continue to be necessary on streams with TMDLs and those that have not yet been assessed in the Upper Clark Fork Phase 2 TPA to better assess nutrient loading.

It will be important to continually assess nutrient sources in a watershed with changing land uses and/or new MPDES permitted discharges to surface waters.

9.3.3 Consistent Data Collection and Methodologies
Data has been collected throughout the Upper Clark Fork Phase 2 TPA for many years and by many different agencies and entities, however the type and quality of information is often variable. Where ever possible, it is recommended that the type of data and methodologies used to collect and analyze the information be consistent so as to allow for comparison to TMDL targets and track progress toward meeting TMDL goals.

DEQ is the lead agency for developing and conducting impairment status monitoring. However, other agencies or entities may work closely with DEQ to provide compatible data if interest arises. Impairment determinations are conducted by the state but can use data collected from other sources. The information in this section provides general guidance for future impairment status monitoring and effectiveness tracking.

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

9.3.3.1 Sediment
Sediment and habitat assessment protocols consistent with DEQ field methodologies and that serve as the basis for sediment targets and assessment within this TMDL should be conducted whenever possible. Current protocols are identified within Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments (Montana Department of Environmental Quality, 2012b). 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, when collecting sediment and habitat data in the Upper Clark Fork Phase 2 TPA it is recommended that at a minimum the following parameters be collected to allow for comparison to TMDL targets:

- Riffle Cross Section; using Rosgen methodology
- Riffle Pebble Count; using Wolman Pebble Count methodology
- Pool Assessment; Count and Residual Pool Depth Measurements
- Greenline Assessment; NRCS methodology

Additional information will undoubtedly be useful and assist DEQ with TMDL effectiveness monitoring in the future. Macroinvertebrate studies, McNeil core sediment samples, and fish population surveys and redd counts are examples of additional useful information used in impairment status monitoring and TMDL effectiveness monitoring which were not developed as targets but reviewed where available during the development of this TMDL.

9.3.3.2 Nutrients

For those watershed groups and/or government agencies that monitor water quality, it is recommended that the same analytical procedures and reporting limits are used in order that water quality data may be compared to TMDL targets (**Table 9-1**). In addition, stream discharge should be measured at time of sampling.

Table 9-1. DEQ Nutrient Monitoring Parameter Requirements

Analyte	Preferred Method	Alternate Method	Required Reporting Limit (ppb)	Holding Time (days)	Bottle	Preservative
Total Persulfate Nitrogen (TPN)	A4500-NC	A4500-N B	40	28	250mL High-Density Polyethylene	≤6°C (7d HT); Freeze (28d HT)
Total Phosphorus as P	EPA-365.1	A4500-P F	3			H2S04, ≤6°C of Freeze
Nitrate-Nitrite as N	EPA-353.2	A4500-N03 F	10			

9.3.4 Effectiveness Monitoring for Restoration Activities

As restoration activities are implemented, watershed-scale monitoring may be valuable in determining if restoration activities are improving water quality, instream flow, and aquatic habitat and communities. It is important to remember that degradation of aquatic resources happens over many decades and that restoration is often also a long-term process. An efficiently executed long-term monitoring effort is an essential component to any restoration effort.

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

As restoration activities begin throughout the watershed, pre and post monitoring to understand the change that follows implementation will be necessary to track the effectiveness of specific projects. Monitoring activities should be selected such that they directly investigate those subjects that the project is intended to effect, and when possible, linked to targets and allocations in the TMDL. For example, is bank erosion is to be addressed, pre and post BEHI analysis on the subject banks will be valuable to understand the extent of improvement and the amount of sediment reduced.

9.3.5 Watershed Wide Analyses

Recommendations for monitoring in the Upper Clark Fork Phase 2 TPA should not be confined to only those streams addressed within this document. The water quality targets presented herein are applicable to all streams in the watershed, and the absence of a stream from the State's 303(d) list does not necessarily imply a stream that fully supports all beneficial uses. Furthermore, as conditions change over time and land management evolves, consistent data collection methods throughout the watershed will allow resource professionals to identify problems as they occur, and to track improvements over time.

10.0 Stakeholder and Public Participation

Stakeholder and public involvement is a component of TMDL planning supported by EPA's 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 Upper Clark Fork Phase 2 TPA.

10.1 Participants and Roles

Throughout completion of the Upper Clark Fork Phase 2 TPA nutrient 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 Upper Clark Fork Phase 2 TPA and their roles is contained below.

10.1.1 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.

10.1.2 U.S. Environmental Protection Agency

EPA is the federal agency responsible for administering and coordinating requirements of the 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, Montana.

10.1.3 TMDL Advisory Group

The Upper Clark Fork Phase 2 TPA TMDL Advisory Group consisted of selected resource professionals who possess a familiarity with water quality issues and processes in the Upper Clark Fork Phase 2 TPA, and also representatives of applicable interest groups. All members were solicited to participate in an advisory capacity per Montana state law (75-5-703 and 704). DEQ requested participation from the interest groups defined in MCA 75-5-704 and included local city and county representatives, livestock-oriented and farming-oriented agriculture representatives, conservation groups, watershed groups, state and federal land management agencies, and representatives of recreation and tourism interests. The advisory group also included additional stakeholders and landowners with an interest in maintaining and improving water quality and riparian resources.

Advisory group involvement was voluntary and the level of involvement was at the discretion of the individual members. Members had the opportunity to provide comment and review of technical TMDL assessments and reports and to attend meetings organized by DEQ for the purpose of soliciting feedback on project planning. Typically, draft documents were released to the advisory group for review 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 email 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.

10.1.4 Area Landowners

Since 58% of the planning area is in private ownership, 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.

10.2 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 began on March 4, 2014, and ended on April 2, 2014. DEQ made the draft document available to the public, solicited public input and comments, and announced public meetings at which the TMDLs were presented to the public. These outreach efforts were conducted via emails to watershed advisory group members and other interested parties, posts on the DEQ website, and announcements in the following newspapers: the Montana Standard (Butte), the Anaconda Leader, the Silver State Post (Deer Lodge), and the Missoulian. DEQ provided an overview of these nutrient and sediment TMDLs at public presentations in Butte and Deer Lodge on March 11.

No public comments were received by DEQ for the *Upper Clark Fork Phase 2 Sediment and Nutrients TMDLs and Framework Water Quality Improvement Plan* during the public comment period.

11.0 REFERENCES

Andrews, Edmund D. 1987. "Longitudinal Dispersion of Trace Metals in the Clark Fork River, Montana," in *Chemical Quality of Water and the Hydrologic Cycle*, Averett, Robert C. and McKnight, Dale, (Chelsea, MI: Lewis Publishers): 179-191.

Andrews, Edmund D. and James M. Nankervis. 1995. "Effective Discharge and the Design of Channel Maintenance Flows for Gravel-Bed Rivers: Natural and Anthropogenic Influences in Fluvial Geomorphology," in *Natural and Anthropogenic Influences in Fluvial Geomorphology: The Wolman Volume*, Costa, John E., Miller, Andrew J., Potter, Kenneth W., and Wilcock, Peter R. Geophysical Monograph Series, Ch. 10: American Geophysical Union): 151-164.

Asmussen, Loris, A. W. White, Ellis W. Hauser, and Joseph M. Sheridan. 1976. Reduction of 2, 4-D Load in Surface Runoff Down a Grassed Waterway. *Journal of Environmental Quality.* 6(2): 159-162.

Atlantic Richfield Company. 1997. Final Comprehensive Remedial Design Work Plan (CRDWP), Streamside Tailings Operable Unit, Silver Bow Creek/Butte Area NPL Site.

Baigun, Claudio R. M. 2003. Characteristics of Deep Pools Used by Adult Summer Steelhead in Steamboat Creek, Oregon. *North American Journal of Fisheries Management.* 23(4): 1167-1174.

Barbour, Michael T., Jeroen Gerritsen, Blaine D. Snyder, and James B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish: Second Edition. Washington, DC: United States Department of Environmental Protection, Office of Water. EPA 841-B-99-002.

Barr Engineering Company. 2012. RCRA Facility Investigation Report, Corrective Action Oder on Consent, Docket No. RCRA-08-2004-0001, Silver Bow Plant, Butte, Montana.

Bauer, Stephen B. and Stephen C. Ralph. 1999. Aquatic Habitat Indicators and Their Application to Water Quality Objectives Within the Clean Water Act. Seattle, WA: US Environmental Protection Agency, Region 10. EPA 910-R-99-014.

Bengeyfield, Pete. 2004. Beaverhead-Deerlodge National Forest Stream Morphology Data. Unpublished.

Bjornn, Ted C. and Dudley W. Reiser. 1991. "Habitat Requirements of Salmonids in Streams," in *Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats*, Special Publication 19 ed., (Bethesda, MD: American Fisheries Society): 83-138.

Boettcher, F and E. Juvan. 1970. Soil Survey and Interpretations for Resources Planning and Urban Development in the Area of Butte, Montana. United States Soil Conservation Service.

Bond, Jim L., Lisa Kusnierz, Kyle F. Flynn, and Michael W. Van Liew. 2009. Upper Clark Fork River Tributaries Sediment, Metals, and Temperature TMDLs and Framework for Water Quality Restoration: DRAFT. Helena, MT: Montana Dept. of Environmental Quality. C01-TMDL-02.

Bonneau, Joseph L. 1998. Seasonal and Diel Changes in Habitat Use by Juvenile Bull Trout (Salvelinus Confluentus) and Cutthroat Trout (Oncorhynchus Clarki) in a Mountain Stream. *Canadian Journal of Zoology.* 76(5): 783-790.

Botz, Maxwell K. 1969. Hydrogeology of the Upper Silver Bow Creek Drainage Area, Montana. Butte, MT: Montana College of Mineral Science and Technology. MBMG Bulletin 75.

Bryce, Sandra A., Gregg A. Lomnicky, and Philip R. Kaufmann. 2010. Protecting Sediment-Sensitive Aquatic Species in Mountain Streams Through the Application of Biologically Based Streambed Sediment Criteria. *North American Benthological Society.* 29(2): 657-672.

Butte Silver Bow Public Works Department. 2011. Butte Silver Bow's Municipal Storm Water System Improvement Plan.

Camp, Dresser & McKee and Applied Geomorphology, Inc. 2010. Clark Fork River Operable Unit Milltown Reservoir/Clark Fork River NPL Site, Powell, Deer Lodge, and Granite Counties, Montana; Part 2: Geomorphic, Hydrologic, and Hydraulic Investigation for Phase 1 Remedial Design and Remedial Action.

Cappiella, Karen, Tom Schueler, Julie Tasillo, and Tiffany Wright. 2006. Wetlands and Watersheds: Adapting Watershed Tools to Protect Wetlands. Ellicott City, Maryland: Center for Watershed Protection.

Carey, Jennifer Hunt. 1991. Phosphorus Sources in Gold Creek, A Tributary of the Clark Fork River in Western Montana. Master of Science. Missoula, MT: University of Montana.

Carstarphen, Camela A., John I. LaFave, and Tom W. Patton. 2004. Water Levels and Nitrate in Warne Heights, Upper Summit Valley, Silver Bow County, Montana. Montana Bureau of Mines and Geology. Open-File Report 18.

CDM-Smith and Applied Geomorphology, Inc. 2013. Clark Fork River Operable Unit, Milltown Reservoir/Clark Fork River Superfind Site, Powell, Deer Lodge, and Granite Counties: Geomorphology and Hydrology of Reach A.

Confluence, Inc. 2008. Stream-Irrigation Network Relationships in the Upper Clark Fork TMDL Planning Area.

Cover, Matthew R., Christine L. May, William E. Dietrich, and Vincent H. Resh. 2008. Quantitative Linkages Among Sediment Supply, Streambed Fine Sediment, and Bethic Macroinvertebrates in Northern California Streams. *Journal of the North American Benthological Society.* 27(1): 135-149.

DEQ SRF Section personnel. 2012. Perconal Communication.

DOWL HKM. 2012. Anaconda-Deer Lodge County West Valley Sewer Extension Preliminary Engineering Report.

Feller, M. C. and J. P. Kimmins. 1984. Effects of Clearcutting and Slash Burning on Streamwater Chemistry and Watershed Nutrient Budgets in Southwestern British Columbia. *Water Resources Research.* 20: 29-40.

Gammons, Christopher H., John N. Babcock, Stephen R. Parker, and Simon R. Poulson. 2011. Diel Cycling and Stable Isoptopes of Dissolved Oxygen, Dissolved Inorganic Carbon, and Nitrogenous Species in a Stream Receiving Treated Municipal Sewage. 283.

Geosyntec Consultants and Wright Water Engineers, Inc. 2008. Overview of Performance by BMP Category and Common Pollutant Type (International Stormwater Best Management Practices Database [1999-2007]). Water Environment Research Foundation; American Society of Civil Engineers; U.S.E.P.A.; Federal Highway Administration; American Public Works Association. http://www.bmpdatabase.org/Docs/Performance%20Summary%20Cut%20Sheet%20June%202008.pdf.

-----. 2011. Internationational Stormwater Best Management Practices Database Pollutant Category Summary: Solids (TSS, TDS, and Turbidity). www.bmpdatabase.org.

Geosyntec Consultants, Inc. and Wright Water Engineers, Inc. 2012. International Stormwater Best Management Practices (BMP) Database Pollutant Category Summary Statistical Addendum: TSS, Bacteria, Nutrients, and Metals.

Green, Douglas M. and J. B. Kauffman. 1989. "Nutrient Cycling at the Land-Water Interface: The Importance of the Riparian Zone," in *Practical Approaches to Riparian Resource Management: An Education Workshop*, Gresswell, Robert E., Barton, Bruce A., and Kershner, Jeffrey L., (Billings, MT: U.S. Bureau of Land Management): 61-68.

Grumbles, Benjamin. 2006. Letter From Benjamin Grumbles, US EPA, to All EPA Regions Regarding Dail Load Development. U.S. Environmental Protection Agency.

Hall, Jon K., Nathaniel L. Hartwig, and Lynn D. Hoffman. 1983. Application Mode and Alternative Cropping Effects on Atrazine Losses From a Hillside. *Journal of Environmental Quality.* 12(3): 336-340.

Han, Jun, Jy S. Wu, and Craig Allan. 2005. Suspended Sediment Removal by Vegetative Filter Strip Treating Highway Runoff. *Journal of Environmental Science and Health.* 40(8): 1637-1649.

Harmon, Will. 1999. Best Management Practices (BMPs) for Grazing: Montana. Helena, MT: Conservation Districts Bureau, Department of Natural Resources and Conservation.

Harris, James and Vicki Watson. 2000. Watershed Restoration Assessment for Lost Creek - A Tributary of the Upper Clark Fork River. Missoula, MT: University of Montana.

Heckenberger, Brian. 2009. Personal Communication. Kusnierz, Lisa. Accessed 5/2009.

Hornberger, Michelle I., John H. Lambing, Samuel N. Luoma, and Ellen V. Axtmann. 1997. Spatial and Temporal Trends of Trace Metals in Surface Water, Bed Sediment, and Biota of the Upper Clark Fork Basin, Montana, 1985-95. Menlo Park, CA: U. S. Geological Survey. Open-File Report 97-669.

Irving, John S. and Ted C. Bjornn. 1984. Effects of Substrate Size Composition on Survival of Kokanee Salmon and Cutthroat and Rainbow Trout Embryos. Idaho Cooperative Fishery Research Unit, College of Forestry, Wildlife, and Range Sciences, University of Idaho. Technical Report No. 84-6.

Jacobson, R. B. 2004. Downstream Effects of Timber Harvest in the Ozarks of Missouri. *Toward Sustainability For Missouri Forests.*: 106-1260.

Kapustka, L. A. 2002. Natural Resource Injury Report on Riparian and Upland Areas of Grant-Kohrs Ranch National Historic Site, Clark Fork River Basin, Montana.

Kendy, Eloise and Ruth E. Tresch. 1996. Geographic, Geologic, and Hydrologic Summaries of Intermontane Basins of the Northern Rocky Mountains, Montana. Helena, MT: US Geological Survey. Water-Resources Investigations Report 96-4025.

Kershner, Jeffrey L., Brett B. Roper, Nicolaas Bouwes, Richard C. Henderson, and Eric K. Archer. 2004. An Analysis of Stream Habitat Conditions in Reference and Managed Watersheds on Some Federal Lands Within the Columbia River Basin. *North American Journal of Fisheries Management.* 24: 1363-1375.

KirK Environmental, LLC. 2003. East Valley Watershed Baseline Report. Sheridan, MT: Kirk Environmental, LLC. DEQ Contract #202073.

-----. 2004. Draft Gold Creek Watershed TMDL Phase 1 Assessment. Helena, MT: KirK Environmental.

-----. 2006. Browns Gulch Watershed Baseline Report. Prepared for the Watershed Restoration Coalition.

Knighton, David. 1998. Fluvial Forms and Processes: A New Perspective, New York, New York: John Wiley and Sons Inc.

Knutson, K. Lea and Virginia L. Naef. 1997. Management Recommendations for Washington's Priority Habitats: Riparian. Olympia, WA: Washington Department of Fish and Wildlife (WDFW).

Kramer, Richard P., Brian W. Riggers, and Kenneth R. Furrow. 1993. Basinwide Methodolgoy: Stream Habitat Inventory Methodology. Missoula, MT: USDA Forest Service.

Krier, Sara M. 2004. A Watershed Assessment of Griffin Creek, Headwaters Tributary to Montana's Clark Fork of the Columbia River. Master of Science. Missoula, MT: University of Montana.

LaFave, John I. 2008. Nitrate in the Ground Water and Surface Water of the Summit Valley Near Butte, Montana. Montana Bureau of Mines and Geology. Open File Report 22.

Lakel, William A. I., Wallace M. Aust, M. C. Bolding, C. A. Dolloff, Patrick Keyser, and Robert Feldt. 2010. Sediment Trapping by Streamside Management Zones of Various Widths After Forest Harvest and Site Preparation. *Forest Science.* 56(6): 541-5.

Lee, Ki H., T. M. Isenhart, and R. C. Schultz. 2003. Sediment and Nutrient Removal in an Established Multi-Species Riparian Buffer. *Journal of Soil and Water Conservation.* 58(1): 1-8.

Lewis, Reed S. 1998. Geologic Map of the Butte 1 X 2 Quadrangle, Southwestern Montana. Butte, MT: Montana Bureau of Mines and Geology. http://www.mbmg.mtech.edu/mbmgcat/public/ListCitation.asp?selectby=series&series_type=MBMG&series_number=363&series_sub=&.

Liermann, Brad W., Jason Lindstrom, and Ryan Kreiner. 2009. An Assessment of Fish Populations and Riparian Habitat in Tributaries of the Upper Clark Fork River Basin: Phase II. Montana Department of Fish, Wildlife and Park.

Likens, Gene E., F. H. Bormann, Robert S. Pierce, and W. A. Reiners. 1978. Recovery of a Deforested Ecosystem. *Science.* 199(4328): 492-496.

Lindstrom, Jason. 2011. An Assessment of Fish Populations and Riparian Habitat in Tribuatries of the Upper Clark Fork River Basin - 2009 Report.

Lindstrom, Jason, Brad W. Liermann, and Ryan Kreiner. 2008. An Assessment of Fish Populations and Riparian Habitat in Tributaries of the Upper Clark Fork River Basin. Helena, MT: Montana Department of Fish, Wildlife and Parks.

MacDonald, Lee H., Alan W. Smart, and Robert C. Wissmar. 1991. Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska. Seattle, WA: U.S. Environmental Protection Agency. EPA 910/9-91-001.

Madison, James, Jeffrey D. Lonn, Richard K. Marvin, John Metesh, and Robert Wintergerst. 1998. Abandoned-Inactive Mines Program: Deerlodge National Forest, Volume IV: Upper Clark Fork River Drainage. Butte, MT: Montana Bureau of Mines and Geology. MBMG Open-file Report 346.

Martin, C. W. and R. D. Harr. 1989. Logging of Mature Douglas-Fir in Western Oregon Has Little Effect on Nutrient Output Budgets. *Canadian Journal of Forest Research.* 19(1): 35-43.

May, Christine L. and Danny C. Lee. 2004. The Relationships Among in-Channel Sediment Storage, Pool Depth, and Summer Survival of Juvenile Salmonids in Oregon Coast Range Streams. *North American Journal of Fisheries Management.* 24: 761-744.

Mayer, Paul M., Steven K. Reynolds, Jr., Timothy J. Canfield, and Marshall D. McCutchen. 2005. Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness: A Review of Current Science and Regulations. Cincinnati, OH: National Risk Management Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency. EPA/600/R-15/118.

McDowell, Will and Ruth Watkins. 2004. Phosphorus Reduction in the Upper Clark Fork River: Report on Goal #2: Phosphorus Sources and Load From Selected Tributary Watersheds in the Upper Clark Fork. Sandpoint, ID: Tri-State Water Quality Council.

Mebane, Christopher A. 2001. Testing Bioassessment Metrics: Macroinvertebrate, Sculpin, and Salmonid Responses to Stream Habitat, Sediment, and Metals. *Environmental Monitoring and Assessment.* 67(3): 293-322.

Mickelson, Steven K., James L. Baker, and Syed I. Ahmed. 2003. Vegetative Filter Strips for Reducing Atrazine and Sediment Runoff Transport. *Journal of Soil and Water Conservation.* 58(6): 359-367.

Montana Bureau of Mines and Geology. 2013. Montana Groundwater Information Center Water Well Data. http://apps.msl.mt.gov/Geographic_Information/Data/DataList/datalist_Details.aspx?did={B40FCBD4-DA34-483A-A8C9-F9C1E95F7A21}. Accessed 7/24/2013.

Montana Department of Environmental Quality. 1997. Channel Stability Analysis, Silver Bow Creek SSTOU Subarea 1.

-----. 2003. Channel Stability and Conceptual Design Report, Subarea 2, Streamside Tailings Operable Unit, Silver Bow Creek/Butte Area NPL Site.

-----. 2007. Channel Stability Analysis and Conceptual Design Report, Subarea 3, Streamside Tailings Operable Unit, Silver Bow Creek/Butte Area NPL Site.

-----. 2008. Channel Stability Analysis and Conceptual Design Report, Subarea 4, Streamside Tailings Operable Unit, Silver Bow Creek/Butte Area NPL Site.

-----. 2010. Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments.

-----. 2012a. Circular DEQ-13 Montana's Policy for Nutrient Trading.

-----. 2012b. Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments.

-----. 2012c. Little Blackfoot 2011 Metals, Sediment & Nutrients TMDL Development History and Archive. Montana Department of Environmental Quality.

-----. 2012d. Prospect Creek 2009 Sediment TMDL Development History and Archive. Montana Department of Environmental Quality.

Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8. 2011. Little Blackfoot River Watershed TMDLs and Framework Water Quality Improvement Plan: Final. Helena, MT: Montana Department of Environmental Quality. C01-TMDL-03A-F.

Montana Department of Environmental Quality, Mine Waste Cleanup Bureau. 2013. Final Construction Report; FOrest ROse Mine Reclamation Project.

Montana Department of Environmental Quality, Planning, Prevention and Assistance Division. 2010. Upper Clark Fork River Tributaries Sediment, Metals, and Temperature TMDLs and Framework for Water Quality Restoration. Helena, MT: Montana Dept. of Environmental Quality. C01-TMDL-02a-F.

Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau. 2006. DEQ Benthic Macroinvertebrate Standard Operating Procedure.

-----. 2008. St. Regis Watershed Total Maximum Daily Loads and Framework Water Quality Restoration Assessment: Sediment and Temperature TMDLs. Helena, MT: Montana Dept. of Environmental Quality.

-----. 2011. Tobacco Planning Area Sediment TMDLs and Framework Water Quality Improvement Plan: Final. Helena, MT: Montana Department of Environmental Quality. K01-TMDL-03aF.

-----. 2012a. Montana 2012 Final Water Quality Integrated Report. Helena, MT: Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau. WQPBIMTSR-004f.

-----. 2012b. Montana Nonpoint Source Management Plan. Helena, MT: Montana Department of Environmental Quality, Water Quality Planning Bureau, Watershed Protection Section. WQPBWPSTR-005.

Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, Water Quality Standards Section. 2012. Circular DEQ-7 Montana Numeric Water Quality Standards.

Montana State University Extension Service. 2001. Water Quality BMPs for Montana Forests. Bozeman, MT: MSU Extension Publications.

Muhlfeld, Clint C., David H. Bennett, and Brian L. Marotz. 2001. Fall and Winter Habitat Use and Movement by Columbia River Redband Trout in a Small Stream in Montana. *North American Journal of Fisheries Management.* 21(1)

Natural Resource Conservation Service. 2011a. Montana Conservation Practice Standard: Filter Strips, Code 393. http://efotg.sc.egov.usda.gov/references/public/mt/393_standard_june_2011.pdf. Accessed 11/7/11 A.D.a.

-----. 2011b. Montana Conservation Practice Standard: Riparian Forest Buffer, Code 391. MT: NRCS. http://efotg.sc.egov.usda.gov/references/public/mt/391_standard_june_2011.pdf. Accessed 11/7/11 A.D.b.

Naughton, Joseph Patrick. 2013. Salmonid Response to Superfind Remediation in Silver Bow Creek, Montana.

Nielson, Jennifer L., Thomas E. Lisle, and Vicki Ozaki. 1994. Thermally Stratified Pools and Their Use by Steelhead in Northern California Streams. *Transactions of the American Fisheries Society.* 123(4): 613-626.

Nimick, David A. 1990. Stratigraphy and Chemistry of Metal-Contaminated Flood Plain Sediments, Upper Clark Fork River, Montana: MIssoula, University of Montana M.S. Thesis 118 P.

-----. 1993. Hydrology and Water Chemistry of Shallow Aquifers Along the Upepr Clark Fork, Western Montana. U.S. Geological Survey Water-Resources Investigations Report 93-4052.

Nimick, David A., Christopher H. Gammons, and Stephen R. Parker. 2011. Diel Biogeochemical Processes and Their Effect on the Aqueous Chmistry of Streams: a Review. 283.

Nimick, David A. and Johnnie N. Moore. 1991. Prediction of Water-Soluble Metal Concentrations in Fluvially Deposited Tailings. *Applied Geochemistry.* 6: 635-646.

Pitt, R., A Maestre, and R. Morquecho. 2004. The National Stormwater Quality Database (NSQD, Version 1.1).

Plumb, Beverly. 2009. Geochemistry of Nutrients in Silver Bow Creek, Butte, Montana (Thesis). Butte, MT: Montana Tech of the University of Montana.

Portner, Ryan and Marc S. Hendrix. 2005. Preliminary Geologic Map of the Eastern Flint Creek Basin, West-Central Montana. Butte, MT: Montana Bureau of Mines and Geology. MBMG Open File Report 521,17.

Priscu, John C. 1987. Environmental Factors Regulating the Dynamics of Blue-Green Algal Blooms in Canyon Ferry Reservoir, Montana. Bozeman, MT: Montana Water Resources Research Institute. Report # 159.

PRISM Group. 2004. Parameter-Elevation Regressions on Independent Slopes Model Climate Mapping System. http://www.ocs.orst.edu/prism/index.phtml. Accessed 11/8/11 A.D.

Relyea, Christina, G. Wayne Minshall, and Robert J. Danehy. 2000. Stream Insects As Bioindicators of Fine Sediment. In: Watershed 2000. Water Environment Federation Specialty Conference. Boise, ID: Idaho State University.

Rennick, R and G. Coleman C. Emilsson. 2009. Land Reclamation Performance Evaluation Process and Standards Used at the Anacodna Smelter Site, Montana.

Rosgen, David L. 1996. Applied River Morphology, Pagosa Springs, CO: Wildland Hydrology.

-----. 2006. Watershed Assessment of River Stability and Sediment Supply (WARSSS). Fort Collins, CO: Wildland Hydrology.

Ross, Clyde P., D. A. Andres, and Irving J. Witkind. 1955. Geologic Map of Montana.

Rowe, Mike, Don A. Essig, and Benjamin K. Jessup. 2003. Guide to Selection of Sediment Targets for Use in Idaho TMDLs. Pocatello, ID: Idaho Department of Environmental Quality.

Saffel, Pat and Tom Mostad. 2011. Lost Creek Watershed Project Final Report. DOJ Contract No. 600122.

Schmidt, Larry J. and John P. Potyondy. 2004. Quantifying Channel Maintenance Instream Flows: An Approach for Gravel-Bed Streams in the Western United States. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. General Technical Report RMRS-GTR-128.

Shepard, Bradley B., Stephen A. Leathe, Thomas M. Weaver, and Michael D. Enk. 1984. Monitoring Levels of Fine Sediment Within Tributaries to Flathead Lake, and Impacts of Fine Sediment on Bull Trout Recruitment. In: Wild Trout III, Proceedings of the Symposium. Sept. 24, 1984. Yellowstone National Park, MT: Wild Trout III.

Smith, J. Dungan, John H. Lambing, David A. Nimick, Charles Parrett, Michael Ramey, and William M. Schafer. 1998. Geomorphology, Flood-Plain Tailings, and Metal Transport in the Upper Clark Fork Valley, Montana. Helena, MT: US Department of the Interior, US Geological Survey. Water-Resources Investigations Report 98-4170.

Soil Conservation Service, Department of Agriculture. 1986. Technical Release 55: Urban Hydrology for Small Watersheds.

Spratt & Associates. 1990. Anaconda Sewage Treatment Facility Plan Rapid Infiltration Basin Hydrogeology Final Report.

Staedler, F. 2013. Personal Communication.

Staples, James Mark, Laura Gamradt, Otto Stein, and Xianming Shi. 2004. Recommendations for Winter Traction Materials Management on Roadways Adjacent to Bodies of Water. Helena, MT: Montana Department of Transportation.

Straw W.T. 1980. Geology for Planning in Butte-Silver Bow Area. Montana Bureua of Mines and Geology. Open-File Report 58.

Sullivan, S. M. P. and Mary C. Watzin. 2010. Towards a Functional Understanding of the Effects of Sediment Aggradation on Stream Fish Conditions. *Rier Research and Applications.* 26(10): 1298-1314.

Suplee, Michael W. and Rosie Sada de Suplee. 2011. Assessment Methodology for Determining Wadeable Stream Impairment Due to Excess Nitrogen and Phosphorus Levels. Helena, MT: Montana Department of Environmental Quality Water Quality Planning Bureau. WQPMASTR-01.

Suplee, Michael W. and Vicki Watson. 2013. Scientific and Technical Basis of the Numeric Nutrient Criteria for Montana's Wadeable Streams and Rivers—Update 1. Helena, MT: Montana Department of Environmental Quality.

Suplee, Michael W., Vicki Watson, Mark E. Teply, and Heather McKee. 2009. How Green Is Too Green? Public Opinion of What Constitutes Undesirable Algae Levels in Streams. *Journal of the American Water Resources Association.* 45(1): 123-140.

Suplee, Michael W., Vicki Watson, Arun Varghese, and Joshua Cleland. 2008. Scientific and Technical Basis of the Numeric Nutrient Criteria for Montana's Wadeable Streams and Rivers. Helena, MT: Montana Department of Environmental Quality.

Suttle, Kenwyn B., Mary E. Power, Jonathan M. Levine, and Camille McNeely. 2004. How Fine Sediment in Riverbeds Impairs Growth and Survival of Juvenile Salmonids. *Ecological Applications.* 14(4): 969-974.

Terragraphics. 2012. Draft Geomorphic, Hydrologis, Adn Hydraulic Investigation of Clark Fork River Operable Unit Phases 5 and 6.

Tetra Tech, Inc., Geum Environmental Consulting, Inc., and Applied Geomorphology, Inc. 2012. Clark Fork River Operable Unit Phases 15 and 16 Draft Preliminary Design.

Titan Environmental Corporation. 1995. Milltown Reservoir Sediments NPL Site Clark Fork River Operable Unit: Development of Alternatives and Initial Screening Report. Bozeman, MT: Titan Environmental Corporation.

Tri-State Implementation Council. 1998. Clark Fork River: Voluntary Nutrient Reduction Program. Sandpoint, ID: Tri-State Implementation Council.

Tri-State Water Quality Council. 2009. The Clark Fork River Voluntary Nutrient Reduction Program 1998-2008.

U.S Environmental Protection Agency. 2010. Fourth FIve-Year Review Report; Anaconda Smelter Superfund Site, Anaconda, MT.

U.S. Department of Agriculture and U.S. Environmental Protection Agency. 1999. Unified National Strategy for Animal Feeding Operations. EPA Number 833R99900. http://www.epa.gov/npdes/pubs/finafost.pdf.

U.S. Department of Agriculture, Forest Service. 2006. Effectiveness Monitoring for Streams and Riparian Areas Within the Pacific Northwest: Stream Channel Methods for Core Attributes. United States Department of Agriculture, Forest Service.

U.S. Environmental Protection Agency. 1990. EPA Superfund Record of Decision: SIlver Bow Creek/Butte Area, Warm Springs Ponds Operable Unit.

-----. 1993. EPA Superfund Record of Decision: Montana Pole and Treating.

-----. 1995a. EPA Superfund Record of Decision: Rocker Timber Framing and Treatemnt Plant.

-----. 1995b. EPA Superfund Record of Decision: Silver Bow Creek/Butte Area, Streamside Tailings Operable Unit.

-----. 1999a. Protocol for Developing Nutrient TMDLs. Washington, D.C.: Office of Water, U.S. Environmental Protection Agency. EPA 841-B-99-007.

-----. 1999b. Protocol for Developing Sediment TMDLs. Washington, D.C.: Office of Water, United States Environmental Protection Agency. EPA 841-B-99-004.

-----. 2004. Record of Decision, Clark Fork River Operable Unit of the Milltown Reservoir/Clark Fork River Superfund Site.

-----. 2006. Record of Decision, Butte Priority Soils Operable Unit, Silver Bow Creek/Butte Area NPL Site.

-----. 2009a. Development Document for Final Effluent Guidelines and Standards for the Contruction & Development Category. U.S. Environmental Protection Agency. http://water.epa.gov/scitech/wastetech/guide/construction/upload/2009_12_8_guide_construction_files_chapters.pdf.

-----. 2009b. Draft Stormwater Modeling Report Butte Priority Soils Operable Unit Silver Bow Creek/Butte Area NPL Site.

-----. 2010. Using Stressor-Response Relationships to Derive Numeric Nutrient Criteria. Washington, DC: Office of Science and Technology, Office of Water, EPA. EPA-820-S-10-001.

United States Census Bureau. 2012. 2010 Population Finder.

United States Code of Federal Regulations. 2012. 40 CFR 130.2. http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=3dbaff7898ca5c8e8a0f5f9f1752a972&rgn=div8&view=text&node=40:22.0.1.1.1.0.1.3&idno=40. Accessed 8/30/2012.

United States Geological Survey. 2007. National Land Cover Dataset 2001 Land Cover.

United States Geological Survey, J. Dunga Smith, and Eleanor R. ffin. 2002. Relation Between Geomorphic Stability and the Density of Large Shrubs on the Flood Plain of the Clark Fork of the Columbia River in the Deer Lodge Valley, Montana. Water Resources INvestigations Report 02-4070. http://pubs.er.usgs.gov/publication/wri024070:

Water & Environmental Technologies. 2004. Nutrient Source Assessment: Upper Silver Bow Creek Watershed. Butte, MT: Water & Environmental Technologies.

-----. 2009. Road Sediment Assessment & Modeling: Little Blackfoot River TMDL Planning Area. Task 1. Road GIS Layers & Summary Statistics. Butte, MT: Water & Environmental Technologies. DEQ Contract #206038.

Watershed Restoration Coalition. 2012. Watershed Restoration Plan for the Upper Clark Fork Tributaries.

-----. 2013. Upper Clark Fork Tributaries Riparian Health and Water Conservation Projects; Final Report: Project Effectiveness Monitoring.

Weaver, Thomas M. and John J. Fraley. 1991. Fisheries Habitat and Fish Populations in Flathead Basin Forest Practices Water Quality and Fisheries Cooperative Program. Kalispell, MT: Flahead Basin Commission.

Wegner, Seth. 1999. A Review of the Scientific Literature on Riparian Buffers Width, Extent and Vegetation. Institute of Ecology, University of Georgia.

Wischmeier, Walter H. and Dwight D. Smith. 1978. Predicting Rainfall Erosion Losses: A Guide to Conservation Planning. Washington, D.C.: United States Department of Agriculture. Agriculture Handbook No. 537. http://topsoil.nserl.purdue.edu/usle/AH_537.pdf.

Wolman, M. G. 1954. A Method of Sampling Coarse River-Bed Material. *Transactions of the American Geophysical Union.* 35(6): 951-956.

World Health Organization. 2003. Guidelines for Safe Recreational Water Environments, Volume 1: Coastal and Fresh Waters. Geneva, Switzerland: World Health Organization. http://www.who.int/water_sanitation_health/bathing/srwe1/en/.

Zweig, Leanna D. and Charles F. Rabeni. 2001. Biomonitoring for Deposited Sediment Using Benthic Invertebrates: A Test on Four Missouri Streams. *Journal of the North American Benthological Society.* 20(4): 643-657.

APPENDIX A – FIGURES AND TABLES

LIST OF TABLES

LIST OF FIGURES

Table A-1. Status of Waterbody Impairments in the Upper Clark Fork Phase 2 TMDL Planning Area based on the 2012 Integrated Report

Waterbody and Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impairment Cause Status
CABLE CREEK, headwaters to mouth (Warm Springs Creek)	MT76G002_030	Chlorophyll-*a*	Not a Pollutant	Not yet addressed
CLARK FORK, Flint Creek to Little Blackfoot River	MT76G001_010	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Addressed by sediment TMDL in this document
		Arsenic	Metals	Addressed by a metals TMDL in a separate, concurrent document
		Copper	Metals	Addressed by a metals TMDL in a separate, concurrent document
		Lead	Metals	Addressed by a metals TMDL in a separate, concurrent document
		Low flow alterations	Not a Pollutant	No action
		Physical substrate habitat alterations	Not a Pollutant	Addressed by sediment TMDL in this document
		Sedimentation/Siltation	Sediment	Addressed by sediment TMDL in this document
		Zinc	Metals	Not impaired based on updated assessment
CLARK FORK RIVER, the Little Blackfoot River to Cottonwood Creek	MT76G001_030	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Addressed by sediment TMDL in this document
		Copper	Metals	Addressed by a metals TMDL in a separate, concurrent document
		Lead	Metals	Addressed by a metals TMDL in a separate, concurrent document
		Low flow alterations	Not a Pollutant	No action
		Physical substrate habitat alterations	Not a Pollutant	Addressed by sediment TMDL in this document
		Sedimentation/Siltation	Sediment	Addressed by sediment TMDL in this document
		Zinc	Metals	Addressed by a metals TMDL in a separate, concurrent document

Table A-1. Status of Waterbody Impairments in the Upper Clark Fork Phase 2 TMDL Planning Area based on the 2012 Integrated Report

Waterbody and Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impairment Cause Status
CLARK FORK RIVER, Cottonwood Creek to Warm Springs Creek	MT76G001_040	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Addressed by sediment TMDL in this document
		Arsenic	Metals	Not impaired based on updated assessment
		Cadmium	Metals	Addressed by a metals TMDL in a separate, concurrent document
		Copper	Metals	Addressed by a metals TMDL in a separate, concurrent document
		Lead	Metals	Addressed by a metals TMDL in a separate, concurrent document
		Low flow alterations	Not a Pollutant	No action
		Sedimentation/Siltation	Sediment	Addressed by sediment TMDL in this document
DEMPSEY CREEK, the national forest boundary to mouth (Clark Fork River)	MT76G002_100	Nitrate/Nitrite	Nutrients	Not impaired based on updated assessment
DUNKLEBERG CREEK, headwaters to T9N R12W S2 SW	MT76G005_071	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Not yet addressed
DUNKLEBERG CREEK, T9N R12W S2 to mouth (Un-named Canal), T10N R11W S30	MT76G005_072	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Not yet addressed
		Nitrogen (Total)	Nutrients	Addressed by a TN TMDL in this document
GOLD CREEK, headwaters to National Forest boundary	MT76G005_091	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Not yet addressed
GOLD CREEK, the forest boundary to mouth (Clark Fork River)	MT76G005_092	Low flow alterations	Not a Pollutant	Not yet addressed
		Nitrogen (Total)	Nutrients	Addressed by a TN TMDL in this document
HOOVER CREEK, Miller Lake to mouth (Clark Fork River)	MT76G005_082	Nitrogen (Total)	Nutrients	Addressed by a TN TMDL in this document

Table A-1. Status of Waterbody Impairments in the Upper Clark Fork Phase 2 TMDL Planning Area based on the 2012 Integrated Report

Waterbody and Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impairment Cause Status
LOST CREEK, the south State Park boundary to mouth (Clark Fork River)	MT76G002_072	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Not yet addressed
		Iron	Metals	Not impaired based on updated assessment
		Low flow alterations	Not a Pollutant	Not yet addressed
		Manganese	Metals	Not impaired based on updated assessment
		Nitrate/Nitrite (Nitrite + Nitrate as N)	Nutrients	Addressed by a TN TMDL in this document
		Physical substrate habitat alterations	Not a Pollutant	Not yet addressed
		Sulfates	Metals	Addressed by a metals TMDL in a separate, concurrent document
MILL CREEK, headwaters to section line between Sec 27 and 28, T4N, R11W	MT76G002_051	Chromium (Total)	Metals	Not impaired based on updated assessment
MILL CREEK, to section line between Sec 27 and 28, T4N, R11W to Mill-Willow bypass diversion	MT76G002_052	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Not yet addressed
		Aluminum	Metals	Not impaired based on updated assessment
		Low flow alterations	Not a Pollutant	Not yet addressed
MODESTY CREEK, headwaters to mouth (Clark Fork River)	MT76G002_080	Low flow alterations	Not a pollutant	Not yet addressed
PETERSON CREEK, headwaters to Jack Creek	MT76G002_131	Phosphorus (Total)	Nutrients	Addressed by a TP TMDL in this document
		Nitrogen (Total)	Nutrients	Addressed by a TN TMDL in this document
		Total Kjeldahl Nitrogen (TKN)	Nutrients	Addressed by a TN TMDL in this document
RACETRACK CREEK, the national forest boundary to mouth (Clark Fork River)	MT76G002_090	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Not yet addressed
		Low flow alterations	Not a Pollutant	Not yet addressed

Table A-1. Status of Waterbody Impairments in the Upper Clark Fork Phase 2 TMDL Planning Area based on the 2012 Integrated Report

Waterbody and Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impairment Cause Status
SILVER BOW CREEK, headwaters to mouth (Clark Fork River)	MT76G003_020	Aluminum	Metals	Not impaired based on updated assessment
		Arsenic	Metals	Addressed by a metals TMDL in a separate, concurrent document
		Copper	Metals	Addressed by a metals TMDL in a separate, concurrent document
		Iron	Metals	Not impaired based on updated assessment
		Lead	Metals	Addressed by a metals TMDL in a separate, concurrent document
		Manganese	Metals	Addressed by a metals TMDL in a separate, concurrent document
		Nitrates	Nutrients	Addressed by a TN TMDL in this document
		Physical substrate habitat alterations	Not a pollutant	Addressed by a sediment TMDL in this document
		Sedimentation/Siltation	Sediment	Addressed by a sediment TMDL in this document
		Silver	Metals	Not impaired based on updated assessment
		Zinc	Metals	Addressed by a metals TMDL in a separate, concurrent document
STORM LAKE CREEK, headwaters to mouth (Un-Named canal/Ditch)	MT76G002_040	Chlorophyll-*a*	Not a Pollutant	Not yet addressed
WARM SPRINGS CREEK, headwaters to Meyers Dam, T5N R12W S25	MT76G002_011	Physical substrate habitat alterations	Not a Pollutant	Not yet addressed
WARM SPRINGS CREEK, Meyers Dam T5N R12W S25 to mouth (Clark Fork), T6N R9W S6	MT76G002_012	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Not yet addressed
		Low flow alterations	Not a Pollutant	Not yet addressed
		Physical substrate habitat alterations	Not a Pollutant	Not yet addressed
WARM SPRINGS CREEK, headwaters to line between R9W and R10W	MT76G005_111	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Addressed by a sediment TMDL in a separate, concurrent document
		Sedimentation/Siltation	Sediment	Addressed by a sediment TMDL in a separate, concurrent document

Table A-1. Status of Waterbody Impairments in the Upper Clark Fork Phase 2 TMDL Planning Area based on the 2012 Integrated Report

Waterbody and Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impairment Cause Status
WILLOW CREEK, headwaters to T4N R10W S30	MT76G002_061	Phosphorus (Total)	Nutrients	Addressed by a TP TMDL in this document

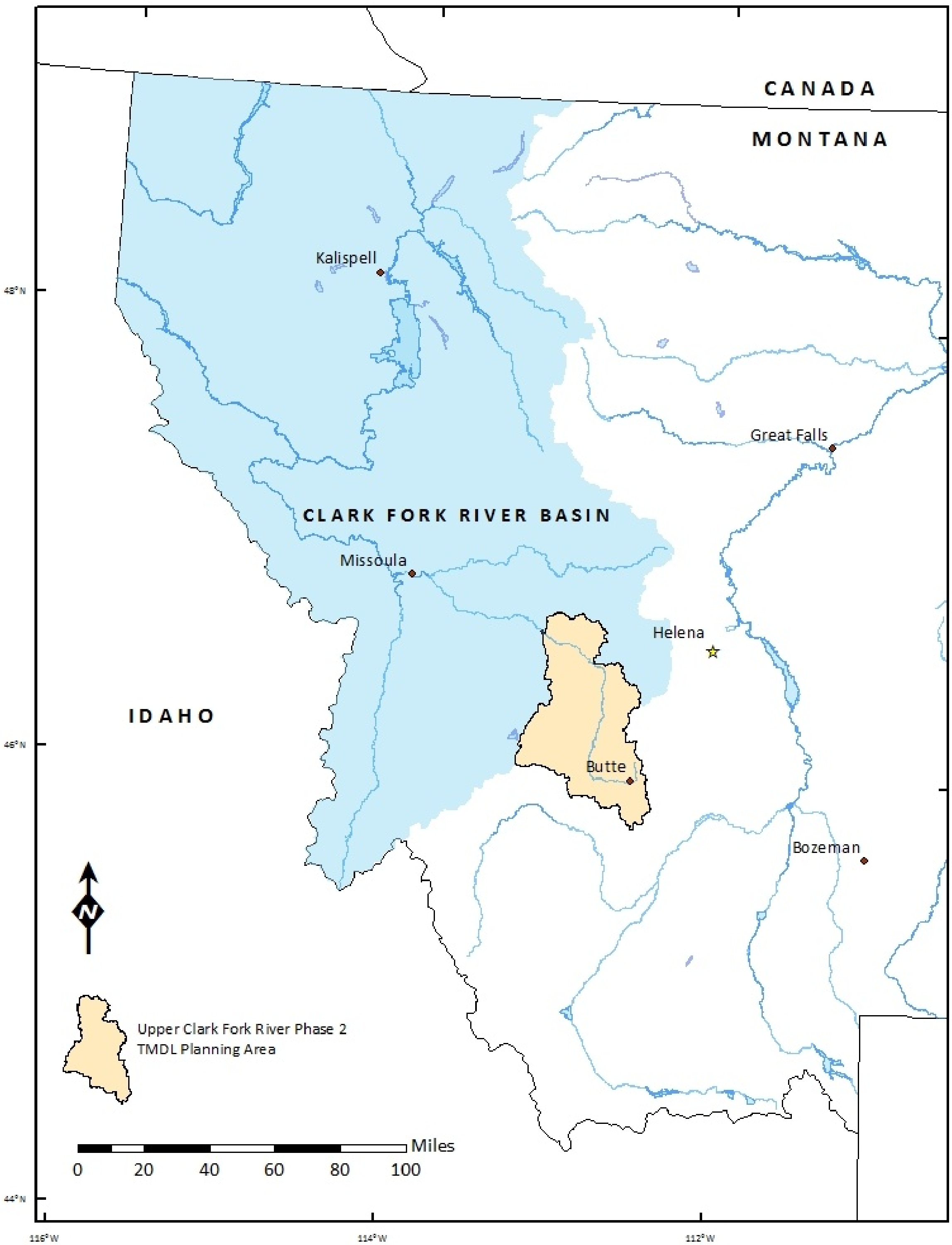

Figure A-1. Location of the Upper Clark Fork Phase 2 TMDL Planning Area

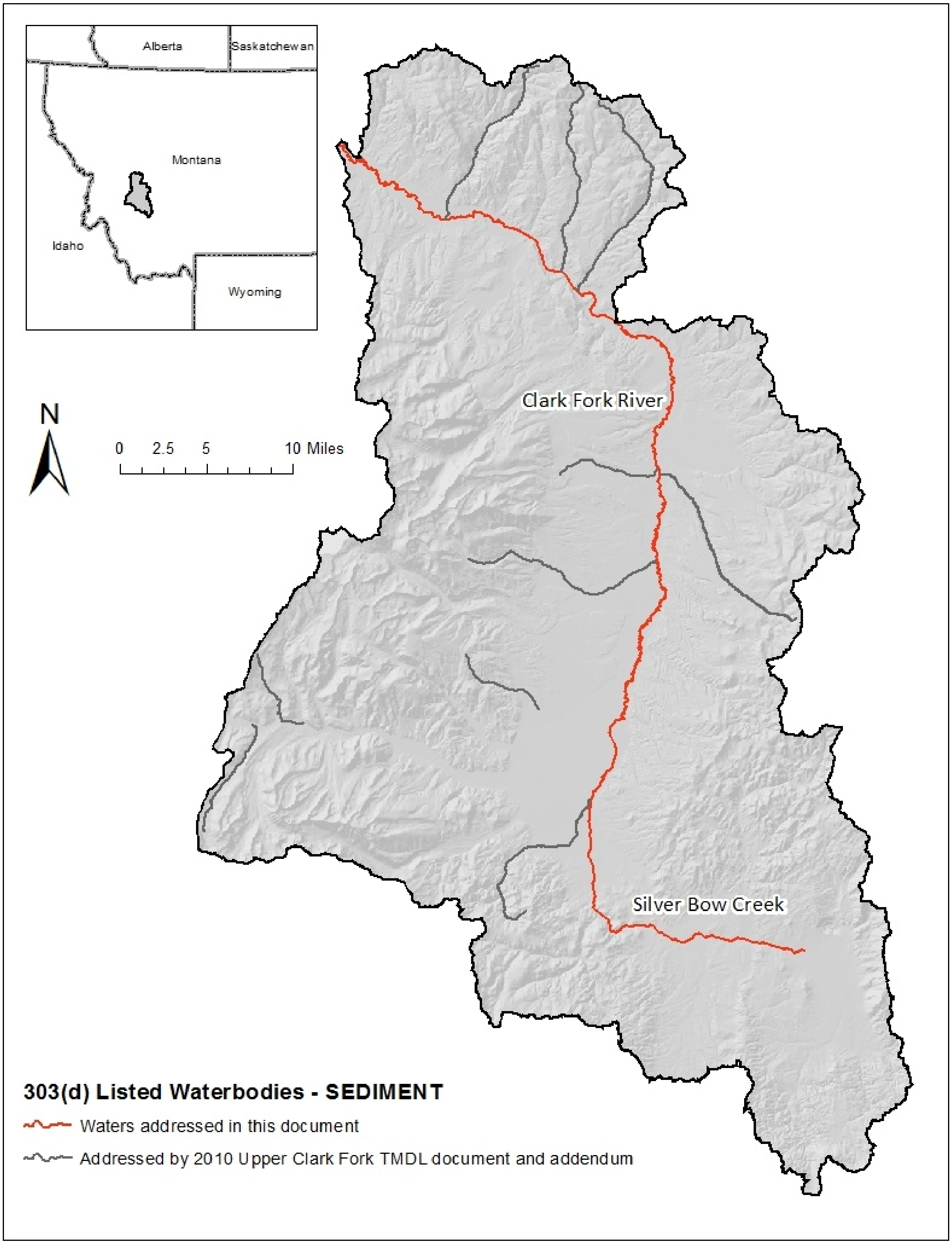

Figure A-2a. Map of Sediment Listed Waterbodies Addressed in this Document

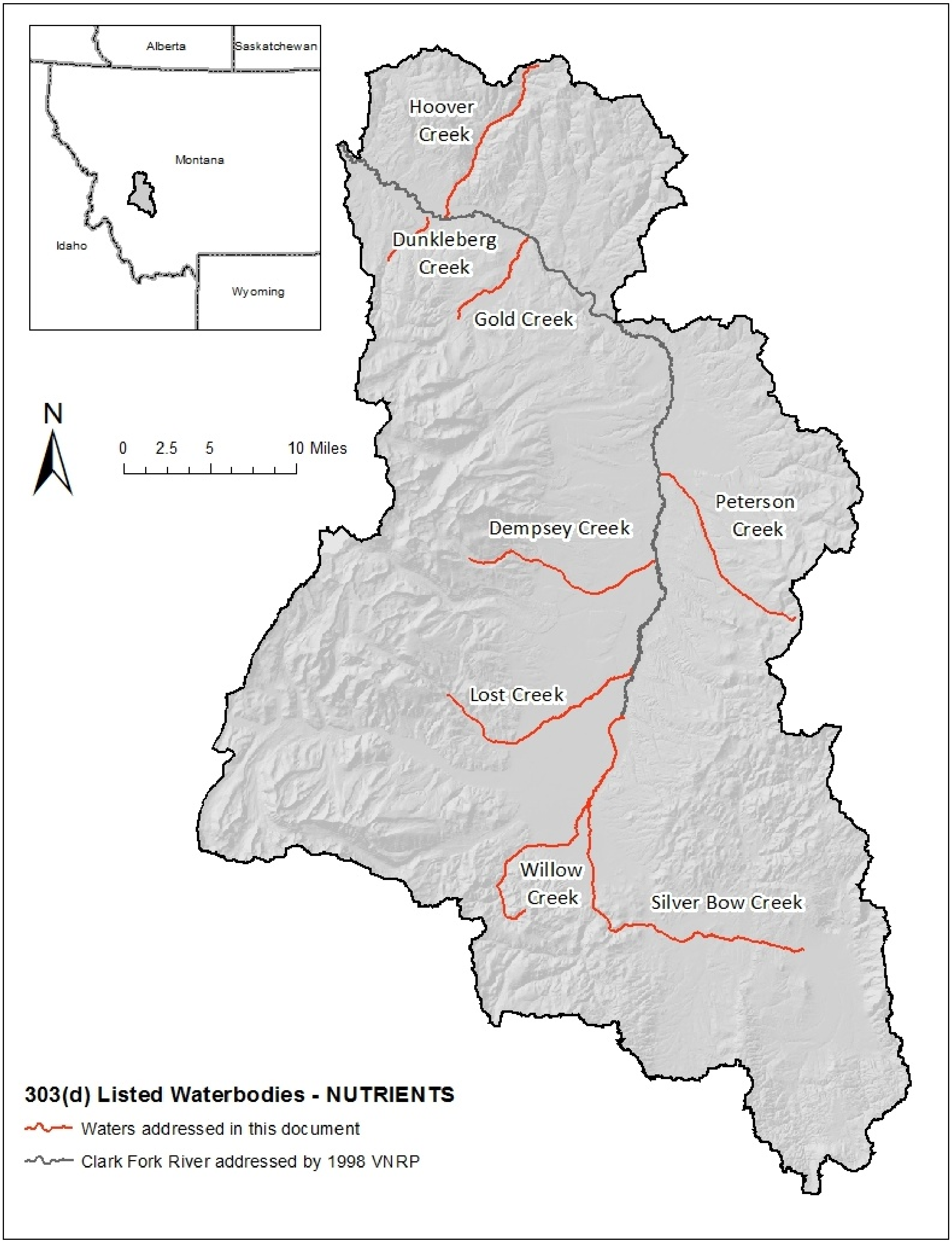

Figure A-2b. Map of Nutrient Listed Waterbodies Addressed in this Document

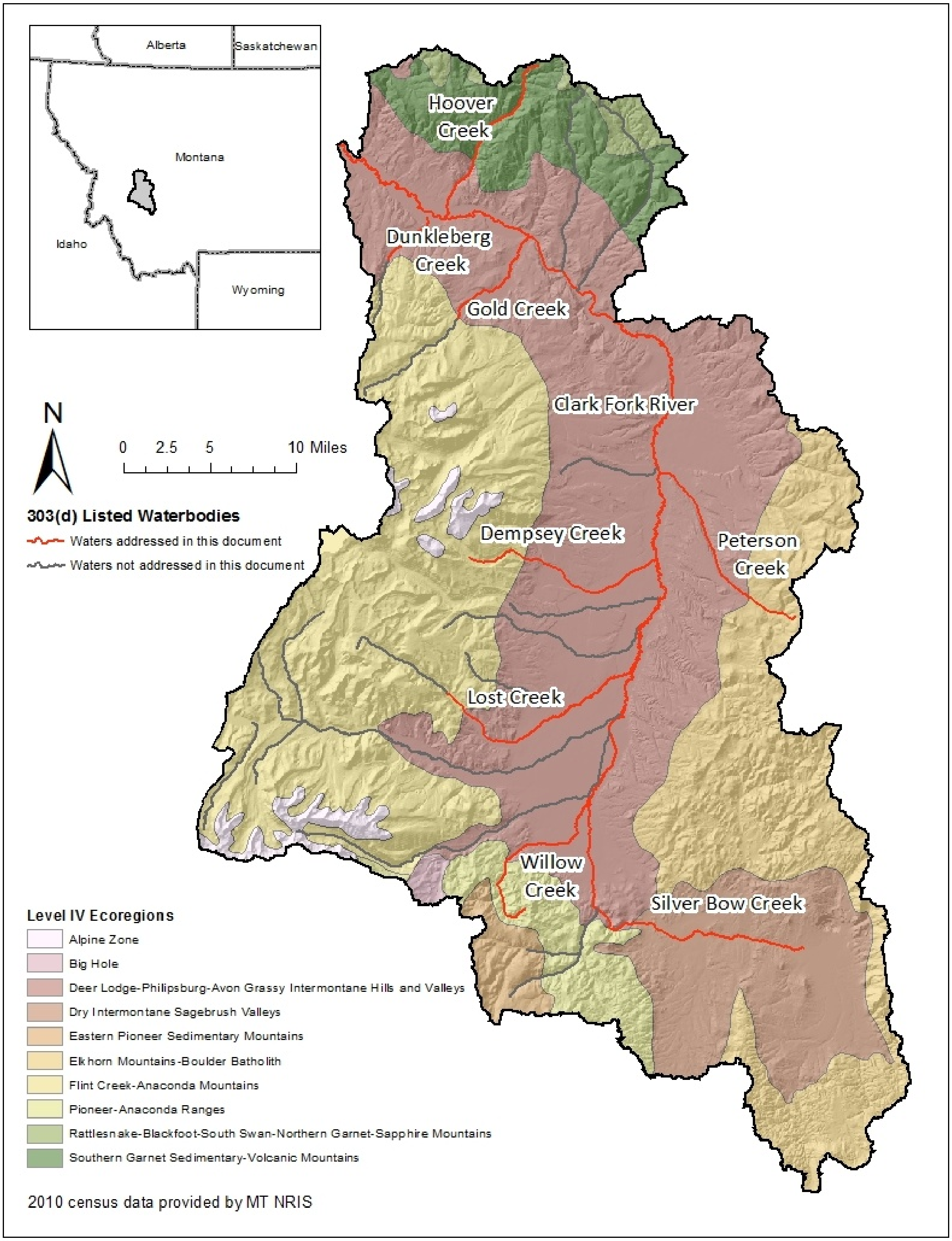

Figure A-3. Map of the Level IV Ecoregions Found in the Upper Clark Fork Phase 2 TMDL Planning Area

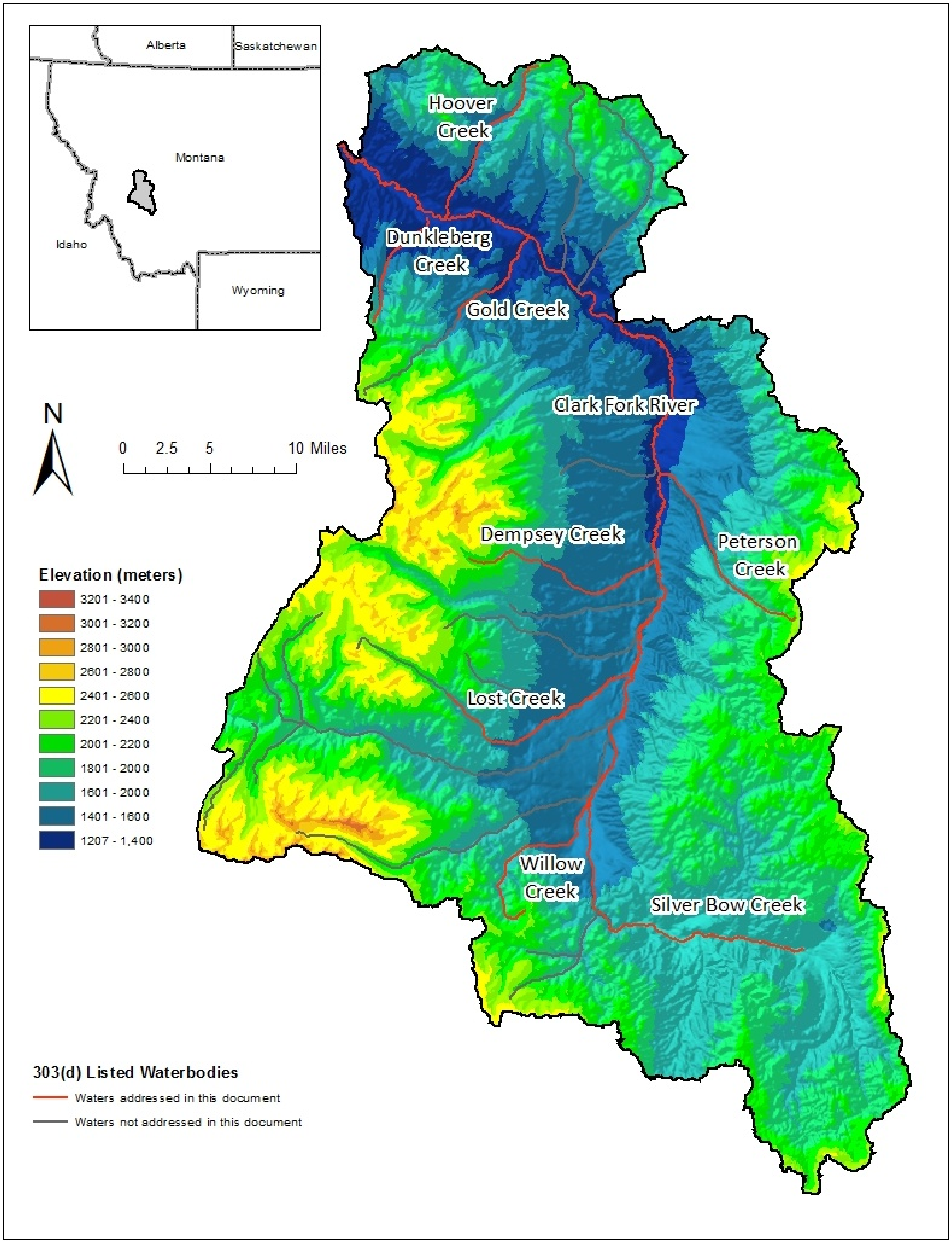

Figure A-4. Map Showing Elevations within the Upper Clark Fork Phase 2 TMDL Planning Area

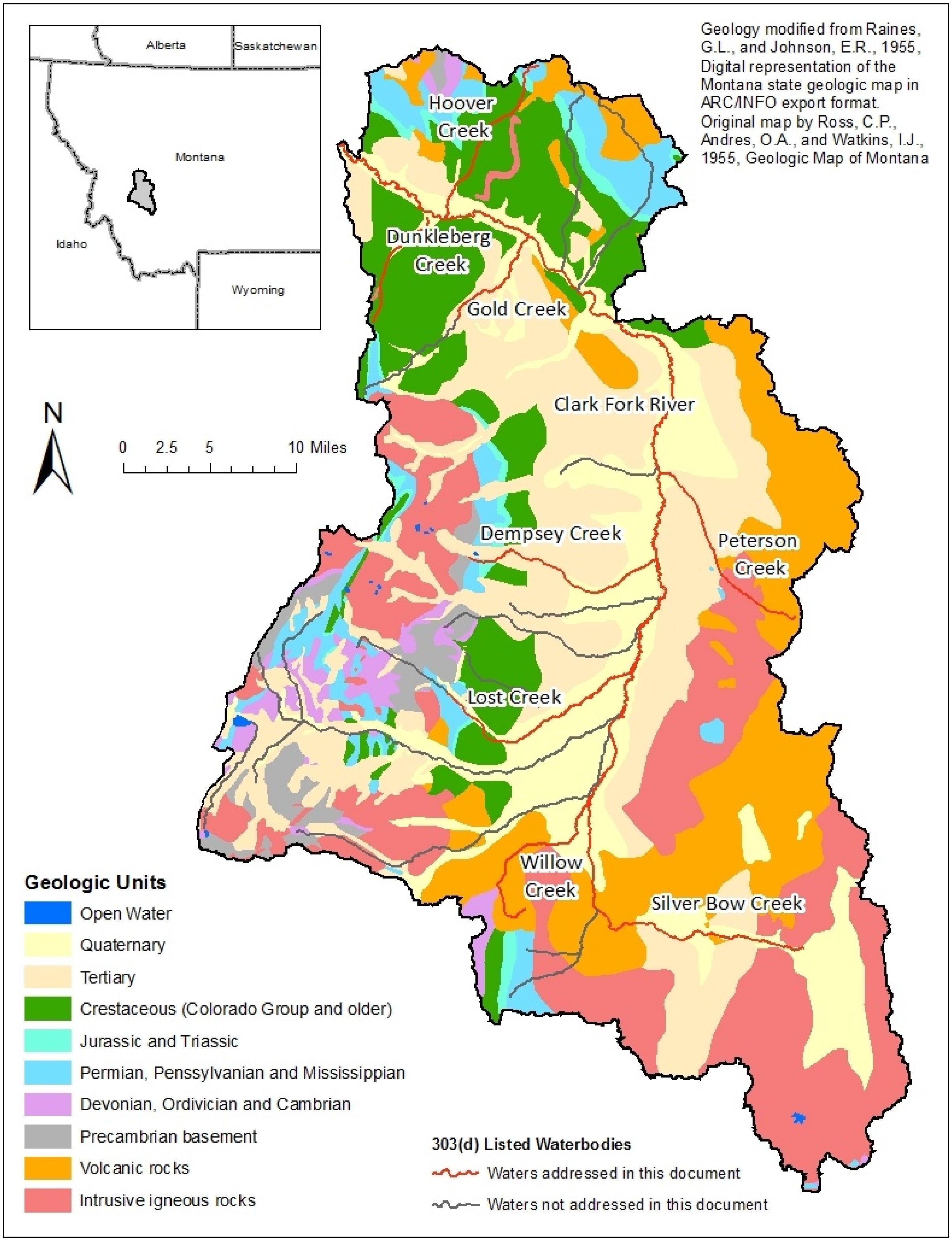

Figure A-5. Map Showing the Geology of the Upper Clark Fork Phase 2 TMDL Planning Area

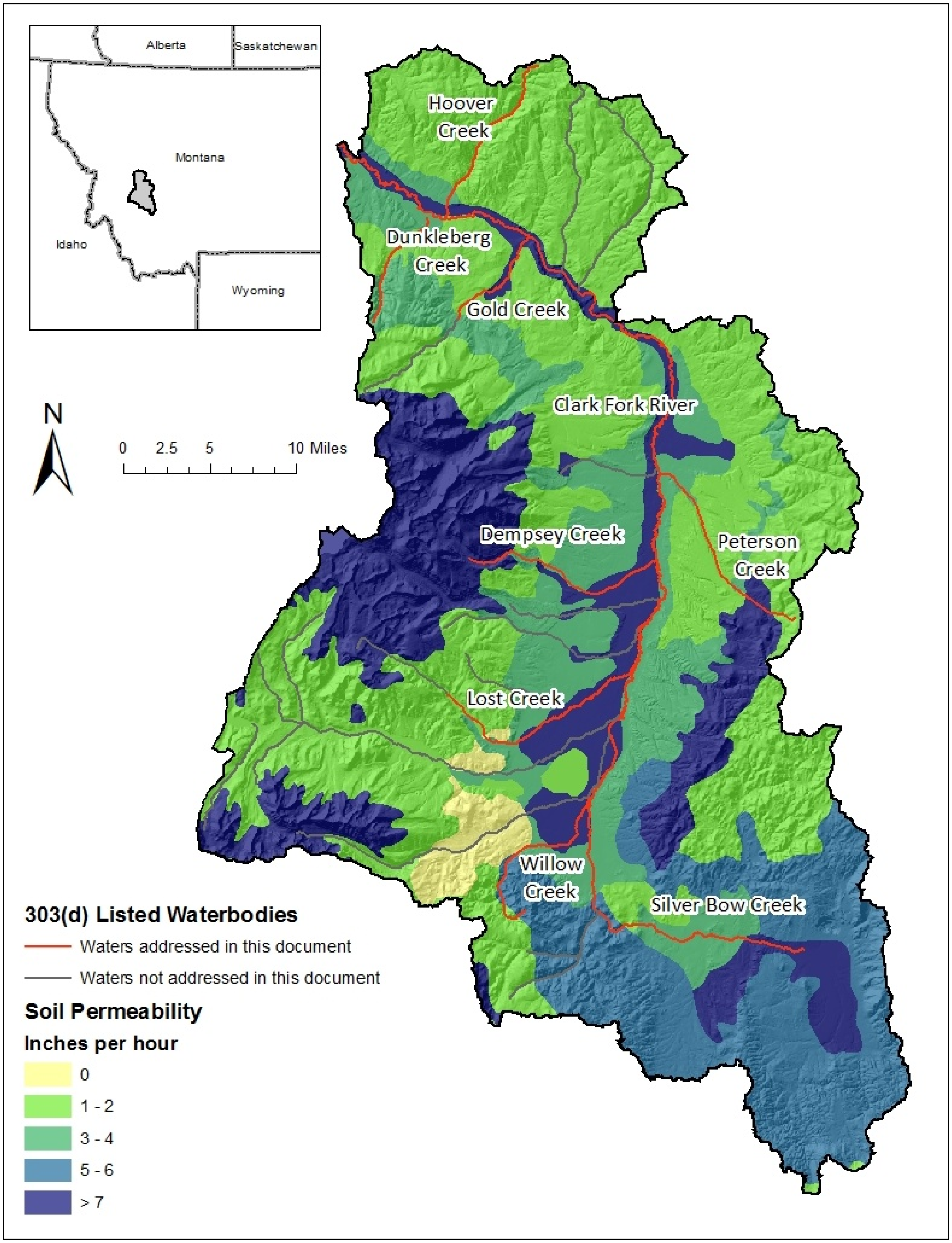

Figure A-6a. Map Showing the Soil Permeability of the Upper Clark Fork Phase 2 TMDL Planning Area

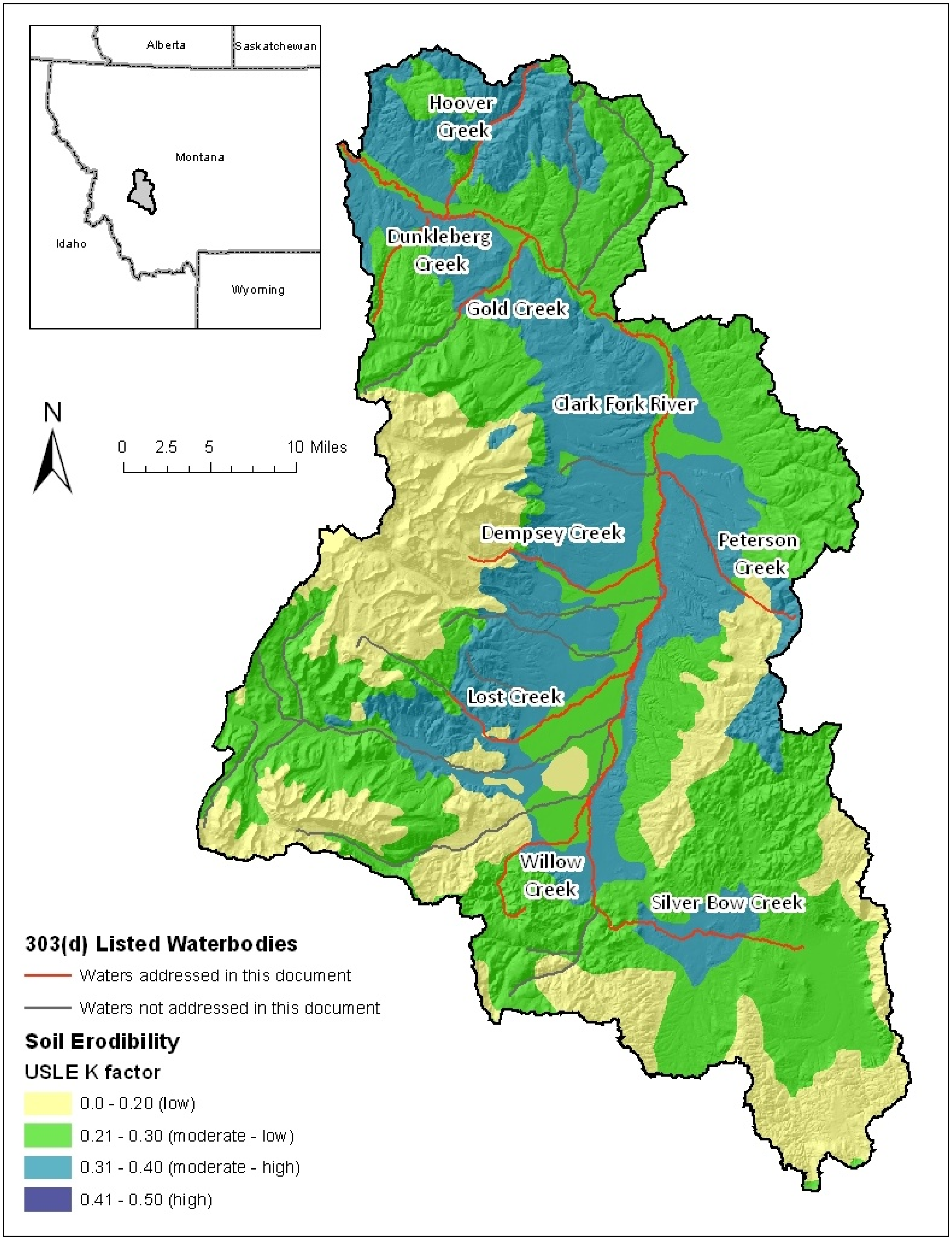

Figure A-6b. Map Showing the Soil Erodibility (K Factor) of the Upper Clark Fork Phase 2 TMDL Planning Area

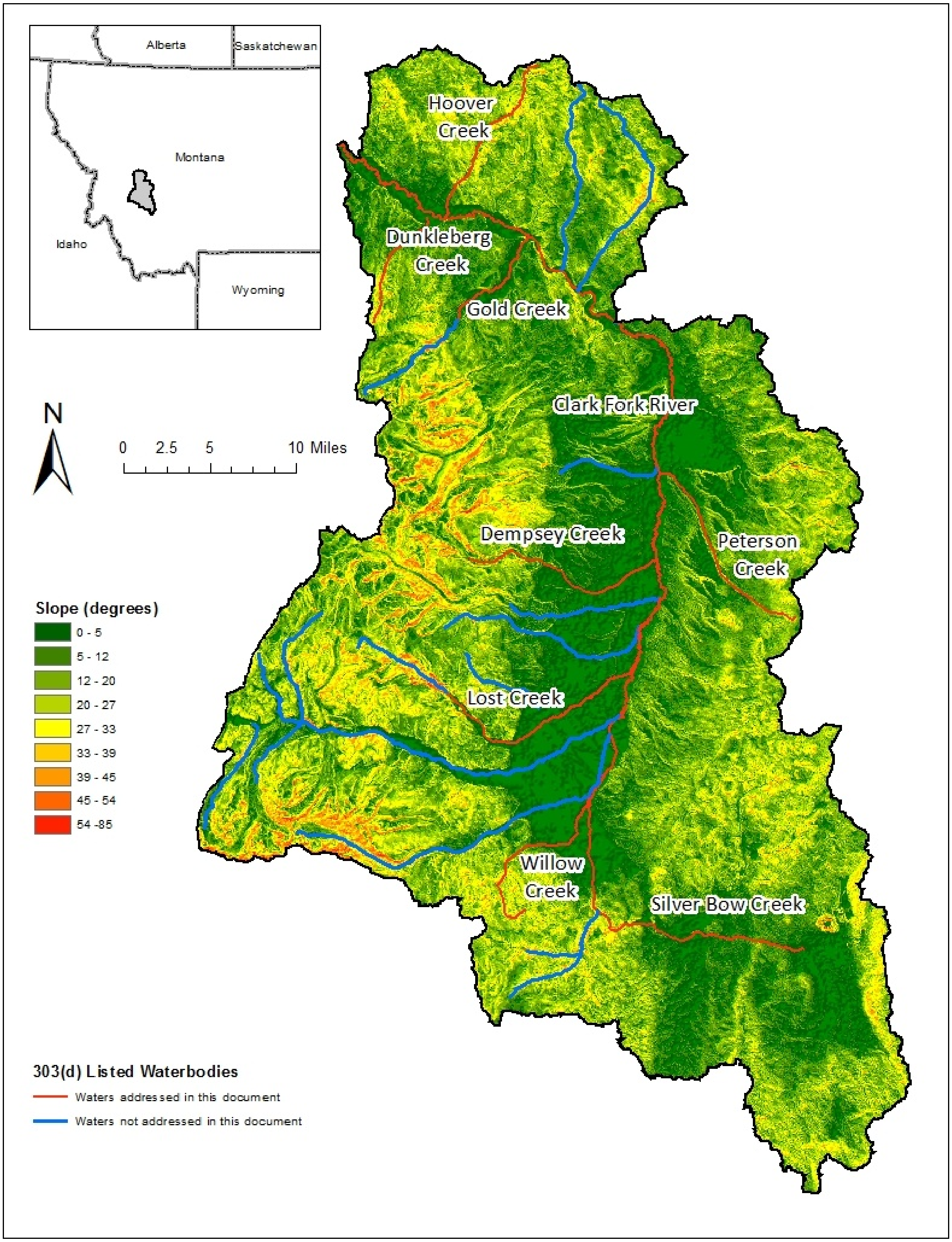

Figure A-7. Map Showing the Surface Slope in the Upper Clark Fork Phase 2 TMDL Planning Area

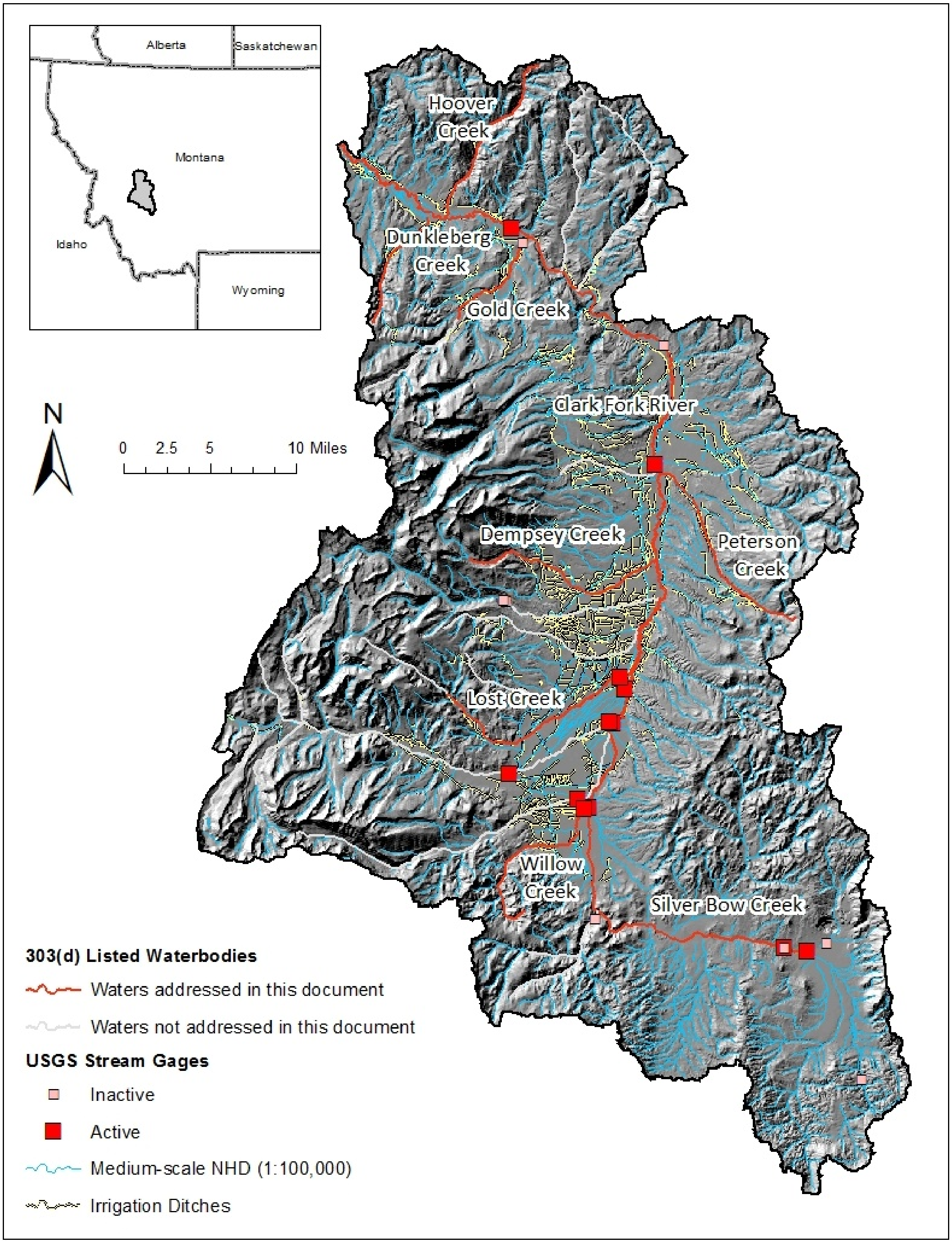

Figure A-8. Map Showing the Hydrography in the Upper Clark Fork Phase 2 TMDL Planning Area

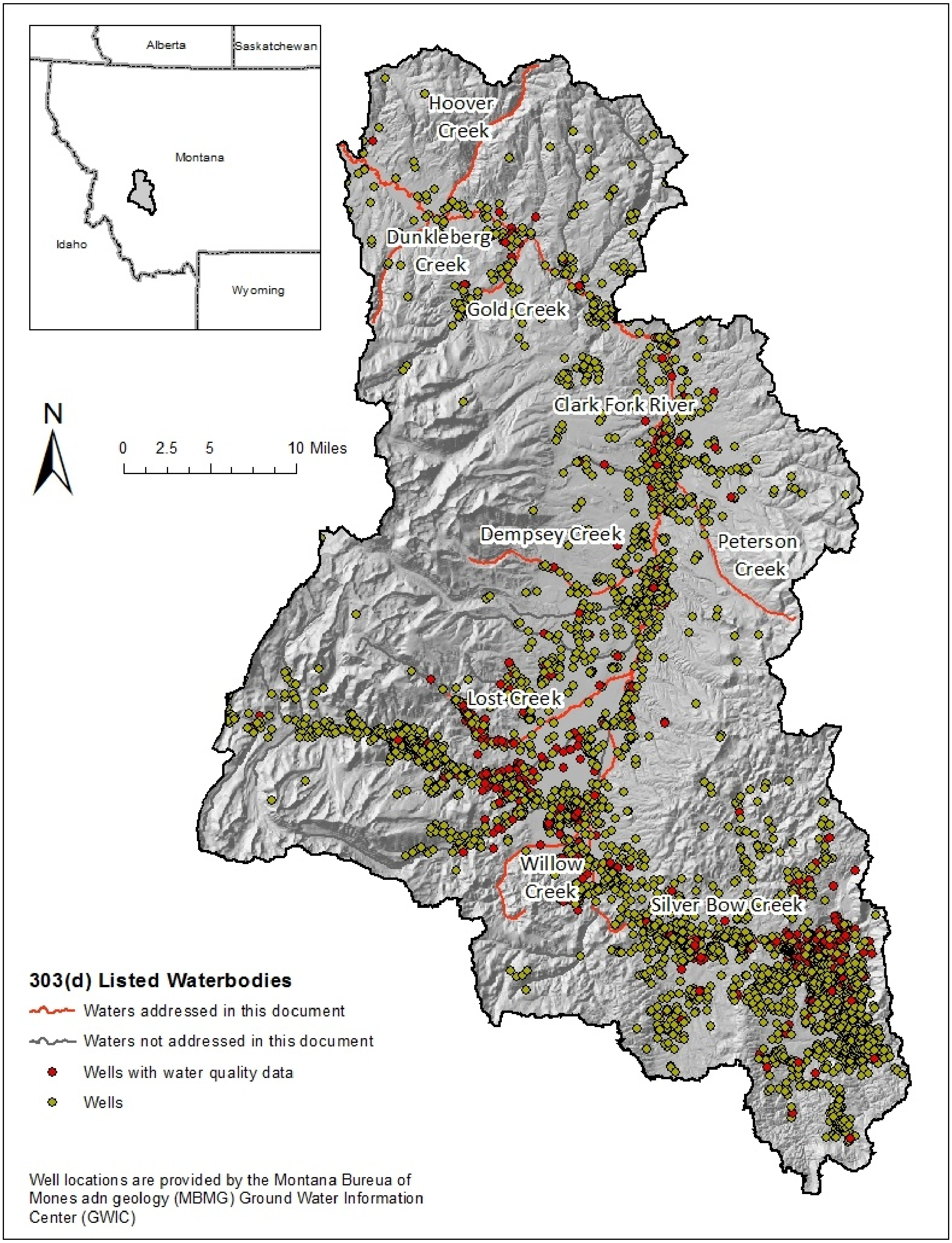

Figure A-9. Map Showing Locations of Wells in the Upper Clark Fork Phase 2 TMDL Planning Area

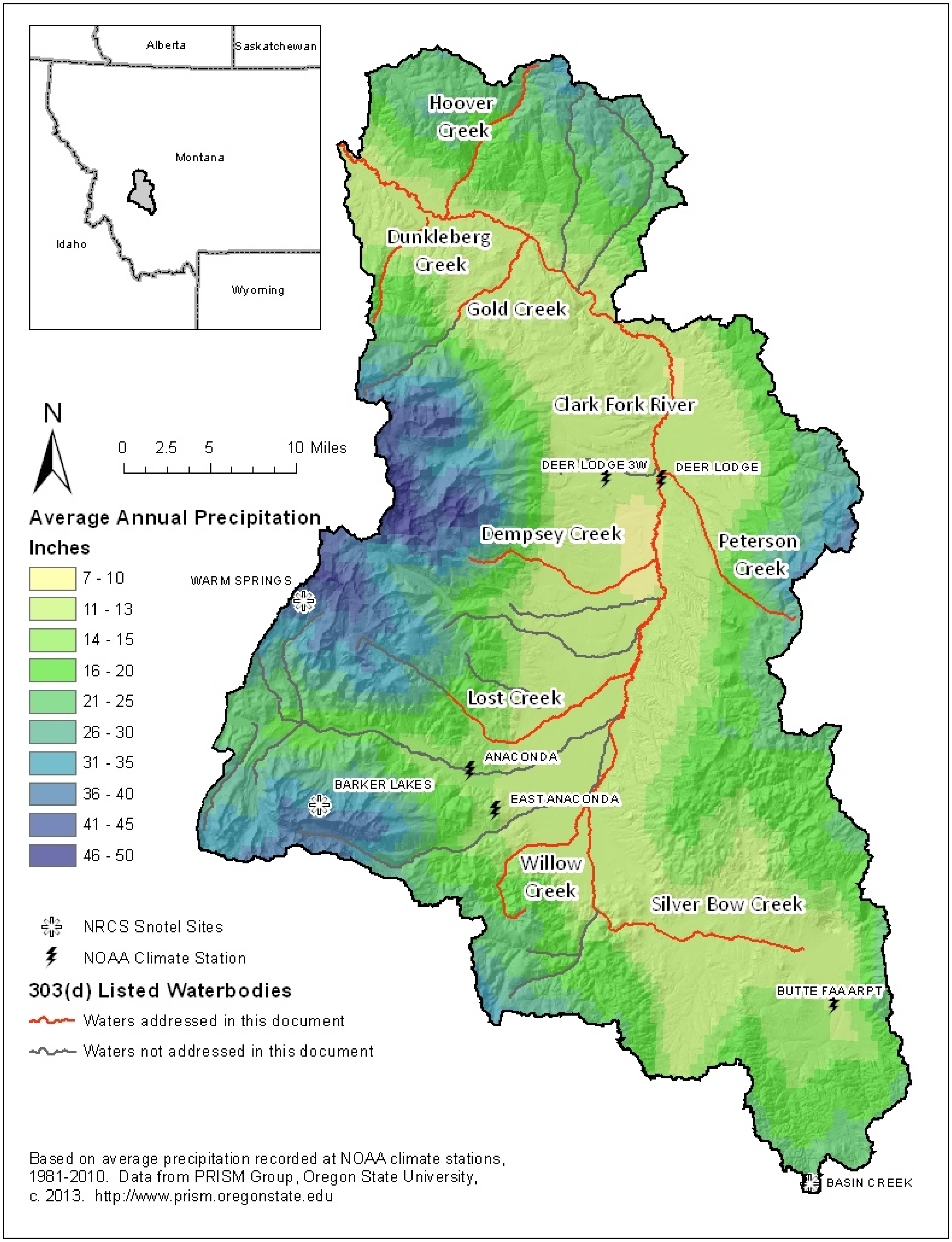

Figure A-10. Map Showing the Average Annual Precipitation in the Upper Clark Fork Phase 2 TMDL Planning Area

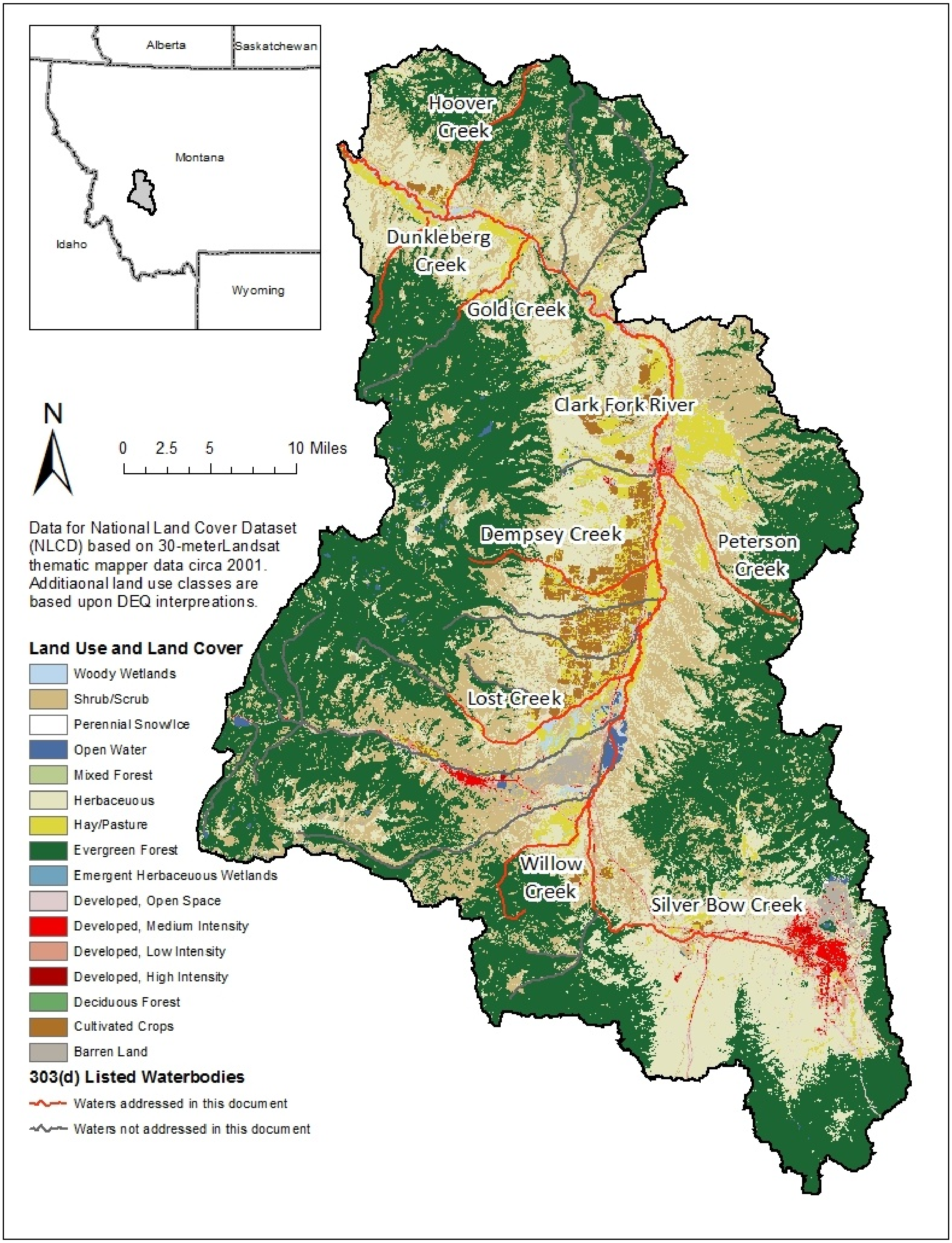

Figure A-11. Map Showing the Land Cover in the Upper Clark Fork Phase 2 TMDL Planning Area

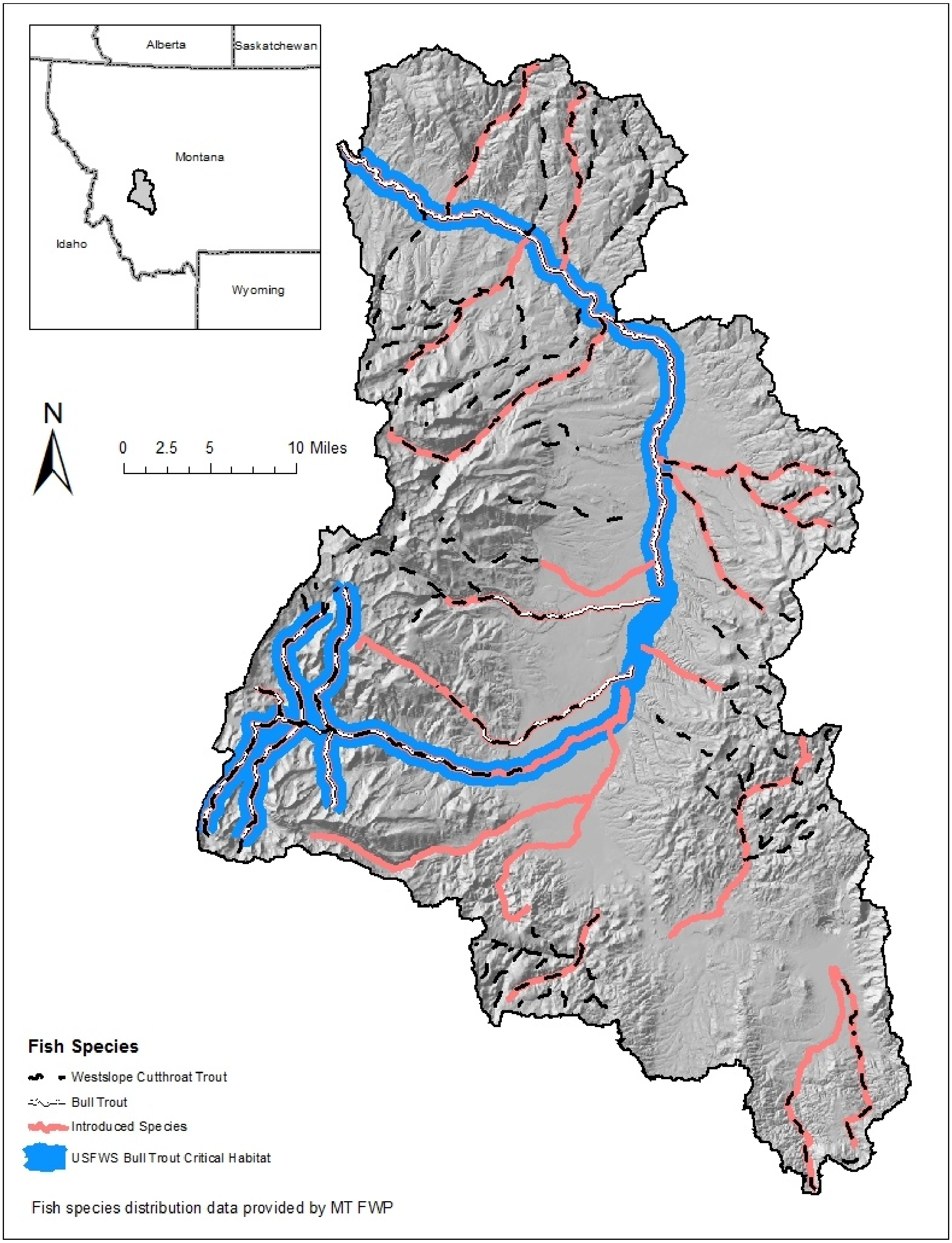

Figure A-12. Map Showing Fish Species Distribution in the Upper Clark Fork Phase 2 TMDL Planning Area

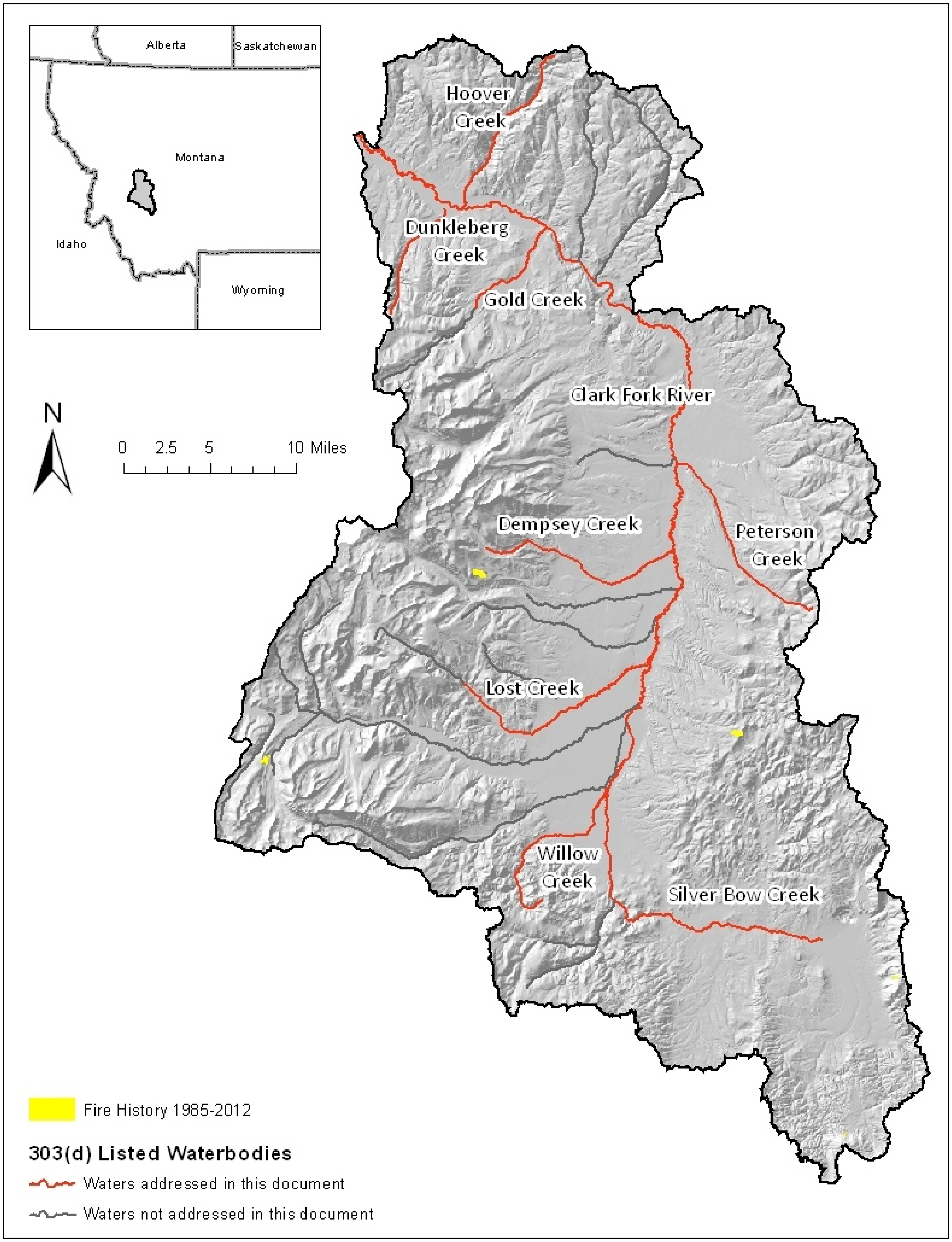

Figure A-13. Map Showing the Fire History in the Upper Clark Fork Phase 2 TMDL Planning Area

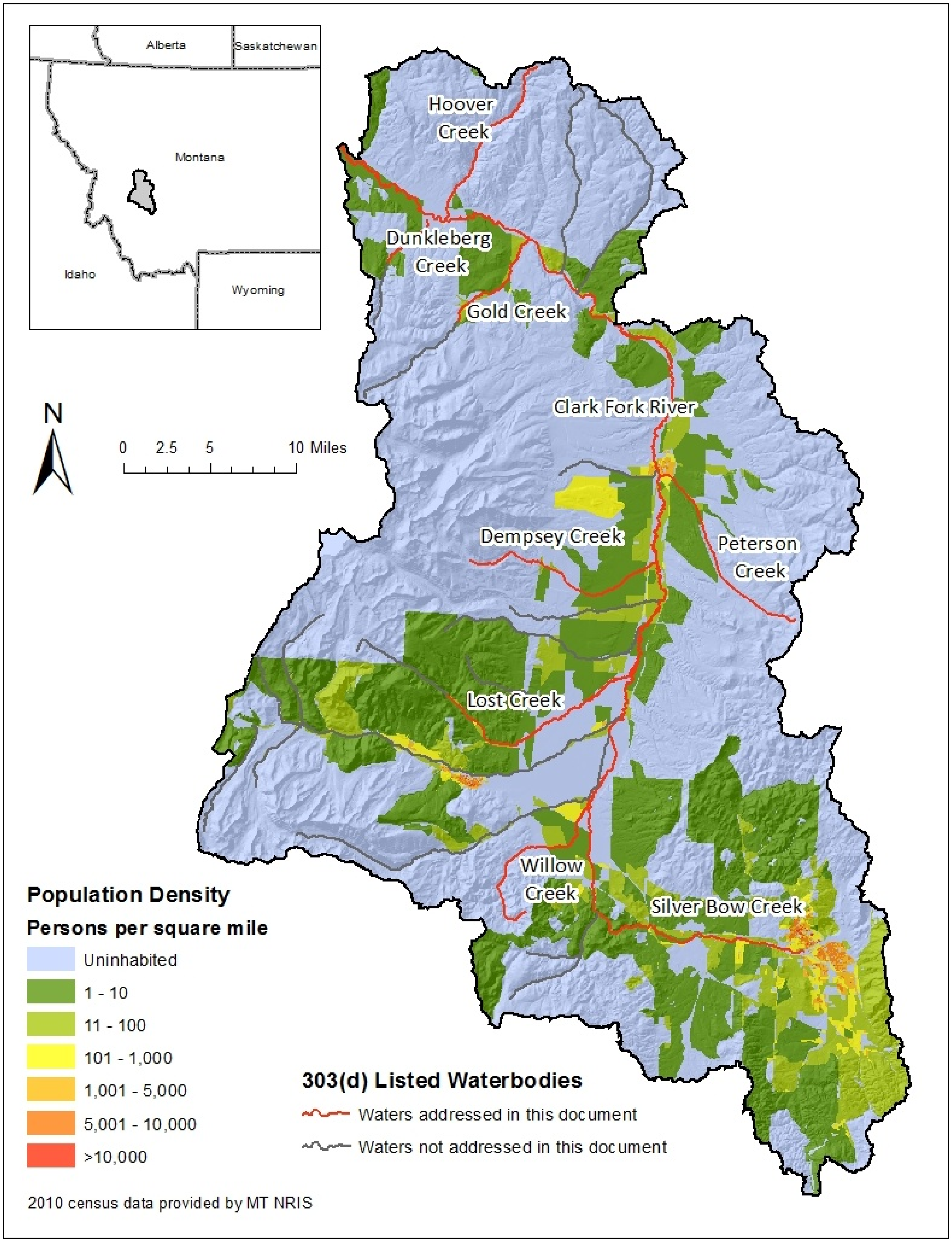

Figure A-14. Map Showing Population Densities in the Upper Clark Fork Phase 2 TMDL Planning Area

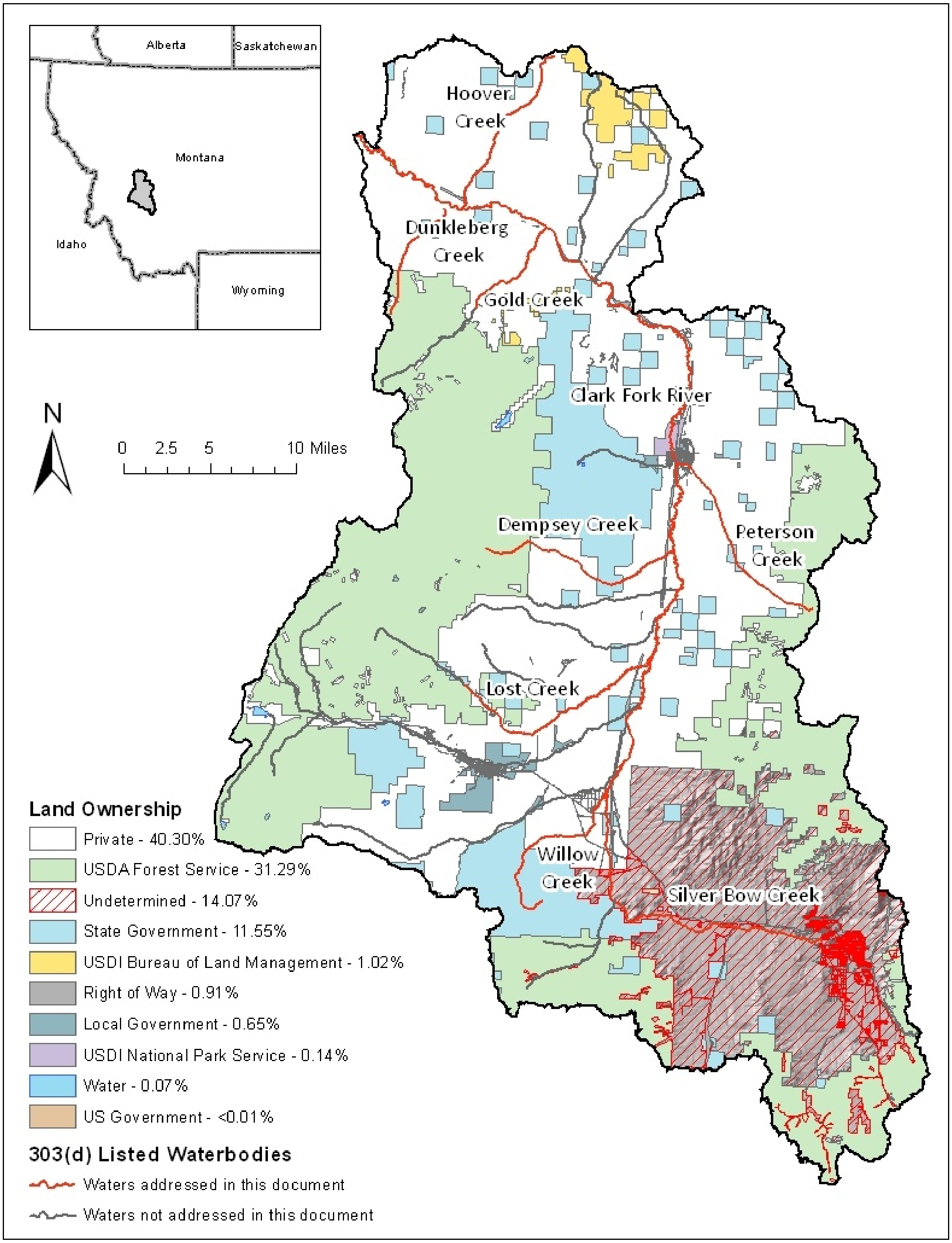

Figure A-15. Map Showing the Land Ownership in the Upper Clark Fork Phase 2 TMDL Planning Area

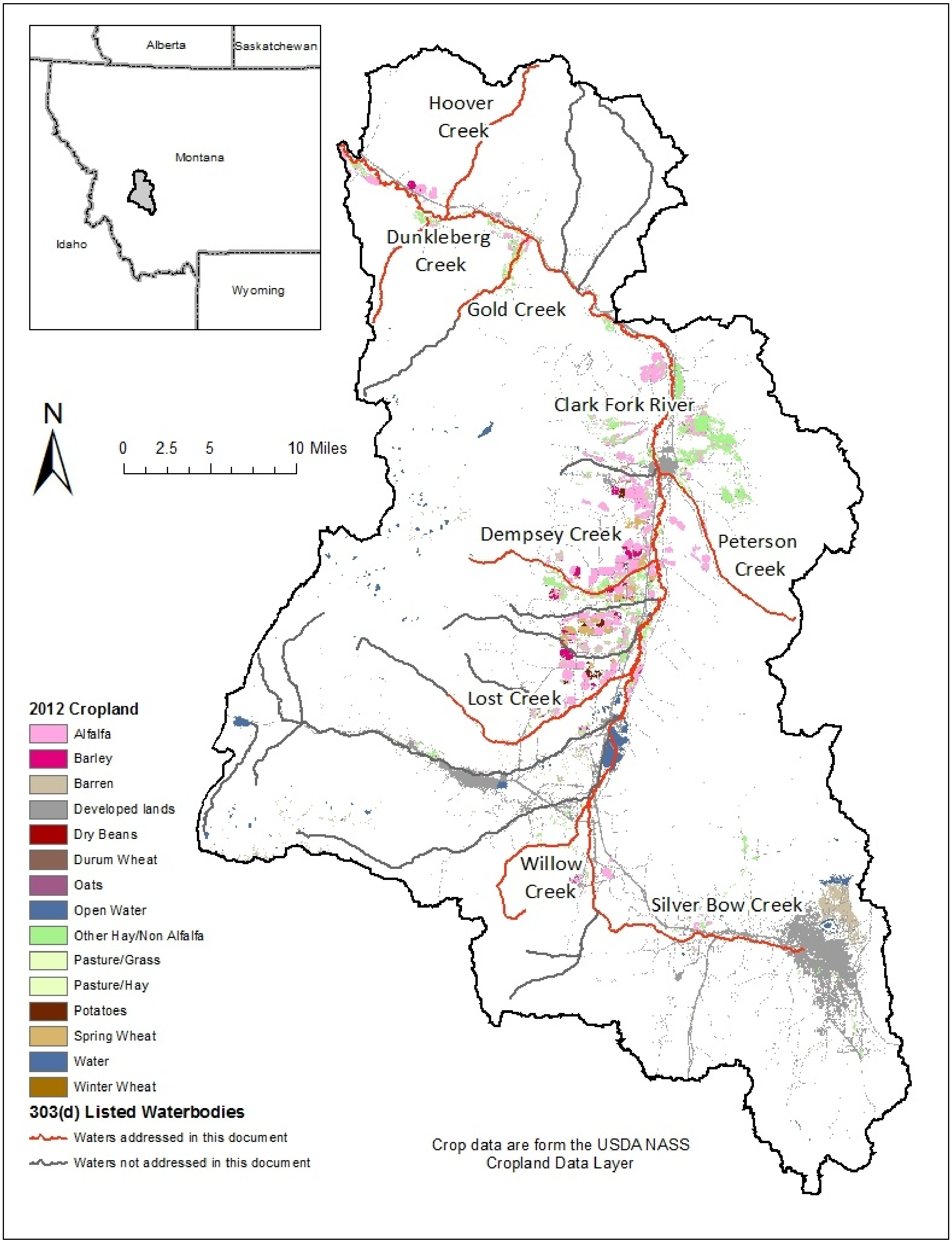

Figure A-16. Map Showing Cropland in the Upper Clark Fork Phase 2 TMDL Planning Area

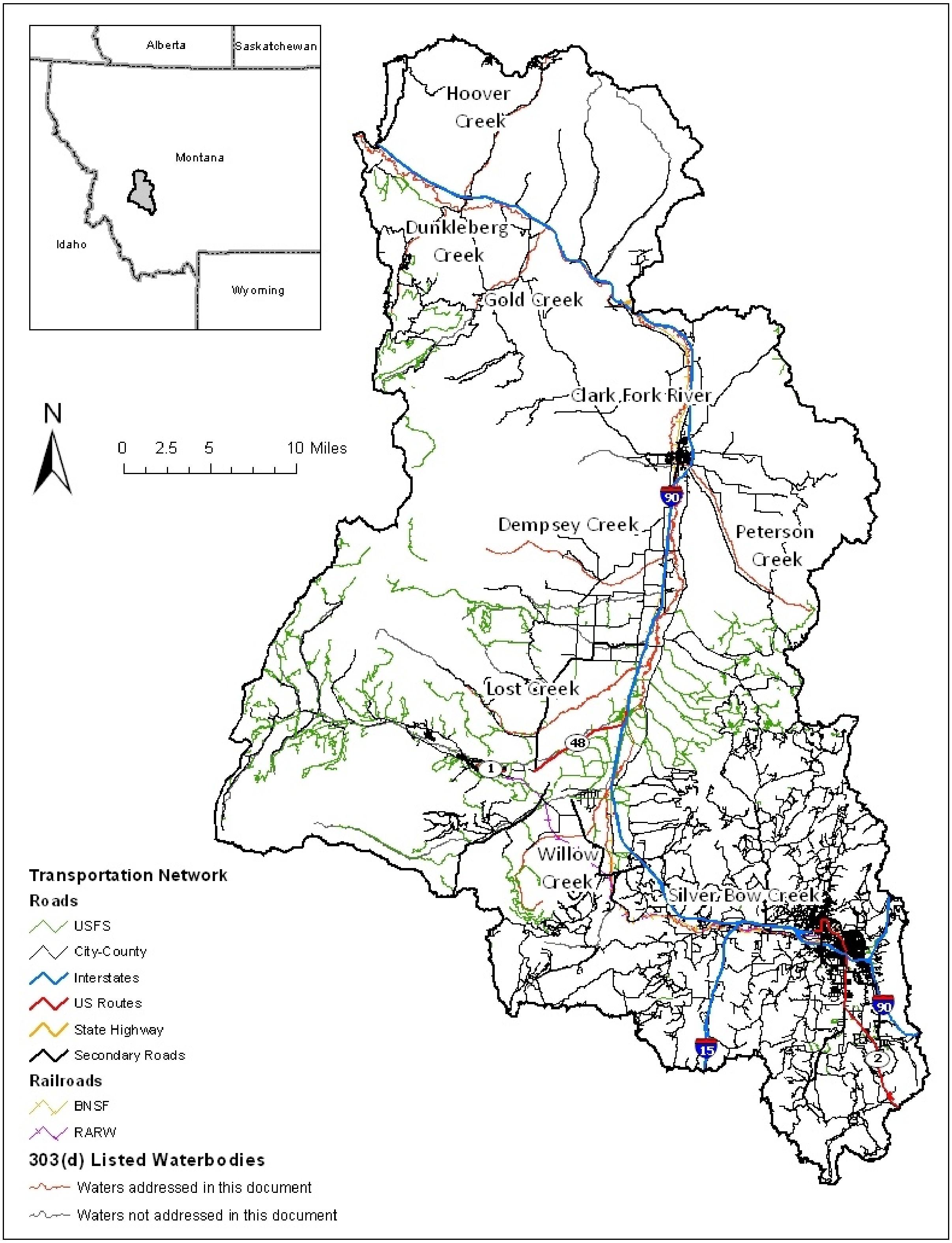

Figure A-17. Map Showing the Transportation Network within the Upper Clark Fork Phase 2 TMDL Planning Area

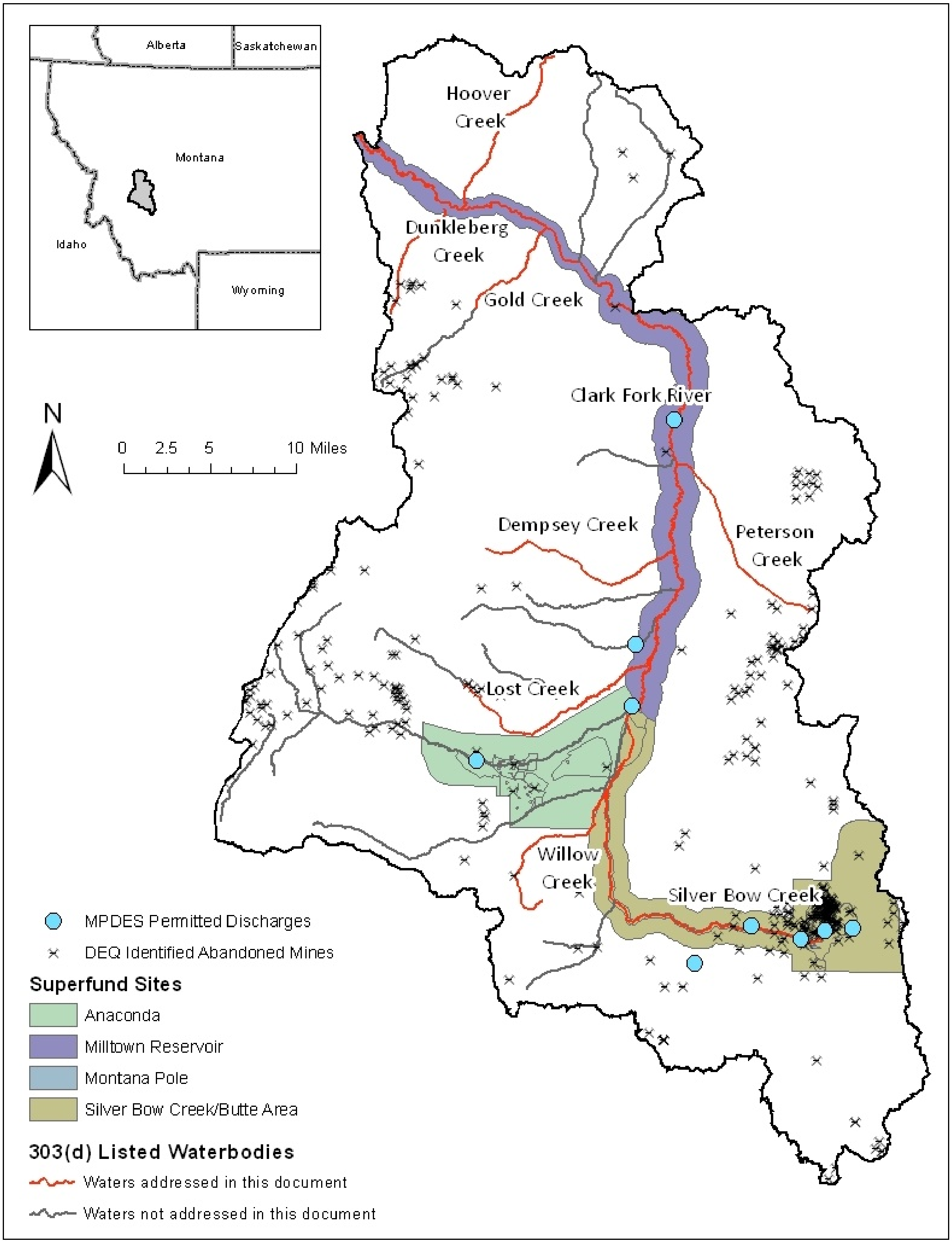

Figure A-18. Map Showing Permitted Discharges, Abandoned Mines, and Superfund Sites in the Upper Clark Fork Phase 2 TMDL Planning Area

APPENDIX B – REGULATORY FRAMEWORK AND REFERENCE CONDITION APPROACH

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

Acronym	Definition
ARM	Administrative Rules of Montana
BER	Board of Environmental Review (Montana)
CWA	Clean Water Act
DEQ	Department of Environmental Quality (Montana)
EPA	Environmental Protection Agency (U.S.)
MCA	Montana Code Annotated
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

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

B1.0 TMDL DEVELOPMENT REQUIREMENTS

Waterbodies, or individual waterbody segments where streams have been split into multiple segments, can become impaired from a variety of causes defined as either pollutants or non-pollutants. Pollutants include sediment, temperature, nutrients, and metals. Non-pollutants include flow alterations and different forms of habitat degradation. Section 303 of the Federal Clean Water Act (CWA) and the Montana Water Quality Act (WQA) (Section 75-5-703) require development of Total Maximum Daily Loads (TMDLs) for impaired waterbodies where one or more pollutants are the cause of impairment within the waterbody segment of interest.

Section 303(d) requires states to submit a list of impaired waterbodies in need of TMDL development to the U.S. Environmental Protection Agency (EPA) every 2 years. This list is referred to as the 303(d) list, and only includes waterbodies with impairment causes linked to a pollutant as defined under the CWA. The 303(d) list also includes the suspected source(s) of the pollutants of concern such as various land-use activities. Prior to 2004, EPA and the Montana Department of Environmental Quality (DEQ) defined the 303(d) list as the list of all impaired waterbodies and associated impairment causes (pollutants and non-pollutants), versus just those waters with impairment causes linked to pollutants. Montana integrates the 303(d) list within the 305(b) report, which contains an assessment of Montana's water quality, information on streams impaired by non-pollutants, TMDL development status, and a description of Montana's water quality programs. This 305(b) report is also referred to as the Integrated Water Quality Report.

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 WQA; Section 75-5-103(11)). State law (Montana Code Annotated (MCA) 75-5-702) identifies that a sufficient credible data methodology for determining the impairment status of each waterbody is used for consistency; the actual methodology is identified in DEQ's Water Quality Assessment Process and Methods (Montana Department of Environmental Quality, 2006). This methodology was developed via a public process and was incorporated into the EPA-approved 2000 version of the 305(b) report.

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. TMDLs are often expressed in terms of an amount, or mass, of a particular pollutant over a particular time period (e.g., pounds of total nitrogen (TN) per day). TMDLs can also be expressed in other appropriate measures such as a percent reduction in pollutant loading. 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.

To satisfy the Federal CWA and Montana state law, TMDL development will eventually be needed for each waterbody-pollutant combination identified on Montana's 2012 303(d) List of impaired waters in the Upper Clark Fork Phase 2 TMDL Planning Area (TPA), unless new data and associated analyses is sufficient to remove a pollutant cause of impairment from one or more waterbodies. State law (Administrative Rules of Montana (ARM) 75-5-703(8)) also directs DEQ to "...support a voluntary program of reasonable land, soil, and water conservation practices to achieve compliance with WQS 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 standards are met. WQS form the basis for the targets described in **Sections 5.0 and 6.0** of the main document. These sections provide a summary of the applicable WQS for sediment and nutrients. The sediment and nutrient TMDLs presented in this document also inherently address the additional non-pollutant causes of impairment identified in **Section 1.0** of the main document, **Table 1-1**.

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) 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 (§ 75-5-301(1), MCA) and to adopt standards to protect those uses ((§ 75-5-301(1), MCA).

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. 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 may 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 Code of Federal Regulations 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 B-1**.

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

Classification	Designated Uses
A-CLOSED CLASSIFICATION:	Waters classified A-Closed are to be maintained suitable for drinking, culinary and food processing purposes after simple disinfection.
A-1 CLASSIFICATION:	Waters classified A-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment for removal of naturally present impurities.
B-1 CLASSIFICATION:	Waters classified B-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B-2 CLASSIFICATION:	Waters classified B-2 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B-3 CLASSIFICATION:	Waters classified B-3 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-1 CLASSIFICATION:	Waters classified C-1 are to be maintained suitable for bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-2 CLASSIFICATION:	Waters classified C-2 are to be maintained suitable for bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-3 CLASSIFICATION:	Waters classified C-3 are to be maintained suitable for bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers. The quality of these waters is naturally marginal for drinking, culinary and food processing purposes, agriculture and industrial water supply. Degradation which will impact established beneficial uses will not be allowed.
I CLASSIFICATION:	The goal of the State of Montana is to have these waters fully support the following uses: drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

B2.2 Numeric and Narrative Water Quality Standards

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

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

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

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.

B2.3 Pollutant Specific Standards

The standards applicable to the TMDLs addressed in this Upper Clark Fork Phase 2 TPA document are summarized below.

B2.3.1 Sediment Standards

Sediment (i.e., coarse and fine bed sediment) and suspended sediment are addressed via the narrative criteria identified in **Table B-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 B-2**). Naturally occurring levels are evaluated using a reference approach as defined in **Section B3.0**.

Table B-2. Applicable Water Quality Standards for Sediment

Rule(s)	Standard or Definition
17.30.622(2) – A-1 Class 17.30.623(2) – B-1 Class 17.30.626(2) – C-1 Class 17.30.627(2) – C-2 Class 17.30.628(2) – I Class	No person may violate the following specific WQS for waters classified *A-1, B-1, C-1, C-2, I*:
17.30.622(2)(f) – A-1 Class 17.30.623(2)(f) – B-1 Class 17.30.626(2)(f) – C-1 Class 17.30.627(2)(f) – C-2 Class 17.30.628(2)(f) – I Class	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.
17.30.622(3)(d) – A-1 Class	No increase above naturally occurring turbidity or suspended sediment is allowed except at permitted in 75-5-318, MCA. Note: 75-5-318, MCA allows for short term variances linked to construction activities, etc.
17.30.623(2)(d) – B-1 Class 17.30.626(2)(d) – C-1 Class	The maximum allowable increase above naturally occurring turbidity five nephelometric turbidity units except at permitted in 75-5-318, MCA. Note: 75-5-318, MCA allows for short term variances linked to construction activities, etc.
17.30.627(2)(d) – C-2 Class	The maximum allowable increase above naturally occurring turbidity ten nephelometric turbidity units except at permitted in 75-5-318, MCA. Note: 75-5-318, MCA allows for short term variances linked to construction activities, etc.
17.30.628(2)(d) – I Class	Except as permitted in 75-5-318, MCA, no increase in naturally occurring turbidity is allowed which will or is 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. Note: 75-5-318, MCA allows for short term variances linked to construction activities, etc.
17.30.637(1)(a) & (d)	State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will: (a) settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines; ….. and (d) create concentrations or combinations of materials that are toxic or harmful to human, animal, plant, or aquatic life.
17.30.602	DEFINITIONS
	“Sediment” means solid material settled from suspension in a liquid; mineral or organic solid material that is being transported or has been moved from its site of origin by air, water, or ice and has come to rest on the earth’s surface, either above or below sea level; or inorganic or organic particles originating from weathering, chemical precipitation, or biological activity.
	“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.
	“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.

B2.3.2 Nutrient Standards

The narrative standards applicable to nutrients in Montana are contained in the General Prohibitions of the surface WQS (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 TN and total phosphorus (TP) based on the level III ecoregion in which a stream is located (Suplee and Watson, 2013a). In addition, Suplee and Watson (2013a) developed a target for nitrate (also known as nitrate+nitrite nitrogen or NO_2+NO_3) for the Middle Rockies Level III Ecoregion that provides an appropriate numeric translation of the applicable narrative nutrient water quality standard. For the Middle Rockies Level III Ecoregion, draft water quality criteria for TN and TP and the target for nitrate are presented in **Table B-3**. This target and the proposed criteria are growing season, or summer, values applied from July 1[st] through September 30[th]. Additionally, numeric human health standards exist for nitrogen (**Table B-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 B-3. Nitrate Target and Proposed Numeric Nutrient and Criteria for the Middle Rockies Ecoregion

Parameter	Criteria/Target
Nitrate (Nitrate+Nitrite)	≤ 0.100 mg/L[a]
Total Nitrogen	≤ 0.300 mg/L[b]
Total Phosphorus	≤ 0.030 mg/L[b]

[a] From Suplee et al. (2008)

[b] From Suplee and Watson (2013b)

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

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

[a] Maximum allowable concentration

B2.4 NONDEGRADATION

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 Department. 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 the waterbody. Although these nondegradation rules are not integrated into TMDL development, they help limit pollutant loading in waters where designated uses are currently satisfied. Some of these waters may be healthy tributaries to waters where a TMDL is developed; thus nondegradation can help implement TMDL related pollutant controls at a watershed scale.

B3.0 Reference Conditions

B3.1 DEQ Approach for Defining a Reference Condition

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 waterbody's greatest potential for water quality given historic land-use activities. Although sediment water quality targets typically relate most directly to the aquatic life use, the targets are protective of all designated beneficial uses because they are based on the reference approach, which strives for the highest possible condition.

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.

Montana WQS do not contain specific provisions addressing detrimental modifications of habitat. However, detrimental modifications of habitat may often lead to or result from increases above naturally occurring concentrations of sediment, etc., and therefore the reference condition approach is used to help determine whether beneficial uses are supported when habitat modifications are present. The reference approach can also be used to develop riparian and shade target parameters when evaluating temperature.

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 or other primary reference data is available, and uses the secondary approach to estimate reference condition when primary approach data is limited or unavailable. 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 B-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 (U.S. Environmental Protection Agency, 1999). 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.

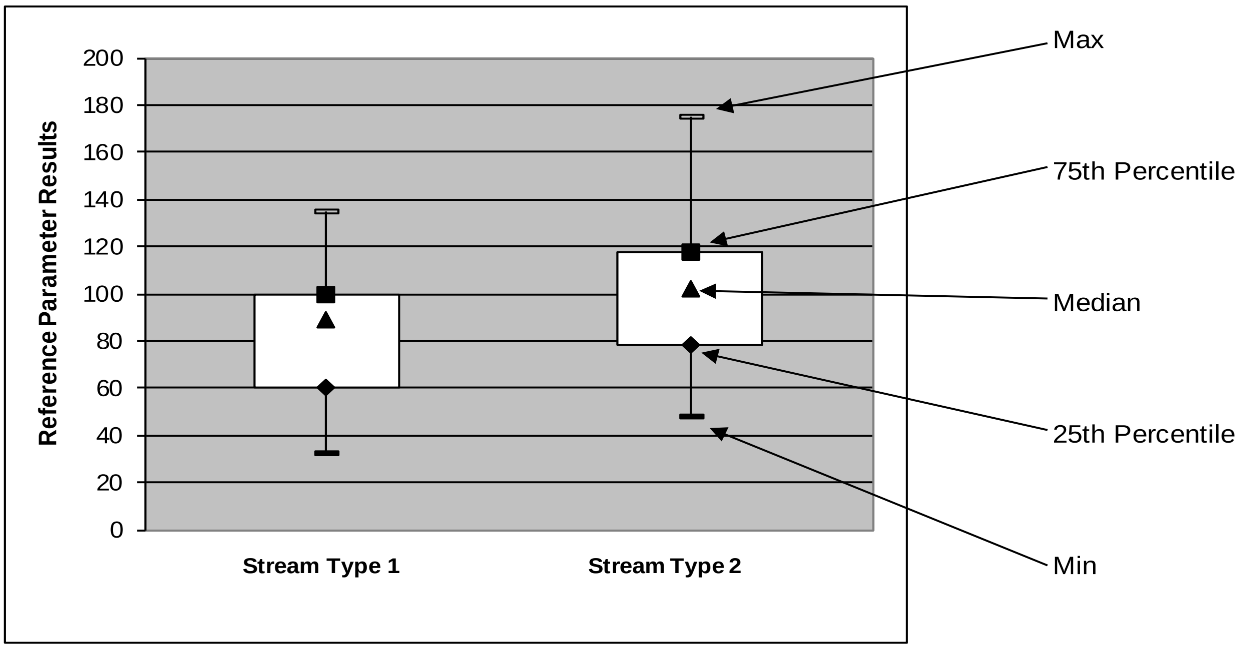

Figure B-1. Boxplot Example for Reference Data

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

- It is a simple approach that is easy to apply and understand.
- 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.
- 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.
- 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.
- 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 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 B-2** is an example statistical distribution of an entire dataset where lower values represent better water quality (and reference data are limited). In **Figure B-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.

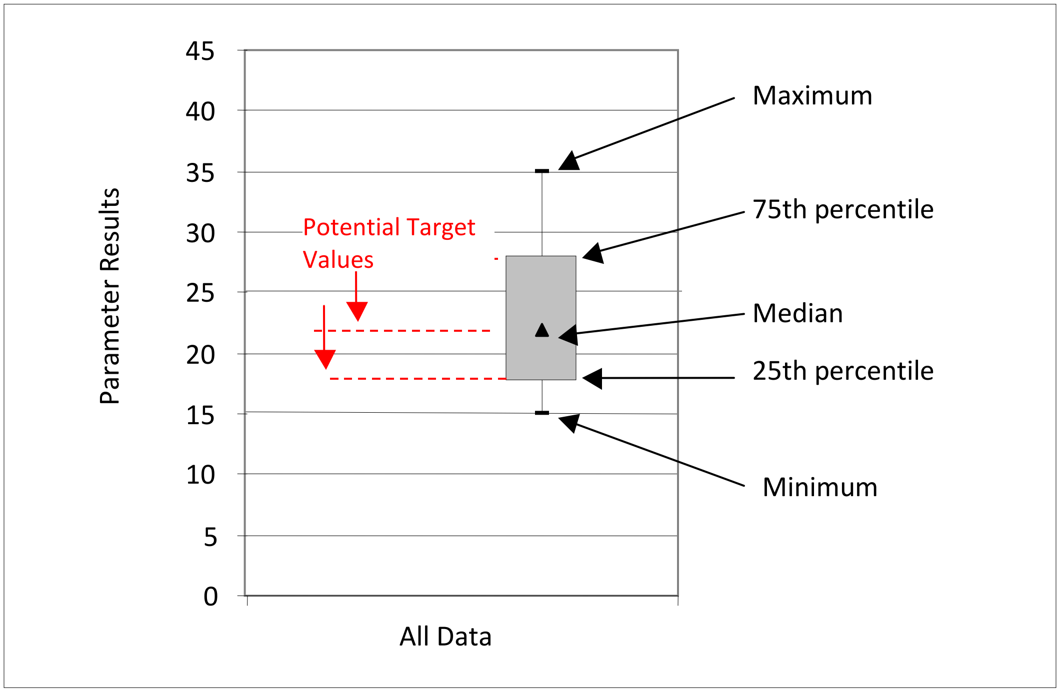

Figure B-2. Boxplot Example for the Use of All Data to Set Targets

B4.0 References

Buck, Sharon, Walter K. Dodds, Jen Fisher, David A. Flemer, Debra Hart, Amanda K. Parker, Jan Stevenson, Vicki Watson, and Eugene B. Welch. 2000. Nutrient Criteria Technical Guidance Manual, Rivers and Streams. Washington, DC: United States Environmental Protection Agency. EPA-822-B00-002. http://www.epa.gov/waterscience/criteria/nutrient/guidance/rivers/index.html.

Helsel, Dennis R. and Robert M. Hirsch. 1995. Statistical Methods in Water Resources Studies in Environmental Science, Vol. 49, Amsterdam, The Netherlands: Elsevier Science Publishers B.V.

Montana Department of Environmental Quality. 2006. Water Quality Assessment Process and Methods Standards Operating Procedure. Appendix A to 303(d) 2000-2004. WQPBWQM-001. http://deq.mt.gov/wqinfo/qaprogram/sop%20wqpbwqm-001.pdf.

-----. 2010. Circular DEQ-7: Montana Numeric Water Quality Standards. Helena, MT: Montana Department of Environmental Quality. http://deq.mt.gov/wqinfo/Standards/PDF/DEQ-7.pdf. Accessed 6/9/2011.

Suplee, Michael W. 2004. Wadeable Streams of Montana's Hi-Line Region: An Analysis of Their Nature and Condition With an Emphasis on Factors Affecting Aquatic Plant Communities and Recommendations to Prevent Nuisance Algae Conditions. Helena, MT: Montana Department of Environmental Quality, Water Quality Standards Section.

Suplee, Michael W. and Vicki Watson. 2013a. Scientific and Technical Basis of the Numeric Nutrient Criteria for Montana's Wadeable Streams and Rivers - Update 1. Helena, MT: Montana Department of Environmental Quality. http://deq.mt.gov/wqinfo/Standards/PDF/ScienceTech2013FnlCom.pdf. Accessed 5/16/2013a.

-----. 2013b. Scientific and Technical Basis of the Numeric Nutrient Criteria for Montana's Wadeable Streams and Rivers—Update 1. Helena, MT: Montana Department of Environmental Quality.

Suplee, Michael W., Vicki Watson, Arun Varghese, and Joshua Cleland. 2008. Scientific and Technical Basis of the Numeric Nutrient Criteria for Montana's Wadeable Streams and Rivers. Helena, MT: Montana Department of Environmental Quality.

U.S. Environmental Protection Agency. 1999. Protocol for Developing Nutrient TMDLs. Washington, D.C.: Office of Water, U.S. Environmental Protection Agency. EPA 841-B-99-007.

APPENDIX C – 2011 SEDIMENT AND HABITAT ASSESSMENT

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

Acronym	Definition
BEHI	Bank Erosion Hazard Index
BMP	Best Management Practices
DEQ	Department of Environmental Quality (Montana)
GIS	Geographic Information System
LWD	Large Woody Debris
MCA	Montana Code Annotated
NBS	Near Bank Stress
NHD	National Hydrography Dataset
RSI	Riffle Stability Index
TMDL	Total Maximum Daily Load
TPA	TMDL Planning Area

C1.0 INTRODUCTION

The Upper Clark Fork Total Maximum Daily Load (TMDL) Planning Area (TPA) is located within Granite, Silver Bow, and Deerlodge County and includes the Clark Fork watershed. The TPA encompasses the headwater tributaries from near Butte to Drummond at the confluence of Flint Creek. The Clark Fork River begins as Silver Bow Creek which originates from the confluence of Basin and Blacktail Creeks near Butte. Silver Bow Creek, flowing northwest and then north along the valley floor, becomes the Clark Fork River as it meets the confluence of Warm Springs Creek east of Anaconda. The watershed drains an area 1,495 square miles (956,800 acres).

The TPA does not coincide with the fourth-code Hydrologic Unit Code 17010201 as the Little Blackfoot River (413 square miles) was addressed as a separate TPA (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011).

Under Montana law, an impaired waterbody is defined as a waterbody for which sufficient and credible data indicates non-compliance with applicable water quality standards (Montana Code Annotated (MCA) 75-5-103). Section 303 of the Federal Clean Water Act requires states to submit a list of impaired waterbodies or stream segments to the U.S. Environmental Protection Agency every 2 years in an "Integrated Report" (formerly referred to as the "303(d) list"). The Montana Water Quality Act further directs states to develop TMDLs for all waterbodies appearing on the 303(d) list as impaired or threatened by "pollutants" (MCA 75-5-703).

This document focuses on sediment and habitat impairments on the upper Clark Fork River (segments MT76G001_010, MT76G001_030and MT76G001_040) and Silver Bow Creek (segment MT76G003_020).

A detailed sediment and habitat assessment of streams in the Upper Clark Fork TPA was conducted to facilitate the development of sediment TMDLs. During this assessment, streams were first analyzed in Geographic Information System (GIS) using color aerial imagery and broken into similar reaches based on landscape characteristics. Following the aerial assessment reach stratification process, field data were collected at 11 different stream reaches during August and September 2011. Field data were then used to quantify stream condition variables at assessment reaches within the Upper Clark Fork TPA. A list of data collected for each selected reach is included in **Section C3.1**.

The following sections are descriptions of three main components of this project: aerial assessment reach stratification, and sediment and habitat assessment.

C2.0 AERIAL ASSESSMENT REACH STRATIFICATION

An aerial assessment of streams in the Upper Clark Fork TPA from Little Blackfoot to Flint Creek was conducted using National Agricultural Imagery Program color imagery from 2009 in GIS along with other relevant data layers, including the National Hydrography Dataset (NHD) 1:100,000 stream layer and United States Geological Survey 1:24,000 Topographic Quadrangle Digital Raster Graphics. GIS data layers were used to stratify streams into distinct reaches based on landscape and land-use factors following techniques described in *Watershed Stratification Methodology for TMDL Sediment and Habitat Investigations* (Montana Department of Environmental Quality, 2008). Stream reaches in the TPA upstream of the Little Blackfoot River were completed as part of a different project following the same methodology (2006).

The reach stratification methodology involves breaking a waterbody stream segment into stream reaches and sub-reaches. The Montana Department of Environmental Quality (DEQ) tracks stream water quality status by stream segment, which may encompass the entire stream or just a portion of the stream. Each of the stream segments in the Upper Clark Fork TPA was initially divided into distinct reaches based on four landscape factors: ecoregion, valley gradient, Strahler stream order, and valley confinement. Stream reaches classified by these four criteria were then further divided into sub-reaches based on the surrounding vegetation and land-use characteristics, including predominant vegetation type, adjacent land use, riparian area condition, anthropogenic (human) influences on streambank erosion, level of development, and the presence of anthropogenic activity within 100 feet of the stream channel. This stratification resulted in a series of stream reaches and sub-reaches delineated based on landscape and land-use factors which were compiled into an Aerial Assessment Database for the Upper Clark Fork TPA.

C2.1 Reach Types

As described above, the aerial assessment reach stratification process involved dividing each stream segment into distinct reaches based on ecoregion, valley gradient, Strahler stream order, and valley confinement. Each individual combination of the four landscape factors is referred to as a "**reach type**" in this report. Reach types were labeled using the following naming convention based on landscape features in the order listed below:

Level III Ecoregion – Valley Gradient – Strahler Stream Order – Confinement

Landscape feature values and associated reach type identifiers are presented in **Table C2-1**.

Table C2-1. Reach Type Identifiers

Landscape Factor	Stratification Category	Reach Type Identifier
Level III Ecoregion	Middle Rockies	MR
Valley Gradient	0-<2%	0
	2-<4%	2
	4-<10%	4
	>10%	10
Strahler Stream Order	1^{st} order	1
	2^{nd} order	2
	3^{rd} order	3
	4^{th} order	4
	5^{th} order	5
	6^{th} order	6
	7^{th} order	7
Confinement	unconfined	U
	confined	C

Thus, a stream reach identified as MR-2-2-U is a mid-gradient (2-<4%), 2^{rd} order, unconfined stream in the Middle Rockies Level III Ecoregion.

C2.2 Reach Stratification Results

A total of 46 reaches were delineated during the aerial assessment reach stratification process covering 101.5 miles of streams in the Upper Clark Fork TPA (**Table C2-2**). Based on the Level III Ecoregion, a total of two distinct reach types was delineated in the Upper Clark Fork TPA for this project and field data was collected in both reach types.

Table C2-2. Aerial Assessment Stream Segments

Stream Segment	Number of Reaches	Length (miles)
Clark Fork River	27	74.4
Silver Bow Creek	19	27.1

C3.0 Sediment and Habitat Assessment

C3.1 Methods

Sediment and habitat data were collected following the methodology described in *Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments* (Montana Department of Environmental Quality, 2010). Field monitoring sites were selected in relatively low-gradient segments of the study streams where sediment deposition is likely to occur. Other considerations in selecting field monitoring sites included representativeness of the reach to other reaches of the same slope, order, confinement and ecoregion, the extent of anthropogenic impacts relative to other reaches, and ease of access.

Sediment and habitat assessments were performed at 12 field monitoring sites, which were selected based on the aerial assessment in GIS and on-the-ground reconnaissance conducted in August, 2010.

Sediment and habitat data were collected within three reach types (**Table C3-1**, **Figure C3-1)**.

Table C3-1. Reach Types and Monitoring Sites

Reach Type	Number of Reaches	Sites Monitored
MR-0-6-U	9	CFR-2-3
		CFR-8-1
		CFR-12-1
		CFR-13-1
		CFR-16-2
		CFR-17-2
		CFR-22-2
		CFR-24-1
		CFR-26-1
MR-0-5-U	2	SVB-4-2
		SVB-9-2

The length of the monitoring site was based on the bankfull channel width. An assessment reach length of 1,000 feet was used at two sites in which the bankfull width was between 10 feet and 50 feet. A monitoring site length of 1,500 feet was used at two sites in which the bankfull width was between 50 and 75 feet. A monitoring site length of 2,000 feet was used at seven sites in which the bankfull width was greater than 75 feet. Each monitoring site was divided into five equally sized study cells numbered 1 through 5 progressing in an upstream direction. Sites were assessed from downstream to upstream.

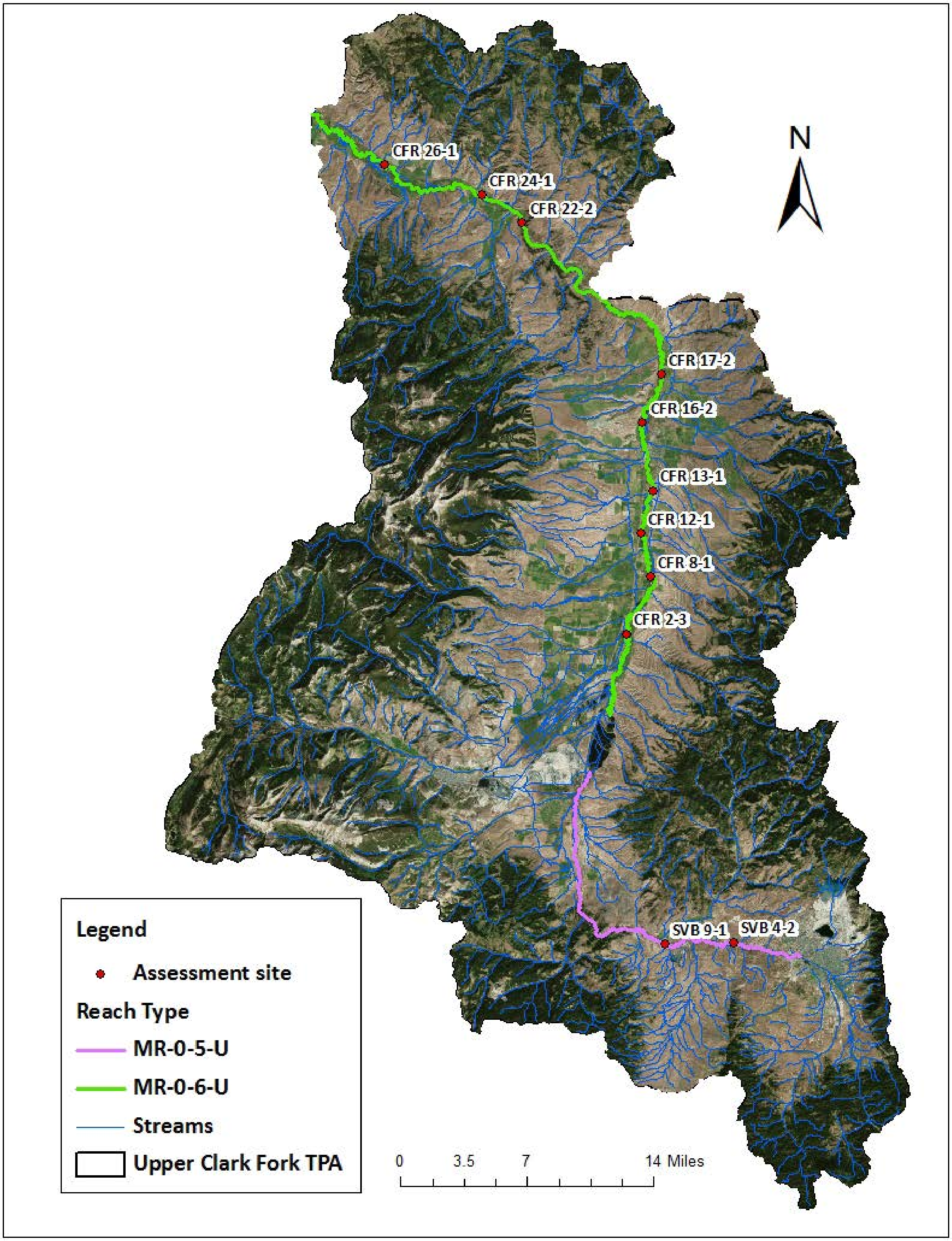

Figure C3-1. Aerial Assessment Reach Type Stratification and Sampled Sites

The following sections provide brief descriptions of the field methodologies employed during this assessment. A more in-depth description is available in *Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments* (Montana Department of Environmental Quality, 2010).

C3.1.1 Channel Form and Stability Measurements

Channel form and stability measurements include the field determination of bankfull, channel cross-sections, floodprone width, and surface water slope.

C3.1.1.1 Field Determination of Bankfull

The bankfull elevation was determined for each monitoring site. Bankfull is a concept used by hydrologists to define a regularly occurring channel-forming high flow. One of the first generally accepted definitions of bankfull was provided by Dunne and Leopold (1977):

> The bankfull stage corresponds to the discharge at which channel maintenance is the most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels.

Indicators that were used to estimate the bankfull elevation included scour lines, changes in vegetation types, tops of point bars, changes in slope, changes in particle size and distribution, staining of rocks, and inundation features. Multiple locations and bankfull indicators were examined at each site to determine the bankfull elevation, which was then applied during channel cross-section measurements.

C3.1.1.2 Channel Cross-Sections

Channel cross-section measurements were performed at the first riffle in each cell using a line level and a measuring rod. At each cross-section, depth measurements at bankfull were performed across the channel at regular intervals, which varied depending on channel width. The thalweg depth was recorded at the deepest point of the channel independent of the regularly spaced intervals.

C3.1.1.3 Floodprone Width Measurements

The floodprone elevation was determined by multiplying the maximum depth value by two (Rosgen, 1996). The floodprone width was then measured by stringing a tape from the bankfull channel margin on both the right and left banks until the tape (pulled tight and "flat") touched the ground at the floodprone elevation. When dense vegetation or other features prevented a direct line of tape from being strung, the floodprone width was estimated by pacing or making a visual estimate.

C3.1.1.4 Water Surface Slope

Water surface slope was measured by a two-person team using a transit and stadia rod. This measurement was compared with the slope assigned in the GIS-based aerial assessment to verify reach type. The field measured slope was also used in determining the Rosgen stream type at each monitoring site.

C3.1.2 Fine Sediment Measurements

Channel cross-section measurements were performed at the first riffle in each cell using a leveled tape and a measuring rod. At each cross-section, depth measurements at bankfull were performed across the channel at regular intervals, which varied depending on channel width. The thalweg depth was recorded at the deepest point of the channel independent of the regularly spaced intervals.

C3.1.2.1 Riffle Pebble Count

One Wolman pebble count (Wolman, 1954) was performed at the first riffle encountered in four cells, generally including cells 1, 3 and 5, providing a minimum of 400 particles measured within each assessment reach. Particle sizes were measured along their intermediate length axis (b-axis) using a gravelometer and results were grouped into size categories. The pebble count was performed from bankfull to bankfull using the "heel to toe" method. Location of the counted pebbles within the wet vs. dry part of the channel was also noted.

C3.1.2.2 Riffle Grid Toss

The riffle grid toss was performed at the same location as the pebble count measurement. The riffle grid toss measures accumulation of fine sediment (particles less than 6mm diameter) on the surface of the streambed. Grid tosses were performed prior to the pebble count to avoid disturbances to surface fine sediment.

C3.1.2.3 Pool Tail-Out Grid Toss

A measurement of the percent of fine sediment in pool tail-outs was taken using the grid toss method at each pool in which potential spawning gravels were identified. Three measurements were taken in each pool with appropriately sized spawning gravels using a 49-point grid. The suitability for spawning was recorded as "Yes" (Y), or "No" (N) in cases where gravels of appropriate size were scarce or not available. No grid toss measurements were made when the substrate was determined to be too large to support spawning. Grid toss measurements were still performed when the substrate was observed to be too fine to support spawning since the goal of this assessment is to quantify fine sediment accumulation in spawning areas.

C3.1.2.4 Riffle Stability Index

A Riffle Stability Index (RSI) evaluation was performed in streams that had well-developed point bars. For assessment sites in which enough well-developed point bars were present, a total of three RSI measurements was taken, which entailed measurement of the intermediate axis (b-axis) of 15 particles determined to be among the largest size group of recently deposited particles that occur on over 10% of the point bar. During post-field data processing, the RSI was determined by calculating the geometric mean of the dominant bar particle size measurements and comparing the result to the cumulative particle distribution from the riffle pebble count in an adjacent or nearby riffle.

C3.1.3 Instream Habitat Measurements

Instream habitat measurements include channel bed morphology, residual pool depth and width, and pool habitat quality (cover type and woody debris quantification).

C3.1.3.1 Channel Bed Morphology

The length of pools and riffles within monitoring sites was recorded progressing in an upstream direction. The upstream and downstream stations of "dominant" riffle features were recorded. A riffle is considered "dominant" when occupying over 50% of the bankfull channel width (Heitke et al., 2006). Pools were documented if they were concave in profile, bounded by a "head crest" at the upstream end and a "tail crest" at the downstream end, and had a maximum depth at least 1.5 times the pool-tail depth (Kershner et al., 2004). Dammed pools were also assessed; backwater pools were not assessed.

C3.1.3.2 Residual Pool Depth
Maximum pool depth and the depth of the pool tail crest at its deepest point were measured at each pool encountered. The difference between the maximum depth and the tail crest depth is considered the residual pool depth. No pool tail crest depth was recorded for dammed pools.

C3.1.3.3 Pool Habitat Quality
Qualitative assessments of each pool feature were undertaken, including pool type, size, formative feature, and cover type, along with the depth of any undercut banks associated with the pool. The total number of pools was also quantified.

C3.1.3.4 Woody Debris Quantification
The amount of Large Woody Debris (LWD) within each monitoring site was recorded. Large pieces of woody debris located within the bankfull channel that were stable enough to influence the channel form were counted as either single, aggregate or "willow bunch." The term "willow bunch" refers to dead, decadent or living riparian shrubs (not just willows) that are influencing the channel bed morphology. A single piece of LWD was counted when it was greater than 9 feet long or spanned two-thirds of the wetted stream width, and 4 inches in diameter at the small end (Overton et al., 1997).

C3.1.4 Riparian Health Measurements
Riparian conditions were documented using the riparian greenline assessment.

C3.1.4.1 Riparian Greenline Assessment
Along each monitoring site, an assessment of riparian vegetation cover was performed. Vegetation types were recorded at 10-foot intervals, with the number of sampled points depending on the bankfull channel width. The riparian greenline assessment described the general vegetation community type of the groundcover, understory and overstory on both banks. At 50-foot intervals, the riparian buffer width was estimated on either side of the channel. The riparian buffer width corresponds to the belt of vegetation buffering the stream from adjacent land uses. Hummocking from livestock hoof action was also recorded where encountered during the greenline assessment.

C3.2 RESULTS

In the Upper Clark Fork TPA, sediment and habitat variables were assessed in late August and early September 2011 at 11 assessment reaches. Sediment and habitat assessments were performed in the dominant reach types on the Clark Fork River upstream of Flint Creek and on Silver Bow Creek. In the Upper Clark Fork TPA, both streams are comprised of a single reach type according to the DEQ stratification methodology. A statistical analysis of the sediment and habitat data is presented by reach type and for individual assessment reaches in the following sections.

C3.2.1 Reach Type Analysis
This section presents a statistical analysis of sediment and habitat base parameters for each of the reach types assessed in the Upper Clark Fork TPA. Reach type discussions are based on mean values, while summary statistics for the minimum, 25th percentile, median, 75th percentile and maximum values are also provided since these may be more applicable for developing sediment TMDL targets. Sediment and habitat analysis is provided by reach type for the following metrics:

- width/depth ratio
- entrenchment ratio

- riffle pebble count <2mm
- riffle pebble count <6mm
- riffle grid-toss <6mm
- pool tail-out grid toss <6mm
- residual pool depth
- pool frequency
- LWD frequency
- greenline understory shrub cover
- greenline percent bare ground
- RSI

C3.2.1.1 Width/Depth Ratio

The channel width/depth ratio is defined as the channel width at bankfull height divided by the mean bankfull depth (Rosgen, 1996). The channel width/depth ratio is one of several standard measurements used to classify stream channels, making it a useful variable for comparing conditions between reaches with the same stream type (Rosgen, 1996). A comparison of observed and expected width/depth ratios is also a useful indicator of channel over-widening and aggradation, which are often linked to excess streambank erosion and/or sediment inputs from sources upstream of the study reach. Channels that are over-widened are often associated with excess sediment deposition and streambank erosion, contain shallower and warmer water, and provide fewer deepwater habitat refugia for fish.

Figure C3-2 illustrates trends in width/depth ratio among reach types. Mean width/depth ratios for assessed reach types ranged from 17.0 in MR-0-5-U to 44.1 in MR-0-6-U (**Table C3-2**). A higher stream order indicates a larger, thus generally wider, stream.

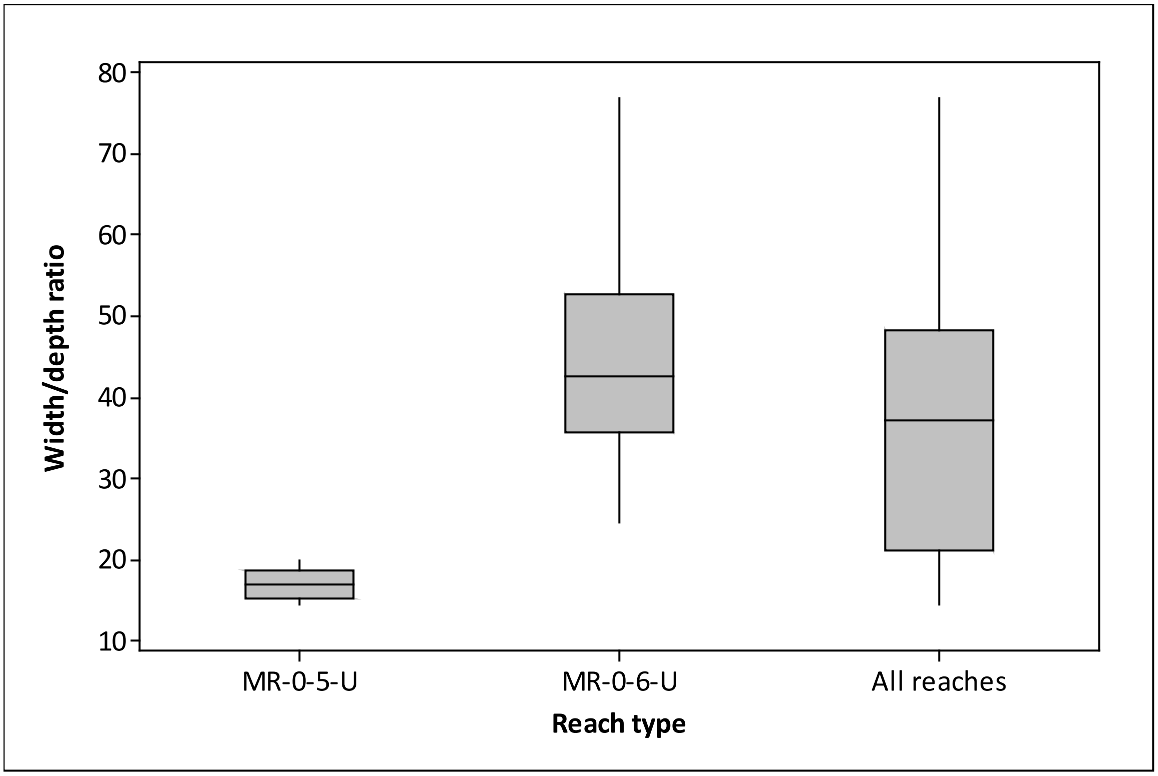

Figure C3-2. Width/Depth Ratio

Table C3-2. Width/Depth Ratio

Statistic	Reach Types		
	MR-0-5-U	**MR-0-6-U**	**All Reaches**
Number of Reaches	2	9	11
Sample Size	10	30	40
Minimum	14.5	24.6	14.5
25th Percentile	15.2	35.7	21.0
Median	17.0	42.7	37.1
Mean	17.0	44.1	37.3
75th Percentile	18.5	52.5	48.3
Maximum	19.8	76.9	76.9

C3.2.1.2 Entrenchment Ratio

A stream's entrenchment ratio is equal to the floodprone width divided by the bankfull width (Rosgen, 1996). The entrenchment ratio is used to help determine if a stream shows departure from its natural stream type and is an indicator of stream incision that describes how easily a stream can access its floodplain. Streams can become incised due to detrimental land management activities or may be naturally incised due to landscape characteristics. A stream that is overly entrenched generally is more prone to streambank erosion due to greater energy exerted on the banks during flood events. Greater scouring energy along incised channels results in higher sediment loads derived from eroding banks. If the stream is not actively degrading (downcutting), the sources of human caused incision may be historical in nature, though sediment loading may continue to occur. The entrenchment ratio is an important measure of channel conditions since it relates to sediment loading and habitat condition.

Figure C3-3 illustrates the distribution of values for entrenchment ratio among reach types. The mean entrenchment ratio for assessed reach types ranged from 2.2 in MR-0-6-U to 9.2 in MR-0-5-U (**Table C3-3**). The entrenchment ratio for reach type MR-0-6-U, which applies to reaches on the Clark Fork River, may be biased low because the floodprone width on these reaches with wide shrub-covered floodplain was often recorded as ">200," which was treated as 200 in the data analysis.

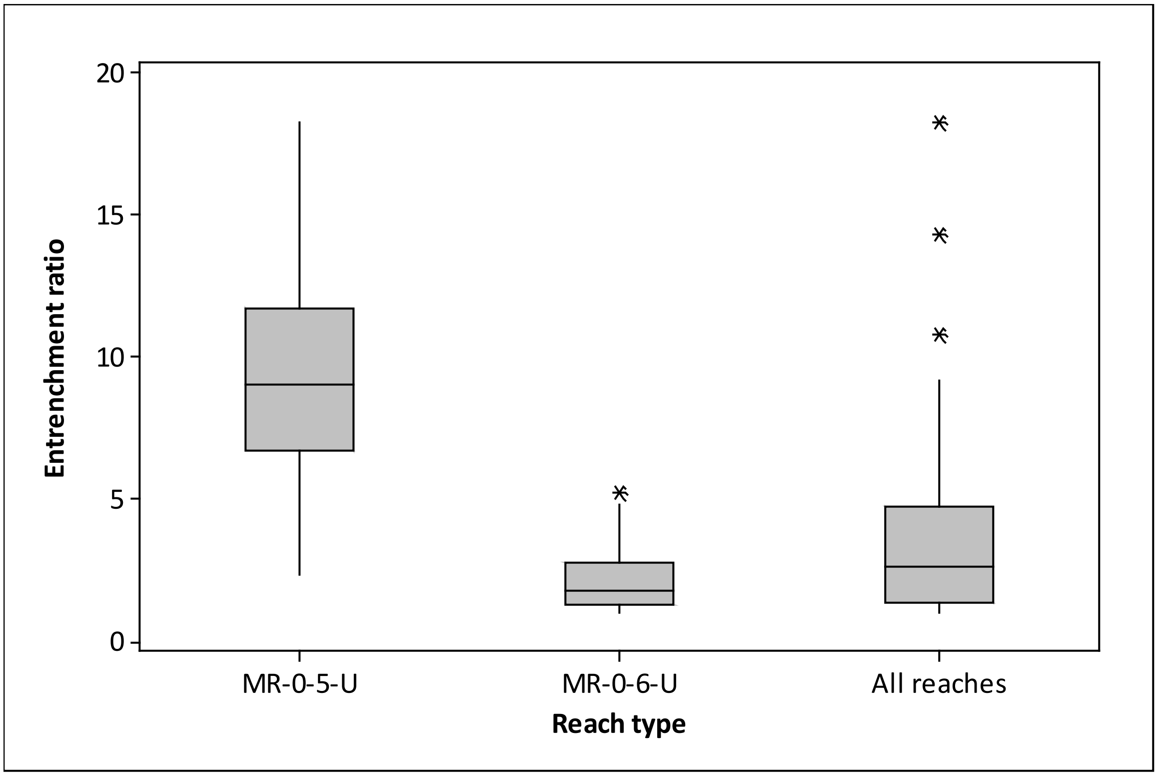

Figure C3-3. Entrenchment Ratio

Table C3-3. Entrenchment Ratio

Statistic	Reach Types		
	MR-0-5-U	**MR-0-6-U**	**All Reaches**
Number of Reaches	2	9	11
Sample Size	10	30	40
Minimum	2.3	1.0	1.0
25th Percentile	6.7	1.3	1.3
Median	9.0	1.7	2.6
Mean	9.2	2.2	4.0
75th Percentile	11.7	2.8	4.7
Maximum	18.2	5.2	18.2

C3.2.1.3 Riffle Pebble Count %<2mm

Percent surface fine sediment provides a good measure of the siltation occurring in a river system. Surface fine sediment measured using the Wolman (1954) pebble count method is one indicator of aquatic habitat condition and can signify excessive sediment loading. The Wolman pebble count provides a survey of the particle distribution of the entire channel width, allowing investigators to calculate a percentage of the surface substrate (as frequency of occurrence) composed of fine sediment.

Figure C3-4 illustrates the distribution of values for percent substrate size < 2mm from riffle pebble count among reach types. Mean values for the percent of fine sediment <2mm based on riffle pebble counts ranged from 13% in MR-0-6-U to 28% in MR-0-5-U (**Table C3-4**). Reaches documented as an E Rosgen channel type are generally removed from analyses for fine sediment because E channels inherently have a higher percentage of fine sediment than other types. None of the assessed reaches in the Upper Clark Fork TPA was considered an E type at present; therefore all reaches are included in the analysis.

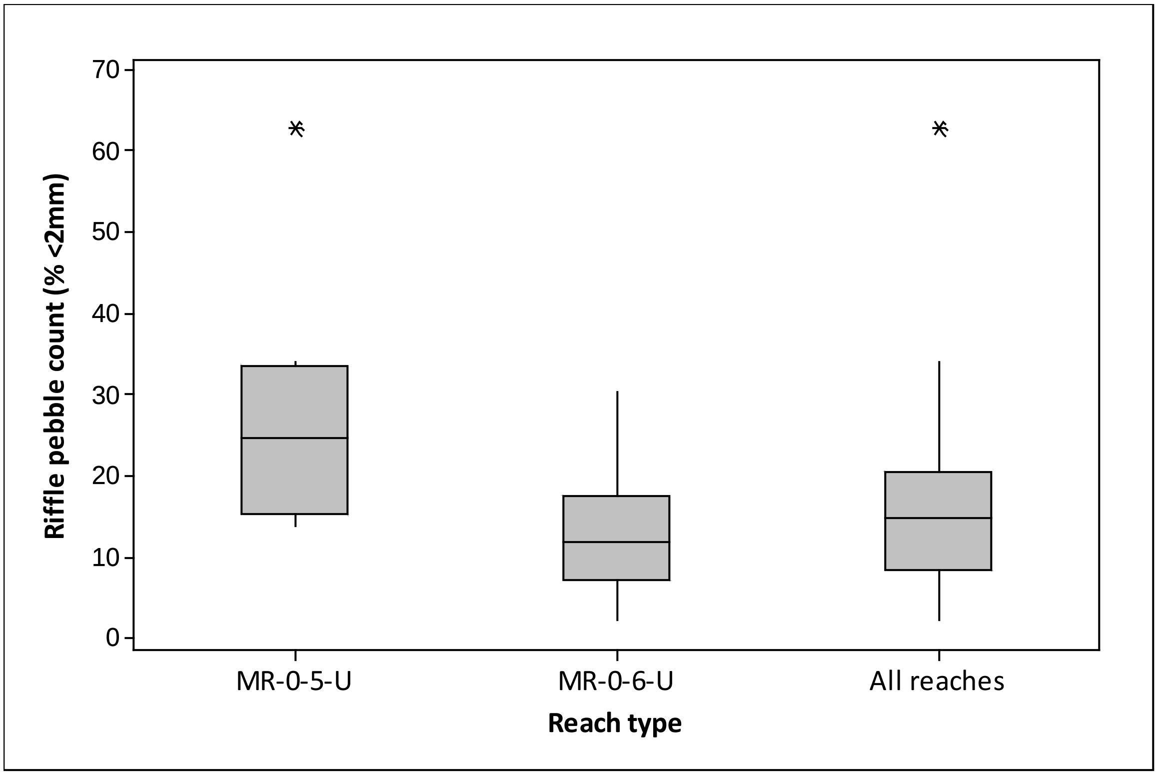

Figure C3-4. Riffle Pebble Count, % <2mm

Table C3-4. Riffle Pebble Count (% <2mm)

Statistic	Reach Types		
	MR-0-5-U	**MR-0-6-U**	**All Reaches**
Number of Reaches	2	9	11
Sample Size	8	28	36
Minimum	13.8	2.2	2.2
25th Percentile	15.3	7.1	8.5
Median	24.7	11.9	14.8
Mean	27.8	12.8	16.2
75th Percentile	33.4	17.5	20.4
Maximum	62.8	30.4	62.8

C3.2.1.4 Riffle Pebble Count %<6mm

As with surface fine sediment <2mm, an accumulation of surface fine sediment <6mm may indicate excess sedimentation and be detrimental to coldwater fish spawning. **Figure C3-5** illustrates the distribution of values for surface fine sediment < 6mm from riffle pebble counts. Mean values for the percent of fine sediment <6mm based on pebble counts conducted in riffles ranged from 17% in MR-0-

6-U to 35% in MR-0-5-U (**Table C3-5**). The two reaches on Silver Bow Creek, both in MR-0-5-U, had the highest percent fine sediment. These two reaches have undergone restoration from a highly disturbed state and are likely still in adjustment. These reaches also flow over the Boulder Batholith, a geologic formation that is composed primarily of undifferentiated granitic rocks which weather readily, supplying sand-sized sediment to Silver Bow Creek and lower-gradient streams in the region; therefore, the underlying geology is considered the primary long-term source of sediment to reaches on Silver Bow Creek (Montana Department of Environmental Quality, 1997).

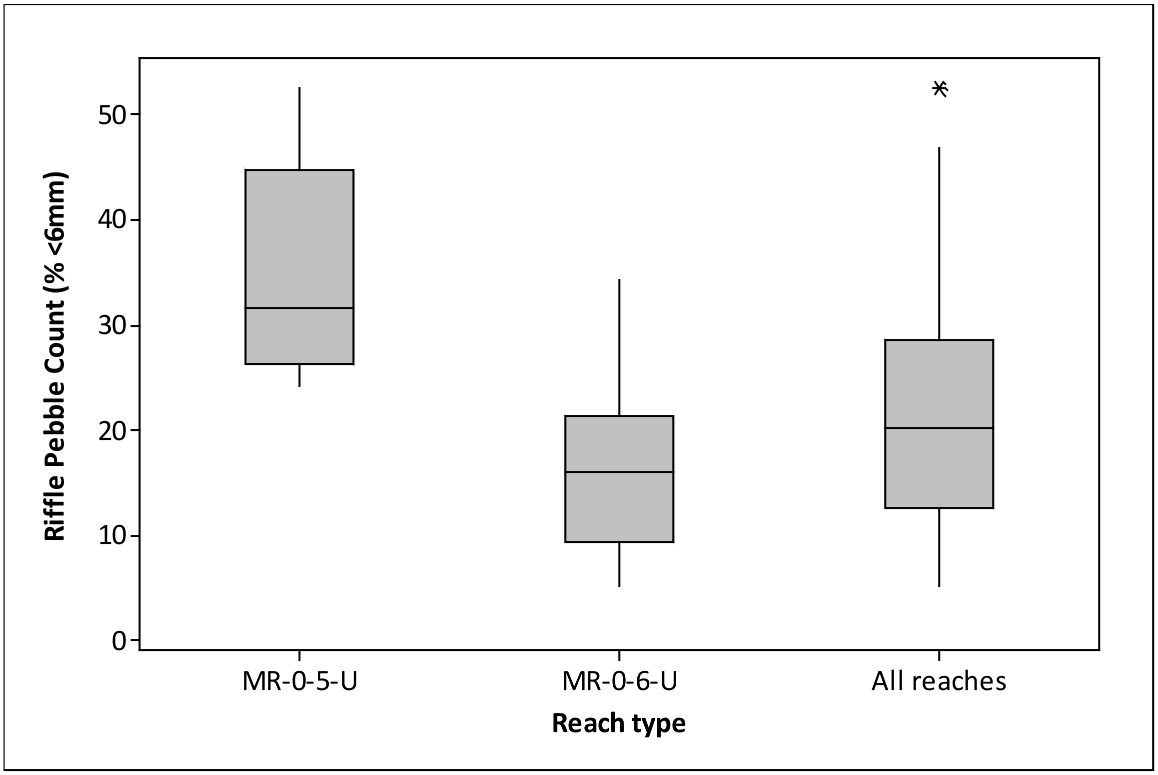

Figure C3-5. Riffle Pebble Count, % <6mm

Table C3-5. Riffle Pebble Count (% <6mm)

Statistic	Reach Types		
	MR-0-5-U	**MR-0-6-U**	**All Reaches**
Number of Reaches	2	9	11
Sample Size	8	28	36
Minimum	24.1	5.1	5.1
25th Percentile	26.4	9.3	12.7
Median	31.6	16.0	20.1
Mean	35.0	16.6	20.7
75th Percentile	44.8	21.2	28.5
Maximum	52.6	34.3	52.6

C3.2.1.5 Riffle Grid Toss %<6mm

The riffle grid toss is a standard procedure frequently used in aquatic habitat assessment that provides complimentary information to the Wolman pebble count. **Figure C3-6** illustrates the distribution of values for substrate < 6mm from riffle grid toss. Mean values for riffle grid toss fine sediment <6mm range 4.0% in MR-0-5-U to 4.7% in MR-0-6-U (**Table C3-6**).

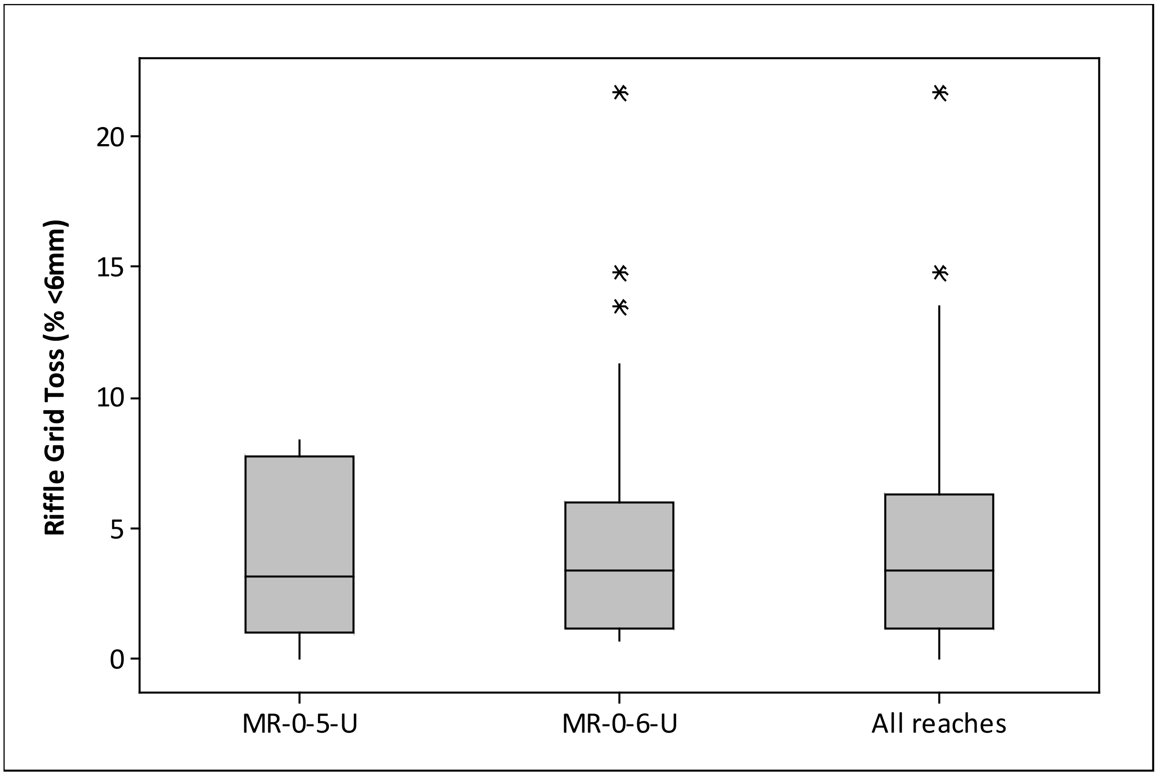

Figure C3-6. Riffle Grid Toss, % <6mm

Table C3-6. Riffle Grid Toss (% <6mm)

Statistic	Reach Types		
	MR-0-5-U	**MR-0-6-U**	**All Reaches**
Number of Reaches	2	9	11
Sample Size	8	29	37
Minimum	0.0	0.7	0.0
25th Percentile	1.0	1.2	1.2
Median	3.2	3.4	3.4
Mean	4.0	4.7	4.5
75th Percentile	7.7	6.0	6.3
Maximum	8.3	21.7	21.7

C3.2.1.6 Pool Tail-Out Grid Toss % <6mm

Grid toss measurements in pool tail-outs provide a measure of fine sediment accumulation in potential spawning sites, which may have detrimental impacts on aquatic habitat by cementing spawning gravels, preventing flushing of toxins in egg beds, reducing oxygen and nutrient delivery to eggs and embryos, and impairing emergence of fry (Meehan, 1991). Weaver and Fraley (Weaver and Fraley, 1991) observed a significant inverse relationship between the percentage of material less than 6.35mm and the emergence success of westslope cutthroat trout and bull trout.

Figure C3-7 illustrates the distribution of values for substrate < 6mm from pool tail-out grid toss among reach types. Mean values for pool tail-out grid toss fine sediment <6mm range from 4.3% in MR-0-6-U to 5.2% in MR-0-5-U (**Table C3-7**).

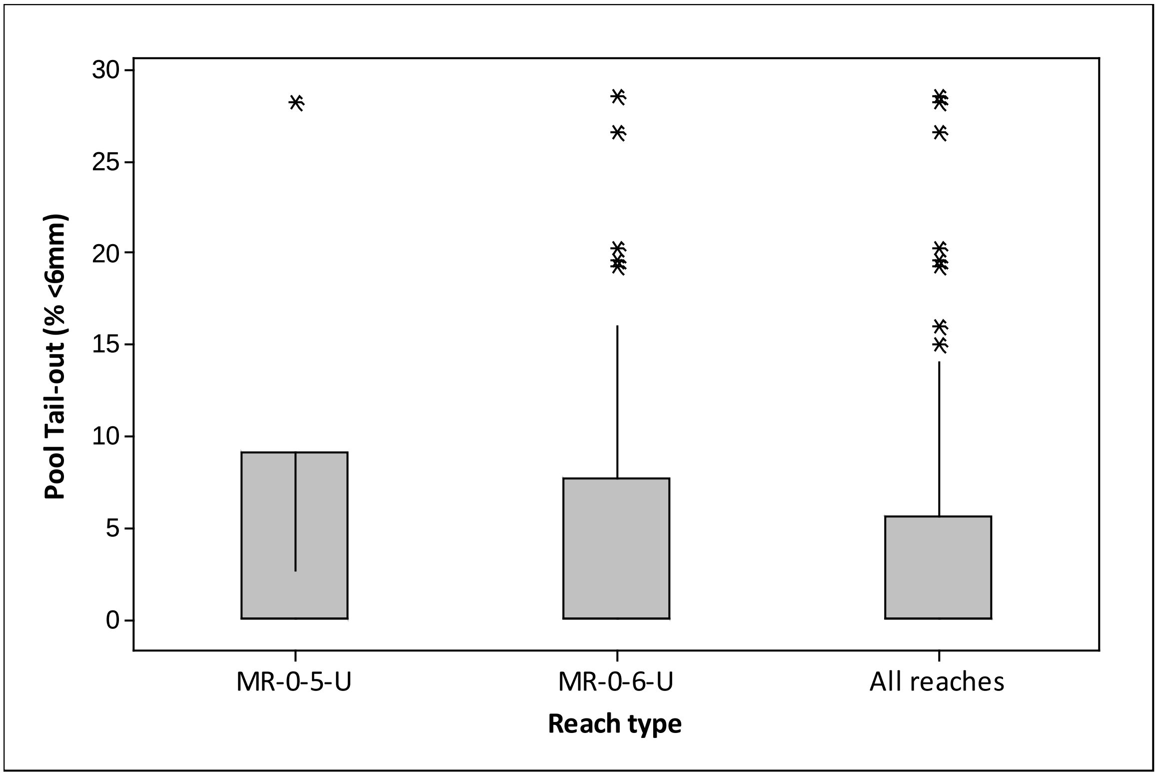

Figure C3-7. Poll Tail-Out Grid Toss, % <6mm

Table C3-7. Pool Tail-Out Grid Toss (% <6mm)

Statistic	**Reach Types**		
	MR-0-5-U	**MR-0-6-U**	**All Reaches**
Number of Reaches	2	9	11
Sample Size	6	51	57
Minimum	0.0	0.0	0.0
25th Percentile	0.0	0.0	0.0
Median	0.0	0.0	0.0
Mean	5.2	4.3	4.4
75th Percentile	9.1	7.7	5.7
Maximum	28.3	28.6	28.6

C3.2.1.7 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. Residual pool depth is also an indirect measurement of sediment inputs to streams because an increase in sediment loading can cause pools to fill, thus decreasing residual pool depth over time.

Figure C3-8 illustrates the distribution of values for residual pool depth among reach types. Mean residual pool depths ranged from 1.8 feet in MR-0-5-U to 2.4 feet in MR-0-6-U (**Table C3-8**). In general, residual pool depths were greater for reaches on lower-gradient, larger streams.

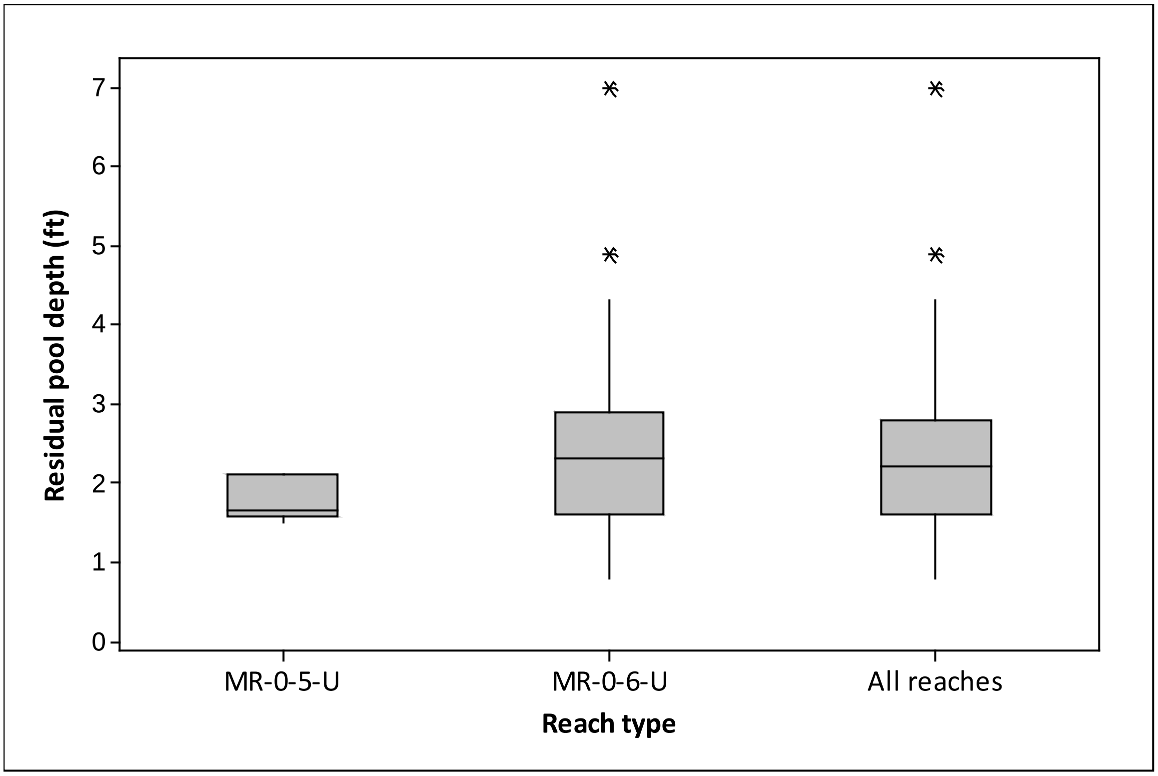

Figure C3-8. Residual Pool Depth (ft)

Table C3-8. Residual Pool Depth (ft)

Statistic	Reach Types		
	MR-0-5-U	MR-0-6-U	All Reaches
Number of Reaches	2	9	11
Sample Size	6	51	57
Minimum	1.5	0.8	0.8
25th Percentile	1.6	1.6	1.6
Median	1.7	2.3	2.2
Mean	1.8	2.4	2.4
75th Percentile	2.1	2.9	2.8
Maximum	2.1	7.0	7.0

C3.2.1.8 Pool Frequency

Pool frequency is a measure of the availability of pools to provide rearing habitat, cover, and refugia for salmonids. Pool frequency is related to channel complexity, availability of stable obstacles, and sediment supply. Excessive erosion and sediment deposition can reduce pool frequency by filling in smaller pools. Pool frequency can also be adversely affected by riparian habitat degradation resulting in a reduced supply of LWD or less scouring from stable root masses in streambanks.

Figure C3-9 illustrates the distribution of values for pool frequency among reach types. The mean value for the number of pools per mile was 16 for both MR-0-5-U and MR-0-6-U (**Table C3-9**).

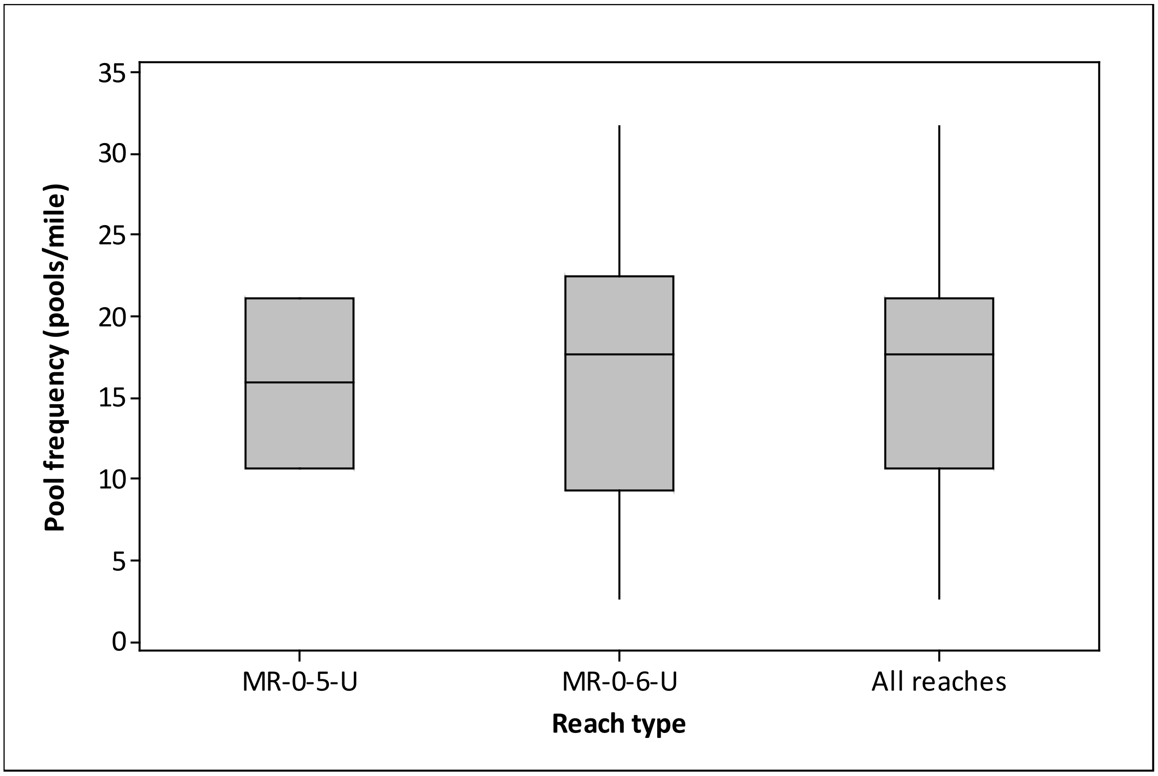

Figure C3-9. Pool Frequency (pools/mile)

Table C3-9. Pool Frequency (pools/mile)

Statistic	Reach Types		
	MR-0-5-U	**MR-0-6-U**	**All Reaches**
Number of Reaches	2	9	11
Sample Size	2	9	11
Minimum	10.6	2.6	2.6
25th Percentile	13.2	9.2	10.6
Median	15.8	17.6	17.6
Mean	15.8	16.3	16.2
75th Percentile	18.5	22.4	21.2
Maximum	21.1	31.7	31.7

C3.2.1.9 Large Woody Debris Frequency

LWD is a critical component of high-quality salmonid habitat, 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 can be measured and compared to reference reaches or literature values to determine if more or less LWD is present than would be expected under optimal conditions. In the case of Silver Bow Creek and the upper Clark Fork River, many reaches do not support forested riparian ecosystems and are instead willow-dominated; thus, LWD generally occurs as willow bunches for those reaches, which includes all Silver Bow Creek reaches.

LWD was not recorded in reach type MR-0-5-U (Silver Bow Creek) as none was observed in the 2 restored reaches where sampling was conducted. LWD per mile for MR-0-6-U (Clark Fork River) is provided in **Table C3-10**. "Willow bunches" recorded in the field were not tallied with LWD; thus, these results do not include reaches in which the only LWD recorded were willow bunches.

Table C3-10. Large Woody Debris (per mile)

Statistic	Reach Types
	MR-0-6-U
Number of Reaches	3
Sample Size	7
Minimum	0.379
25th Percentile	0.38
Median	0.38
Mean	0.38
75th Percentile	0.38
Maximum	0.379

C3.2.1.10 Greenline Understory Shrub Cover

Riparian shrub cover is one of the most important influences on streambank stability. Removal of riparian shrub cover can dramatically increase streambank erosion and increase channel width/depth ratios. Shrubs stabilize streambanks by holding soil and armoring lower banks with their roots, and reduce scouring energy of water by slowing flows with their branches.

Good riparian shrub cover is also important for fish habitat. Riparian shrubs provide shade, reducing solar inputs and increases in water temperature. The dense network of fibrous roots of riparian shrubs allows streambanks to remain intact while water scours the lowest portion of streambanks, creating important fish habitat in the form of overhanging banks and lateral scour pools. Overhanging branches of riparian shrubs provide important cover for aquatic species. In addition, riparian shrubs provide critical inputs of food for fish and their feed species. Terrestrial insects falling from riparian shrubs provide one of the main food sources for fish. Organic inputs from shrubs, such as leaves and small twigs, provide food for aquatic macroinvertebrates, which are also an important food source for fish.

Figure C3-10 illustrates the distribution of values greenline understory shrub cover among reach types. The mean value for greenline understory shrub cover ranged from 26% in MR-0-6-U to 60% in MR-0-5-U, the reach type containing the restored reaches on Silver Bow Creek that were heavily planted with willows (**Table C3-11**).

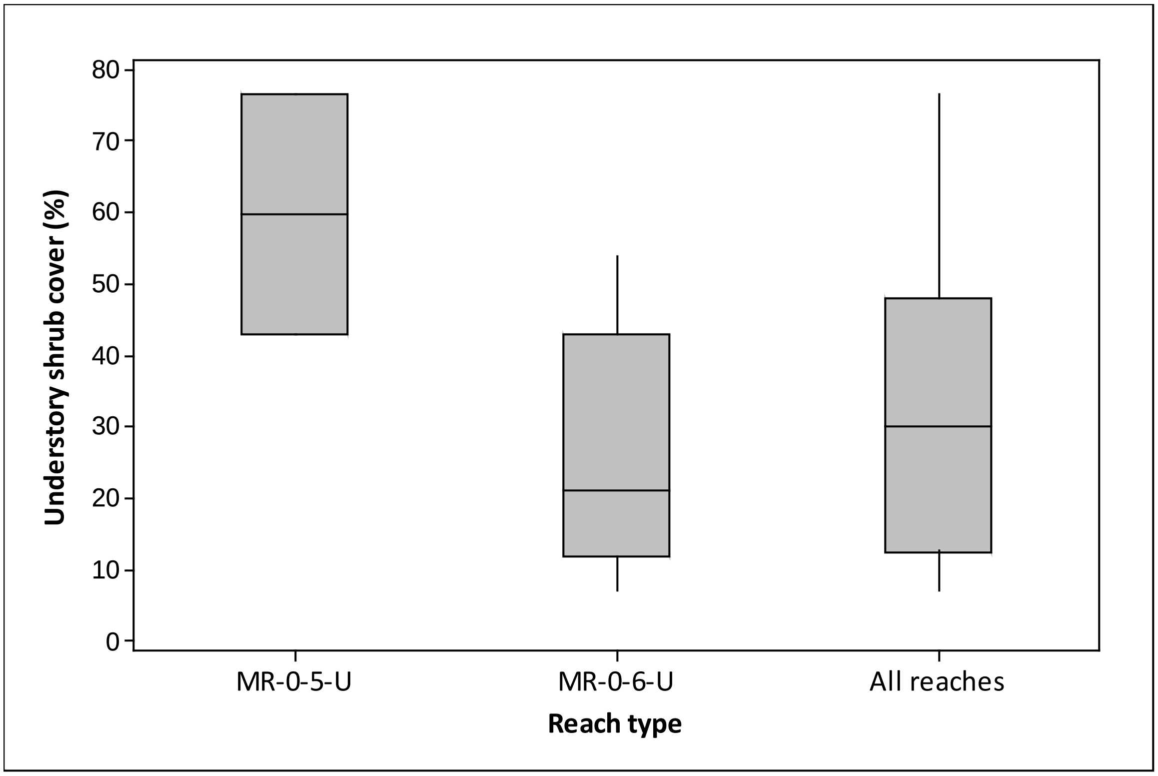

Figure C3-10. Understory Shrub Cover (%)

Table C3-11. Understory Shrub Cover (%)

Statistic	Reach Types		
	MR-0-5-U	MR-0-6-U	All Reaches
Number of Reaches	2	9	11
Sample Size	2	9	11
Minimum	43.0	7.0	7.0
25th Percentile	-	11.8	12.5
Median	59.8	21.0	30.0
Mean	59.8	26.1	32.23
75th Percentile	-	43.0	48.0
Maximum	76.5	54.0	76.5

C3.2.1.11 Greenline Bare Ground

Percent bare ground is an important indicator of erosion potential, as well as an indicator of land management influences on riparian habitat. Bare ground was noted in the greenline inventory in cases where recent ground disturbance has resulted in exposed bare soil. Bare ground is often caused by trampling from livestock or wildlife, fallen trees, recent bank failure, new sediment deposits from overland or overbank flow, or severe disturbance in the riparian area, such as from past mining, road-building, or fire. Groundcover on streambanks is important to prevent sediment recruitment to stream channels since sediment can wash in from unprotected areas during snowmelt, storm runoff and flooding. Bare areas are also much more susceptible to erosion from hoof shear. Most stream reaches have a small amount of naturally occurring bare ground. As conditions are highly variable, this measurement is most useful when compared to reference values from best available conditions within the study area or literature values.

Figure C3-11 illustrates the distribution of values for bare ground among reach types. The mean value for greenline percent bare ground ranged from 0% in MR-0-5-U to 16.3% in MR-0-6-U (**Table C3-12**). Reach type MR-0-5-U represents the restored reaches on Silver Bow Creek where extensive remediation efforts now support a dense cover of riparian graminoid (grass-like) species or shrubs.

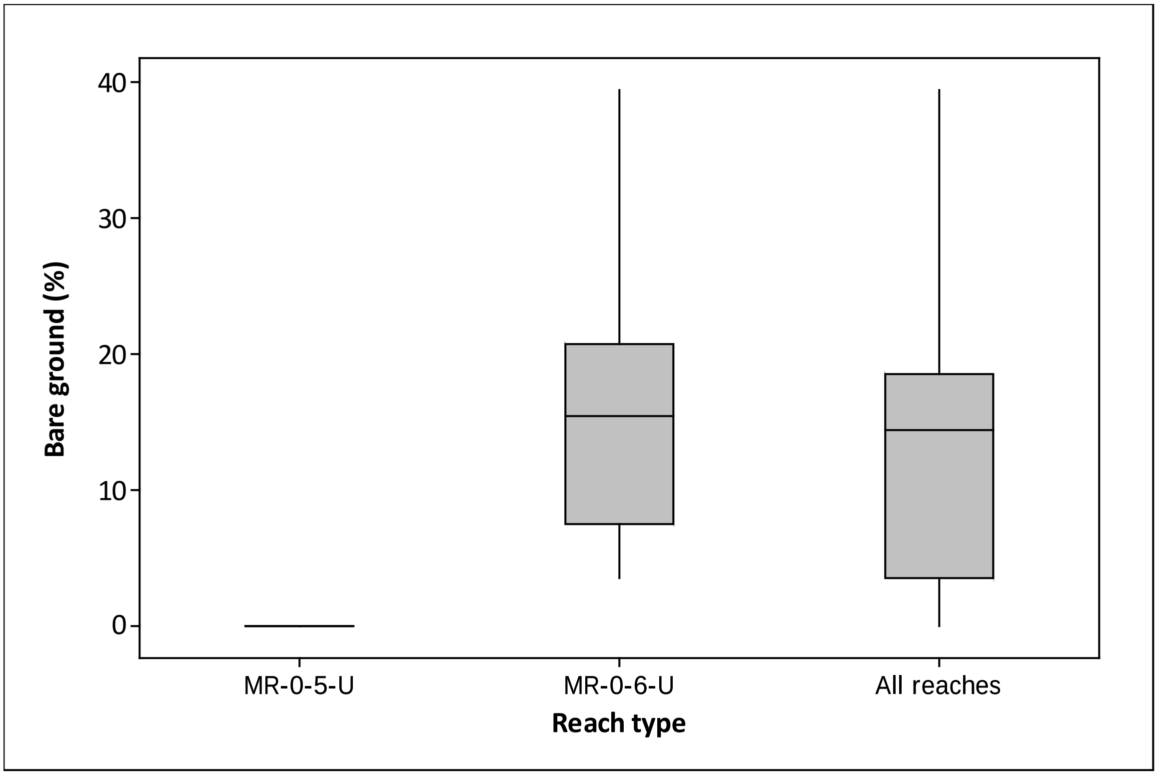

Figure C3-11. Bare Ground (%)

Table C3-12. Bare Ground (%)

Statistic	Reach Types		
	MR-0-5-U	**MR-0-6-U**	**All Reaches**
Number of Reaches	2	9	11
Sample Size	2	9	11
Minimum	0.0	3.5	0.0
25th Percentile	-	7.5	3.5
Median	0.0	15.5	14.5
Mean	0.0	16.3	13.3
75th Percentile	-	20.8	18.5
Maximum	0.0	39.5	39.5

C3.2.2 Monitoring Site Analysis

Sediment and habitat data collected at each monitoring site were reviewed individually in the following sections. Monitoring site discussions are based on median values, referencing the box plot statistics shown. Summary statistics for the minimum, 25th percentile, 75th percentile and maximum values are presented graphically, since these may be more applicable for developing sediment TMDL criteria. Statistics from these channels are included in the following analysis. **Table C3-13** outlines reaches by current channel type.

Table C3-13. Reaches by Rosgen Stream Type

Existing Rosgen Stream Type	REACH ID
C	CFR-02-3
	CFR-08-1
	CFR-12-1
	CFR-17-2
	CFR-24-1
	CFR-26-1
	SVB-4-2
	SVB-9-1
F	CFR-13-1
	CFR-16-2
	CFR-22-2

C3.2.2.1 Width/Depth Ratio

The highest median width/depth ratio was observed in CFR-24-1, a reach in the Clark Fork River (**Figure C3-12**). Width/depth ratio appears to follow a trend increasing from highest to lowest elevation reaches in the Upper Clark Fork TPA.

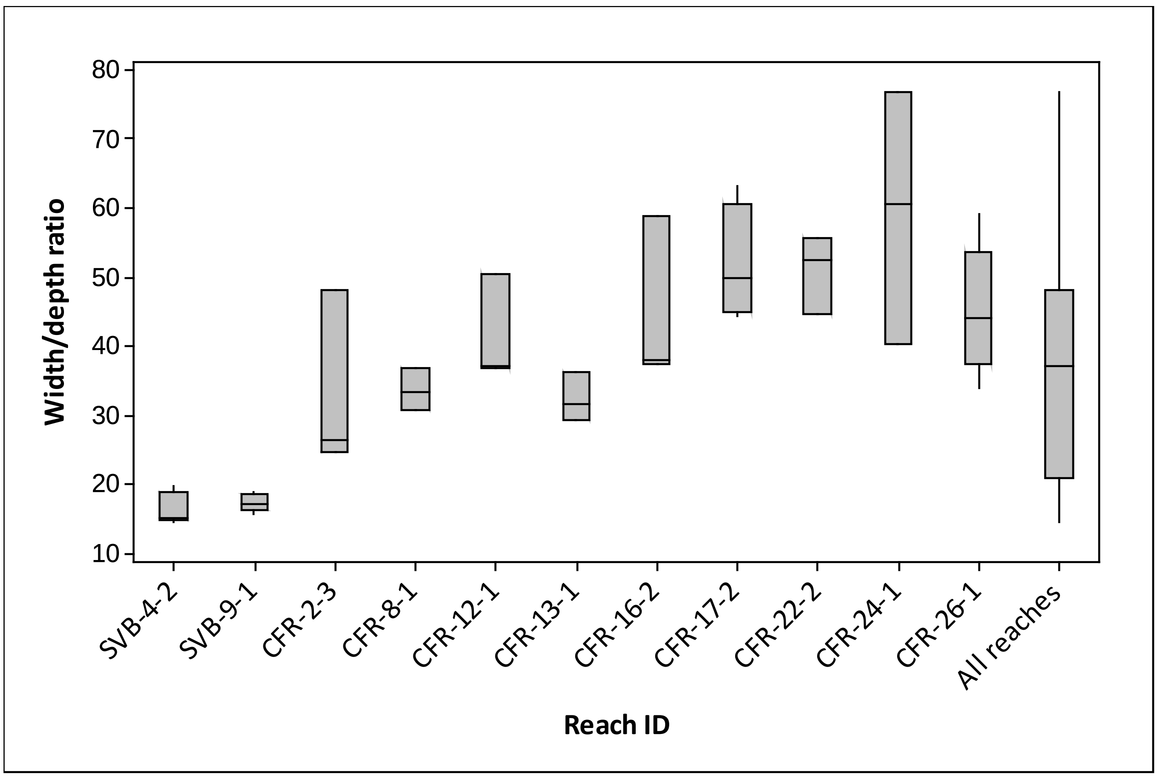

Figure C3-12. Width/Depth Ratio by Sample Location

C3.2.2.2 Entrenchment Ratio

Entrenchment ratio data collected within the Upper Clark Fork TPA indicates the following (**Figure C3-13**):

1. Of the sites assessed, reach SVB-9-1 has a significantly higher entrenchment ratio than the other sites (**Figure C3-13**). This trend could be in part because the floodplain on the mainstem CFR was generally recorded as “greater than 200 feet” on at least one side, which was treated as 200 feet

in the reach averages. Entrenchment ratio also could be higher on SVB reaches because these sites have undergone stream restoration and were designed to have more floodplain.

2. Variation in entrenchment ratio was generally low within reaches on the mainstem CFR.

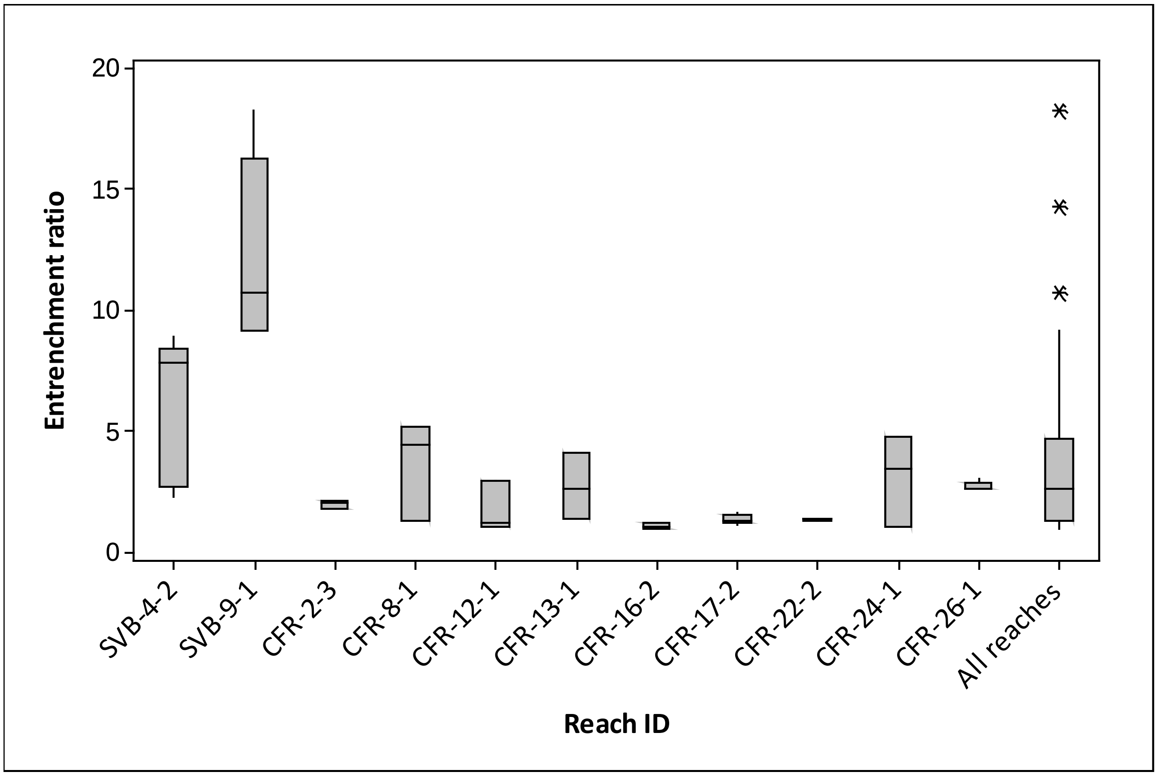

Figure C3-13. Entrenchment Ratio by Sample Location

C3.2.2.3 Riffle Pebble Count, % <2mm

The median percent of fine sediment in riffles <2mm as measured by a pebble count was highest in SVB-4-2 and generally decreased moving downstream through the Clark Fork River. A lot of aquatic vegetation in this SVB-4-2 contributed to higher fine sediment cover in addition to high natural fines in streams draining the Boulder Batholith (**Figure C3-14**).

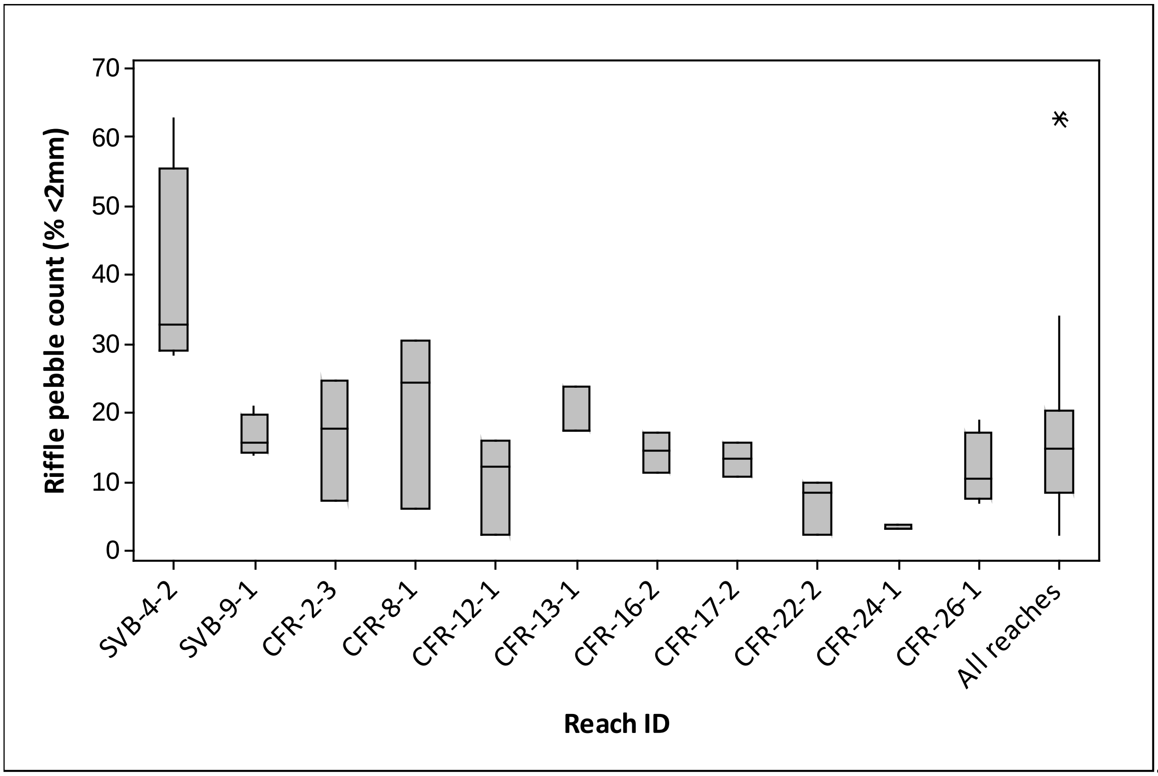

Figure C3-14. Riffle Pebble Count, % <2mm, by Sample Location

C3.2.2.4 Riffle Pebble Count, %<6mm

The percent of fine sediment in riffles <6mm as measured by a pebble count followed a similar trend as the percent of fine sediment <2mm, with the highest median value in SVB-9-1 (**Figure C3-15**). The same downward trend with distance downstream is observable in this dataset.

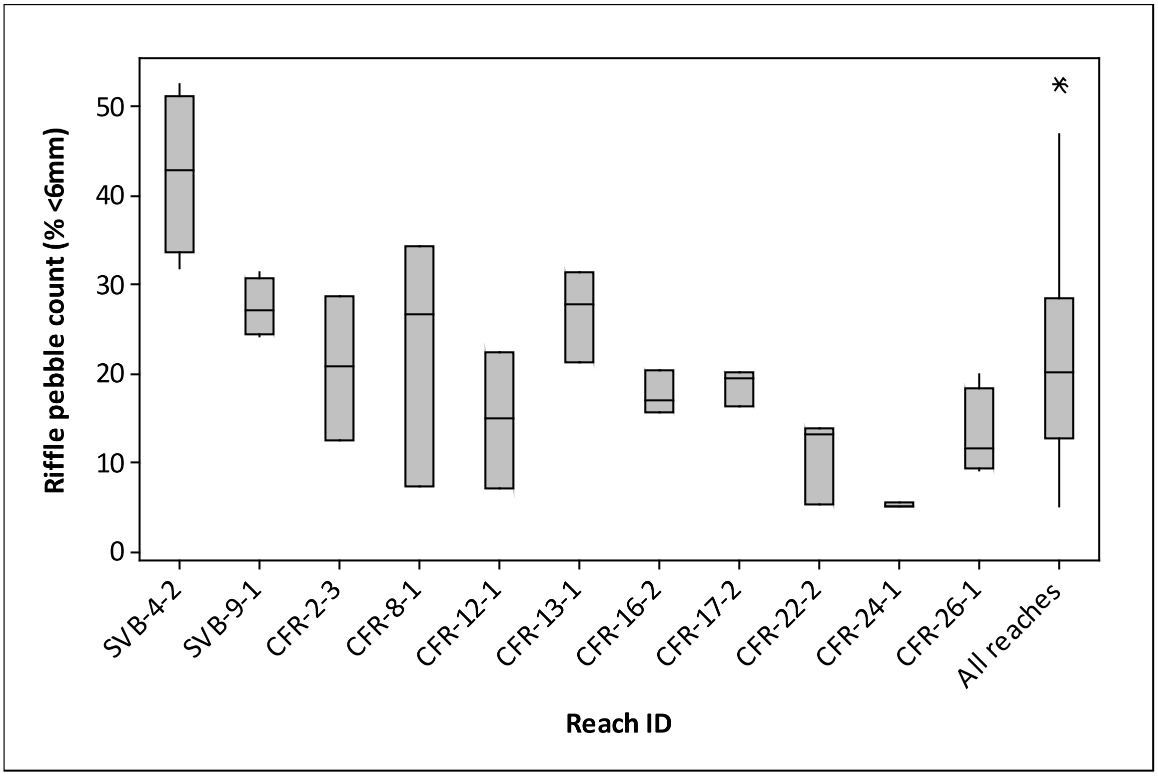

Figure C3-15. Riffle Pebble Count, % <6mm, by Sample Location

C3.2.2.5 Riffle Grid Toss, %<6mm

The median percent of fine sediment in riffles <6mm as measured by a grid toss was highest in CFR-17-2 (**Figure C3-16**). CFR-8-1 had the greatest range of observations among all sites.

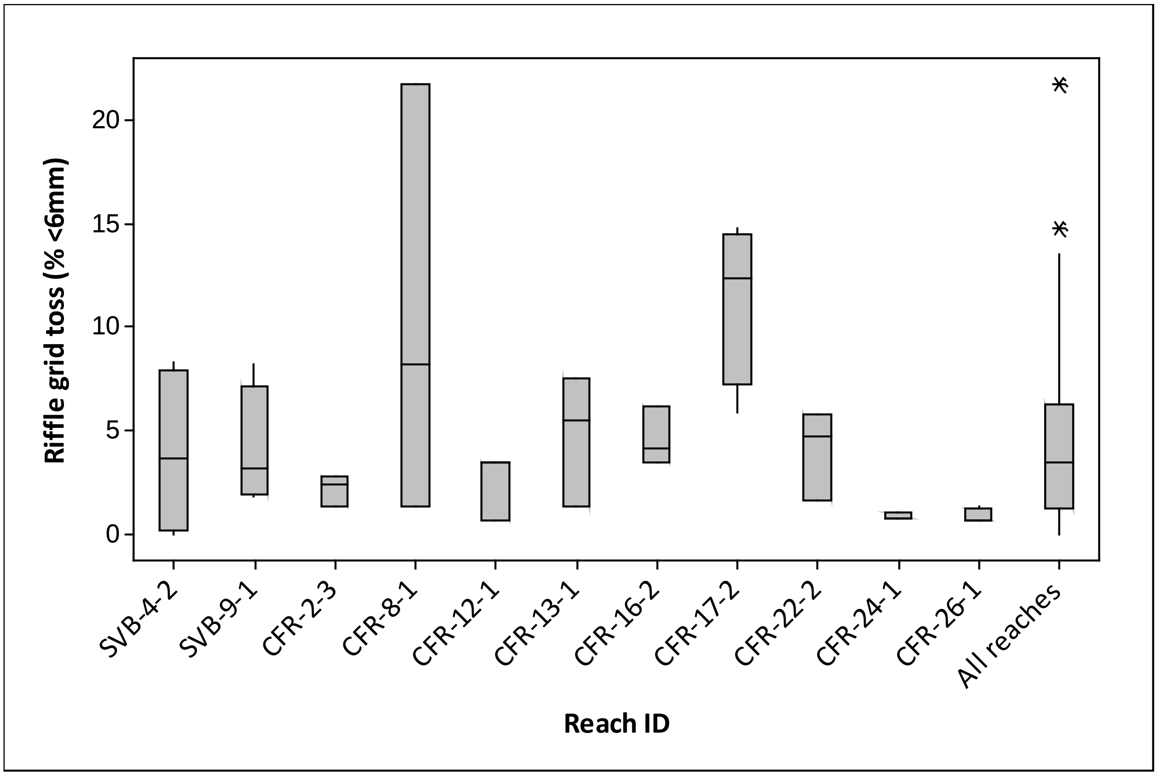

Figure C3-16. Riffle Grid Toss, % <6mm, by Sample Location

C3.2.2.6 Riffle Stability Index

The mobile percentile of particles on the riffle is termed "Riffle Stability Index" (RSI) and provides a useful estimate of the degree of increased sediment supply to riffles. The RSI addresses situations in which increases in gravel bedload from headwater activities is depositing material on riffles and filling pools, and it reflects qualitative differences between reference and managed watersheds. In the Upper Clark Fork TPA, very few gravel bars were encountered. RSI evaluations were, therefore, only performed in the assessment sites listed in **Table C3-14**. The D50 is the median pebble size encountered in the pebble count taken in closest proximity to the gravel bar used for RSI, and is used in calculating the RSI value.

Table C3-14. Riffle Stability Index Summary

Reach ID	Pebble Count Analysis		RSI
	Cell	D50	
CFR-02-3	1	45	31.25
CFR-02-3	3	56	65.75
CFR-02-3	4	58	64.84
CFR-08-1	1	45	42.68
CFR-08-1	3	106	97.78
CFR-08-1	4	61	86.27
CFR-12-1	1	55	46.73
CFR-12-1	4	51	52.13
CFR-16-2	3	69	89.77
CFR-22-2	4	85	54.46
CFR-24-1	1	89	62.38
CFR-24-1	2	118	52.78

Table C3-14. Riffle Stability Index Summary

Reach ID	Pebble Count Analysis		RSI
	Cell	D50	
CFR-24-1	3	116	96.94
CFR-26-1	1	89	71.72
CFR-26-1	3	144	100
CFR-26-1	4	76	76.67
CFR-26-1	5	35	13.51

C3.2.2.7 Pool Tail-Out Grid Toss %<6mm

The median percent of fine sediment in pool tail-outs as measured with the grid toss was highest in CFR-17-2 (**Figure C3-17**). This measure may be biased by the methodology which identifies 'spawning gravels' in pool tails where a grid toss measurement is performed. Some reaches had numerous pools where spawning gravels were determined to be present. CFR-17-2 only had a single pool where the measurement was done.

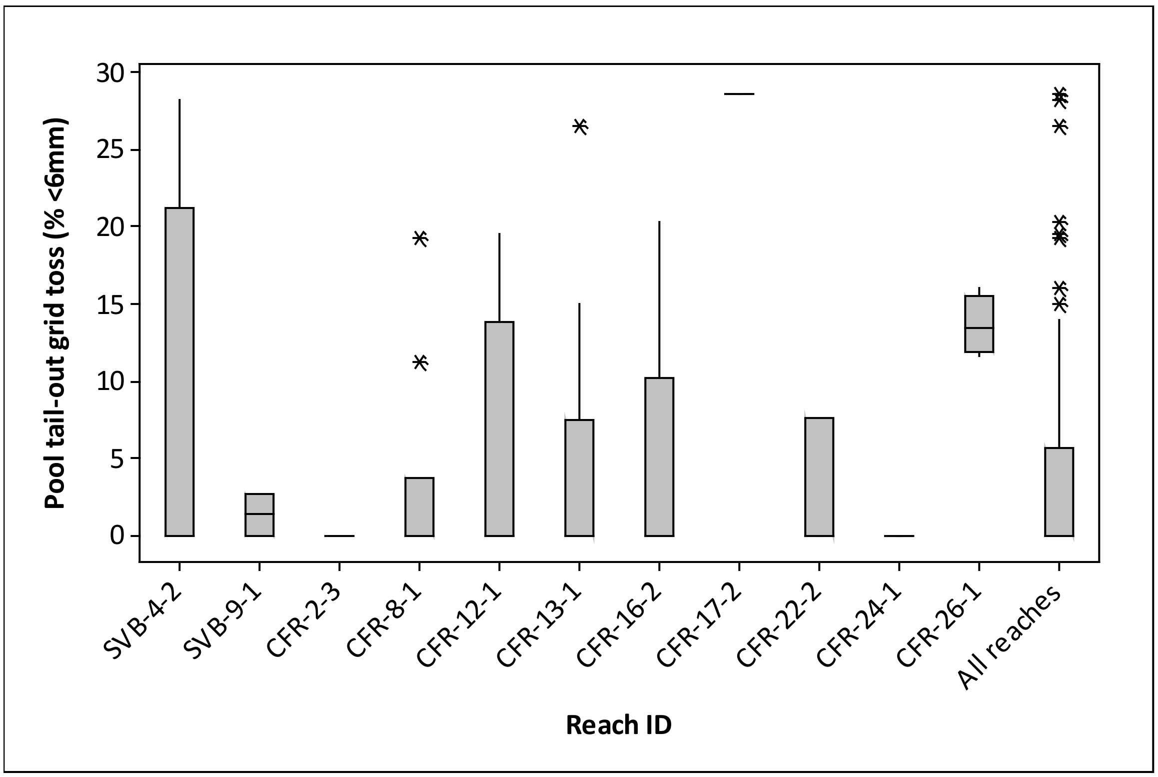

Figure C3-17. Pool Tail-Out Grid Toss, % <6mm, by Sample Location

C3.2.2.8 Residual Pool Depth

The greatest median residual pool depth was measured in CFR-8-1 (**Figure C3-18**). The lowest residual pool depth was observed in SVB-4-2, the most upstream reach in the dataset. Residual pool depths do not increase in the downstream direction within the assessed streams, as they do for greater stream orders among reach types (5th order (Silver Bow Creek) versus 6th order (Clark Fork River)).

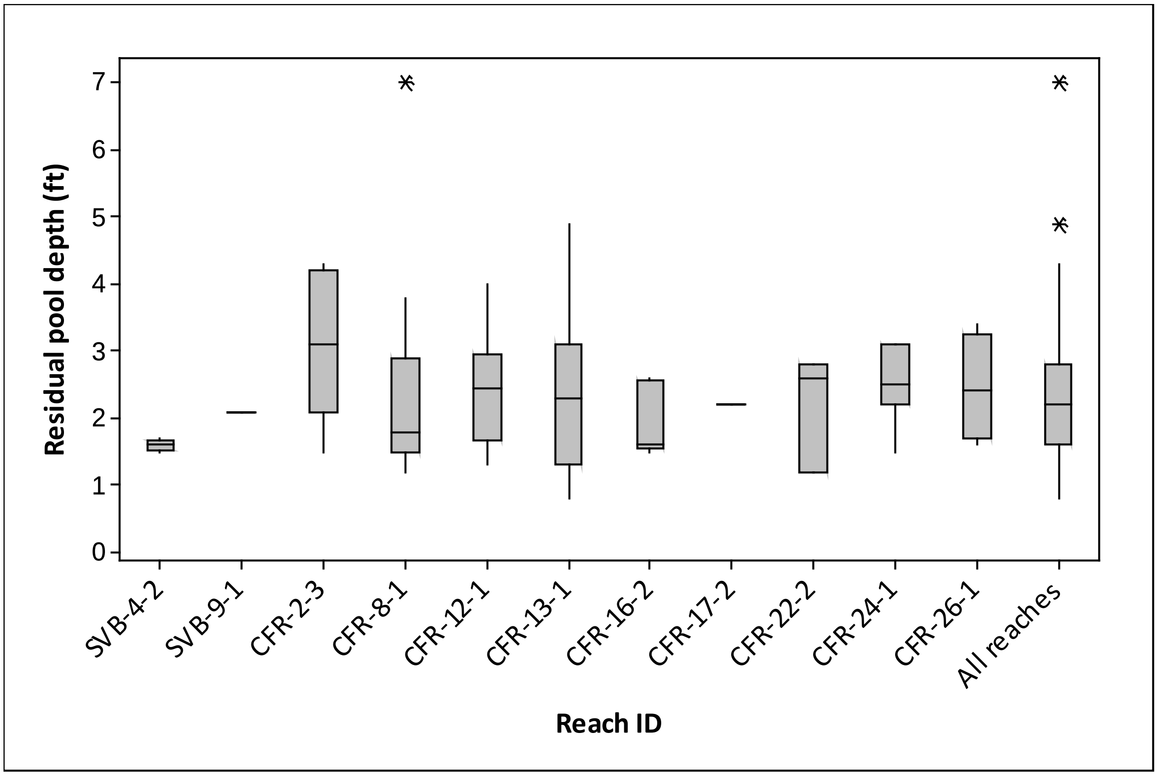

Figure C3-18. Residual Pool Depth (ft) by Sample Location

C3.2.2.9 Pool Frequency

The greatest number of pools per mile was found in CFR-8-1, a highly sinuous reach (**Figure C3-19**). It would be expected that pool frequency would decrease in the downstream direction although this is not well reflected in the data.

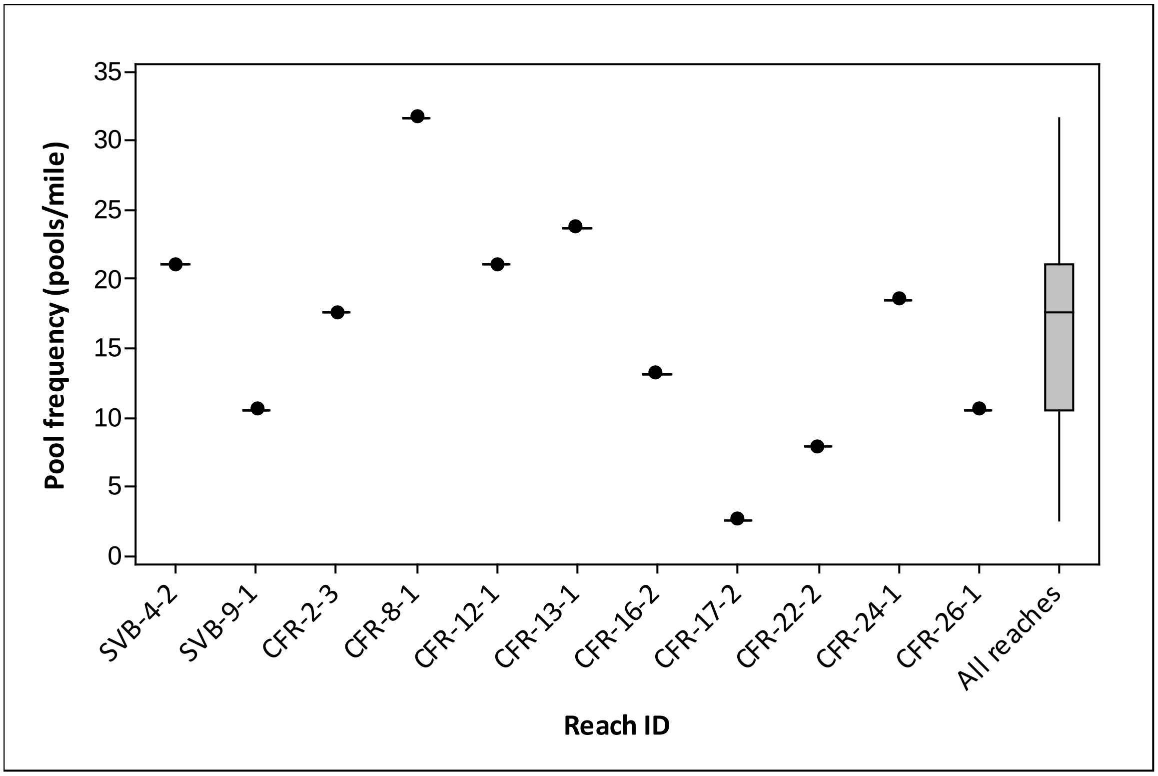

Figure C3-19. Pool Frequency (pools/mile) by Sample Location

C3.2.2.10 Large Woody Debris Frequency

The greatest concentration of LWD was found in CFR-26-1 the most downstream sampled reach on the Clark Fork mainstem (**Figure C3-20**). In general, LWD was rare among the assessed sites in the Upper Clark Fork TPA, which is predominantly willow-dominated. Upper reaches of the main CFR also are willow-dominated. Historic clearing of floodplain vegetation and reduced vegetation growth on tailings deposits may also contribute to low LWD counts.

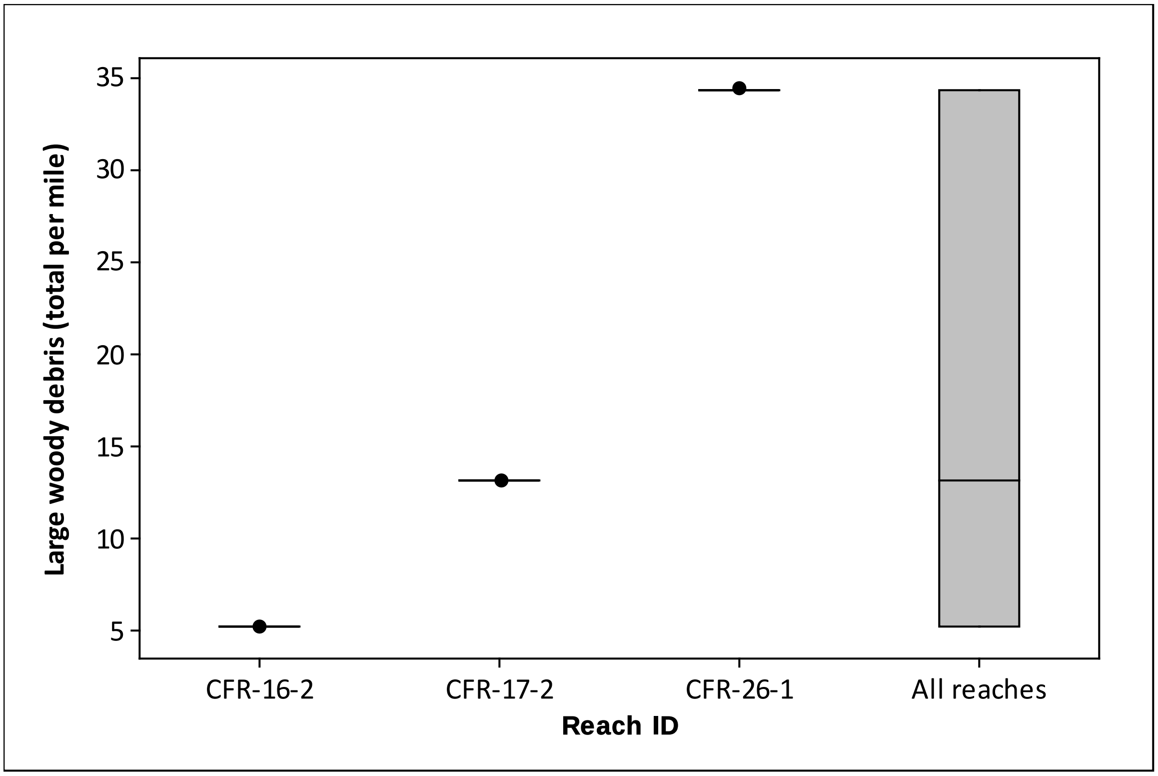

Figure C3-20. Large Woody Debris (total per mile) for Reaches in the Clark Fork River where Large Woody Debris Was Recorded

C3.2.2.11 Greenline Understory Shrub Cover

Reach SVB-4-2 had the highest percentage of understory shrub cover, at 76.5%. Nine of the 11 reaches sampled had less than 50% shrub cover. Four of the 11 reaches sampled had less than 20% shrub cover. (**Figure C3-21**). CFR-12-1, CFR-13-1 and CFR-16-2 are located immediately upstream and downstream of the city of Deer Lodge, Montana.

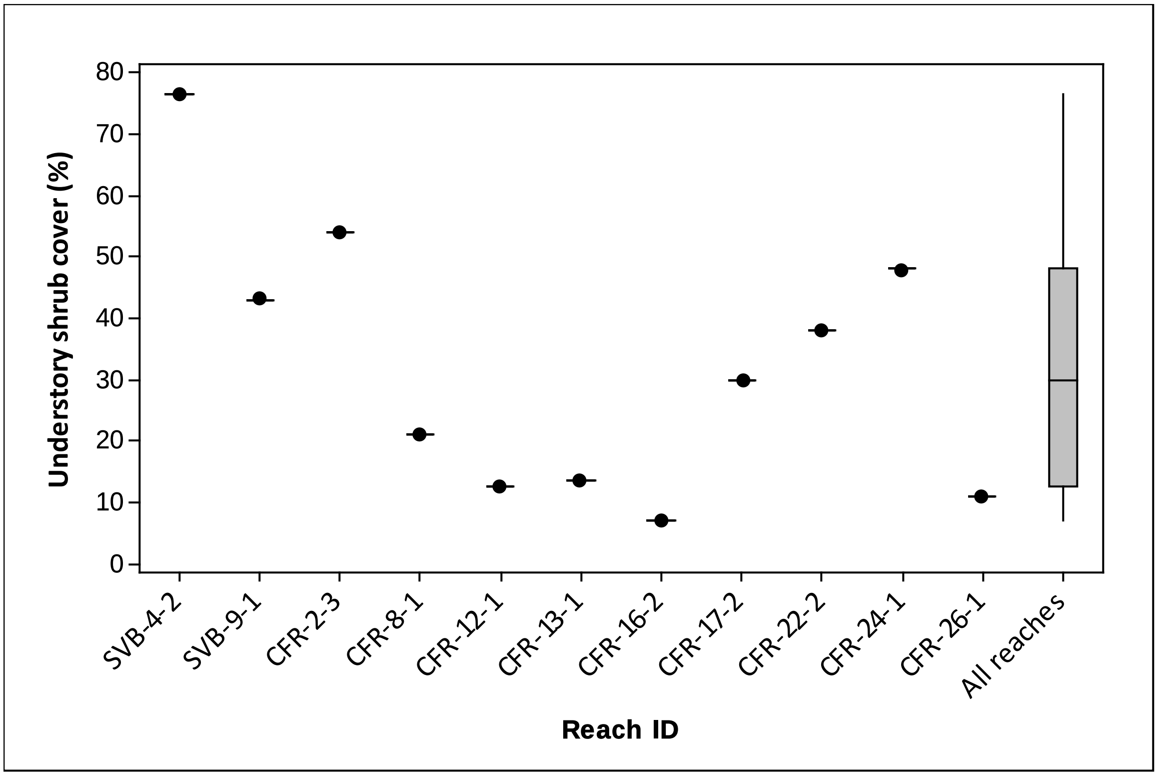

Figure C3-21. Understory Shrub Cover (%) by Sample Location

C3.2.2.12 Greenline Bare Ground

The highest percentage of bare ground was found at CFR-12-1. Two of the eleven sites surveyed had 20% or more bare ground, while approximately 5 of 11 reaches had less than 10% bare ground (**Figure C3-22**).

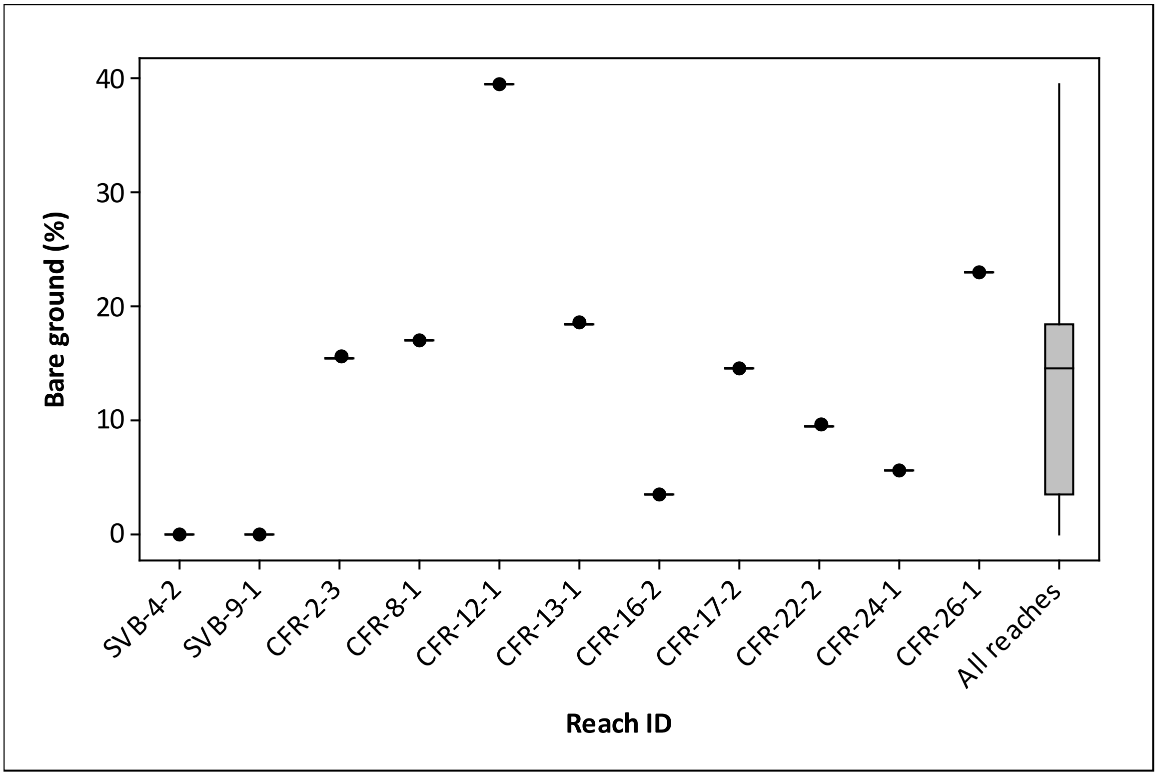

Figure C3-22. Bare Ground (%) by Sample Location

C4.0 Streambank Erosion Assessment

C4.1 Methods

Streambank erosion data were collected at 11 monitoring sites in the Upper Clark Fork TPA. At each of the sites, eroding streambanks were assessed for erosion severity and categorized as either "actively/visually eroding" or "slowly eroding/vegetated/undercut." **Bank Erosion Hazard Index (BEHI)** measurements were performed and **Near Bank Stress (NBS)** was evaluated at each eroding bank (Rosgen, 1996; Rosgen, 2006). Bank erosion severity was rated from "very low" to "extreme" based on the BEHI score, which was determined based on the following six variables: bank height, bankfull height, root depth, root density, bank angle, and surface protection. NBS was also rated from "very low" to "extreme" depending on the shape of the channel at the toe of the bank and the force of the water (i.e., "stream power") along the bank. In addition, the source, or underlying cause, of streambank erosion was evaluated based on observed anthropogenic disturbances within the riparian corridor, as well as current and historic land-use practices observed within the surrounding landscape. Source of streambank instability was identified based on the following near-stream source categories: natural, historic, residential/urban, irrigation, timber, mining, cropland and "other," for sources not included in the other categories. Sources of erosion in the "historic" or "other" categories included historic mining activities, historic beaver removal, and channel straightening in the Upper Clark Fork TPA. Natural sources of streambank erosion included natural channel scour or wildlife trails. If multiple sources were observed, then a percent of the total influence was estimated for each source.

Streambank erosion data collected at **monitoring sites** were extrapolated to the **stream reach**, **stream segment**, and **sub-watershed** scales based on similar reach type characteristics as identified in the Aerial

Assessment Database. Sediment load calculations were performed for monitoring sites, stream reaches, stream segments, and sub-watersheds which are distinguished as follows:

Assessment Reach	*- A 500-, 1,000-, 1,500-, or 2,000-foot section of a stream reach where field monitoring was conducted*
Stream Reach	*- Subdivision of the stream segment based on ecoregion, stream order, gradient and confinement as evaluated in GIS*
Stream Segment	*- Assessed segment*
Sub-Watershed	*- Assessed segment and tributary streams based on 1:100,000 NHD data layer*

The annual sediment load was estimated for each assessed bank based on the streambank length, mean height, and the annual retreat rate for each eroding streambank. The length and mean height were measured in the field, while the annual retreat rate was determined based on the relationship between the BEHI and NBS ratings. Annual retreat rates for the Upper Clark Fork TPA were estimated based on retreat rates from Rosgen BEHI studies in Colorado (Rosgen, 1996) (**Table C4-1**). While the predominant geologies between the Colorado research sites and the upper Clark Fork are different, they are similar enough in character to warrant their application. The annual sediment load in cubic feet was then calculated from the field data (annual retreat rate x mean bank height x bank length), converted into cubic yards, and finally converted into tons per year based on the bulk density of streambank material, which was assumed to average 1.3 tons/yard^3 as identified in *Watershed Assessment of River Stability and Sediment Supply* (WARSSS) (Rosgen, 2006; United States Environmental Protection Agency, 2006). This process resulted in a sediment load for each eroding bank expressed in tons per year.

Table C4-1. Annual Streambank Retreat Rates (ft/yr), Colorado, U.S. Department of Agriculture Forest Service (adapted from Rosgen (2006))

BEHI	NBS					
	Very Low	Low	Moderate	High	Very High	Extreme
Very Low	NA	NA	NA	NA	NA	NA
Low	0.02	0.05	0.07	0.16	0.32	0.67
Moderate	0.09	0.15	0.25	0.42	0.70	1.16
High - Very High	0.17	0.25	0.38	0.58	0.87	1.32
Extreme	0.16	0.42	1.07	2.75	7.03	17.97

C4.1.1 Streambank Erosion Sediment Load Extrapolation Method

Monitoring site sediment loads were extrapolated to the stream reach, stream segment and sub-watershed scales based on the aerial assessment reach type analysis and field-verified reach types for assessment sites. Streambank erosion data were extrapolated using the following procedure:

1. Monitoring site sediment loads were extrapolated directly to the stream reach in which the monitoring site was located, based on total loading per 1,000 ft.
2. Existing streambank erosion sediment loads were extrapolated to un-assessed reaches based on average sediment loading/1,000 ft from assessed sites for each reach type. Field data were collected within 2 individual reach types that were delineated by confinement, stream order and gradient. There were no un-assessed reach types for Silver Bow Creek and the Clark Fork River upstream of Flint Creek (**Table C4-2**).

Table C4-2. Measured Reach Types and Average Sediment Loads per Reach Types

Measured Reach Type	Number of Monitoring Sites	Measured Reach Type Avg. Sediment Load/1,000 ft (tons/yr)	Un-assessed Reach Types Grouped with Measured Reach Type
MR-0-5-U	2	4.3	All reaches in MR-0-5-U
MR-0-6-U	9	38.6	All reaches in MR-0-6-U

C4.1.2 Streambank Erosion Sediment Load Reduction Analysis Methods

The narrative water quality standards that apply to sediment relate to the naturally occurring condition, which is defined as conditions that occur if all reasonable land, soil, and water conservation practices are applied. To assist with TMDL development, the streambank erosion assessment includes an estimation of sediment loading reductions that could be achieved if implementation of Best Management Practices (BMPs) were applied to achieve naturally occurring condition. Streambank erosion sediment load reductions were evaluated based on field collected data and anticipated reductions through BMP implementation along the Clark Fork River mainstem and Silver Bow Creek. Given the extensive historic channel alteration and sediment deposition in in these systems, all reaches in the Clark Fork River mainstem are considered to be anthropogenically influenced. Anthropogenic alteration includes the sediment deposition from early 20th Century flooding up to existing land management practices leading to bank instability. Reductions from bank erosion were calculated from the following:

1. BEHI and NBS scores were calculated for 123 banks in Silver Bow Creek and in the Clark Fork River upstream of Flint Creek. While NBS will decrease with increased access to the floodplain. Improvements to bank cover, shaping and stability will decrease BEHI scores. The range of scores is in **Table C4-1**.
2. Sediment volume from bank erosion was normalized and the average value calculated for each BEHI/NBS score combination from the 123 assessed banks (**Table C4-3**).

Table C4-3. 2011 DEQ Average Sediment Volume per BEHI/NBS Score for Assessed Banks in Silver Bow Creek and the Clark Fork River Upstream of Flint Creek

	NBS Rating		
BEHI Rating	**Moderate**	**Low**	**Very Low**
Extreme	*No data*	1.93	*No data*
Very High	*No data*	1.03	1.27
High	*No data*	0.86	0.51
Moderate	1.04	0.54	0.22
Low	*No data*	0.09	0.03

All units are normalized to cu. ft./1 foot of bank length

3. The BMP reduction scenario assumed that banks with BEHI scores greater than Moderate (Extreme, Very High, High) can be reduced to Moderate. No assumptions were made regarding changes to NBS as this will likely require a long-term reduction in width/depth ratio and increase in entrenchment ratio. As an example, a bank with a BEHI/NBS of High/Low was assigned the average sediment load from Moderate/Low (0.54 cu. ft./1 foot of bank length).
4. For banks with BEHI scores less than Moderate (Low, Very Low), no changes were made from the assessed sediment load. As an example, for a bank with a BEHI/NBS of Low/Low the normalized sediment load from that bank was not changed even if it was greater than the average volume from **Table C4-3** (Low/Low = 0.09 cu. ft./1 foot of bank length).
5. Reductions from this BMP scenario were determined based on the composite reduction between the existing bank erosion sediment load and the BMP scenario for banks specific to each sub-watershed.

6. Sub-watershed composites included all upstream segments. For example, the Clark Fork River upstream of the Little Blackfoot River included the Clark Fork River segment from Warm Springs Ponds to Cottonwood Creek and the segment from Cottonwood Creek to the Little Blackfoot River as well as Silver Bow Creek.

C4.2 Streambank Erosion Results

C4.2.1 Streambank Erosion Sediment Load Reduction

A total annual sediment load of 656.7 tons/year was attributed to the 123 assessed eroding streambanks within the 11 sites monitored for streambank erosion in the Upper Clark Fork TPA by DEQ in 2011. Average annual sediment loads for each monitoring site were normalized to a length of 1,000 feet for the purpose of comparison. Sediment loads per 1,000 feet for each monitoring site are presented in **Figure C4-1**. Sediment loads per 1,000 feet ranged from 1.1 tons/yr at site SVB-4-2 to 57.3 tons/yr at site CFR-13-1. **Table C4-3** also lists monitoring sites for each reach type, with load totals by reach and reach type.

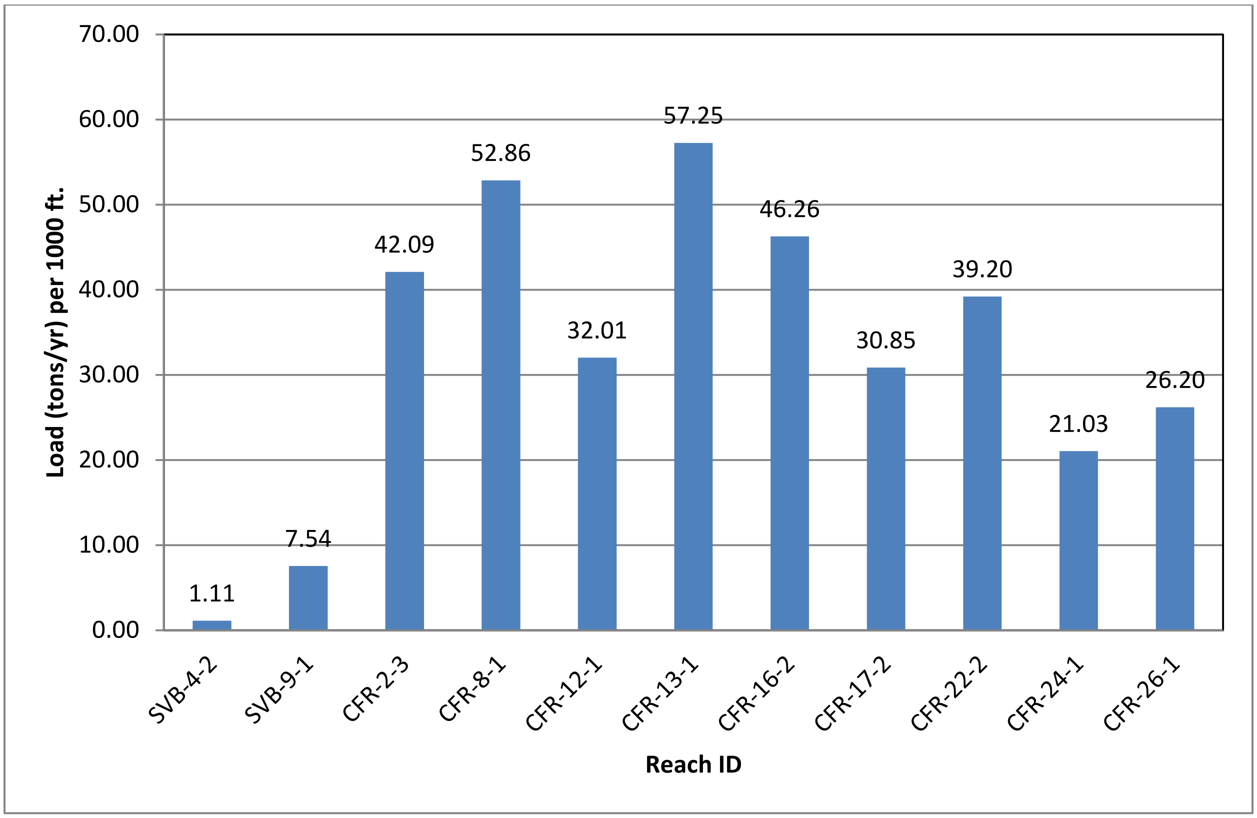

Figure C4-1. Assessment Site BEHI Sediment Load per 1,000 ft

Table C4-4. Streambank Erosion Summary for 2011 DEQ Field Work in Silver Bow Creek and the Clark Fork River Upstream of Flint Creek

Reach Type	Reach ID	Reach Length	Load per 1,000 ft (tons/yr)	Number of Assessed Banks	Sub-Watershed
MR-0-5-U	SVB-4-2	1000	1.11	5	Silver Bow Creek
MR-0-5-U	SVB-9-1	1000	7.54	3	
MR-0-6-U	CFR-2-3	1500	42.09	11	Clark Fork River, Warm Springs Ponds to Cottonwood Creek
MR-0-6-U	CFR-8-1	1500	52.86	9	
MR-0-6-U	CFR-12-1	2000	32.01	20	
MR-0-6-U	CFR-13-1	2000	57.25	16	Clark Fork River, Cottonwood Creek to Little Blackfoot River
MR-0-6-U	CFR-16-2	2000	46.26	16	
MR-0-6-U	CFR-17-2	2000	30.85	16	
MR-0-6-U	CFR-22-2	2000	39.20	8	Clark Fork River, Flint Creek to Little Blackfoot River
MR-0-6-U	CFR-24-1	2000	21.03	8	
MR-0-6-U	CFR-26-1	2000	26.20	11	

As described in **Section C4.1.2,** bank erosion reduction estimates were based on a decrease in the BEHI/NBS ratings to a Moderate BEHI rating by replacing calculated sediment erosion volume with the average sediment erosion volume for a given BEHI/NBS rating. Summarized sediment loads for the existing condition and the improved BMP scenario with the overall % reduction are provided per sub-watershed in **Table C4-5**.

Table C4-5. Calculated Bank Erosion Percent Reductions for Silver Bow Creek and the Clark Fork River Upstream of Flint Creek

Sub-Watershed	Existing Bank Erosion Load (cu. ft./yr)	BMP Scenario Bank Erosion Load (cu. ft./yr)	Percent Reduction
Silver Bow Creek	191.32	191.32	0%
Clark Fork, upstream of Cottonwood Creek	2699.34	2109.67	22%
Clark Fork, upstream of Little Blackfoot River	5749.60	3890.48	32%
Clark Fork, upstream of Flint Creek	7232.59	4935.37	32%

C5.0 Assumptions and Uncertainty

This assessment assumes that different streams with similar reach type characteristics will have similar physical attributes and sediment loads due to streambank erosion.

The analysis contains several potential sources of uncertainty:

- Calculating segment and reach lengths from GIS layers also may a create uncertainty, since layers are digitized based on topographic maps and generally underestimate stream lengths.
- Some degree of uncertainty is inherent in the BEHI methods and categorization of sediment loading by erosion source, as the index values for the BEHI ratings are based on studies conducted in a similar region but different geographic location, and percent loading due to different erosion sources must be estimated using best professional judgment.

- The identification of sediment as a pollutant in many streams in the Upper Clark Fork TPA relate to the fine sediment fraction found on the stream bottom, while streambank erosion sediment modeling examined all sediment sizes.
- Since sediment source modeling may underestimate or overestimate sediment inputs due to selection of sediment monitoring sites and the extrapolation methods used, model results should not be taken as an absolutely accurate calculation of sediment production within each assessment unit. Instead, the streambank erosion assessment model results should be considered an instrument for estimating sediment loads and making general comparisons of sediment loads from various sources.
- Per the BMP reduction scenario, implementation of all reasonable land, soil and water conservation practices can reduce BEHI ratings to Moderate.

C6.0 Summary

The 2011 sediment and habitat assessment in the Upper Clark Fork TPA provides a broad-scale analysis of existing sediment conditions within impaired stream segments and estimated streambank erosion sediment loads for use in TMDL development. A total of 46 reaches were delineated during the aerial assessment reach stratification process covering approximately 101.5 miles of stream. Only 2 distinct reach types were assigned within the one Level III Ecoregion (Middle Rockies) in the Upper Clark Fork TPA based on stream and landscape characteristics. Sediment and habitat variables and streambank erosion were assessed at 11 monitoring sites. Statistical analysis of the sediment and habitat data from the monitoring sites will aid in developing sediment TMDL targets that are specific for the Upper Clark Fork TPA, while streambank erosion data and calculated load reductions will be used in the sediment TMDL. A total annual sediment load of 666.9 tons/year was attributed to the 123 assessed eroding streambanks within the 11 sites monitored for streambank erosion in the Upper Clark Fork TPA. Based on a BMP reduction scenario using BEHI/NBS ratings, it is estimated that this sediment load can be reduced by 22–32% from streambanks in the Clark Fork River upstream of Flint Creek. A 0% reduction in streambank erosion from restored reaches in Silver Bow Creek was also determined based on the slowly eroding banks which all had BEHI ratings equal or less than moderate.

C7.0 References

Upper Clark Fork Total Maximum Daily Load (TMDL) Planning Area: Watershed Characterization Report. 2006.

Bilby, Robert E. and Jack W. Ward. 1989. Changes in Characteristics and Function of Woody Debris With Increasing Size of Stream in Western Washington. *Transactions of the American Fisheries Society.* 118: 368-378.

Dunne, Thomas and Luna B. Leopold. 1977. Water in Environmental Planning, New York, NY: W.H. Freeman and Company.

Heitke, Jeremiah D., Eric K. Archer, Dax D. Dugaw, Boyd A. Bouwes, Richard C. Henderson, and Jeffrey L. Kershner. 2006. Effectiveness Monitoring for Streams and Riparian Areas: Sampling Protocol for Stream Channel Attributes. http://www.fs.fed.us/biology/fishecology/emp.

Kershner, Jeffrey L., Eric K. Archer, Marc Coles-Ritchie, Ervin R. Cowley, Richard C. Henderson, Kim Kratz, Charles M. Quimby, David L. Turner, Linda C. Ulmer, and Mark R. Vinson. 2004. Guide to Effective Monitoring of Aquatic and Riparian Resources. Fort Collins, Co: U.S. Department of Agriculture, Rocky Mountain Research Station. General Technical Report RMRS-GTR-121.

Meehan, William R. 1991. Influences of Forest and Rangeland Management on Salmonids Fishes and Their Habitats. American Fisheries Society. Special Publication 19.

Montana Department of Environmental Quality. 1997. Channel Stability Analysis, Silver Bow Creek SSTOU Subarea 1.

-----. 2008. Watershed Stratification Methodology for TMDL Sediment and Habitat Investigations. Helena, MT: Montana Department of Environmental Quality.

-----. 2010. Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments.

Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8. 2011. Little Blackfoot River Watershed TMDLs and Framework Water Quality Improvement Plan: Final. Helena, MT: Montana Department of Environmental Quality. C01-TMDL-03A-F.

Overton, C. Kerry, Sherry P. Wollrab, Bruce C. Roberts, and Michael A. Radko. 1997. R1/R4 (Northern Intermountain Regions) Fish and Fish Habitat Standard Inventory Procedures Handbook. Ogden, UT: Intermountain Research Station. General Technical Report INT-GTR-346.

Rosgen, David L. 1996. Applied River Morphology, Pagosa Springs, CO: Wildland Hydrology.

-----. 2006. Watershed Assessment of River Stability and Sediment Supply (WARSSS). Fort Collins, CO: Wildland Hydrology.

United States Environmental Protection Agency. 2006. Watershed Assessment of River Stability and Sediment Supply (WARSSS) Version 1.0. http://www.epa.gov/warsss/index.htm. Accessed 4/5/2012.

Weaver, Thomas M. and John J. Fraley. 1991. Fisheries Habitat and Fish Populations in Flathead Basin Forest Practices Water Quality and Fisheries Cooperative Program. Kalispell, MT: Flahead Basin Commission.

Wolman, M. G. 1954. A Method of Sampling Coarse River-Bed Material. *Transactions of the American Geophysical Union.* 35(6): 951-956.

APPENDIX D - SEDIMENT TOTAL MAXIMUM DAILY LOADS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

Acronym	Definition
TMDL	Total Maximum Daily Load
TPA	TMDL Planning Area
USGS	United States Geological Survey

D1.0 SEDIMENT

D1.1 OVERVIEW

A percent reduction based on average yearly loading was used as the primary approach for expressing the sediment Total Maximum Daily Loads (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 Environmental Protection Agency 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.

D1.2 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. Since sediment loading in the Upper Clark Fork TMDL Planning Area (TPA) is associated with small point sources, nonpoint sources and stormwater related point sources, the hydrograph is assumed to be a reasonable surrogate for sediment loading to streams (i.e., peak contributions during periods of runoff and high flow). Therefore, mean daily discharge values from 10 years of record (2003–2013) at the gage on the Clark Fork River at Goldcreek (#12324680) were used to calculate daily sediment values for TMDLs in the Upper Clark Fork TPA.

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 D-1**). For each TMDL, the daily load can be calculated by multiplying the daily percentages in **Table D-1** by the total average annual load associated with the TMDL percent reductions in **Section 5.9** of the main document. For instance, the total allowable annual sediment load for the Clark Fork River (Little Blackfoot River to Flint Creek) is 21,478 tons. To determine the TMDL for January 1st, 21,478 tons is multiplied by 0.16% which provides a daily load for the Clark Fork River (Little Blackfoot River to Flint Creek) on January 1st of 34.1 tons. To conserve resources, this appendix contains the daily loads for the Clark Fork River (Little Blackfoot River to Flint Creek) as an example (**Table D-2** and **Figure D-1**). Daily loads for all other TMDLs can be calculated by multiplying the percentages in **Table D-1** by the values in **Table D-3**. 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 appendix. If desired, daily allocations may be obtained by applying allocations provided in **Section 5.9** of the main document to the daily load.

Table D-1. USGS Stream Gage 12324680 (Clark Fork River at Goldcreek, Montana) – Percent of Mean Annual Discharge Based on Mean of Daily Mean Discharge Values for each Day of Record (Calculation Period 2003-10-01 → 2013-09-30)

Day of Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.16%	0.17%	0.20%	0.27%	0.35%	0.67%	0.48%	0.14%	0.12%	0.15%	0.21%	0.21%
2	0.16%	0.17%	0.19%	0.26%	0.34%	0.71%	0.50%	0.14%	0.13%	0.16%	0.21%	0.20%
3	0.16%	0.17%	0.20%	0.25%	0.34%	0.77%	0.46%	0.14%	0.13%	0.16%	0.21%	0.20%
4	0.16%	0.18%	0.21%	0.24%	0.36%	0.81%	0.43%	0.13%	0.12%	0.16%	0.21%	0.20%
5	0.16%	0.19%	0.22%	0.25%	0.35%	0.81%	0.42%	0.13%	0.12%	0.17%	0.21%	0.19%
6	0.16%	0.19%	0.22%	0.27%	0.34%	0.84%	0.40%	0.13%	0.12%	0.18%	0.21%	0.20%
7	0.17%	0.19%	0.21%	0.28%	0.34%	0.90%	0.38%	0.13%	0.12%	0.18%	0.21%	0.19%
8	0.18%	0.18%	0.23%	0.28%	0.35%	0.93%	0.36%	0.14%	0.12%	0.18%	0.22%	0.19%
9	0.20%	0.18%	0.23%	0.28%	0.35%	0.94%	0.33%	0.13%	0.13%	0.19%	0.22%	0.18%
10	0.19%	0.17%	0.24%	0.28%	0.37%	0.96%	0.31%	0.13%	0.13%	0.19%	0.22%	0.19%
11	0.18%	0.18%	0.23%	0.28%	0.40%	0.96%	0.30%	0.13%	0.13%	0.19%	0.22%	0.19%
12	0.17%	0.18%	0.25%	0.30%	0.40%	0.90%	0.29%	0.13%	0.13%	0.19%	0.22%	0.19%
13	0.17%	0.18%	0.26%	0.32%	0.39%	0.84%	0.28%	0.13%	0.13%	0.20%	0.22%	0.19%
14	0.18%	0.18%	0.23%	0.32%	0.40%	0.78%	0.29%	0.13%	0.13%	0.20%	0.22%	0.18%
15	0.19%	0.19%	0.22%	0.31%	0.41%	0.76%	0.30%	0.13%	0.13%	0.20%	0.21%	0.17%
16	0.18%	0.19%	0.24%	0.30%	0.43%	0.78%	0.28%	0.13%	0.13%	0.21%	0.22%	0.17%
17	0.19%	0.17%	0.23%	0.29%	0.46%	0.85%	0.26%	0.13%	0.14%	0.21%	0.22%	0.17%
18	0.21%	0.17%	0.24%	0.30%	0.48%	0.85%	0.25%	0.12%	0.14%	0.21%	0.22%	0.17%
19	0.21%	0.17%	0.23%	0.31%	0.51%	0.78%	0.23%	0.12%	0.14%	0.21%	0.21%	0.17%
20	0.21%	0.17%	0.23%	0.31%	0.57%	0.72%	0.22%	0.12%	0.14%	0.22%	0.21%	0.17%
21	0.19%	0.17%	0.23%	0.32%	0.61%	0.69%	0.21%	0.12%	0.15%	0.22%	0.21%	0.18%
22	0.19%	0.20%	0.25%	0.34%	0.62%	0.68%	0.20%	0.12%	0.15%	0.22%	0.20%	0.18%
23	0.19%	0.20%	0.25%	0.36%	0.65%	0.67%	0.19%	0.12%	0.15%	0.21%	0.20%	0.18%
24	0.18%	0.19%	0.23%	0.36%	0.68%	0.64%	0.18%	0.12%	0.15%	0.21%	0.19%	0.18%
25	0.18%	0.18%	0.23%	0.36%	0.74%	0.60%	0.17%	0.12%	0.15%	0.21%	0.20%	0.19%
26	0.18%	0.18%	0.23%	0.36%	0.73%	0.58%	0.17%	0.12%	0.16%	0.21%	0.20%	0.19%
27	0.17%	0.18%	0.23%	0.37%	0.71%	0.54%	0.17%	0.11%	0.15%	0.21%	0.20%	0.19%
28	0.18%	0.19%	0.23%	0.37%	0.71%	0.52%	0.17%	0.11%	0.15%	0.21%	0.20%	0.18%
29	0.18%	0.17%	0.23%	0.36%	0.73%	0.49%	0.16%	0.11%	0.15%	0.21%	0.20%	0.19%
30	0.19%		0.23%	0.36%	0.72%	0.49%	0.15%	0.11%	0.15%	0.21%	0.20%	0.18%
31	0.18%		0.25%		0.69%		0.15%	0.11%		0.21%		0.17%

Table D-2. Daily Sediment TMDL for the Clark Fork River (Little Blackfoot River to Flint Creek) in tons

Day of Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	34.1	37.4	42.0	57.3	75.7	144.6	103.8	30.5	26.6	33.1	44.8	44.1
2	34.8	36.6	40.5	56.5	73.1	152.4	106.4	30.5	28.1	33.5	45.2	43.6
3	34.6	36.4	42.3	53.9	73.7	164.8	98.9	29.8	27.2	34.1	45.9	43.0
4	33.7	38.1	45.9	52.5	76.3	173.4	92.5	28.5	26.4	35.1	46.1	42.8
5	35.0	40.0	47.1	52.7	74.3	175.0	91.3	28.0	26.3	37.2	46.0	41.5
6	35.1	40.5	46.5	57.3	73.5	181.2	86.7	27.8	26.2	39.0	45.6	42.5
7	35.9	39.8	44.4	59.9	73.2	192.5	82.2	28.9	26.2	38.9	45.5	40.8
8	39.2	39.2	49.2	59.3	74.4	200.7	78.1	29.8	26.2	39.4	47.0	40.3
9	42.0	38.6	49.4	60.6	75.7	201.5	71.8	28.7	27.2	40.2	47.9	39.7
10	40.8	37.5	51.7	59.1	79.7	205.2	67.4	27.9	28.6	40.4	46.5	39.8
11	38.8	37.8	50.4	60.6	86.3	205.4	63.9	27.6	28.7	41.2	46.3	40.8
12	36.1	37.6	54.8	63.9	85.5	192.6	61.3	27.6	28.6	41.6	46.5	41.0
13	37.3	38.8	56.0	67.9	84.7	180.3	60.3	27.6	28.2	42.1	47.7	41.1
14	39.1	39.3	49.4	68.0	86.0	168.5	63.1	27.7	28.0	42.7	48.2	38.2
15	41.1	39.9	46.9	67.4	88.8	162.4	64.4	27.6	28.0	43.3	46.0	37.3
16	39.6	40.5	50.8	63.6	91.4	167.5	60.2	27.1	28.7	44.4	46.2	37.2
17	41.2	36.9	50.4	62.7	99.4	181.9	56.4	27.0	29.6	45.4	46.4	36.3
18	44.7	36.5	50.8	65.3	103.9	181.9	53.6	26.8	30.1	45.0	46.5	35.5
19	44.6	36.7	48.6	67.2	110.1	166.9	50.2	25.9	30.3	44.9	46.1	35.8
20	44.7	37.3	48.4	67.5	121.5	153.8	48.0	25.3	31.0	46.7	45.6	36.6
21	41.0	36.6	48.8	68.6	130.5	149.2	45.5	25.0	31.5	47.2	45.2	38.3
22	41.2	42.8	53.9	72.5	132.1	145.2	42.9	25.1	31.7	46.5	43.9	38.6
23	40.2	42.0	53.4	76.9	138.9	144.4	41.0	25.4	32.3	46.0	42.9	38.8
24	39.0	40.1	48.8	77.2	145.1	137.7	39.1	25.4	33.1	45.8	41.7	39.2
25	39.2	39.2	48.4	77.3	159.4	129.7	37.1	25.1	33.2	46.0	42.7	40.3
26	38.7	38.0	49.1	77.7	156.5	123.6	36.1	24.9	33.3	45.5	42.8	40.8
27	37.5	38.1	48.5	79.5	152.1	116.9	37.1	24.4	32.9	45.3	42.7	40.5
28	37.7	41.6	48.9	78.5	153.3	110.9	37.5	23.8	32.7	45.1	42.7	39.6
29	39.4	36.8	49.5	76.9	157.6	105.9	35.3	23.6	32.2	45.5	42.4	41.7
30	40.6		49.6	76.3	153.9	104.7	32.5	24.1	33.0	46.0	42.8	39.7
31	39.1		53.7		148.3		31.2	24.4		45.2		36.3

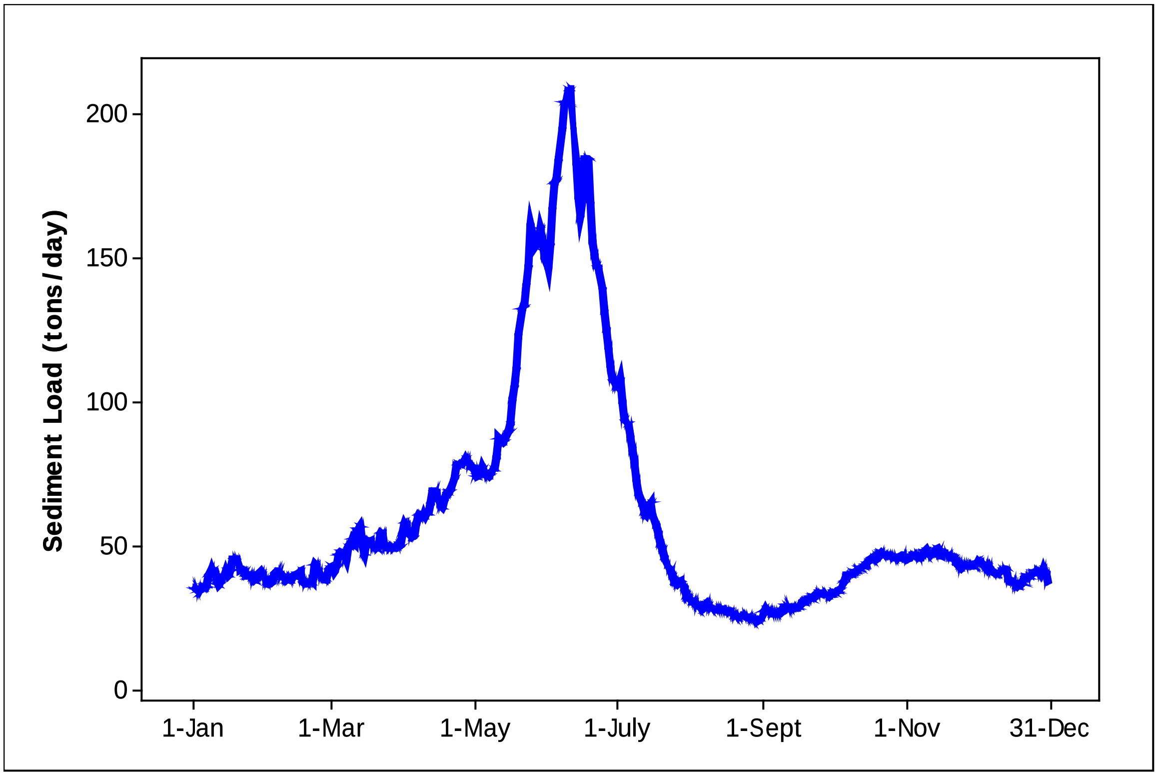

Figure D-1. TMDL for Sediment in the Clark Fork River (Little Blackfoot River to Flint Creek)

Table D-3. TMDLs Expressed as an Average Annual Load and Can Be Used in Conjunction with the Values in Table D-1 to Compute Daily Loads

Stream Segment	Waterbody Number	TMDL Expressed as Average Annual Load (tons/year)
SILVER BOW CREEK, headwaters to mouth (Clark Fork River)	MT76G003_020	2,109
CLARK FORK RIVER, Little Blackfoot River to Flint Creek	MT76G001_010	21,478
CLARK FORK RIVER, Cottonwood Creek to Little Blackfoot River	MT76G001_030	5,053
CLARK FORK RIVER, Warm Springs Creek to Cottonwood Creek	MT76G001_040	3,580

ERRATA SHEET FOR:

APRIL 18, 2014 EPA SUBMITTAL VERSION OF THE

"UPPER CLARK FORK PHASE 2 SEDIMENT AND NUTRIENTS TMDLS AND FRAMEWORK WATER QUALITY IMPROVEMENT PLAN"

This TMDL document was submitted to EPA on April 18, 2014 and was approved on April 29, 2014. Minor edits were made to the document after EPA approval and those edits are shown in this erratum. The final document, with these changes incorporated, is dated 4/29/14.

Edits were made to Table 7-1, and in Section 7.1. All changes are editorial in nature and are denoted by strike-through or underline. Struck text represents deletions and underlined text represents new, added text.

Location in the TMDL	**Original Text**	**Corrected Text**
Page 7-1, Section 7.1, Last sentence	The Clark Fork-Silver Bow Metals TMDL document will address many of the impairment listing not addressed in this document or the 2010 document.	The Clark Fork-Silver Bow Metals TMDL document will address many of the impairment listings not addressed in this document or the 2010 document.
Page 7-1, Section 7.2, Table 7-1 table header	Table 7-1. Waterbody Segments with Non-Pollutant Listings on the 2014 303(d) List	Table 7-1. Waterbody Segments with Non-Pollutant Listings in the 2014 Water Quality Integrated Report