Rock Creek Watershed Total Maximum Daily Loads and Water Quality Improvement Plans

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ACRONYM LIST

Acronym	Definition
AAL	Acute Aquatic Life
AFDW	Ash Free Dry Weight
AFO	Animal Feeding Operation
AMB	Abandoned Mine Bureau
AML	Abandoned Mine Lands
ANFO	Ammonium Nitrate and Fuel Oil
ARD	Acid Rock Drainage
ARM	Administrative Rules of Montana
AUM	Animal Unit Month
BDNF	Beaverhead Deerlodge National Forest
BEHI	Bank Erosion Hazard Index
BFW	Bankful Width
BLM	Bureau of Land Management (Federal)
BMP	Best Management Practices
CAFO	Concentrated (or Confined) Animal Feeding Operations
CAL	Chronic Aquatic Life
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
CFS	Cubic Feet per Second
CNMP	Comprehensive Nutrient Management Plans
CTM	Critical Thermal Maximum
CWA	Clean Water Act
DEQ	Department of Environmental Quality (Montana)
DNRC	Department of Natural Resources & Conservation (Montana)
DO	Dissolved Oxygen
DQO	Data Quality Objectives
EFRC	East Fork Rock Creek
EPA	Environmental Protection Agency (U.S.)
EQIP	Environmental Quality Initiatives Program
FS	Forest Service
FWP	Fish, Wildlife & Parks (Montana)
FWS	Fish & Wildlife Service (US)
GIS	Geographic Information System
GWIC	Groundwater Information Center
HBI	Hilsenhoff's biotic index
HDPE	high-density polyethylene
HH	Human Health
ICIS	Integrated Compliance Information System
INFISH	Inland Native Fish Strategy
IR	Integrated Report
IRMH	Integrated Riparian Monitoring Hydrology Report
LA	Load Allocation

Acronym	Definition
LWD	Large Woody Debris
MARS	Montana Aquatic Resources Services
MBMG	Montana Bureau of Mines and Geology
MCA	Montana Code Annotated
MCL	Maximum Contaminant Level
MDL	Maximum Detection Limit
MDT	Montana Department of Transportation
MFISH	Montana Fisheries Information System
MOS	Margin of Safety
MPDES	Montana Pollutant Discharge Elimination System
MSL	Mean Sea Level
MSU	Montana State University
NAIP	National Agricultural Imagery Program
NBS	Near Bank Stress
NHD	National Hydrography Dataset
NLCD	National Land Cover Dataset
NOAA	National Oceanographic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NRCS	National Resources Conservation Service
NWIS	National Water Information System
OIT	Office of Information Technology (DEQ)
OSM	Office of Surface Mining Reclamation and Enforcement
PEL	Probable Effects Levels
PIBO	PACFISH/INFISH Biological Opinion
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RAWS	Remote Automatic Weather Station
RIT/RDG	Resource Indemnity Trust/Reclamation and Development Grants Program
RSI	Riffle Stability Index
SAP	Sampling and Analysis Plan
SC	Specific Conductivity
SFAC	South Fork Antelope Creek
SILC	Satellite Imagery land Cover (Montana)
SMCRA	Surface Mining Control & Reclamation Act
SMES	Small Miner's Exclusion Statement
SMZ	Streamside Management Zone
SS	Sediment Sources
SSURGO	Soil Survey Geographic database
STORET	EPA STOrage and RETrieval database
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TPA	TMDL Planning Area
TPN	Total Persulfate Nitrogen
TSS	Total Suspended Solids
UILT	Upper Incipient Lethal Temperature

Acronym	**Definition**
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFWS	US Fish and Wildlife Service
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation
VCRA	Voluntary Cleanup and Redevelopment Act
VFS	Vegetated Filter Strips
WCW	Wetted Channel Width
WLA	Wasteload Allocation
WRP	Watershed Restoration Plan

Document Summary

This document presents a total maximum daily load (TMDL) and water quality improvement plans for 11 impaired tributaries in the Rock Creek watershed including: Antelope Creek, Basin Gulch, East Fork Rock Creek, Eureka Gulch, Flat Gulch, Miners Gulch, Quartz Gulch, Scotchman Gulch, Sluice Gulch, South Fork Antelope Creek, West Fork Rock Creek (**Map A-1** found in **Appendix A)**.

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.

Rock Creek flows northwards from the Anaconda Range to its confluence with the Clark Fork River, near Clinton. The TMDL planning area (TPA) is located in the Clark Fork River Basin of western Montana, as shown on **Map A-2 (Appendix A)**. The majority of the TPA is within Granite County, with a minor percentage (near the mouth of Rock Creek) in Missoula County. The TPA is bounded by the John Long Mountains to the east, the Anaconda Range to the south, and the Sapphire Range to the west. The total area is 569,320 acres, or approximately 890 square miles.

DEQ determined that 11 tributaries do not meet the applicable water quality standards. The scope of the TMDLs in this document addresses problems with sediment, temperature, nutrients, and metals (see **Table DS-1**). In total, 33 TMDLs were written, addressing 34 waterbody pollutant combinations.

Sediment
Sediment was identified as impairing aquatic life in Antelope Creek, East Fork Rock Creek, Eureka Gulch, Flat Gulch, Miners Gulch, Quartz Gulch, Scotchman Gulch, Sluice Gulch, South Fork Antelope Creek, and West Fork Rock Creek. 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 the following sources: bank erosion, hillslope erosion, and unpaved roads. The most significant sources include: bank and hillslope erosion from current and historical rangeland grazing and hay production in the riparian (streamside) area. The Rock Creek TPA sediment TMDLs indicate that reductions in sediment loads ranging from 9% to 56% 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 grazing, cropland and irrigation. In addition, they include BMPs for expanding riparian buffer areas and using other land, soil, and water conservation practices that improve stream channel conditions and associated riparian and wetland vegetation.

Temperature
DEQ identified temperature-related effects as a cause of impairment on East Fork Rock Creek. Anthropogenic sources for temperature include reductions in riparian shade from riparian grazing and crop production. Additionally, in summer months, the majority of water in the creek is diverted to provide irrigation water for users in the Flint Creek watershed, thereby reducing stream volumetric heat capacity; where less stream water heats more rapidly from the same energy inputs.

Recommended strategies for reducing temperature include applying best management practices to improve shade producing riparian vegetation by improving grazing practices and providing vegetated riparian buffers between irrigated fields and the stream. Additionally, improved irrigation delivery and application efficiency could lead to water savings and that conserved water or some percentage of that conserved water should be allowed to flow down East Fork Rock Creek past the diversion during summer months. Improved irrigation management can be achieved through best management practices including irrigation scheduling, delivery upgrades, and equipment modification.

Nutrients
A total of 6 waterbody segments in the Rock Creek TPA appeared on the 2012 Montana 303(d) List for nutrient (phosphorus and/or nitrogen) impairments. These impairments occur on the East Fork of Rock Creek, South Fork of Antelope Creek, Scotchman's Gulch, Sluice Gulch and Flat Gulch. An overabundance of these nutrients in aquatic ecosystems accelerates the process known as eutrophication. Eutrophication is the enrichment of a waterbody, usually by nitrogen and phosphorus, leading to increased aquatic plant production (including algae). The increased aquatic plant or algal growth can reach nuisance levels and harm multiple beneficial uses of the waterbody. Water quality restoration goals for nutrients were established on the basis of Montana's established criteria for water quality, which include the narrative water quality standards for nutrients. DEQ believes that once these water quality targets are met, all water uses currently affected by nutrients will be restored.

Nutrient loads are quantified for the following sources: Agricultural activities, historical mining practices, silvicultural practices and natural background. The most significant source is agricultural activities. The Rock Creek TPA nutrient TMDLs indicate that reductions in nutrient loads ranging from 0% to 94% will satisfy the water quality restoration goals.

Recommended strategies for achieving the nutrient reduction goals are also presented in this plan. 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, cropland, and historically impacted areas.

Metals
A total of 7 waterbody segments in the Rock Creek TPA have been identified as being impaired for metals pollution. Eureka Gulch, Quartz Gulch, Sluice Gulch, and West Fork Rock Creek were included on the 2012 Montana 303(d) List of metal-impaired waters. Basin Gulch, Flat Gulch, and Scotchman Gulch were not; however, these three streams are considered impaired as a result of review of recent water quality data that indicates beneficial uses for these streams are impaired by elevated metals concentrations. Waterbodies with metals concentrations exceeding the aquatic life and/or human health standards are impairing several beneficial uses of surface water including aquatic life support, drinking water, and agriculture. Water quality restoration goals for metals were established on the basis of Montana's established criteria for water quality, which include the aquatic life and human health

standards. DEQ believes that once these water quality targets are met, all water uses currently affected by metals will be restored.

Metals loads are quantified for historical mining operations and naturally occurring metals sources. The most significant source is historical mining operations. The Rock Creek TPA metals TMDLs indicate that reductions in metals loads ranging from 0% to 99% will satisfy the water quality restoration goals.

Recommended strategies for achieving the metals reduction goals are also presented in this plan. Generally restoration programs and funding mechanisms are more applicable to metals sources instead of specific BMPs. A number of state and federal regulatory programs have been developed to address water quality problems stemming from historical mines and associated disturbances. These include the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the State of Montana Abandoned Mine Lands (AML) Reclamation Program, the Montana Comprehensive Environmental Cleanup and Responsibility Act (CECRA), which incorporates additional cleanup options under the Controlled Allocation of Liability Act (CALA) and the Voluntary Cleanup and Redevelopment Act (VCRA).

Implementation of 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.

Table DS-1. List of Impaired Waterbodies and their Impaired Uses in the Rock Creek TPA with Completed Sediment, Temperature, Nutrients and Metals TMDLs Contained in this Document

<table>
<tr><th>Waterbody & Location Description</th><th>TMDL Prepared</th><th>TMDL Pollutant Category</th><th>Impaired Use(s)</th></tr>
<tr><td>ANTELOPE CREEK, headwaters to mouth (Rock Creek)</td><td>Sediment</td><td>Sediment</td><td>Aquatic Life</td></tr>
<tr><td>BASIN GULCH, headwaters to mouth (Eureka Gulch)</td><td>Arsenic</td><td>Metals</td><td>Drinking Water</td></tr>
<tr><td rowspan="4">EAST FORK ROCK CREEK, East Fork Reservoir to mouth (Middle Fork Rock Creek)</td><td>Sediment</td><td>Sediment</td><td>Aquatic Life</td></tr>
<tr><td>Temperature</td><td>Temperature</td><td>Aquatic Life</td></tr>
<tr><td>Total Phosphorous</td><td>Nutrients</td><td>Aquatic Life and Primary Contact Recreation</td></tr>
<tr><td>Total Nitrogen</td><td>Nutrients</td><td>Aquatic Life and Primary Contact Recreation</td></tr>
<tr><td rowspan="3">EUREKA GULCH, confluence of Quartz Gulch and Basin Gulch to mouth (Un-Named Ditch)</td><td>Sediment*</td><td>Sediment</td><td>Aquatic Life</td></tr>
<tr><td>Arsenic</td><td rowspan="2">Metals</td><td>Drinking Water</td></tr>
<tr><td>Mercury</td><td>Drinking Water</td></tr>
</table>

Table DS-1. List of Impaired Waterbodies and their Impaired Uses in the Rock Creek TPA with Completed Sediment, Temperature, Nutrients and Metals TMDLs Contained in this Document

<table>
<tr><th>Waterbody & Location Description</th><th>TMDL Prepared</th><th>TMDL Pollutant Category</th><th>Impaired Use(s)</th></tr>
<tr><td rowspan="5">FLAT GULCH, headwaters to mouth (Rock Creek)</td><td>Sediment</td><td>Sediment</td><td>Aquatic Life</td></tr>
<tr><td>Total Phosphorous</td><td rowspan="2">Nutrients</td><td>Aquatic Life and Primary Contact Recreation</td></tr>
<tr><td>Total Nitrogen</td><td>Aquatic Life and Primary Contact Recreation</td></tr>
<tr><td>Aluminum</td><td rowspan="2">Metals</td><td>Aquatic Life</td></tr>
<tr><td>Iron</td><td>Aquatic Life</td></tr>
<tr><td>MINERS GULCH, headwaters to mouth (Upper Willow Creek), T8N R15W S23</td><td>Sediment</td><td>Sediment</td><td>Aquatic Life</td></tr>
<tr><td rowspan="3">QUARTZ GULCH, headwaters to mouth (Eureka Gulch)</td><td>Sediment</td><td>Sediment</td><td>Aquatic Life</td></tr>
<tr><td>Aluminum</td><td rowspan="2">Metals</td><td>Aquatic Life</td></tr>
<tr><td>Lead</td><td>Drinking Water</td></tr>
<tr><td rowspan="4">SCOTCHMAN GULCH, headwaters to mouth (Upper Willow Creek)</td><td>Sediment</td><td>Sediment</td><td>Aquatic Life</td></tr>
<tr><td>Total Phosphorous</td><td rowspan="2">Nutrients</td><td>Aquatic Life and Primary Contact Recreation</td></tr>
<tr><td>Total Nitrogen</td><td>Aquatic Life and Primary Contact Recreation</td></tr>
<tr><td>Aluminum</td><td>Metals</td><td>Aquatic Life</td></tr>
<tr><td rowspan="5">SLUICE GULCH, headwaters to mouth (Rock Creek)</td><td>Sediment</td><td>Sediment</td><td>Aquatic Life</td></tr>
<tr><td>Total Nitrogen</td><td rowspan="2">Nutrients</td><td>Aquatic Life and Primary Contact Recreation</td></tr>
<tr><td>Nitrate + Nitrite</td><td>Aquatic Life and Primary Contact Recreation</td></tr>
<tr><td>Arsenic</td><td rowspan="2">Metals</td><td>Drinking Water</td></tr>
<tr><td>Copper</td><td>Aquatic Life</td></tr>
<tr><td rowspan="4">SOUTH FORK ANTELOPE CREEK, headwaters to mouth (Antelope Creek), T6N R15W S22</td><td>Sediment</td><td>Sediment</td><td>Aquatic Life</td></tr>
<tr><td>Total Phosphorous</td><td>Nutrients</td><td>Aquatic Life and Primary Contact Recreation</td></tr>
<tr><td>Total Nitrogen</td><td>Nutrients</td><td>Aquatic Life and Primary Contact Recreation</td></tr>
<tr><td>Nitrate + Nitrite</td><td>Nutrients</td><td>Aquatic Life and Primary Contact Recreation</td></tr>
<tr><td rowspan="2">WEST FORK ROCK CREEK, headwaters to mouth (Rock Creek)</td><td>Sediment</td><td>Sediment</td><td>Aquatic Life</td></tr>
<tr><td>Aluminum</td><td>Metals</td><td>Aquatic Life</td></tr>
</table>

*This sediment TMDL addresses two impairment causes

1.0 INTRODUCTION

This document presents an analysis of water quality information and establishes total maximum daily loads (TMDLs) for sediment, temperature, nutrients, and metals problems in the Rock Creek Watershed (also referred to throughout this document as the Rock Creek TMDL Planning Area). This document also presents a general outline for resolving these problems. **Map A-1**, found in **Appendix A,** shows a map of waterbodies in the Rock Creek TMDL Planning Area (TPA) with sediment, temperature, nutrients, and metals pollutant listings.

1.1 BACKGROUND

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

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

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

Each waterbody in Montana has a set of designated uses from the list above. Montana has established water quality standards to protect these uses, and a waterbody that does not meet one or more standards is called an impaired water. Each state must monitor their waters to track if they are supporting their designated uses, and every two years DEQ prepares a Water Quality Integrated Report (IR) which lists all impaired waterbodies and their identified impairment causes. Impairment causes fall within two main categories: pollutant and non-pollutant.

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 1-1** in **Section 1.2** identifies all impaired waters for the Rock Creek TPA from Montana's 2012 303(d) List, includes non-pollutant impairment causes included in Montana's "2012 Water Quality Integrated Report," and identifies new impairment causes that will be included in the Montana "2014 Water Quality Integrated Report." **Table 1-1** 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 total maximum daily loads 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 **Map A-1** in **Appendix A**). Each pollutant impairment falls within a TMDL pollutant category (e.g., sediment, temperature, nutrients, or metals), and this document is organized by those categories.

New data assessed during this project identified new sediment, total phosphorus, total nitrogen, arsenic, aluminum, iron, lead, and copper impairment causes. These impairment causes are also identified in **Table 1-1** and noted as not being on the 2012 303(d) List (within the integrated report). Instead, these waters will be documented within DEQ assessment files and incorporated into the 2014 IR.

TMDLs are completed for each waterbody – pollutant combination, and this document contains 35 TMDLs (**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 9**. **Sections 9** and **10** also provide some basic water quality solutions to address those non-pollutant causes not specifically addressed by TMDLs in this document.

Table 1-1. Water Quality Impairment Causes for the Rock Creek TPA

Waterbody & Location Description*	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status	Included in 2012 Integrated Report**
ANTELOPE CREEK, headwaters to mouth (Rock Creek)	MT76E002_061	Sedimentation/Siltation	Sediment	Sediment TMDL completed	No
BASIN GULCH, headwaters to mouth (Eureka Gulch)	MT76E002_080	Arsenic	Metals	Arsenic TMDL completed	No
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed within document (see **Sections 9** and **10**); not linked to a TMDL	Yes
BREWSTER CREEK, East Fork to mouth (Rock Creek)	MT76E002_050	Sedimentation/Siltation	Sediment	Not impaired based on updated assessment	Yes
		Total Phosphorous	Nutrients	Not impaired based on updated assessment	Yes
		Fish Passage Barrier	Not Applicable; Non-Pollutant	Addressed within document (see **Sections 9** and **10**); not linked to a TMDL	Yes
		Low Flow Alterations	Not Applicable; Non-Pollutant	Addressed within document (see **Sections 9** and **10**); not linked to a TMDL	Yes
EAST FORK ROCK CREEK, East Fork Reservoir to mouth (Middle Fork Rock Creek)	MT76E002_020	Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Temperature, water	Temperature	Temperature TMDL completed	Yes
		Total Phosphorous (TP)	Nutrients	TP TMDL completed	No
		Total Nitrogen (TN)	Nutrients	TN TMDL completed	No
		Nitrogen, Nitrate (Equivalent to Nitrate + Nitrite)	Nutrients	Impairment cause replaced with TN	Yes
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
		Low Flow Alterations	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
		Chlorophyll-*a*	Not Applicable; Non-Pollutant	Addressed by TP	Yes

Table 1-1. Water Quality Impairment Causes for the Rock Creek TPA

Waterbody & Location Description*	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status	Included in 2012 Integrated Report**
EUREKA GULCH, confluence of Quartz Gulch and Basin Gulch to mouth (Un-Named Ditch)	MT76E002_090	Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Solids		Addressed by sediment TMDL	Yes
		Arsenic	Metals	Arsenic TMDL completed	Yes
		Mercury		Mercury TMDL completed	Yes
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
FLAT GULCH, headwaters to mouth (Rock Creek)	MT76E002_120	Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Total Phosphorous	Nutrients	TP TMDL completed	Yes
		Total Nitrogen		TN TMDL completed	Yes
		Aluminum	Metals	Aluminum TMDL completed	No
		Iron		Iron TMDL completed	No
MINERS GULCH, headwaters to mouth (Upper Willow Creek), T8N R15W S23	MT76E002_160	Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
QUARTZ GULCH, headwaters to mouth (Eureka Gulch)	MT76E002_070	Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Aluminum	Metals	Aluminum TMDL completed	No
		Lead		Lead TMDL completed	No
		Mercury	Metals	Not impaired based on updated assessment	Yes
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
SCOTCHMAN GULCH, headwaters to mouth (Upper Willow Creek)	MT76E002_100	Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Total Phosphorous	Nutrients	TP TMDL completed	Yes
		Total Nitrogen		TN TMDL completed	No
		Aluminum	Metals	Aluminum TMDL completed	No

Table 1-1. Water Quality Impairment Causes for the Rock Creek TPA

Waterbody & Location Description*	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status	Included in 2012 Integrated Report**
SLUICE GULCH, headwaters to mouth (Rock Creek)	MT76E002_110	Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Total Nitrogen	Nutrients	TN TMDL completed	No
		Nitrate + Nitrite		Nitrate + Nitrite TMDL completed	Yes
		Arsenic		Arsenic TMDL completed	Yes
		Copper		Copper TMDL completed	No
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
SOUTH FORK ANTELOPE CREEK, headwaters to mouth (Antelope Creek), T6N R15W S22	MT76E002_060	Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Temperature, water	Temperature	Not impaired based on updated assessment	Yes
		Total Phosphorous	Nutrients	TP TMDL completed	Yes
		Total Nitrogen	Nutrients	TN TMDL completed	No
		Nitrate + Nitrite	Nutrients	Nitrate + Nitrite TMDL completed	Yes
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
UPPER WILLOW CREEK, headwaters to mouth (Rock Creek)	MT76E002_040	Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed within document (see **Sections 9** and **10**); not linked to a TMDL	Yes
		Low Flow Alterations	Not Applicable; Non-Pollutant	Addressed within document (see **Sections 9** and **10**); not linked to a TMDL	Yes
		Physical substrate habitat alterations	Not Applicable; Non-Pollutant	Addressed within document (see **Sections 9** and **10**); not linked to a TMDL	Yes
WEST FORK ROCK CREEK, headwaters to mouth (Rock Creek)	MT76E002_030	Sedimentation/Siltation	Sediment	Sediment TMDL completed	No
		Mercury	Metals	Not impaired based on updated assessment	Yes
		Aluminum	Metals	Aluminum TMDL completed	No

*All waterbody segments within Montana's Water Quality Integrated Report are indexed to the National Hydrography Dataset (NHD)
**Impairment causes not in the "2012 Water Quality Integrated Report" were recently identified and will be included in the 2014 Integrated Report.

1.3 DOCUMENT LAYOUT

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

Section 2.0 Rock Creek 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 Rock Creek watershed.

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

Sections 5.0 – 8.0 Sediment, Temperature, Nutrients, and Metals 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 9.0 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 10.0 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 11.0 Monitoring for Effectiveness:
Describes a water quality monitoring plan for evaluating the long-term effectiveness of the "Rock Creek Watershed Total Maximum Daily Loads and Framework Water Quality Protection Plan."

Section 12.0 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 Rock Creek Watershed Description

This watershed description provides a general overview of the physical and social characteristics of the Rock Creek watershed. Although certain information is not current up to 2013, the addition of more recently collected watershed description data would not affect overall TMDL development given the purpose of this section of the document.

2.1 Physical Characteristics

The following information describes the physical characteristics of the Rock Creek watershed.

2.1.1 Location

Rock Creek flows northwards from the Anaconda Range to its confluence with the Clark Fork River, near Clinton. The TPA is located in the Clark Fork River Basin of western Montana, as shown on **Map A-2 (Appendix A)**. The majority of the TPA is within Granite County, with a minor percentage (near the mouth of Rock Creek) in Missoula County. The TPA is bounded by the John Long Mountains to the east, the Anaconda Range to the south, and the Sapphire Range to the west. The total area is 569,320 acres, or approximately 890 square miles.

The TPA is located on the border between the Middle Rockies and the Idaho Batholith Level III Ecoregions. Five Level IV Ecoregions are mapped within the TPA (Woods et al., 2002). These include: Flint Creek – Anaconda Mountains (17am), Alpine (17h), Deer Lodge – Philipsburg – Avon Grassy Intermontane Hills and Valleys (17ak), Rattlesnake – Blackfoot – South Swan – Northern Garnet – Sapphire Mountains (17x) and Eastern Batholith (16a). Level IV Ecoregions are illustrated on **Map A-3 (Appendix A)**.

2.1.2 Topography

Elevations in the TPA range from 1,073 to 3,190 meters (3,520 - 10,463 feet) above mean sea level (**Map A-4, Appendix A**). The highest point in the watershed is Warren Peak, at 10,463 feet. The lowest point is the confluence of Rock Creek and the Clark Fork River.

The topography is characterized by alpine terrain to the south, and lower elevation mountains along the axis of Rock Creek. These exhibit rounded peaks and ridges with steep valley slopes.

2.1.3 Climate

As there are no climate stations within the TPA, the climate summary is based on the station at Philipsburg. Climate in the area is typical of mid-elevation intermontane valleys in western Montana. Summer highs exceed 90° and winter lows are commonly less than 0°. Precipitation is most abundant in May and June. Philipsburg receives an annual average of 14.8 inches. The mountains may exceed 40 inches average annual moisture (Voeller and Waren, 1997). See **Table 2-1** for climate summaries; **Map A-5 (Appendix A)** shows the distribution of average annual precipitation.

2.1.3.1 Climate Stations

There are no climate stations identified within the TPA. Two are located on divides bordering the TPA: one SNOTEL station (Skalkaho Summit) and one Bureau of Land Management (BLM) remote automatic weather station (RAWS) (Climate Station Welch-Gillispie). RAWS stations are primarily used to assess conditions related to fire hazard, and provide telemetry to the National Interagency Fire Center in Boise, Idaho. Climate data for the TPA is based upon the stations at Philipsburg (although it is located outside the TPA) and Clinton. The United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) operates four SNOTEL snowpack monitoring stations near the TPA margin: Daly Creek, Black Pine, Combination and Peterson Meadows.

Precipitation data is mapped by Oregon State University's PRISM Group, based on the records from National Oceanic and Atmospheric Administration (NOAA) stations (PRISM Group, 2004). Climate data is provided by the Western Regional Climate Center, operated by the Desert Research Institute of Reno, Nevada. **Map A-5 (Appendix A)** shows the locations of the NOAA and SNOTEL stations, in addition to average annual precipitation.

Table 2-1. Monthly Climate Summaries

Philipsburg, Montana (246470) Period of Record : 9/16/1903 to 10/12/1955													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Ave. Max. Temp (F)	30.8	35.2	42.2	53.7	61.6	69.3	80.5	79.2	68.7	57.4	43.5	33.9	54.7
Ave. Min. Temp. (F)	11.7	14.6	19.8	27.0	33.3	39.1	43.8	41.9	35.5	28.9	21.5	15.5	27.7
Ave Tot. Precip. (in.)	0.81	0.78	1.03	1.30	2.15	2.82	1.34	1.03	1.40	1.00	0.81	0.68	15.17
Ave. Snowfall (in.)	9.7	9.6	11.4	8.8	5.9	1.5	0.0	0.2	1.2	4.0	8.0	8.2	68.6
Ave Snow Depth (in.)	3	3	1	0	0	0	0	0	0	0	1	2	1
Philipsburg Ranger Station, Montana (246472) Period of Record : 10/13/1955 to 9/30/2010													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Ave. Max. Temp (F)	33.1	37.5	44.2	53.2	62.2	70.5	80.2	79.7	69.7	57.9	42.0	33.9	55.3
Ave. Min. Temp. (F)	13.4	16.0	20.4	26.3	33.0	39.6	42.6	41.3	34.4	28.0	20.4	14.5	27.5
Ave Tot. Precip. (in.)	0.64	0.47	0.84	1.37	2.26	2.46	1.24	1.51	1.33	1.07	0.73	0.64	14.55
Ave. Snowfall (in.)	8.9	5.1	7.3	4.3	1.3	0.0	0.0	0.0	0.2	1.3	4.8	5.6	38.9
Ave Snow Depth (in.)	3	3	1	0	0	0	0	0	0	0	1	2	1
Clinton 6 SE, Montana (241831) Period of Record : 10/1/2002 to 8/31/2008													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Ave. Max. Temp (F)	30.0	36.4	46.5	55.1	63.8	72.8	87.8	83.1	70.3	56.1	37.1	29.7	55.7
Ave. Min. Temp. (F)	13.3	17.1	23.7	28.3	35.7	42.2	47.7	44.8	37.3	29.9	19.6	14.8	29.5
Ave Tot. Precip. (in.)	1.25	1.11	1.73	1.82	2.62	2.22	0.54	1.36	1.97	1.47	1.78	1.09	18.97
Ave. Snowfall (in.)	13.0	12.5	15.3	4.1	0.8	0.3	0.0	0.0	0.1	1.3	12.7	10.2	70.3
Ave Snow Depth (in.)	8	9	7	1	0	0	0	0	0	0	2	5	3

2.1.4 Surface Water

Rock Creek drains from the Anaconda Range to the Clark Fork River near Clinton, a linear distance of approximately 55 miles. Rock Creek hydrography is illustrated on **Map A-6 (Appendix A)**. The United States Geological Survey (USGS) National Hydrography Dataset (NHD) maps 184.5 miles of streams in the TPA (at a medium resolution scale of 1:100,000).

Rock Creek has five significant tributaries: the East, Middle, Ross and West Forks of Rock Creek, and Upper Willow Creek. The drainage pattern is largely controlled by structure and lithology of the underlying bedrock

Forty-five lakes are present in the TPA (using the NHD 1:100,000), covering 810 acres. Of these, only 28 are named. The largest is East Fork Rock Creek Reservoir (described below). The other named lakes are generally tarns present in the higher portions of the Anaconda range.

2.1.4.1 Impoundments
The East Fork Rock Creek Reservoir (16,000 acre-feet) stores water for agricultural use within the east-adjacent Flint Creek watershed. Water from this reservoir is diverted via the Flint Creek Main Canal, built in 1938. This canal drains to Trout Creek, a tributary of Flint Creek (Voeller and Waren, 1997).

2.1.4.2 Stream Gaging Stations
The United States Geological Survey (USGS) maintains 2 gauging stations within the watershed. The USGS gauging stations are shown on **Map A-6 (Appendix A)**.

Table 2-2. Stream Gages

Name	Number	Drainage Area	Agency	Period of Record
Rock Creek near Clinton	12334510	885 $miles^2$	USGS	1972-
Middle Fork Rock Cr nr Philipsburg MT	12332000	123 $miles^2$	USGS	1937-

2.1.4.3 Streamflow
Streamflow data is based on records from the USGS stream gages described above, and is available on the Internet from the USGS (United States Department of Interior, Geological Survey, 2011). Flows in Rock Creek and its tributaries vary considerably over a calendar year, and from one year to another.

The earliest recorded peak annual discharge in Rock Creek occurred on May 1 (1987), and the latest was June 26 (1998). Peak annual discharge in Rock Creek has ranged from 6,500 cubic feet per second (cfs; June 1, 1972) to 922 cfs (May 25, 1977). All annual peak discharges measured in the Rock Creek have occurred in May or June.

2.1.4.4 Surface Water Quality
Water quality and chemistry data is available from the Rock Creek near Clinton gauging station (12334510). Parameters include: pH, specific conductance, temperature, hardness as CaCO3; filtered and total recoverable inorganics: Ca, Mg, As, Cd, Cu, Fe, Pb, Mn, Zn; and suspended sediment.

2.1.5 Groundwater
2.1.5.1 Hydrogeology
Groundwater flow within the valleys of the Rock Creek TPA is presumed to be 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 average groundwater flow velocity in bedrock is probably several orders of magnitude lower than in the valley fill sediments. However, carbonate and siliciclastic sedimentary rocks in the mountains may have zones of significant permeability. The hydrologic role of the structural geology (faults and folds) is uncertain. Faults may act as flow conduits or flow barriers. No studies of the bedrock hydrogeology were identified.

Natural recharge occurs from infiltration of precipitation, stream loss and flow out of the adjacent bedrock aquifers. Flood irrigation also contributes to aquifer recharge.

2.1.5.2 Groundwater Quality

The Montana Bureau of Mines and Geology (MBMG) Groundwater Information Center (GWIC) program monitors and samples a statewide network of wells (Montana Bureau of Mines and Geology, 2008). 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.

As of July 2008, the GWIC database reports 366 wells within the TPA (Montana Bureau of Mines and Geology, 2013). Water quality data are available for 14 of those wells. The locations of these data points are shown on **Map A-7 (Appendix A)**.

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

A review of GWIC data reports for agricultural chemical monitoring programs did not yield any data points for Granite County.

There are 3 public water supplies within the TPA. These are small transient, non-community systems (i.e. that serve a dynamic population of more than 25 persons daily) using groundwater for their supplies. These systems are all located near the mouth of Rock Creek. Water quality data is available from these utilities via the State Safe Drinking Water Information System database, although the data reflect the finished water provided to users, not raw water at the source.

2.1.6 Geology

Map A-8 (Appendix A) provides an overview of the geology, based on the most recent geologic map of the Butte and Dillon 1° x 2° quadrangles (Lewis, 1998; Ruppel et al., 1993). The geology of the Rock Creek area is complex, and has been considerably reinterpreted in recent years. Much of the debate and complexity is beyond the scope of this characterization.

In general, much of the TPA is underlain by a structural unit informally called the Sapphire Block (although no longer considered an intact body), which extends west to the Bitterroot detachment fault in the Bitterroot Valley (Lonn et al., 2003a). The 'Sapphire Block' may be considered a slab of Precambrian Belt Series rocks located between the Bitterroot and Flint Creek Valleys.

2.1.6.1 Bedrock

The 'Sapphire Block' includes the Sapphire Mountains and the John Long Mountains. Both ranges are composed of Middle Proterozoic (~1.5 billion years old) Belt Supergroup rocks. These rocks are interpreted as passive margin deposits, and the dominant lithologies are siltstone, sandstone and limestone (and their metamorphic equivalents). The total stratigraphic thickness of Belt Series rocks in this area exceeds 20,000 feet (Lonn et al., 2003b). These rocks are less resistant than the granitic rocks in surrounding mountain ranges, giving the Sapphire and John Long ranges their subdued topography and lower elevations (relative to the Anaconda or Flint Creek ranges).

Younger (Paleozoic) sedimentary rocks are limited in the TPA, found only along the northern margin of the Anaconda range. Mesozoic sedimentary rocks are not mapped in the TPA.

This package of sedimentary rocks has been intruded by several generations of Cretaceous and Tertiary igneous rocks. Metamorphism and hydrothermal activity associated with these rocks produced economically significant ores. Volcanic rocks of Tertiary age are also present, including the Rock Creek volcanic field, a rhyolitic flow that is the source of the eponymous sapphires. Pleistocene glaciation sculpted the Anaconda range, producing the rugged alpine geomorphology.

2.1.6.2 Basin Sediments

Unlike many valleys in western Montana that occupy fault-bounded basins between uplifted mountains, the Rock Creek Valley is located on the 'Sapphire Block.' Consequently, the valley is underlain by relatively shallow, continuous bedrock. This is responsible for the smaller size of the valley bottom in the TPA relative to surrounding watersheds.

Tertiary sediments are found mostly in the Upper Willow Creek drainage, and in the upper half of the TPA. These sediments are found on terraces and at higher elevations than the modern alluvium. The Tertiary sediments are not well described in available maps, but include a wide range of clast sizes, from clay to gravel, and are presumably similar in character to Tertiary sediments described in the Flint Creek and Bitterroot Valleys.

2.1.6.3 Glacial History

The glacial history of the watershed is presumably similar to that of the rest of the Central and Northern Rockies, although no detailed studies were identified. While evidence of earlier glaciations (before 150,000 years ago) is not well-preserved, there is widespread evidence for two recent episodes of significant glacial activity. The earlier (Bull Lake) is generally dated to ~130,000 years ago, and the later (Pinedale) to 23,000 – 16,000 years ago (Chadwick et al., 1997; Pierce et al., 1976). The dates are general; alpine glacial activity varied somewhat according to elevation and other local variables. Each period of glaciation included multiple advances and retreats.

Glacial deposits are widespread in the southern portion of the TPA, along the northern flank of the Anaconda Range (Lonn et al., 2003b). The nature of the sedimentary deposits varies according to the depositional environment. Areas underlain by till tend to be swampy and poorly drained due to the low permeability of these deposits. Springs are common. In contrast, kame deposits (stream sediments deposited by streams flowing on or adjacent to glaciers) tend to be well-drained due to the well-sorted and larger grained sediments.

2.1.7 Soils

The USGS Water Resources Division (Schwarz and Alexander, 1995) created a dataset of hydrology-relevant soil attributes, based on the USDA Natural Resources Conservation Service (NRCS) STATSGO soil database. The STATSGO data 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 (SSURGO) data. The soil attributes considered in this characterization are erodibility and slope.

2.1.7.1 Erodibility

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 **Map A-9 (Appendix A)**, with soil units assigned to the following ranges: low (0.0-0.2), moderate-low (0.2-0.29) and moderate-high (0.3-0.4). Values of >0.4 are considered highly susceptible to erosion. No values greater than 0.4 are mapped in the TPA.

Low susceptibility soils comprise 39% of the TPA; moderate susceptibility soils comprise 53% of the TPA, and the remaining 8% is mapped with moderate-high susceptibility soils. No high susceptibility soils are mapped in the TPA.

Low susceptibility soils are associated with the Sapphire batholith and other granitic plutons, as well as the higher-elevation areas of the Anaconda and Sapphire Ranges. Moderate-high susceptibility soils also show a preferred distribution, and are strongly associated with Tertiary sediments.

2.1.7.2 Slope
Below the confluence with Upper Willow Creek, the Rock Creek watershed is considerably steeper, with slopes of greater than 30° common. Above Upper Willow Creek, the TPA exhibits broader valleys, with steep slopes on the flank of the Anaconda Range. A map of soil slope is provided on **Map A-10 (Appendix A)**.

2.2 Ecological Parameters

2.2.1 Vegetation
The primary cover in the uplands is conifer forest. Conifers are dominated by Lodgepole pine, giving way to Douglas fir at lower elevations, and to subalpine fir and spruce at higher elevations. The valleys are characterized by grassland and irrigated agricultural land, with minor shrublands. Landcover is shown on **Maps A-11 and A-12 (Appendix A)**. Data sources include the University of Montana's Satellite Imagery land Cover (SILC) project (University of Montana, 2002), and USGS National Land Cover Dataset (NLCD) mapping (United States Geological Survey, 2011).

2.2.2 Aquatic Life
Native fish species present in the TPA include: bull trout, westslope cutthroat trout, mountain whitefish, longnose dace, redside shiner, slimy scuplin, northern pike minnow, largescale sucker and longnose sucker. Bull trout and westslope cutthroat trout are designated "Species of Concern" by Montana Department of Fish, Wildlife and Parks (FWP). Bull trout are further listed as "threatened" by the US Fish and Wildlife Service (US FWS). Seventy-five miles of Rock Creek and its tributaries (**Map A-13, Appendix A)** have been designated critical habitat for bull trout (50 CFR Part 17, 2005).

Introduced species are also present, including: brook, rainbow and brown trout.

Data on fish species distribution are collected, maintained and provided by FWP (Montana Department of Fish, Wildlife and Parks,2006). Fish species distribution is shown on **Map A-13 (Appendix A)**.

2.2.3 Fires
The TPA has experienced several significant burns in the last 13 years. Nearly 66,450 acres burned in 2007, and over 24,000 acres burned in 2000. Overall, a total of 113,728 acres are mapped burned; according to the most recent fire data provided by United States Forest Service (USFS) Region 1 (includes fire history from 1835 to 2009). Burned areas are shown on **Map A-14 (Appendix A)**.

2.3 Social Profile

The following information describes the social profile of the Rock Creek watershed.

2.3.1 Population

There are no large population centers in the TPA. An estimated 552 persons lived within the TPA in 2010. Population estimates are derived from census data (United States Census Bureau, 2010) and based on spatial analysis of census blocks. Census data are shown on **Map A-15 (Appendix A)**.

2.3.2 Transportation

The principal transportation route in the TPA is Montana Highway 38. Highway 38 connects Philipsburg to Hamilton, via Skalkaho Pass. Granite County Road 102 runs from Highway 38 to Clinton, along Rock Creek. The network of unpaved roads on public and private lands will be further characterized as part of the source assessment. No active or abandoned railways are present in the TPA.

2.3.3 Land Ownership

Over 80% of the TPA is administered by the USFS (**Table 2-3**). Private landowners own 16% of the TPA. Plum Creek Timber Company lands are limited to 2,667 acres at the northeastern edge of the TPA. The remainder is State of Montana or US Bureau of Land Management (BLM) land (**Map A-16, Appendix A**).

Table 2-3. Land Ownership

Owner	Acres	Square Miles	% of Total
US Forest Service	459,204	717.5	80.7%
Private	91,722	143.3	16.1%
US Bureau of Land Management	10,867	17.0	1.9%
State Trust Land	6,815	10.6	1.2%
Total*	569,320	890	—

*includes water and right-of-way acreage

2.3.4 Land Use

Land use within the TPA is dominated by forest and agriculture (**Table 2-4**). Agriculture in the valley is primarily related to the cattle industry: irrigated hay and dry grazing. Information on land use is based on mapping completed by the USGS in the 1980s and on county assessments (Montana Department of Natural Resources and Conservation, 2008b). The USGS data is at 1:250,000 scale. Agricultural land use is illustrated on **Map A-17 (Appendix A)**. Potential sources of human impacts (abandoned mines, livestock feeding areas, and Montana Pollution Discharge Elimination System (MPDES)-permitted discharge sites) are illustrated on **Map A-18 (Appendix A)**.

Table 2-4. Land Use & Land Cover

Land Use	Acres	Square Miles	% of Total
Evergreen Forest	430,988	673.4	75.71%
Grasslands/Herbaceous	88,819	138.8	15.60%
Shrubland	41,005	64.1	7.20%
Pasture/Hay	2,262	3.54	0.40%
Woody Wetlands	1,880	2.94	0.33%
Transitional	1,167	1.82	0.21%
Open Water	901	1.41	0.16%
Deciduous Forest	867	1.36	0.15%

Table 2-4. Land Use & Land Cover

Land Use	Acres	Square Miles	% of Total
Bare Rock/Sand/Clay	760	1.19	0.13%
Emergent Herbaceous Wetlands	426	0.666	0.07%
Commercial/Industrial/Transportation	95.7	0.150	0.02%
Perennial Ice/Snow	55.0	0.086	0.010%
Row Crops	23.1	0.036	0.004%
Small Grains	20.6	0.032	0.004%
Mixed Forest	18.0	0.028	0.003%
Urban/Recreational Grasses	0.2	0.000	0.000%

Information on agricultural land use can be obtained from Department of Revenue data. The Department of Revenue assigns an agricultural use only if more than 50% of a given parcel is so used. Nearly 3,000 acres of irrigated land are reported in the TPA. Irrigation infrastructure includes interbasin diversions and impoundments as described above in **Section 2.5**. Berkas et al. (2005) report that diversions from Rock Creek irrigate nearly 16,100 acres, but this number presumably includes land in the Flint Creek watershed that is irrigated via interbasin diversion from the East Fork Rock Creek Reservoir.

2.3.5 Mining

The Rock Creek TPA includes portions of 7 mining districts: Rock Creek, Moose Lake, Frog Pond Basin, Alps, Antelope Creek, Welcome Creek and Woodman. The TPA was the scene of considerable mining activity. Like many other mining districts, metal production began with gold placers. Lode mines were developed later, but never became as productive as the mines in the nearby Philipsburg and Combination districts. However, the Rock Creek district was (and remains) a major producer of sapphires.

MBMG completed an environmental survey of 119 abandoned mining sites in the Rock Creek and Flint Creek watersheds in the mid-1990s (Metesh et al., 1995). Of these sites, 35 are located in the Rock Creek TPA. Eight sites were found to have potential environmental problems, although these were generally limited to the immediate vicinity of the site. The study was limited to sites on Beaverhead-Deer Lodge National Forest property.

Milling was performed at many locations within the TPA. Waste rock and tailings are still present in many locations. DEQ Remediation Division data on abandoned mine locations are plotted on **Map A-18 (Appendix A)**. Active mining is currently limited to the sapphire operations.

2.3.6 Livestock Operations

The Montana Pollution Discharge Elimination System (MPDES) does not include any regulated concentrated animal feeding operations (CAFOs) within the Rock Creek watershed. Aerial photograph inspection (1-meter resolution, natural color, circa 2005) did not reveal any likely livestock confinement areas.

2.3.7 Wastewater

There are no large population centers in the TPA. Accordingly, no municipal wastewater treatment systems are present. Wastewater treatment needs are met by individual onsite septic tanks and drainfields.

3.0 Montana Water Quality Standards

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

Montana’s water quality standards 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 MCA), and Montana’s Surface Water Quality Standards and Procedures (ARM 17.30.601-670) and Circular DEQ-7 (Montana Department of Environmental Quality, 2012a).

3.1 Rock Creek TPA Stream Classifications and Designated Beneficial Uses

Waterbodies are classified based on their designated uses. All Montana waters are classified for multiple uses. All streams within the Rock Creek watershed are classified as B-1, which specifies that the water must be maintained suitable to support all of the following uses:

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

While some of the waterbodies might not actually be used for a designated use (e.g., drinking water supply), their water quality still must be maintained suitable for that designated use. More detailed descriptions of Montana’s surface water classifications and designated uses are provided in Appendix B. DEQ’s assessment methods are designed to evaluate the most sensitive uses for each pollutant group addressed within this document, thus ensuring protection of all designated uses. For streams in Western Montana, the most sensitive use assessed for sediment is aquatic life; for temperature is aquatic life; for metals is drinking water and/or aquatic life; and for nutrients is aquatic life and primary contact recreation. DEQ determined that 11 tributaries do not meet the applicable water quality standards (**Table 3-1**).

Table 3-1. Impaired Waterbodies and their Impaired Uses* in the Rock Creek TPA

Waterbody & Location Description	TMDL Prepared	TMDL Pollutant Category	Impaired Use(s)
ANTELOPE CREEK, headwaters to mouth (Rock Creek)	Sedimentation/Siltation	Sediment	Aquatic Life
BASIN GULCH, headwaters to mouth (Eureka Gulch)	Arsenic	Metals	Drinking Water
EAST FORK ROCK CREEK, East Fork Reservoir to mouth (Middle Fork Rock Creek)	Sedimentation/Siltation	Sediment	Aquatic Life
	Temperature, water	Temperature	Aquatic Life
	Total Phosphorous	Nutrients	Aquatic Life and Primary Contact Recreation
	Total Nitrogen	Nutrients	Aquatic Life and Primary Contact Recreation
EUREKA GULCH, confluence of Quartz Gulch and Basin Gulch to mouth (Un-Named Ditch)	Sedimentation/Siltation	Sediment	Aquatic Life
	Solids		Aquatic Life
	Arsenic	Metals	Drinking Water
	Mercury		Drinking Water
FLAT GULCH, headwaters to mouth (Rock Creek)	Sedimentation/Siltation	Sediment	Aquatic Life
	Total Phosphorous	Nutrients	Aquatic Life and Primary Contact Recreation
	Total Nitrogen		Aquatic Life and Primary Contact Recreation
	Aluminum	Metals	Aquatic Life
	Iron		Aquatic Life
MINERS GULCH, headwaters to mouth (Upper Willow Creek), T8N R15W S23	Sedimentation/Siltation	Sediment	Aquatic Life
QUARTZ GULCH, headwaters to mouth (Eureka Gulch)	Sedimentation/Siltation	Sediment	Aquatic Life
	Aluminum	Metals	Aquatic Life
	Lead		Drinking Water
SCOTCHMAN GULCH, headwaters to mouth (Upper Willow Creek)	Sedimentation/Siltation	Sediment	Aquatic Life
	Total Phosphorous	Nutrients	Aquatic Life and Primary Contact Recreation
	Total Nitrogen		Aquatic Life and Primary Contact Recreation
	Aluminum	Metals	Aquatic Life
SLUICE GULCH, headwaters to mouth (Rock Creek)	Sedimentation/Siltation	Sediment	Aquatic Life
	Total Nitrogen	Nutrients	Aquatic Life and Primary Contact Recreation
	Nitrate + Nitrite		Aquatic Life and Primary Contact Recreation
	Arsenic		Drinking Water
	Copper		Aquatic Life

Table 3-1. Impaired Waterbodies and their Impaired Uses* in the Rock Creek TPA

Waterbody & Location Description	TMDL Prepared	TMDL Pollutant Category	Impaired Use(s)
SOUTH FORK ANTELOPE CREEK, headwaters to mouth (Antelope Creek), T6N R15W S22	Sedimentation/Siltation	Sediment	Aquatic Life
	Total Phosphorous	Nutrients	Aquatic Life and Primary Contact Recreation
	Total Nitrogen	Nutrients	Aquatic Life and Primary Contact Recreation
	Nitrate + Nitrite	Nutrients	Aquatic Life and Primary Contact Recreation
WEST FORK ROCK CREEK, headwaters to mouth (Rock Creek)	Sedimentation/Siltation	Sediment	Aquatic Life
	Aluminum	Metals	Aquatic Life

*Only pollutant impairments are listed

3.2 WATER QUALITY STANDARDS

In addition to the use classifications described above, Montana's water quality standards include numeric and narrative criteria that protect the designated uses. Numeric criteria define the allowable concentrations of specific pollutants so as not to impair designated uses. Narrative criteria are more "free from" descriptions, or statements, of unacceptable conditions. **Appendix B** defines both the numeric and narrative water quality criteria for the Rock Creek TPA.

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

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

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

The specific sediment, temperature, nutrient, and metals water quality standards that apply to the Rock Creek TPA are summarized in **Appendix B.**

4.0 DEFINING TMDLS AND THEIR COMPONENTS

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

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

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

A TMDL is expressed by the equation:

$TMDL = \Sigma WLA + \Sigma LA$, where:

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

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

TMDL development must include a margin of safety (MOS), which can be explicitly incorporated into the above equation. Alternatively, the MOS can be implicit in the TMDL. A TMDL must also ensure that the waterbody will be able to meet and maintain water quality standards for all applicable seasonal variations (e.g., pollutant loading or use protection).

Development of each TMDL has four major components:

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

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

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

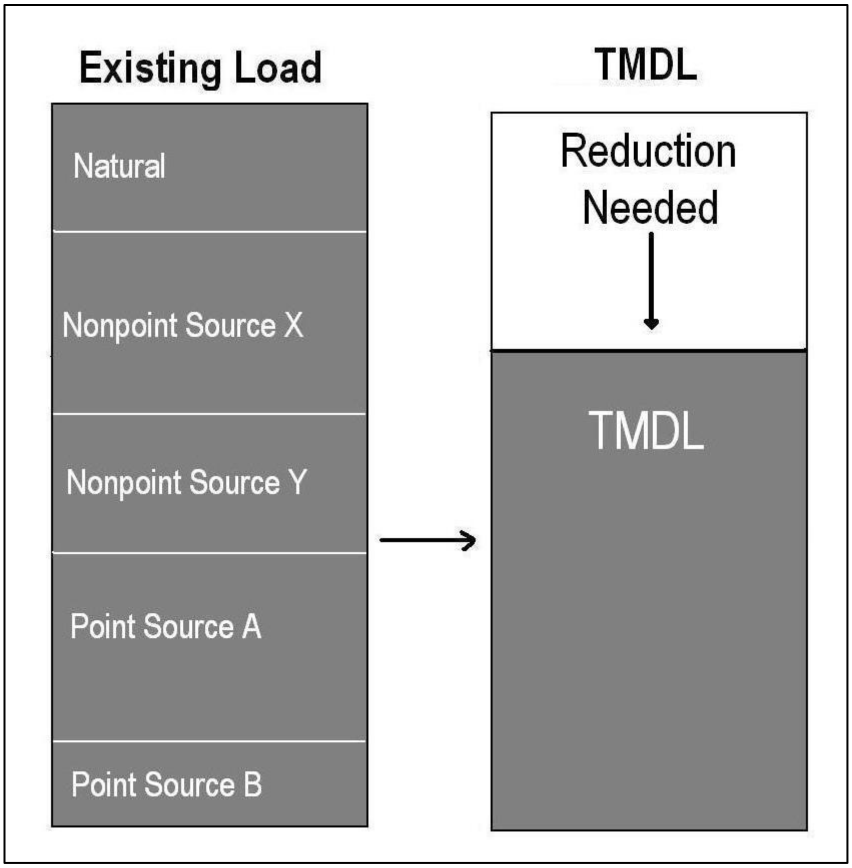

Figure 4-1. Schematic Example of TMDL Development

4.1 Developing Water Quality Targets

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

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

4.2 Quantifying Pollutant Sources

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

A pollutant load is usually quantified for each point source permitted under the Montana Pollutant Discharge Elimination System (MPDES) program. Nonpoint sources are quantified by source categories (e.g., unpaved roads) and/or by land uses (e.g., crop production or forestry). These source categories and land uses can be divided further by ownership, such as federal, state, or private. Alternatively, most, or all, pollutant sources in a sub-watershed or source area can be combined for quantification purposes. Because all potentially significant sources of the water quality problems must be evaluated, source assessments are conducted on a watershed scale. The source quantification approach may produce reasonably accurate estimates or gross allotments, depending on the data available and the techniques used for predicting the loading (40 CFR Section 130.2(I)). Montana TMDL development often includes a combination of approaches, depending on the level of desired certainty for setting allocations and guiding implementation activities.

4.3 Establishing the Total Allowable Load

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

If a stream is impaired by a pollutant for which numeric water quality criteria exist, the TMDL, or allowable load, is typically calculated as a function of streamflow and the numeric criteria. This same approach can be applied when a numeric target is developed to interpret a narrative standard.

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

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

4.4 Determining Pollutant Allocations

Once the allowable load (the TMDL) is determined, that total must be divided among the contributing sources. The allocations are often determined by quantifying feasible and achievable load reductions through application of a variety of best management practices and other reasonable conservation practices.

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

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

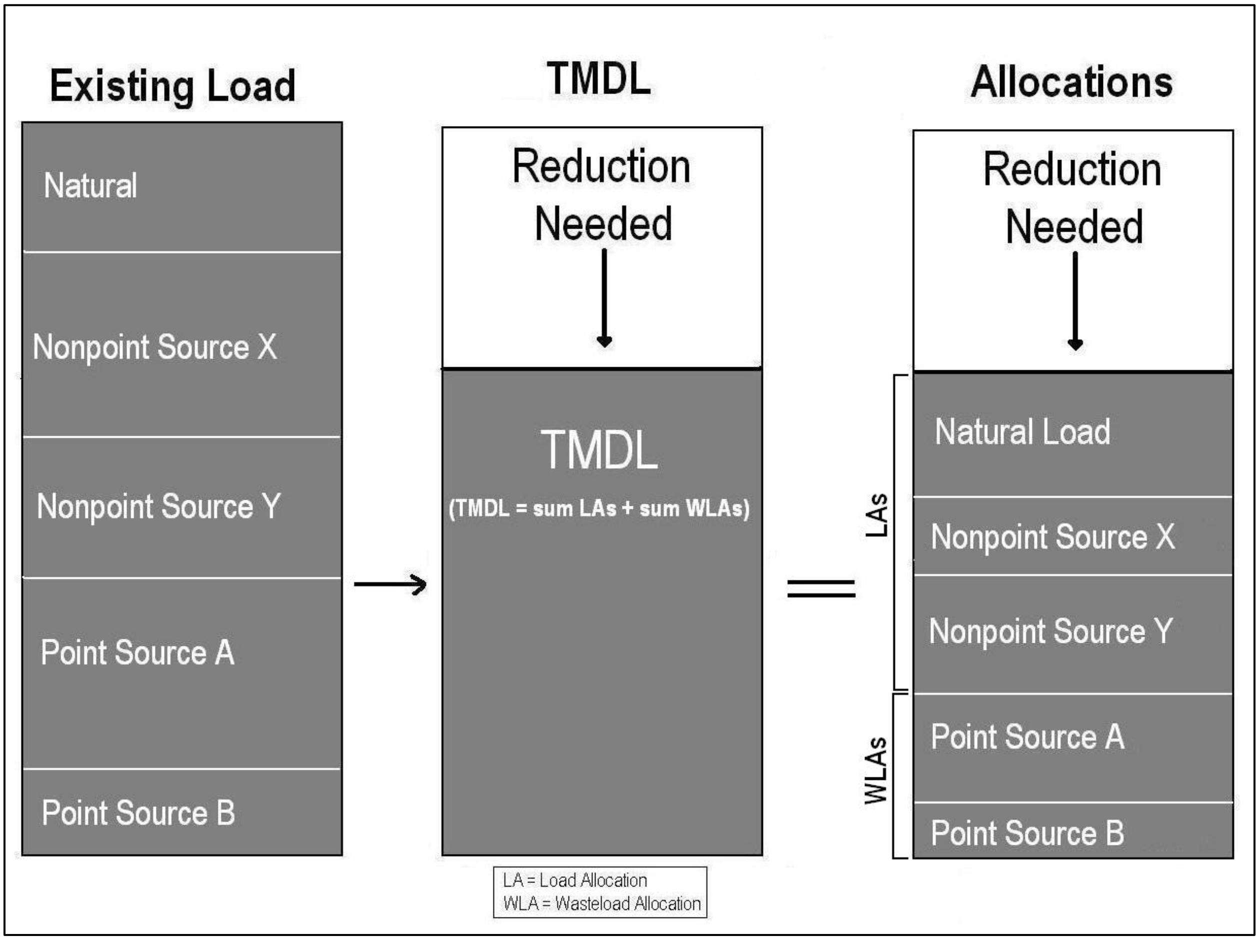

Figure 4-2. Schematic Diagram of a TMDL and its Allocations

TMDLs must also incorporate a margin of safety. The margin of safety accounts for the uncertainty, or any lack of knowledge, about the relationship between the pollutant loads and the quality of the receiving waterbody. The margin of safety 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, 1999). The margin of safety 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.

4.5 Implementing TMDL Allocations

The Clean Water Act (CWA) and Montana state law (Section 75-5-703 of the Montana Water Quality Act) require wasteload allocations to be incorporated into appropriate discharge permits, thereby providing a regulatory mechanism to achieve load reductions from point sources. Nonpoint source reductions linked to load allocations 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 10.0** discusses a restoration and implementation strategy by pollutant group and source category, and provides recommended best management practices (BMPs) per source category (e.g., grazing, cropland, urban, etc.). **Section 10.5** 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 11.0**). This includes a monitoring strategy and an implementation review that is required by Montana statute (see **Section 11.2**). TMDLs may be refined as new data become available, land uses change, or as new sources are identified.

5.0 Sediment TMDL Development

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

5.1 Mechanism of Effects of Excess Sediment on Beneficial Uses

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

More specifically, sediment may block light and cause a decline in primary production, and it may also interfere with fish and macroinvertebrate survival and reproduction. Fine sediment deposition reduces availability of suitable spawning habitat for salmonid fishes and can smother eggs or hatchlings. Effects from excess sediment are not limited to suspended or fine sediment; an accumulation of larger sediment (e.g., cobbles) can fill pools, reduce the percentage of desirable particle sizes for fish spawning, and cause channel overwidening (which may lead to additional sediment loading and/or increased temperatures). This larger sediment can also reduce or eliminate flow in some stream reaches where sediment aggrades within the channel, causing flow to go subsurface (May and Lee, 2004). Although fish and aquatic life are typically the most sensitive beneficial uses regarding sediment, excess sediment may also affect other uses. For instance, high concentrations of suspended sediment in streams can also cause water to appear murky and discolored, negatively impacting recreational use, and excessive sediment can increase filtration costs for water treatment facilities that provide safe drinking water.

5.2 Stream Segments of Concern

A total of 9 waterbody segments in the Rock Creek TPA appeared on the 2012 Montana 303(d) List due to sediment impairments (**Table 5-1**). These include: Brewster Creek, East Fork Rock Creek, Eureka Gulch, Flat Gulch, Miners Gulch, Quartz Gulch, Scotchman Gulch, South Fork Antelope Creek, and Sluice Gulch. As shown in **Table 5-1**, many of the waterbodies with sediment impairments are also listed for habitat and flow alterations, which are non-pollutant forms of pollution frequently 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.

There are three other streams segments of concern in the TPA (**Table 5-1**). Upper Willow Creek (MT76E002_040) and West Fork Rock Creek (MT76E002_030) were not on the 303(d) list for sediment, but do have habitat alterations that are potentially linked to sediment and therefore were also evaluated as part of TMDL development. Antelope Creek (MT76E002_61) was also evaluated as part of TMDL development because of observations of sediment sources during field reconnaissance in June of 2011.

Table 5-1. Waterbody Segments of Concern for Sediment in the Rock Creek TPA

Stream Segment	Waterbody ID	Sediment Pollutant Listing	Non-Pollutant Causes of Impairment Potentially Linked to Sediment Impairment
Antelope Creek, headwaters to mouth (Rock Creek)	MT76E002_061		
Brewster Creek, East Fork to mouth (Rock Creek)	MT76E002_050	Sedimentation/ Siltation	Low flow alterations
East Fork Rock Creek, East Fork Reservoir to mouth (Middle Fork Rock Creek)	MT76E002_020	Sedimentation/ Siltation	Alteration in streamside or littoral vegetative covers & low flow alterations
Eureka Gulch, confluence of Quartz Gulch and Basin Gulch to mouth (Un-Named Ditch)	MT76E002_090	Sedimentation/ Siltation & Solids (Suspended/ Bedload)	Alteration in streamside or littoral vegetative covers
Flat Gulch, headwaters to mouth (Rock Creek)	MT76E002_120	Sedimentation/ Siltation	
Miners Gulch, headwaters to mouth (Upper Willow Creek)	MT76E002_160	Sedimentation/ Siltation	
Quartz Gulch, headwaters to mouth (Eureka Gulch)	MT76E002_070	Sedimentation/ Siltation	Alteration in streamside or littoral vegetative covers
Scotchman Gulch, headwaters to mouth (Upper Willow Creek)	MT76E002_100	Sedimentation/ Siltation	
Sluice Gulch, headwaters to mouth (Rock Creek)	MT76E002_110	Sedimentation/ Siltation	Alteration in streamside or littoral vegetative covers
South Fork Antelope Creek, headwaters to mouth (Antelope Creek)	MT76E002_060	Sedimentation/ Siltation	Alteration in streamside or littoral vegetative covers
Upper Willow Creek, headwaters to mouth (Rock Creek)	MT76E002_040		Alteration in streamside or littoral vegetative covers, low flow alterations, & physical substrate
West Fork Rock Creek, headwaters to mouth (Rock Creek)	MT76E002_030		

5.3 Information Sources and Assessment Methods to Characterize Sediment Conditions

For TMDL development, information sources and assessment methods fall within two general categories. The first category, discussed within this section, is focused on characterizing overall stream health with focus on sediment and related water quality conditions. The second category, discussed within **Section 5.6**, is focused on quantifying sources of sediment loading within the watershed.

5.3.1 Summary of Information Sources

To characterize sediment conditions for TMDL development purposes, a sediment and habitat assessment was completed during 2011. The below listed data sources represent the primary information used to characterize water quality and/or develop TMDL targets (**Figure 5-1**).

- DEQ assessment files
- 2011 DEQ sediment and habitat assessment
- 2011 DEQ macroinvertebrate and periphyton data collection
- 2009/2010 Beaverhead Deerlodge National Forest (BDNF) Integrated Riparian Monitoring Hydrology Report
- PIBO data (PACFISH/INFISH Biological Opinion Effectiveness)
- Beaverhead Deerlodge regional reference data
- GIS data layers and publications regarding historical land usage, channel stability, and sediment conditions

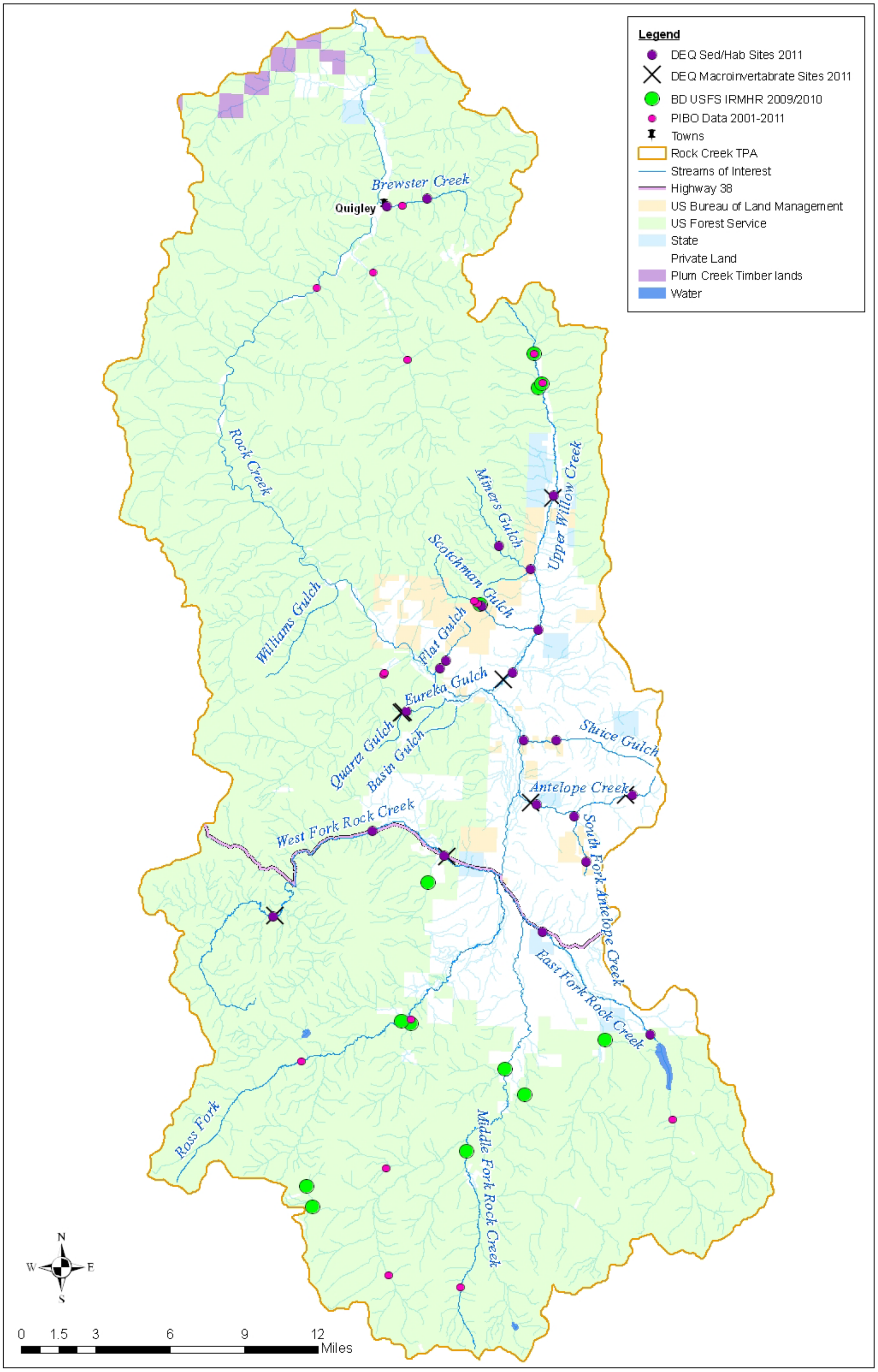

Figure 5-1. Reaches Assessed by DEQ in 2011 and Other Sources of Information

5.3.2 DEQ Assessment Files and Reference Sites

The DEQ assessment files contain information used to make the existing sediment impairment determinations. The files include a summary of physical, biological, and habitat data collected by DEQ on most waterbodies between 1990 and 2009 as well as other historical information collected or obtained by DEQ. The most common quantitative data that will be incorporated from the assessment files are pebble counts and macroinvertebrate index scores. 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 Clean Water Act Information Center website: http://cwaic.mt.gov/. Four DEQ reference sites exist in the Rock Creek TPA, however, sediment and habitat data has not yet been collected at these sites.

5.3.3 DEQ's 2011 Sediment and Habitat Assessments

Field measurements of channel morphology and riparian and instream habitat parameters (Montana Department of Environmental Quality, 2012b) were collected in August 2012 from 22 sites on 11 waterbody segments to aid in TMDL development (**Figure 5-1**). Although Eureka Gulch is listed, no sites were assessed on the stream during the sediment and habitat data collection in 2011 because access was not granted.

Streams are delineated into waterbody segments by the DEQ. Initially, all waterbody segments of interest underwent an aerial assessment procedure by which reaches were characterized by four main attributes not affected by 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 a stratification of waterbody segments 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 waterbody stratification, along with field reconnaissance, provided the basis for selecting the monitoring sites located within a reach. Each monitoring site, ranging from 500 feet to 1500 feet (depending on the channel bankfull width) is broken into five individual and equally-sized cells.

Monitoring sites were chosen with the goal of being representative of various reach characteristics, land use category, and anthropogenic influence. There was a preference toward sampling those sites 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 impairment and non-impairment conditions. Instead, it is a targeted sampling design that aims to assess a representative subset of reach types while ensuring that reaches within each [sediment] 303(d) listed waterbody with potential impairment conditions are incorporated into the overall evaluation. Typically, the effects of excess sediment are most apparent in low gradient, unconfined streams larger than 1st order (i.e., having at least one tributary). However, many of the reach types within the Rock Creek TPA are higher gradient first order streams (**Table 5-2**); therefore, a range of gradients and stream orders were sampled.

The field parameters assessed in 2011 include standard measures of stream channel morphology, fine sediment, stream habitat, riparian vegetation, and streambank erosion. Channel morphology, stream habitat, riparian, and bank erosion measures were performed in all five cells, while fine sediment measures were performed in four of the cells. Field parameters are briefly described in **Section 5.4**, and summaries of all field data are contained in the 2012 monitoring summary report (**Appendix C**).

Table 5-2. Stratified Reach Types and Sampling Site Representativeness within the Rock Creek TPA

Reach Type*	Number of Reaches	Sites Monitored
MR_0_3_U	45	ANTE 21-01
		BREW 06-01
		UWIL 11-05
		WFRK 14-03
		WFRK 27-03
		WFRK 30-02
MR_0_4_U	9	EFRK 03-03
		UWIL 15-01
MR_2_1_U	9	SCOT 08-01
MR_2_2_C	8	SLUI 14-01
MR_2_2_U	18	MINE 14-02
		SLUI 18-02
MR_2_3_U	15	BREW 05-01
		EFRK 01-02
MR_4_1_C	25	QUTZ 09-01
MR_4_1_U	40	FLAT 12-01
		MINE 10-02
		SCOT 16-02
MR_4_2_C	10	SFAN 06-01
MR_4_2_U	12	ANTE 07-01
		SFAN 13-01
MR_10_1_U	20	FLAT 13-01

* Per DEQ's stratification methodology: MR= Middle Rockies; the first number in the series refers to stream gradient: 0=0-2%, 2=2-4%, 4=4-10%, and 10=>10%; the next number in the series refers to Strahler stream order, 1 through 7; and finally U = Unconfined & C = Confined

5.3.4 DEQ Macroinvertebrate and Periphyton Collection 2011

DEQ contracted with Watershed Consulting, LLC to in 2011 to collect and analyze macroinvertebrate and periphyton data in 8 reaches on four streams: Antelope Creek, Quartz Creek, Upper Willow Creek, and West Fork Rock Creek. Additional data collected included aquatic vegetation composition, amount, color and condition; water chemistry indicators such as dissolved oxygen (DO), pH, specific conductivity (SC), and air and water temperature; and digital photos upstream, downstream and across each reach. The full report is available in **Appendix D**.

5.3.5 Beaverhead Deerlodge NF Sediment and Habitat Assessment 2009/2010

In 2009 and 2010, the Beaverhead Deerlodge National Forest (BDNF) surveyed twelve streams (13 sites) in the Rock Creek Watershed for their Integrated Riparian Monitoring Hydrology Report (IRMH). Two of the streams surveyed by BDNF, Upper Willow Creek and Scotchman Gulch, are also streams that were surveyed by the DEQ during the 2011 sediment and habitat assessment for TMDL development. The primary objectives associated with the BDNF sites were to document riparian/stream condition and to evaluate trends based on future management at the allotment level. Sites were distributed across the Forest and were most commonly located where livestock directly influenced channel and/or riparian conditions. Three cross section measurements, bank erosion hazard index (BEHI) ratings, particle size distribution, sinuosity, slope, channel width/depth measurements, discharge, pictures and field notes were collected at each monitoring location.

5.3.6 PIBO Data

The PACFISH/INFISH Biological Opinion Effectiveness (PIBO) monitoring program collects data from reference and managed (i.e., non-reference) stream sites on United States Forest Service (USFS) and Bureau of Land Management (BLM) land within the Rock Creek watershed. 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 Rock Creek TPA, data were collected on reference sites in 2001 and 2002 on Ranch Creek; in 2004 and 2009 on Middle Fork Rock and East Fork Rock creeks; and in 2007 on Welcome Creek (**Figure 5-1**). Data were also collected on managed (non-reference) sites in the Rock Creek TPA between 2002 and 2009 on 10 other streams. The four reference sites in the Rock TPA are located within the Middle Rockies Level IV ecoregion, and because four reference sites provides a small dataset for target development, and ecoregion is a primary stratification category, all PIBO reference data from the Middle Rockies ecoregion between 2001 and 2011 were used for target development. Data was collected following protocols described in *"Effectiveness Monitoring for Streams and Riparian Areas within the Pacific Northwest: Stream Channel Methods for Core Attributes"* (U.S. Department of Agriculture, Forest Service, 2006). Relevant data collected during these assessments include width/depth ratios, residual pool depths, pool frequency, LWD frequency, pebble counts, and the percentage of fine sediment in pool tails <6mm via grid toss.

5.3.7 Beaverhead Deerlodge Regional Reference Data

Regional reference data are available from the BDNF. BDNF data were collected between 1991 and 2002 from approximately two hundred reference sites: seventy 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, and fine sediment <6mm from pebble counts.

5.4 Water Quality Targets and Comparison to Existing Conditions

The concept of water quality targets was presented in **Section 4.1**, but this section provides the rationale for each sediment-related target parameter, discusses the basis of the target values, and then presents a comparison of those values to available data for the stream segments of concern in the Rock Creek TPA (**Table 5-1**). Although placement onto the 303(d) list indicates impaired water quality, a comparison of water quality targets to existing data helps define the level of impairment and establishes a benchmark to help evaluate the effectiveness of restoration efforts.

In developing targets, natural variation throughout the river channel must be considered. As discussed in more detail in **Section 3** 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 utilizing reference site data, but modeling, professional judgment, and literature values may also be used. The DEQ defines "reference" as the condition of a waterbody capable of supporting its present and future beneficial uses when all reasonable land, soil, and water conservation practices have been applied. In other words, the reference condition reflects a waterbody's greatest potential for water quality given historical 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 beneficial 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 due to climate, bedrock, soils, hydrology and other natural physiochemical differences yet allow differentiation between natural conditions and widespread or significant alterations of biology, chemistry or hydrogeomorphology due to human activity.

The basis for the value for each water quality target varies depending on the availability of reference data and sampling method comparability to the 2010/11 DEQ data. As discussed in **Appendix B**, there are several statistical approaches DEQ uses for target development; they include using percentiles of reference data or of the entire sample dataset, if reference data are limited. For example, if low values are desired, the sampled streams are assumed to be severely degraded, and there is a high degree of confidence in the reference data, the 75th percentile of the reference dataset or the 25th percentile of the sample dataset (if reference data are not available) is typically used. However, percentiles may be used differently depending on whether a high or low value is desirable, the representativeness and range of variability of the data, the severity of human disturbance to streams within the watershed, and size of the dataset. For each target, descriptive statistics were generated relative to any available reference data (e.g., BDNF or 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 towards the most protective reference dataset. Additionally, the target value for some parameters may apply to all streams in the Rock Creek TPA, whereas others may be stratified by bankfull width, reach type characteristics (i.e., ecoregion, gradient, stream order, and/or confinement), or by Rosgen stream type if those factors are determined to be important drivers for certain target parameters. Although the basis for target values may differ by parameter, the goal is to develop values that incorporate an implicit margin of safety (MOS) and are achievable. The MOS is discussed in additional detail in **Section 5.8.2**.

5.4.1 Water Quality Targets

The sediment water quality targets for the Rock Creek TPA are summarized in **Table 5-3** and described in detail in the sections that follow. Sediment-related targets for the Rock Creek TPA are based on a combination of reference data from the BDNF, from the Middle Rockies portion of the Montana PIBO dataset, and sample data from the DEQ 2011 sampling effort. **Appendix C** provides a summary of the DEQ 2011 sample data and a description of associated field protocols.

Consistent with EPA guidance for sediment TMDLs (U.S. Environmental Protection Agency, 1999), water quality targets for the Rock Creek TPA are comprised of 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. Water quality targets most closely linked to sediment accumulation or sediment-related effects to aquatic life habitat are given the most weight (i.e., fine sediment and biological indices).

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 or more target values 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 within a watershed may warrant the selection of unique indicator values that differ slightly from those presented below, or special interpretation of the data relative to the sediment target values.

Table 5-3. Sediment Targets for the Rock TPA

Parameter Type	Target Description	Target Value
Fine Sediment	Percentage of fine surface sediment ≤ 6mm in riffles via pebble count (reach average)	≤ 13% (excludes E channels) ≤ 30% (E channels only)
	Percentage of fine surface sediment ≤ 2mm in riffles via pebble count (reach average)	≤ 11% (excludes E channels) E channels: No target
	Percentage of fine surface sediment < 6mm in pool tails via grid toss (reach average)	≤ 9% (excludes E channels) E channels: No target
Channel Form and Stability	Bankfull width/depth ratio (reach average)	B stream type: < 16
		C stream type: < 23
		E & A stream types: < 12
	Entrenchment ratio (reach median)	A stream type: < 1.4
		B stream type: 1.4-2.2
		C and E stream types: > 2.2
Pool Features	Residual pool depth (reach average)	< 15' bankfull width : > 0.7 (ft)
		> 15' bankfull width : > 1.4 (ft)
	Pools/mile	< 15' bankfull width : ≥ 117
		> 15' bankfull width : ≥ 52
Riparian Health	Percent of streambank with understory shrub cover (reach average)	≥ 60% understory shrub cover (where potential exists)
	Percent of streambank with bare ground	1% (recent ground disturbance excluding water gaps or other BMPs)
	Percent of streambank with hummocking	0% (hummocking in water gap areas is excluded)
Sediment Supply	Riffle stability index	<70 for B stream types
		>45 and <75 for C stream types
Biological Index	Macroinvertebrate bioassessment threshold	O/E ≥ 0.80

5.4.1.1 Fine Sediment

The percent of surface fines less than 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 smother fish eggs by limiting oxygen availability (Irving and Bjorn, 1984; Weaver and Fraley, 1991; Shepard et al., 1984; Suttle et al., 2004). Excess fine sediment can also decrease macroinvertebrate abundance and taxa richness (Mebane, 2001; Zweig and Rabeni, 2001). Because similar concentrations of sediment can cause different degrees of impairment to different species, and even age classes within a species, and because the particle size defined as “fine” is variable and some assessment methods measure surficial sediment while others measure 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 percent fine sediment (Bjorn and Reiser, 1991; Mebane, 2001; Relyea et al., 2000). Bryce, et al. (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 < 2mm is 13% for fish and 10% for macroinvertebrates. Literature values are taken into consideration during fine sediment target development, but because increasing concentrations of fine sediment are known to be harmful to aquatic life, targets are developed using a conservative statistical approach consistent with **Appendix B**, and consistent with Montana's water quality standard for sediment as described in **Section 3.2**.

5.4.1.1.1 Percent Fine Sediment < 6mm and < 2mm 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 is an indicator of aquatic habitat condition that can point to excessive sediment loading. Pebble counts in 2011 were performed in four riffles per sampling reach for a total of at least 400 particles.

<u>*Less than 6mm*</u>

The BDNF reference data and the Montana Middle Rockies PIBO reference data were examined for fine sediment < 6 mm during the development of these targets. The BDNF reference data for pebble count was collected using the "zigzag" method, which includes both riffles and pools. The PIBO pebble count data are also a composite of riffle and pool particles. Both of these methods of collection likely result in a higher percentage of fines than a riffle pebble count, which was the method used for TMDL related data collection in the Rock Creek TPA, and because of this difference in methodology, the median statistic is applied (as discussed in **Section 5.4**) to reflect the desired condition. The PIBO reference dataset contains a large sample size and therefore targets for fine sediment < 6 mm are set at less than or equal to the median of the PIBO reference dataset **(bold** in **Table 5-4)**. Due to an inherently high percentage of fines typical in Rosgen Type E channels, E channel values were examined separately. Because of the large amount of data available for E channels from the BDNF reference dataset, E channel targets for percent fines < 6mm are set at ≤ 30. Target values should be compared to the reach average value from pebble counts.

<u>*Less than 2 mm*</u>

For fine sediment <2 mm, PIBO is the only reference data currently available. As mentioned in the above paragraph, PIBO pebble count data are a composite of riffle and pool particles, which are likely to result in higher fines than the DEQ riffle-only pebble count, and therefore the median is used to reflect the desired condition. Again, because there is a larger sample size for the PIBO dataset, targets for fine sediment < 2 mm are set a less than or equal to the median of the PIBO reference dataset (**Table 5-5**). Target values should be compared to the reach average value from pebble counts.

Table 5-4. PIBO Reference Dataset, BDNF IRMH selected sites, and 2011 Rock Creek TPA DEQ Data Summary Percent Fine Sediment < 6 mm.
Target values are indicated in bold.

Data Source	Sample Size (n)	Parameter	Summary
PIBO reference data (Montana only)	64	Median	**13**
2011 DEQ Sample Data (all data)	22	25th	10
BDNF reference (E channels only)	113	Median	**30**

Table 5-5. PIBO Reference Dataset, BDNF IRMH selected sites, and 2011 Rock Creek TPA DEQ Data Summary Percent Fine Sediment < 2 mm.
Target values are indicated in bold.

Data Source	Sample Size (n)	Parameter	Summary
PIBO reference data (Montana only)	64	Median	**11**
2011 DEQ Sample Data (all data)	22	25th	4

5.4.1.1.2 Percent Fine Sediment < 6mm in Pool Tails via Grid Toss
Grid toss measurements in pool tails assess 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 < 6mm in pool tails in the Rock Creek TPA, and three tosses, or 147 points, were performed and then averaged for each assessed pool.

Grid toss reference data for pool tails are available from the PIBO dataset. The 75th percentile of the PIBO reference data for pool tails is 16% and the median is 9% (**Table 5-6**). PIBO performs three grid tosses at every pool encountered, and DEQ performs three grid tosses in each scour pool encountered where appropriate sized spawning gravels have been identified and the potential for spawning exists. Given that the DEQ performs a grid toss only in pools where spawning gravels exist, the resulting fines may be higher in pools found in the PIBO reference dataset, and because of this difference, the median statistic of the PIBO reference data is applied (as discussed in **Section 5.4**) to reflect the desired condition. The pool grid toss target for fine sediment less than 6 mm is set at 9%, using the median of the reference dataset. Due to an inherently high percentage of fines in Rosgen Type E channels, and the lack of reference pool grid toss data specific to E channel types, no target value is set for E channels.

Table 5-6. PIBO Reference and 2011 Rock Creek TPA DEQ Data Percentiles for Percent Fine Sediment < 6 mm via Grid Toss in Pool Tails.
Target values are indicated in bold.

Data Source	Sample Size (n)	Parameter	Summary
PIBO Pool Tail	76	Median	**9**
		75th	16
DEQ 2011 Sample Data Pool Tail	20	Median	9
		25th	2

5.4.1.2 Channel Form and Stability
5.4.1.2.1 Width/Depth Ratio and Entrenchment Ratio
The width/depth ratio and the entrenchment ratio are dimensionless values representing fundamental aspects of channel morphology. Each provides a measure of channel stability, as well as an indication of the ability of a stream to transport and naturally sort sediment into a heterogeneous composition of fish habitat features (i.e., riffles, pools, and near bank zones). 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 coarse 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 as 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 signify that stream energy is concentrated in-channel during flood events versus having energy dissipation on 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 5 riffle cross section measurements.

Width/Depth Ratio Target Development
There is reference riffle width/depth ratio data for both the BDNF and PIBO datasets. The 2011 Rock Creek TPA dataset is primarily comprised of B and C channels and on average B channels tend to have a

smaller width/depth ratio than C channels (Rosgen, 1996). The target value for width/depth ratio is based on the BDNF reference dataset, which is stratified by Rosgen channel type. The width/depth ratio target for Rock Creek TPA B & C channel types is set at less than or equal to the 75th percentile of the reference value; and for A & E channels is set at less than 12 based on Rosgen stream type classification (**Table 5-7**).

Table 5-7. The 75th Percentiles of Reference Data used for Width/Depth Ratio Target Development

Data Source	Category	Sample Size (n)	Parameter	Summary
BDNF Reference	B channel type	30	75th	**16**
BDNF Reference	C channel type	40	75th	**23**

Entrenchment Ratio Target Development
Delineative criteria based on Rosgen stream type classification for entrenchment gives guidance of <1.4 for A, F and G streams, 1.4-2.2 for B streams, and >2.2 for C, E streams. These literature values will serve as the target ranges for entrenchment in the Rock Creek TPA **(Table 5-8)**.

Table 5-8. Entrenchment Targets for the Rock Creek TPA Based on the 25th Percentile of BDNF Reference Data

Rosgen Stream Type	Target Value
A, F, G	<1.4
B	1.4-2.2
C,E	>2.2

5.4.1.3 Pool Features
Pools are stream features characterized by slow moving, deep sections of the stream. These important components aid the balance between flow and sediment load by reducing stream velocity and storing water and sediment. The measure and comparison of pool features can have direct links to sediment load increases and its effect on stream form and function, as well as biological integrity. Pool features play an important role for aquatic life and fisheries by providing refuge from warm water, high velocity, and terrestrial predators. However, when sediment loads are excessive, pool habitat quality and frequency is often diminished as pools fill with sediment. When this happens, velocities increase, stream channels widen, and sediment is transported to other areas of the stream where it may be deposited into areas that have an additional impact on fisheries and aquatic life.

5.4.1.3.1 Residual Pool Depth
Residual pool depth, defined as the difference between the pool maximum depth and the pool 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 (Nielson et al., 1994; Bonneau and Scarnecchia, 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 LWD), 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 impair fish condition by altering habitat, food availability, and productivity (May and Lee, 2004; Sullivan and Watzin, 2010). Residual pool depth is typically greater in larger systems.

The definition of pools for the PIBO protocol is fairly similar to the definition used for the 2011 Rock Creek TPA sample dataset; both define a pool as having its maximum depth greater than or equal to 1.5 times the pool tail crest depth. However, the DEQ dataset could potentially have a greater pool frequency and more pools with a smaller residual pool depth because the DEQ protocol records all pools encountered, whereas the PIBO protocol only counts pools greater than half the wetted channel.

Because of the variance between the PIBO and DEQ methods of counting pools, the residual pool depth target is equal to or greater than the PIBO median value (**bold** in **Table 5-9**). Target comparisons should be based on the reach average residual pool depth value. Because residual pool depths may 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 which 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 5-9. PIBO Reference and 2011 DEQ Sample Data Percentiles for Residual Pool Depth (ft).
Targets are shown in bold.

Category	PIBO Reference			DEQ Sample Data		
	n	Median	25th	n	Median	75th
< 15 ft bankfull width	12	**0.7**	0.6	14	0.5	0.6
> 15 ft bankfull width	66	**1.4**	1.2	7	1.3	1.7

5.4.1.3.2 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 for many of the same reasons associated with the residual pool depth discussed above and also because it can be a major driver of fish density (Muhlfeld and Bennett, 2001; Muhlfeld et al., 2001). Sediment may limit pool habitat by filling in pools with fines. Alternatively, aggradation of larger particles may exceed the stream's capacity to scour pools, thereby reducing the prevalence of this critical habitat feature. Pool frequency generally decreases as stream size (i.e., watershed area) increases.

Again, because of the difference between the PIBO and DEQ pool identification, the median statistic of the PIBO reference data is applied (as discussed in **Section 5.4**) to reflect the desired condition. The pool frequency target is equal to or greater than the PIBO median value (**bold** in **Table 5-10).** 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 5-10. PIBO Reference and 2011 DEQ Sample Data Percentiles for Pool Frequency (pools/mile) and INFISH Riparian Management Objective Values.
Targets are shown in bold.

Category	PIBO Reference			DEQ Sample Data		
	n	Median	25th	n	Median	75th
≤ 15 ft bankfull width	12	**117**	84	15	127	158
> 15 ft bankfull width	66	**52**	24	7	40	56

5.4.1.4 Riparian Health

Although the following categories are not a direct measure of sediment, they do provide insight into the overall riparian quality. Riparian condition is often associated with factors that may be leading to increased sediment loads and the reduction of instream habitat.

During the 2011 DEQ sediment and habitat data collection, a riparian assessment method (ie, Greenline) (Montana Department of Environmental Quality, 2012b) was used to conduct a coarse survey of the riparian corridor and its general vegetation composition. The results are used here to infer riparian corridor health and bank stability.

5.4.1.4.1 Riparian Understory Shrub Cover

Interactions between the stream channel and the riparian vegetation along the streambanks are a vital component in the support of the beneficial uses of coldwater fish and aquatic life. Riparian vegetation provides organic material used as food by aquatic organisms and supplies LWD that influences sediment storage and channel morphology. Riparian vegetation helps filter sediment from upland runoff, stabilize streambanks, and it can provide shading, cover, and habitat for fish. During DEQ assessments conducted in 2011, ground cover, understory vegetation and overstory vegetation were cataloged at 10 to 20 foot intervals along the greenline at the bankfull channel margin along both sides of the stream channel for each monitoring reach. The percent of understory shrub cover is of particular interest in valley bottom streams historically dominated by willows and other riparian shrubs. While understory cover is important for stream health, not all reaches have the potential for dense understory shrub cover or they may have the potential for a dense riparian community of a different composition, such as wetland vegetation or mature pine forest.

At the 2011 assessment sites, the 75th percentile of understory shrub cover was 60%. Based on the 75th percentile, a target value of ≥ 60% is established for understory shrub cover in the Rock Creek TPA. This target value should be assessed based on the reach average greenline understory shrub cover value. For any reaches that do not meet the target value, the greenline assessment results will be more closely examined to evaluate the potential for dense riparian understory shrub cover.

5.4.1.4.2 Bare Ground along Greenline

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 was observed, leaving bare soil exposed, excluding water gaps and other BMPs. 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. Ground cover on streambanks is important to prevent sediment recruitment to stream channels. Sediment can wash in from unprotected areas due to snowmelt, storm runoff, or 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.

At the 2011 assessment sites, the 25th percentile and median of bare ground throughout all reaches was zero percent, and the median of this data set would typically be used; however, because the median value is zero percent and many streams may have a small amount of naturally-occurring recently disturbed bare ground, a target value of 1% is established for bare ground along the greenline for streams in the Rock Creek TPA. This does not apply to disturbed bare ground associated with water gaps or other BMPs.

5.4.1.4.3 Hummocking along Greenline

Hummocking occurs when hoof action associated with overgrazing in riparian areas creates pedestals of soil and vegetation surrounded by troughs of muddy areas. Overgrazing practices in the riparian area can significantly impact vitality and cover of principal native riparian and wetland species and can lead to soil compaction and erosion (U.S. Department of the Interior, Bureau of Land Management, 2001). Hummocking can lead to streambank instability, channel sloughing, increased fine sediment input, stream widening and bank compaction (U.S. Department of the Interior, Bureau of Land Management, 2006). Stream channels in narrow valley bottoms are particularly susceptible to the effects of overgrazing, as livestock tend to concentrate in these areas, rather than on steep upland slopes. Limiting the grazing intensity, frequency, or season of use in these highly sensitive areas provides opportunity to encourage plant vigor, regrowth, and minimize compaction of soils.

During the green line assessment at the 2011 sites (many of which have grazing occurring within the reach) the 25th percentile, median, and 75th percentile of all reaches show 0% hummocking. Therefore a target value of 0% is established for hummocking along the greenline for streams in the Rock Creek TPA. This target does not apply to hummocking in areas associated with water gaps or other BMPs.

5.4.1.5 Sediment Supply

Riffle Stability Index

The Riffle Stability Index (RSI) is an estimate of sediment supply in a watershed. RSI target values are established based on values calculated by Kappesser (2002), who found that RSI values between 40 and 70 in B channels indicate that a stream’s sediment transport capacity is in dynamic equilibrium with its sediment supply. Values between 70 and 85 indicate that sediment supplies are moderately high, while values greater than 85 suggest that a stream has excessive sediment loads. The scoring concept applies to any streams with riffles and depositional bars. Additional research on RSI values in C streams types was conducted in the St. Regis River watershed and applied in the St. Regis TMDL, for which a water quality target of greater than 45 and less than 75 was established based on Kappesser’s research and local reference conditions for least-impacted stream segments. For the Rock Creek TPA an RSI target value of < 70 is established for B streams, while values of > 45 and < 75 are established for C streams. The target should be compared with the mean of measurements within a sample reach. Streams types other than B and C will need to be reviewed on a case-by-case basis.

5.4.1.6 Biological Indices

Macroinvertebrates

Siltation exerts a direct influence on benthic macroinvertebrates assemblages by filling in spaces between gravel and by limiting attachment sites. Macroinvertebrate assemblages respond predictably to siltation with a shift in natural or expected taxa to a prevalence of sediment tolerant taxa over those that require clean gravel substrates. Macroinvertebrate bioassessment scores are an assessment of the macroinvertebrate assemblage at a site, and DEQ uses one bioassessment methodology to evaluate stream condition and aquatic life beneficial-use support. Aquatic insect assemblages 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.

The macroinvertebrate assessment tool used by DEQ is the Observed/Expected model (O/E). The rationale and methodology for the index is presented in the DEQ Benthic Macroinvertebrate Standard Operating Procedure (Montana Department of Environmental Quality, 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 and is expressed as a ratio of the Observed/Expected taxa (O/E value). However, scores in excess of 1.2 may not reflect the effects of sediment in the stream if there is an abundance of nutrients or a condition beyond the experience of the model, such as a large river system or a reference site not used to build the model. An O/E score of > 0.80 is established as a sediment target in the Rock Creek TPA, keeping in mind that scores over 1.2 may indicate excess nutrients or a condition beyond the experience of the 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, 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, measures that indicate an imbalance in sediment supply and/or transport capacity will also be used for TMDL development determinations.

Periphyton

Periphyton-based biometrics are presented in this document as supporting information for TMDL development; however no target is set for this parameter. Periphytonare algae that live attached to or in close proximity to the stream bottom. Algae are ubiquitous in Montana surface waters, easy to collect, and represented by large numbers of species. Different species are differentially sensitive to a variety of pollutants, and have been found to be useful indicators of nutrient and clean-sediment impacts. Measures of the structure of algal associations, such as species diversity and dominance, can be sensitive and useful indicators of water-quality impacts and ecological disturbance.

DEQ has used a variety of periphyton-based biometrics to help interpret stream water quality. DEQ's current approach uses pollutant-diagnosing biometrics based on stressor-specific increaser diatom taxa, as described in Teply (2010a; 2010b) and earlier documents (Bahls et al., 2008; Teply, 2010a; Teply and Bahls, 2006). Currently there are increaser-taxa biometrics available for nutrients and sediment in both the mountainous and plains regions of the state. The rationale and methodology for the periphyton-based biometrics is presented in the DEQ Periphyton Standard Operating Procedure (Montana Department of Environmental Quality, 2011).

5.4.2 Existing Condition and Comparison to Water Quality Targets

This section presents summaries and evaluations of relevant water quality data for Rock Creek TPA waterbodies appearing on the Montana 2012 303(d) List. The weight-of-evidence approach described earlier in **Section 4.1**, using a suite of water quality targets, has been applied to each of the listed water quality impairments. Data presented in the section comes primarily from sediment and habitat assessments performed by DEQ during summer of 2011. Results of the 2011 assessment are supported by additional data collected by DEQ in the DEQ Assessment Files and by data supplied by the BDNF. However, this section is not intended to provide an exhaustive review of all available data.

5.4.2.1 Antelope Creek MT76E002_061

Antelope Creek was not listed for sedimentation/siltation on the 2012 303(d) List; however, because of observations of sediment sources during field reconnaissance in June of 2011, the stream was assessed by the DEQ. Antelope Creek flows 7.2 miles from its headwaters to Rock Creek.

Physical Condition and Sediment Sources

In 2011, DEQ performed sediment and habitat assessments at two monitoring sites on Antelope Creek. The upstream site (ANTE 07-01) was located on private land. The site was inhabited by cattle, the riparian vegetation was grazed to stubble, and banks were heavily trampled and hummocky (**Figure 5-2**). A vegetation exclosure existed approximately 30 feet downstream of the site for a solar powered watering trough. The confined reach upstream of the sample site was also grazed and trampled. A dry stream channel started at station 380 and continued upstream into the confined reach. A dirt road existed approximately 100 feet from the stream on river left. The upper watershed mostly contained grassy slopes with some forest.

Stream channel measurements at the upper site resembled Rosgen type B4. Stream channel conditions at the site included B-type entrenchment, low width/depth ratios, poor riffle/pool development, and a gravel bottom with fines in low gradient areas. No LWD existed within the bankfull margin of the channel. Pool tails had spawning sized gravels, but the entire stream was trampled and not suitable for spawning. Silt accumulated in slow areas and on aquatic vegetation. No wetland species were found on banks; only grass species. The site had minimal understory with some cinquefoil and sage, but most were browsed. No overstory existed within the site. Many noxious weeds were noted above bankfull including mullein, thistle, and dock-leafed smartweed.

Figure 5-2. Riparian stubble and hummocky banks in ANTE 07-01

The downstream site on Antelope Creek (ANTE 21-01) was located on Montana State Trust Lands. Evidence of overgrazing existed throughout the site, although it appeared that no grazing had occurred for several months prior to sampling. Weeds were prevalent, and no understory or overstory existed. Multiple diversions existed above and below the sampled site. Evidence of channel manipulation occurred in places. A dirt road paralleled the stream, but only directly impacted the stream in a few places.

The downstream site resembled an E5 type channel with little entrenchment and low width/depth ratio; but did not have the sinuosity of an E type channel. The potential stream type is a small C4 type channel. The channel had long poorly developed riffles, abundant fine sediment, and very few pools (which were formed by sloughing bank material). The channel had no woody debris. Eroding banks were generally low and trampled, with hummocking along the entire channel on both sides. Clumps of grass had sheared into the stream in places. Banks were composed of fine material (<2 mm).

Comparison to Water Quality Targets

The existing data in comparison to the targets for Antelope Creek are summarized in **Table 5-11** (See **Figure 5-3** for map)**.** Macroinvertebrate scores and periphyton summaries are found in **Table 5-12**. All bolded cells represent conditions where target values are not met.

Table 5-11. Existing Sediment-Related Data for Antelope Creek Relative to Targets

Site ID	Target Stream Type	Field Slope (Percent)	Calculated Sinuosity	Mean BFW (ft)	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health		
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	Width/Depth Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground	Greenline % Hummocking
ANTE 07-01	B4	3.4	1.1	2.7	**17**	9	4	**8.3**	**2.7**	**0.20**	127	**2**	**2**	**71**
ANTE 21-01	C4	1.2	1.4	7.0	**56**	**36**	8	12.8	24.0	**0.36**	**42**	**0**	1	N/R*

* Not recorded - Although hummocking values were not recorded along the greenline in site ANTE 21-01, field notes and photos indicate that the entire site had hummocky banks.

Table 5-12. Antelope Creek Macroinvertebrate and Periphyton Summary

Site ID - DEQ	Sample Date	Macroinvertebrates		Periphyton	
		O/E Score	Pass/Fail	Impairment Probability	Impairment Class
ANTE 08-01	8/10/11	**0.37**	**Fail**	72.45%	Impaired
ANTE 21-03	8/12/11	**0.28**	**Fail**	55.66%	Impaired

Figure 5-3. Antelope Creek DEQ Assessment Sites

Summary and TMDL Development Determination

Both sites exceeded < 6mm fine sediment targets in riffles and the lower site exceeded the <2 mm fine sediment target value. The upper site failed to meet channel form targets. The lower site did not meet the pool frequency target. Both sites failed to meet residual pool depth and most riparian health targets. Both sites failed to meet the O/E macroinvertebrate score and periphyton samples showed impairment. Current and historical grazing practices contribute to high fine sediment percentages within the stream, which is likely limiting its ability to support fish and aquatic life. Fine sediment values were more than double the target values in riffles in the lower site, pool habitat targets were not met at the lower site, and all greenline targets were not met at either site. Because of these factors and obvious sediment sources, a sediment TMDL will be written for Antelope Creek.

5.4.2.2 Brewster Creek MT76E002_050

Brewster Creek is listed for sedimentation/siltation on the 2012 303(d) List. In addition, Brewster Creek is also listed for low flow alterations; which is a non-pollutant form of pollution commonly linked to sediment impairment. Brewster Creek flows 4.6 miles from the East Fork of Brewster Creek to the mouth (Rock Creek).

Physical Condition and Sediment Sources

In 2011, DEQ performed sediment and habitat assessments at two monitoring sites. The upstream site (BREW 05-01) was located on USFS land. The site was located in forest adjacent to USFS road approximately 10 feet from the stream in places. The upper watershed had historically been logged and mined. Evidence of historical logging existed within the riparian area (stumps). No evidence of grazing existed.

The upstream site resembled a B4 type stream, but was similar to an F4b in areas with entrenchment. Stream had a gravel bed with poor riffle development, and long runs and drops created by LWD. Several split channels existed with obvious aggradation. One split channel occurred below a large wood jam. Few fines existed throughout the channel. Pool tails had good spawning sized gravels. Pools were formed by LWD and lateral scour. Eroding banks were well vegetated and undercut with a lot of cobble; and were located on outside meander bends. Erosion was possibly influenced by road encroachment in places, but most erosion appeared to be natural. The site had a very dense understory of birch, currants and raspberry bushes. Some grasses occurred on banks but were mostly forbs. Grass may have been shaded out by dense canopy of tall birch, ponderosa pine and spruce. Some wetland vegetation occurred in the lower part of site and a few weeds (thistle) were noted. Riparian vegetation appears lush and in good health (**Figure 5-4**).

Figure 5-4. Healthy riparian area on Brewster Creek

The downstream site on Brewster Creek (BREW 06-01) was located on private land. Only 800 feet of this site could be surveyed due to access. The site was in a rural residential area, where two homes were within the surveyed site and many residences were upstream (permanent and recreational). Several small bridges existed within the channel (above bankfull). Two diversions existed within the site. Vegetation had been cleared on the left bank adjacent to a residence. A rock wall existed on the same left bank, where a cabin sits 20 feet from the stream. A small pond was present on river right, approximately 25 feet from stream. Historical logging and mining has occurred upstream.

The downstream site resembled an F4 type channel with entrenchment, long runs, poor riffles, and several large plunge/dam pools. Most pools were created by lateral scour. Hand-built rock dams on cell 4 created some pool habitat, but these dams have the potential to be blown out during high flows. A lot of LWD occurred within bankfull, although woody vegetation had been cleared in places adjacent to residences. This site had well vegetated banks with high density roots. A few taller eroding banks existed where downcutting occurs. All banks were slowly eroding, with root mass providing stabilization. The worst eroding banks occurred near bridges. The banks had good grass cover, but no wetland vegetation. A thick understory existed of dogwood, willow, birch, currants and others. A thick overstory existed with cottonwoods and spruce.

Comparison to Water Quality Targets

The existing data in comparison to the targets for Brewster Creek are summarized in **Table 5-13** (See **Figure 5-5** for map). Macroinvertebrate scores are found in **Table 5-14.** All bolded cells represent conditions where target values are not met.

Table 5-13. Existing Sediment-Related Data for Brewster Creek Relative to Targets

Site ID	Target Stream Type	Field Slope (Percent)	Calculated Sinuosity	Mean BFW (ft)	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health		
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	Width/Depth Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground	Greenline % Hummocking
BREW 05-01	B4	2.3	1.3	11.8	10	6	0	13.0	1.9	0.98	**63**	98	0	0
BREW 06-01	B4	2.0	1.4	10.8	6	3	3	**10.8**	1.4	1.36	**59**	85	**42**	0

Table 5-14. Brewster Creek Macroinvertebrate Summary

Site ID - DEQ	Sample Date	Macroinvertebrates	
		O/E Score	Pass/Fail
C02BRWSC10	8/3/04	0.87	Pass

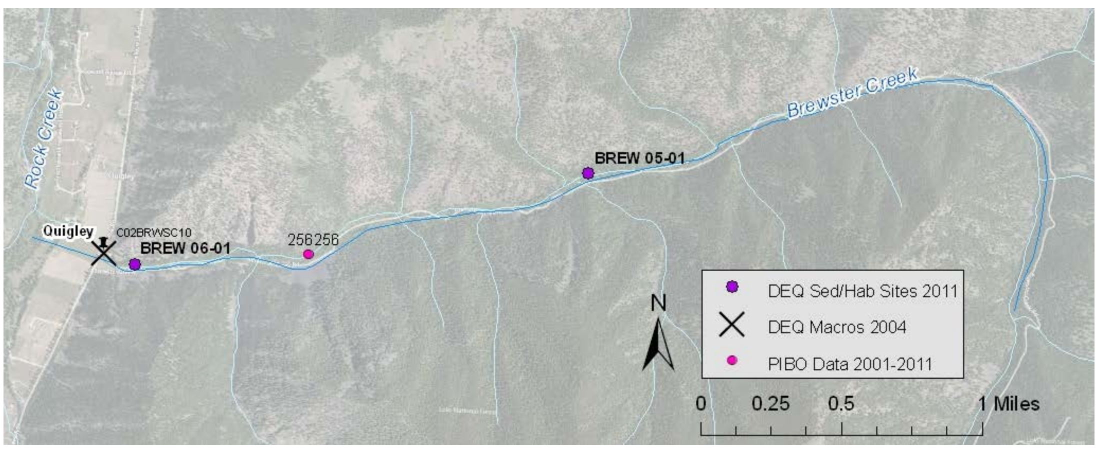

Figure 5-5. Brewster Creek DEQ Assessment Sites

Summary and TMDL Development Determination

Neither site exceeded fine sediment targets in riffles or pools. The lower site failed to meet the width to depth ratio target and the percent bare ground target. Both sites failed to meet pool frequency targets. Macroinvertebrates sampled in 2004 on Brewster Creek met the O/E target score. The upper site on Brewster Creek, despite its location paralleling the road and its historical logging, appeared to be recovering and did not exhibit a sediment impairment. The channel and streamside vegetation at the lower site had been modified by landowners adjacent to the site, with bridges, rip-rap, clearing of the riparian area, and creation of pools by damming. Although the stream appeared to have habitat alterations in areas close to residences on the lower site, there did not appear to be a sediment impairment within the stream and therefore, no sediment TMDL will be written for Brewster Creek. However, additional habitat alterations could lead to a sediment impairment, and therefore a sediment TMDL may be warranted in the future.

5.4.2.3 East Fork Rock Creek MT76E002_020

East Fork Rock Creek is listed for sedimentation/siltation on the 2012 303(d) List. In addition, East Fork Rock Creek is listed for alterations in streamside or littoral vegetative covers and low flow; which are non-pollutant forms of pollution commonly linked to sediment impairment. The East Fork Rock Creek segment flows 9.7 miles from the outlet of the East Fork Rock Reservoir to the mouth (Middle Fork Rock Creek).

Physical Condition and Sediment Sources

In 2011, DEQ performed sediment and habitat assessments at two monitoring sites on East Fork Rock Creek. The upper site (EFRK 01-02) was located mostly on USFS land, downstream of the East Fork Rock Creek Reservoir and diversion. The site had rural residents at the lower end and a USFS campground at the upper end. Evidence of rock dams existed across the stream in multiple locations. A pool created for filling water trucks existed near the campground. Hiking and other recreational use existed along banks, including a few constructed crossings.

The upper site was a C-type channel with some entrenchment into F-type channel. Riffles were well developed, while pools were long and wide with cobbles in pool-tails, especially where man-made dams were present. Spawning gravels were in good abundance, but non-typical, and generally occurred on sides of pools, even in dammed pools. Some small lateral scour pools occurred by large wood and willow bunches. Many fish were noted. Most eroding banks were stable, slowly eroding, well-vegetated, undercut, and located on outside meander bends; with patches of bare banks where undercuts had sloughed. Small recreational trails near the USFS campsite had caused patches of eroding banks, which had the potential to expand. Sedges and rushes were abundant along the stream edge with a willow understory and some young conifers. Grass species occurred in abundance upgradient from the stream edge. Weeds were lacking throughout the site.

The downstream site (EFRK 03-03) was located on private property in an agricultural valley. Evidence of historical grazing existed, but the site was likely not grazed in the year the field work occurred. Multiple diversions existed along the valley edge. A headgate and rock dam was located at station 876 with approximately 8 CFS of flow. A bridge existed at the bottom of the site. Moderate recreational use from fishing existed along the banks. Some return flows were noted along the channel, which could be an indication of old side channels. East Fork Reservoir and siphon diversion (the East Fork Irrigation Canal) exist upstream, which affected the flow regime in the stream at the site. An irrigation diversion (dam with tarp) existed just upstream of the site.

The downstream site had a low slope, with riffle dominated habitat, long runs, and minimal pool habitat. Pools were typically formed on inside meander bends or from cobbles and boulders. Existing channel type was a C4. Minimal spawning gravels were noted, typically occurring on inside slope of pools. A split channel existed from station 350 to 410. No wood was noted within the channel. Significant filamentous algae existed and fine substrate accumulated in the dense aquatic vegetation. Most eroding banks were well vegetated, undercut, and located on outside meander bends. Some evidence of past grazing existed, but most banks were sloughing into channel and recovering with strong-rooted wetland vegetation. Some bare banks also occurred where overland flow was entering into the stream channel. The stream edge was dominated by sedges with intermixed rushes. Grass existed on outside bends where sloughing has occurred. Site had no overstory and minimal understory vegetation. Very little willow was noted, with no mature species. Upland grasses were smooth brome, timothy, and canary reed grass. Bull thistle and mustard were also observed.

Comparison to Water Quality Targets

The existing data in comparison to the targets for East Fork Rock Creek are summarized in **Table 5-15** (See **Figure 5-6** for map). Macroinvertebrate scores are found in **Table 5-16.** All bolded cells represent conditions where target values are not met.

Table 5-15. Existing Sediment-Related Data for East Fork Rock Creek Relative to Targets

Site ID	Target Stream Type	Field Slope (Percent)	Calculated Sinuosity	Mean BFW (ft)	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health		
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	Width/Depth Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground	Greenline % Hummocking
EFRK 01-02	C4	0.1	1.7	24.6	6	3	1	22.1	**1.3**	**0.91**	84	**34**	**5**	0
EFRK 03-03	C4	0.9	1.3	21.4	8	3	1	14.3	3.6	**0.96**	**37**	**13**	1	0

Table 5-16. East Fork Rock Creek Macroinvertebrate Summary

Site ID - DEQ	Sample Date	Macroinvertebrates	
		O/E Score	Pass/Fail
C02ROCEF20	7/26/04	**0.33**	**Fail**

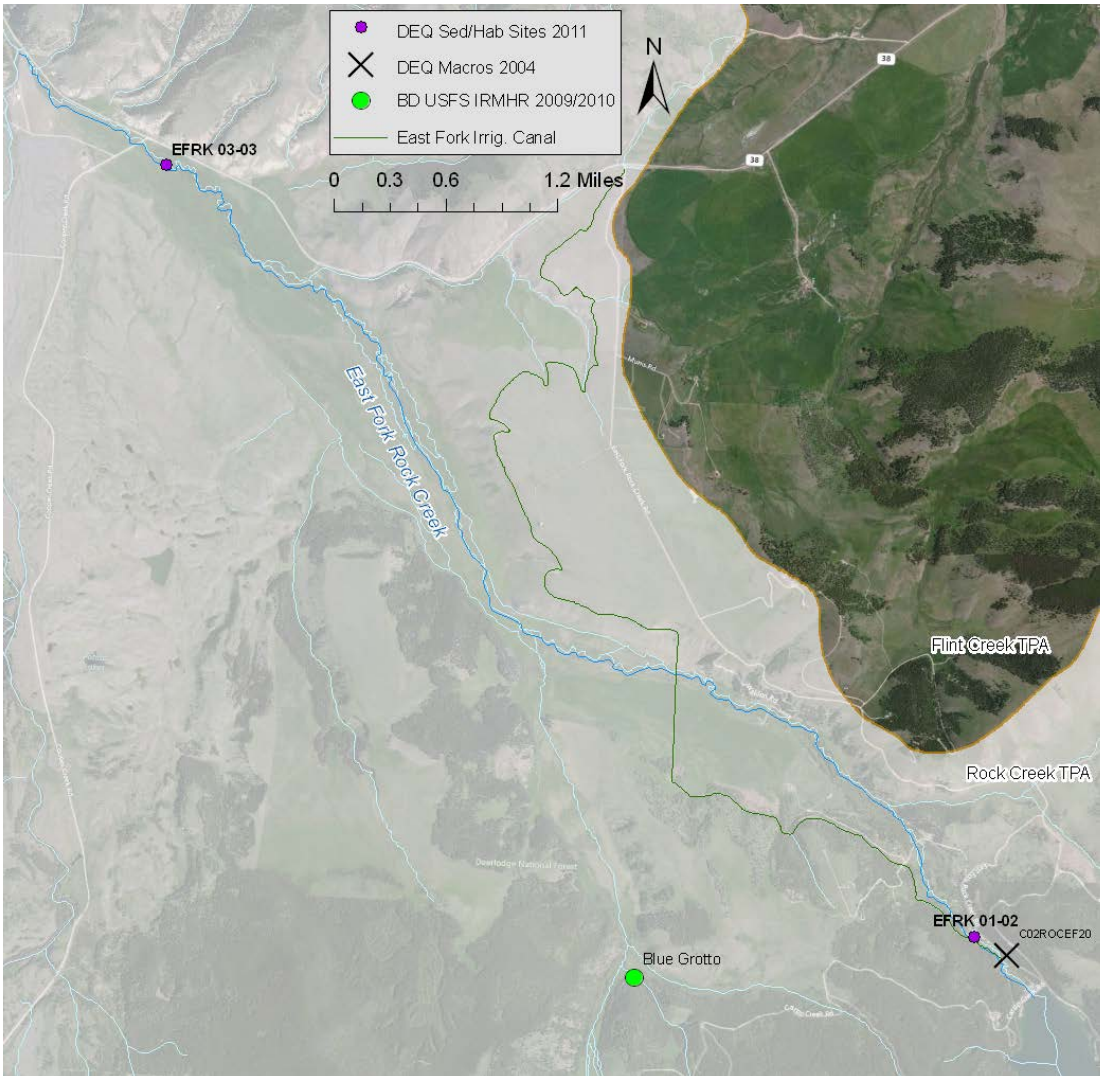

Figure 5-6. East Fork Rock Creek DEQ Assessment Sites

Summary and TMDL Development Determination

Both sites met fine sediment targets in riffles and in pools. Both sites met width to depth ratio targets, but the upper site failed to meet the entrenchment target. Both sites failed to meet residual pool depth and riparian shrub cover. The upper site failed to meet bare ground targets. However, the upstream site did meet the pool frequency target. The macroinvertebrate sample taken in 2004 failed to meet the O/E target score. Both the affected habitat from human manipulation of the stream channel at the upstream site (irrigation, recreation, residential) and grazing along the riparian area are contributing to sediment loading, which is likely limiting its ability to support fish and aquatic life; therefore a sediment TMDL will be written for East Fork Rock Creek.

5.4.2.4 Eureka Gulch MT76E002_090

Eureka Gulch is listed for sedimentation/siltation and solids on the 2012 303(d) List. In addition, Eureka Gulch is listed for alterations in streamside or littoral vegetative covers; which is a non-pollutant form of pollution commonly linked to sediment impairment. Eureka Gulch flows 0.6 miles from the confluence of Basin and Quartz gulches to the mouth (un-named ditch to Rock Creek).

Physical Condition and Sediment Sources

In 2011, DEQ requested access to perform a sediment and habitat assessment on Eureka Gulch, but was denied access. Therefore, observations from previous assessments and aerial photos (**Figure 5-7**) will be used to evaluate the stream.

Figure 5-7. Aerial Photo of Eureka Gulch

In 1996 and 1997, DEQ visited the Small Miners Exclusion Operation located on Eureka Gulch during high flows in April. The entire gulch bottom was disturbed from the mining operations. According to field notes, water was flowing like chocolate milk (see **Figure 5-8**). An extremely turbid plume of sediment was observed in the receiving waterbody on the T-Heart Ranch, which went from clear to opaque below Eureka Gulch. The lower settling pond was completely full and overflowing in the channel. The upper pond was full of turbid water, but not overflowing. The channel was extremely unstable and cutting vertically, where a diversion existed. Above the mine pit there was a very large amount of aggradation occurring with multiple channels cutting through the recently deposited substrate material. It appeared the material may have washed down from Quartz or Basin gulches.

Figure 5-8. Eureka Gulch in high flows 1997 – both leaving the pond and crossing Rock Creek Rd.

In 2004, DEQ revisited Eureka Gulch. The field crew noted that the whole valley bottom had been placer mined and all that was left was gravel and two ponds. No active mining was observed at the time of the visit. The two ponds were still present with an unstable channel connecting the two. There was very little vegetative growth across the valley bottom, mostly noxious weeds. Both ponds had significant amounts of algae growth. In the summer of 2005, a sediment catch basin was installed. The vegetation was taking some time to re-grow and there were still a lot of weeds present. Eureka Gulch is ephemeral and carries water only during spring runoff. How effective the catch basin has been throughout the last 7 years is unknown and no data or observations were collected at the time of sampling in 2011 due to denial of access to the site.

Comparison to Water Quality Targets

Turbidity was collected during the high flows in 1996 and 1997 and found to be very high, but the extent compared to natural is unknown. Total Suspended Solids (TSS) and turbidity were collected together in 1996. Assuming these TSS concentrations persisted for one week, a score of 9 on the Newcombe and Jensen Scale was achieved." Without associated TSS data from 1997, the impacts are unknown. It can be assumed by using the relative turbidity in 1996, that TSS levels were much higher for a duration in 1997 and were having detrimental effects on aquatic life. In the summer of 2004, the only flow observed was for a very short, spring fed section above the mine pit. The water was very cold and flow was estimated to be 0.3 cfs.

Because there is no existing sediment and habitat data to compare to targets set for the Rock Creek TPA, it is unclear if target values are being met. However, based on what is known about the stream, target values for a B4 channel with a bankfull width less than 15 will apply.

Summary and TMDL Development Determination

In June of 2012, Potentate Mining, LLC started work under Exploration License #00739 to test for placer gold. They are currently placer mining under SMES #46-144. The operation is approved to disturb 2.6 acres and has about $3,500 in obligated bond. They also have just under $6,500 in unobligated bond to draw on if they plan to expand their mining disturbance. This area was historically mined, most recently in the 90's, and because the channel was unstable and contributing large loads of sediment in high runoff events, a new sediment catch basin was installed in 2005. Since access was denied at the time of sampling, it is unclear if conditions in Eureka Gulch have improved. Because of this, the DEQ assumes that conditions are comparable to what they were in the 2004 reassessment and that the gulch has the potential to carry a high sediment load in a heavy spring runoff event; therefore, a sediment TMDL will be written. Eureka Gulch is also listed for solids (suspended bedload), which is a pollutant that falls within the sediment pollutant category. In developing the sediment TMDL, it is assumed that solids are also addressed since satisfying the sediment TMDL targets and sediment allocations addressing both fine and coarse sediment, will result in conditions consistent with reference or naturally occurring conditions.

5.4.2.5 Flat Gulch MT76E002_120

Flat Gulch is listed for sedimentation/siltation on the 2012 303(d) List. Flat Gulch flows approximately 3 miles from its headwaters to the mouth (Rock Creek).

Physical Condition and Sediment Sources

In 2011, DEQ performed a sediment and habitat assessment at two monitoring sites on Flat Gulch. The upper site (FLAT 12-01), was located on private property. Cattle grazing was actively occurring within the site. The entire section was heavily trampled with pugging and hummocking along the banks, low grasses, weeds, and browsed alder. A road crossing existed approximately 80 feet upstream of the top of site. Upper hillslopes were bare and were historically logged with many large stumps showing. The stream was trampled throughout, with poor feature development.

The upper site would likely be a B-type channel if grazing were excluded. The channel had some spawning size gravels at cattle crossings and areas without trampling, but mostly fine substrate dominated throughout the channel. LWD was primarily alder bunches with individual pieces smaller than 6 inches in diameter. Trampled eroding banks were found along the entire site, except at browsed alders where cattle could not access the stream, and grasses along banks were grazed down. Upland areas had many noxious weeds including thistle and mullein. Sparse understory consisted of alder and a few small aspen, which had been browsed by cattle. The only overstory consisted of one tall cottonwood and one aspen in the upper part of the site.

The downstream site on Flat Gulch (FLAT 13-01) may have been historically moved from the original channel. Extensive cattle grazing occurred upstream. Logging has historically occurred upstream and within the riparian area. A dirt road parallels within 50 feet of the stream, with a steep bank as a buffer.

At the downstream site, the stream was a B4a type channel with many fines, likely contributed from upstream. The channel had large gravel substrate covered by a layer of fine silt, and a steep slope (around 10% in some locations), with some step-pool development. Riffles were poorly developed throughout the channel. Pools were poor quality scour and LWD dam pools, with many fines and organic debris. A large amount of LWD occurred within the channel, with some aggregates in the stream channel. Banks were stable, with some small vegetated slowly-eroding banks. Some influence from past placer mining and grazing was evident with berms along the channel and hummocky banks. The banks were covered in grass, with some wetland vegetation. A good understory existed with raspberry and alder. Many forbs occurred throughout the site, including some weed species (thistle, mullein, and knapweed). Good overstory occurred throughout the site, with tall firs and a few small conifers.

Comparison to Water Quality Targets

The existing data in comparison to the targets for Flat Gulch are summarized in **Table 5-17** (See **Figure 5-9** for map). Macroinvertebrate scores are found in **Table 5-18.** All bolded cells represent conditions where target values are not met.

Table 5-17. Existing Sediment-Related Data for Flat Gulch Relative to Targets

Site ID	Target Stream Type	Field Slope (Percent)	Calculated Sinuosity	Mean BFW (ft)	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health		
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	Width/Depth Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground	Greenline % Hummocking
FLAT 12-01	B4a	5.1	1.3	2.7	**42**	**31**		**7.0**	**5.1**		**0**	**39**	0	**83**
FLAT 13-01	B4a	5.0	1.2	3.3	**49**	**44**		**11.8**	**4.2**	**0.28**	**84**	63	0	0

Table 5-18. Flat Gulch Macroinvertebrate Summary

Site ID - DEQ	Sample Date	Macroinvertebrates	
		O/E Score	Pass/Fail
C02FLATG01	8/7/09	**0.35**	**Fail**
C02FLATG01	9/11/09	**0.50**	**Fail**
C02FLATG02	8/6/09	**0.50**	**Fail**
C02FLATG02	9/10/09	**0.43**	**Fail**
C02FLATG10	8/7/09	**0.56**	**Fail**
C02FLATG10	9/12/09	**0.56**	**Fail**

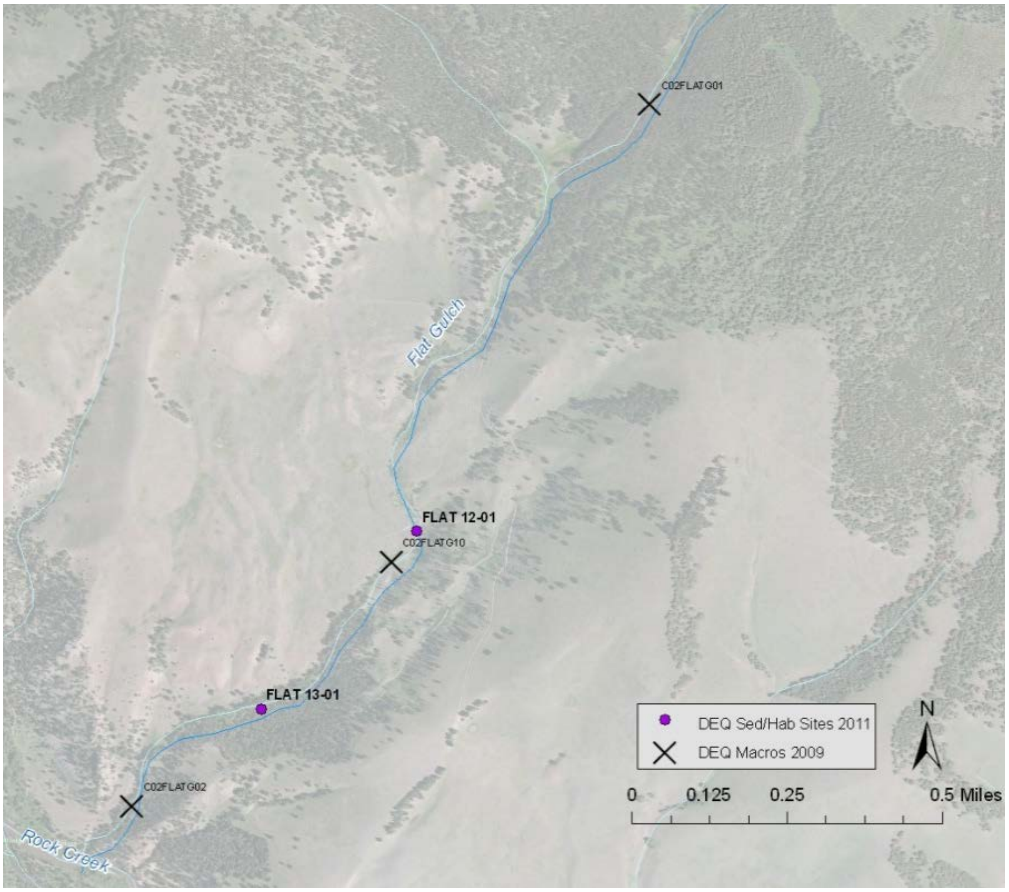

Figure 5-9. Flat Gulch DEQ Assessment Sites

Summary and TMDL Development Determination

Fine sediment targets were well exceeded in riffles. Pool frequency and residual pool depth failed to meet target values in the lower site and no pools were found in the upper site due to a trampled channel. Riparian health throughout the upper site was compromised because of recent browse. All six sites sampled in 2009 for macroinvertebrates failed to meet the O/E macroinvertebrate target score. Current and historical grazing practices contribute to high fine sediment percentages within the stream, which is likely limiting its ability to aquatic life. Because fine sediment targets were more than triple the target values in riffles; and pool habitat targets were not met, a sediment TMDL will be written for Flat Gulch.

5.4.2.6 Miners Gulch MT76E002_160

Miners Gulch is listed for sedimentation/siltation on the 2012 303(d) List. Miners Gulch flows 5.4 miles from its headwaters to the mouth (Upper Willow Creek).

Physical Condition and Sediment Sources

In 2011, DEQ performed a sediment and habitat assessment at two monitoring sites on Miners Gulch. The upper site (MINE 10-02), was located USFS land. The site had been logged historically and more recently up to the stream channel. Evidence of past mining existed at the site (small closed adits). The forest road was approximately 100 meters upslope from the channel. Many fines existed throughout the site. There was no evidence of grazing.

The stream at the upper site was a type B4 channel, with a step-pool system and poor riffle development. Pools were formed by boulders and LWD (dam pools), with few lateral scour pools. Many fines existed in pools and throughout the channel. Few spawning-sized gravels were noted. Abundant LWD occurred in the channel, with a mix of individual pieces and alder bunches. Several fish were seen in the stream (4-6 inches in length). The channel had slowly eroding vegetated banks with high root density and mostly natural sources of bank erosion. Despite past logging and mining in the area, banks appeared stable due to dense root mass. Riparian vegetation was thick with alder and currant up to 15 feet tall. Some overstory existed with lodgepole pine, Douglas fir and spruce; although lodgepole appear to be dying. Banks were well vegetated with grasses and sedges. A few weeds occurred in the riparian area, including thistle.

At the downstream site on Miners Gulch (MINE 14-02), historical mining and logging occurred upstream of the site, but there was no evidence of recent activity. The site was in open agricultural land that was historically logged. Hayfields occurred downstream on Upper Willow Creek, but not at the Miners Gulch site. Old cabins and structures existed just upstream of the site.

The stream channel at the downstream site resembled an E4 type channel, with slight entrenchment and a very low width to depth ratio, but lacked the sinuosity of an E-type channel. The channel had poor riffle and pool development. Decent spawning gravels existed, but riffles were somewhat embedded. Pool tails had good spawning gravels, without embeddedness. Pools were mostly lateral scour or dammed by LWD, and were shallow and not well defined. Stable banks occurred throughout the channel, except for two small actively eroding banks. Many slowly eroding banks occurred, but were stabilized with wetland vegetation. All bank erosion sources were natural. Hay grasses (brome and garrison) and wetland vegetation occurred on banks. Many willows existed throughout the site, but there was almost no overstory. The forest canopy existed upstream of the site on BLM land.

Comparison to Water Quality Targets

The existing data in comparison to the targets for Miners Gulch are summarized in **Table 5-18** (See **Figure 5-10** for map). Macroinvertebrate scores are found in **Table 5-20.** All bolded cells represent conditions where target values are not met.

Table 5-19. Existing Sediment-Related Data for Miners Gulch Relative to Targets

Site ID	Target Stream Type	Field Slope (Percent)	Calculated Sinuosity	Mean BFW (ft)	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health		
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	Width/Depth Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground	Greenline % Hummocking
MINE 10-02	B4	4.0	1.0	6.1	**37**	**14**	**14**	**5.8**	**9.2**	**0.65**	158	89	0	0
MINE 14-02	C4	1.5	1.2	6.4	**25**	**13**	**9**	**6.4**	2.2	**0.56**	137	70	0	0

Table 5-20. Miners Gulch Macroinvertebrate Summary

Site ID - DEQ	Sample Date	Macroinvertebrates	
		O/E Score	Pass/Fail
C02MNRSG10	8/2/04	0.70	**Fail**
C02MNRSG20	8/3/04	0.79	**Fail**

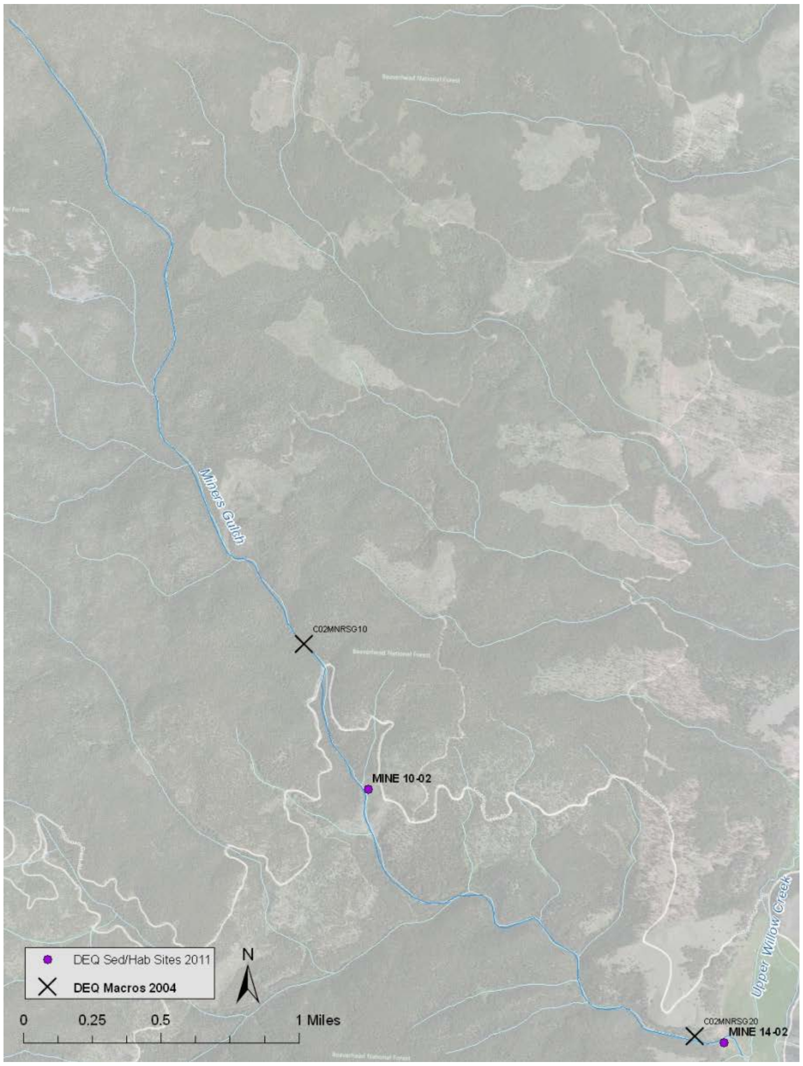

Figure 5-10. Miners Gulch DEQ Assessment Sites

Summary and TMDL Development Determination

Fine sediment targets were exceeded in riffles and pools at both sites. Width to depth ratios failed to meet target values at both sites, and the upper site did not meet the target value for entrenchment. Although pool frequency was good at both sites, residual pool depth at both sites failed to meet the target value. Macroinvertebrates sampled on Miners Gulch did not meet the O/E target score. All greenline targets were met at both sites. Although the stream channel seems to be recovering, the data show a fine sediment issue, which is likely limiting its ability to support fish and aquatic life. Because fine sediment targets were not met in riffles or pools and residual pool depth targets were not met, a sediment TMDL will be written for Miners Gulch.

5.4.2.7 Quartz Gulch MT76E002_070

Quartz Gulch is listed for sedimentation/siltation on the 2012 303(d) List. In addition, Quartz Gulch is listed for alterations in streamside or littoral vegetative covers; which is a non-pollutant form of pollution commonly linked to sediment impairment. Quartz Gulch flows 3.4 miles from its headwaters to the mouth (Eureka Gulch).

Physical Condition and Sediment Sources

In 2011, DEQ performed a sediment and habitat assessment at one monitoring site on Quartz Gulch. The site (QUTZ 09-01), was located on USFS land. The site was in a forested section just downstream of a constructed settling pond. The site appeared to have had restoration work, with cut LWD in the upper part of the site and geotextile fabric near the settling pond. The upland slopes had been logged recently, with a large clearcut upstream. Mining had occurred upstream and downstream of the site. An obliterated forest road ended at the top of the site near the settling pond. Some evidence of cattle grazing existed including cow manure and hummocky banks. A staff gage, with peak flow indicator, was located in cell 3. The seasonal peak flow measured approximately 0.4 to 0.5 feet on the gage.

At the site, the stream channel was entrenched throughout, with a riffle/pool sequence dominated by 32-45 mm size gravels and few fines. The low bankfull elevation (0.4 feet above the water surface) was likely buffered by the settling pond upstream of the site. Good riffles existed, with some point bar development. Pools were mostly dammed and plunge pools with LWD. Good spawning gravels existed in pool tails, with few fines. The lower cells (1-3) had a lower gradient than the upper cells (4-5). Well vegetated slowly-eroding banks occurred on outside meander bends, as the stream downcut and moved. Erosion created sloughed banks that became part of the active channel. Riparian vegetation was mostly grass and forbs on banks, with wetland vegetation on low banks. Large amounts of LWD occurred in the stream channel. The understory was composed of diverse willow, small conifers, raspberry, and chokecherry. Some small aspen were observed. Canopy was dense with old tall aspen, spruce, and Douglas fir.

Comparison to Water Quality Targets

The existing data in comparison to the targets for Quartz Gulch are summarized in **Table 5-21 (**See **Figure 5-11** for map). Macroinvertebrate scores are found in **Table 5-22.** All bolded cells represent conditions where target values are not met.

Table 5-21. Existing Sediment-Related Data for Quartz Gulch Relative to Targets

Site ID	Target Stream Type	Field Slope (Percent)	Calculated Sinuosity	Mean BFW (ft)	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health			Sediment supply
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	Width/Depth Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground	Greenline % Hummocking	RSI
QUTZ 09-01	A4	4.3	1.2	4.7	**14**	6	**18**	**12.6**	1.4	**0.52**	158	83	0	0	71

Table 5-22. Quartz Gulch Macroinvertebrate and Periphyton Summary

Site ID	Sample Date (DEQ)	Macroinvertebrates		Periphyton	
		O/E Score	Pass/Fail	Impairment Probability	Impairment Class
QUTZ 08-01 (U.S.)	8/9/11	**0.78**	**Fail**	72.45%	Impaired
QUTZ 08-01 (D.S)	8/9/11	0.85	Pass	95.00%	Impaired

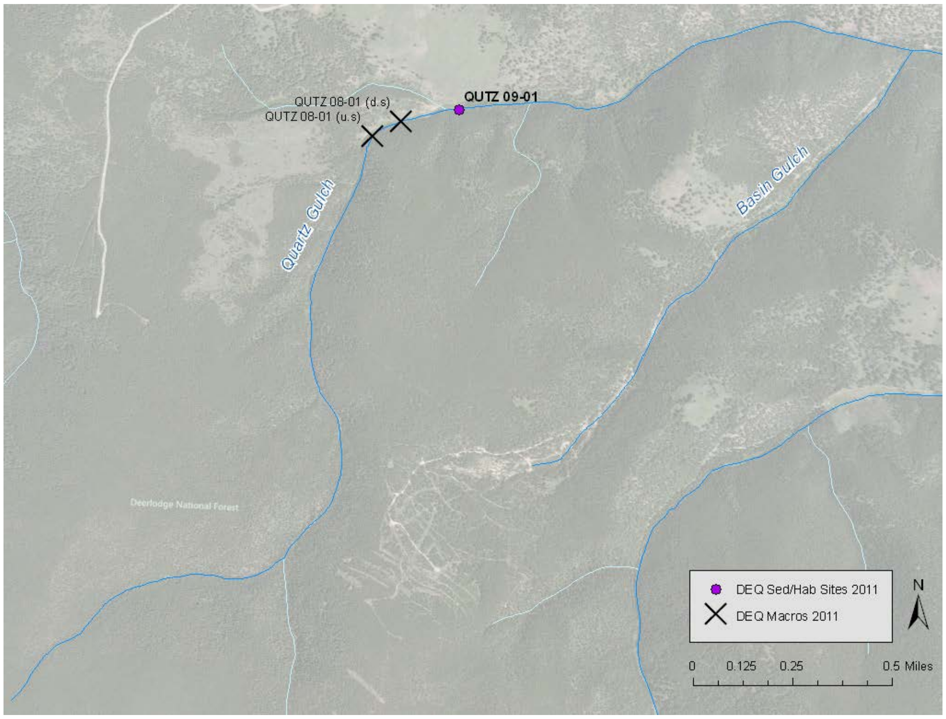

Figure 5-11. Quartz Gulch DEQ Assessment Site

Summary and TMDL Development Determination

Fine sediment in the channel exceeded the target values for percent less than 6 mm in riffles and in pools. Both the width to depth ratio and residual pool depth failed to meet target values. Historical placer mining in the gulch, timber harvest, and grazing impacts have contributed sediment to the stream. Macroinvertebrates did meet target scores at the downstream site, and just failed to meet target values at the upstream site. Although some restoration work has occurred and the stream seems to be in a state of recovery; fine sediment targets were exceeded in both riffles and pools, and width to depth ratio and residual pool depth targets were not met. Therefore, a sediment TMDL will be written for Quartz Gulch.

5.4.2.8 Scotchman Gulch MT76E002_100

Scotchman Gulch is listed for sedimentation/siltation on the 2012 303(d). Scotchman Gulch flows 6.9 miles from its headwaters to the mouth (Upper Willow Creek).

In 2011, DEQ performed sediment and habitat assessments at two monitoring sites on Scotchman Gulch. The first site (SCOT 08-01), was located on USFS land. At the upper site (SCOT 08-01); the lower portion of the site appeared to be modified by mining, and overwidened in places. The entire site was recently fenced around the riparian area, with solar electric fence installed (August 2011). A good riparian buffer existed on both sides of channel. Recent restoration may have occurred. Young willows were flagged in meadow sections of cells 4 and 5. Hummocky banks throughout the site suggested past grazing, but no recent evidence existed.

The stream channel at the upper site was in forest in the bottom three cells and in open meadow in the upper two cells. Large boulders existed in cell 3. No riffles existed in the meadow cells. Many fines were observed, with few spawning gravels. Pools were primarily lateral scour and LWD dam pools. Some LWD existed in the stream channel within the forested section. Eroding banks were primarily slowly-eroding vegetated banks that were recovering from heavy grazing. Many were overhanging and sloughing into the stream. The lower section of the site had berms from historical placer mining. The site had good overstory and understory in the bottom forested cells. Alder and willow made up the understory; with old aspen, Douglas fir, and lodgepole pine in the canopy. A few young aspens existed, but not many mid-aged aspens were found. Cattle exclusion (riparian fencing) could have been helping aspen recruitment. The meadow section had primarily grass (brome, timothy) and some young willows. The bottom of the site had some wetland vegetation, but grasses occurred throughout most of channel.

The lower site (SCOT 16-02) was located up from the mouth of stream in the middle of a hay field. Hay was cut within 10 feet of the stream channel. Upstream from the site the land was historically logged and mined. A small culvert occurred within the channel at station 370-380 for movement of hay equipment, but the culvert appeared to have little effect on stream morphology. A road crossing and small cabin existed just upstream of the site.

The stream at the lower site was engulfed in tall uncut hay grass and formed a stable channel with steep well vegetated banks. Bankfull was located at the top of the bench at the base of grasses. The stream channel was not entrenched and had access to the floodplain within hay grasses. The channel consisted of a crude step-pool type system, with no true riffles and some run-type features below pools. An abundance of fine sediment occurred within larger substrate, which was well embedded. Lower cells had lateral scour pools with no spawning gravels. The upper cells had rock dam pools with some spawning gravels. No LWD occurred within the channel. Slowly-eroding well-vegetated banks occurred on both sides of the stream. Undercut banks existed on meander bends. Thick hay grasses engulfed the entire stream channel. Some forbs were interspersed, but rare. One willow occurred at the bottom of the site, but hay grasses dominated throughout the site.

Comparison to Water Quality Targets

The existing data in comparison to the targets for Scotchman Gulch are summarized in **Table 5-23** (See **Figure 5-12** for map). Macroinvertebrate scores are found in **Table 5-24.** All bolded cells represent conditions where target values are not met.

Table 5-23. Existing Sediment-Related Data for Scotchman Gulch Relative to Targets

Site ID	Target Stream Type	Field Slope (Percent)	Calculated Sinuosity	Mean BFW (ft)	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health		
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	Width/Depth Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground	Greenline % Hummocking
SCOT 08-01	B4	2.6	1.1	6.6	**55**	**22**	**79**	**9.7**	1.9	**0.68**	158	**40**	0	0
SCOT 16-01	E4b	3.8	1.2	2.3	**59**	**45**	**26**	2.8	167.7	**0.43**	190	**7**	0	0

Table 5-24. Scotchman Gulch Macroinvertebrate Summary

Site ID - DEQ	Sample Date	Macroinvertebrates	
		O/E Score	Pass/Fail
C02SCTMG10	8/1/04	**0.77**	**Fail**
C02SCTMG20	8/2/04	0.87	Pass
C02SCTMG01	8/5/09	0.81	Pass
C02SCTMG01	9/15/09	0.81	Pass
C02SCTMG02	8/5/09	**0.56**	**Fail**
C02SCTMG02	9/13/09	**0.63**	**Fail**
C02SCTMG10	8/7/09	**0.77**	**Fail**
C02SCTMG10	9/14/09	0.84	Pass
C02SCTMG20	8/6/09	0.87	Pass
C02SCTMG20	9/12/09	**0.58**	**Fail**

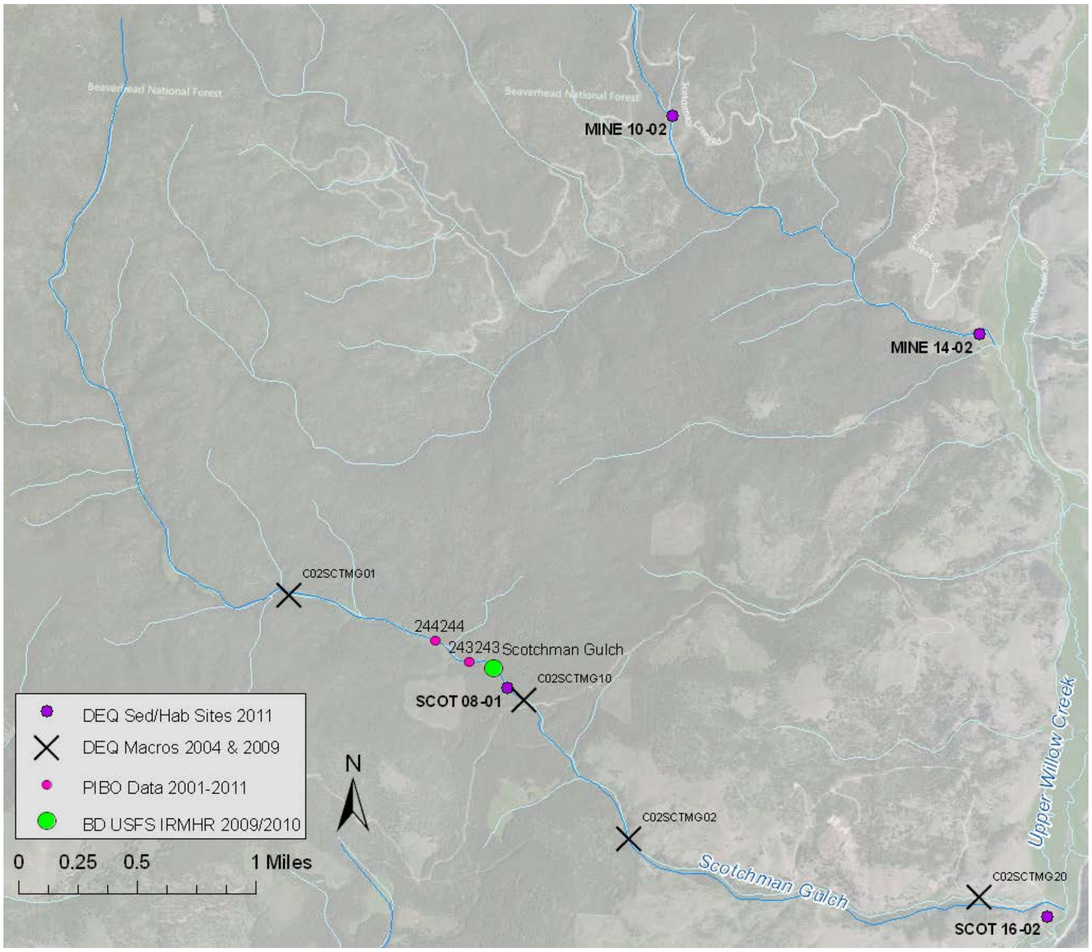

Figure 5-12. Scotchman Gulch DEQ Assessment Sites

Summary and TMDL Development Determination

Both sites far exceeded target values for fine sediment in riffles and pools. The upper site failed to meet width to depth ratios. Both sites failed to meet residual pool depth targets and understory shrub cover. The field measurements and observations indicate that fine sediment liberated from banks due to grazing (both historical and recent activities) and historical placer mining operations have contributed excess sediment loading to the stream that is likely limiting its ability to support fish and aquatic life; therefore, a sediment TMDL will be prepared for Scotchman Gulch.

5.4.2.9 Sluice Gulch MT76E002_110

Sluice Gulch is listed for sedimentation/siltation on the 2012 303(d) List. In addition, Sluice Gulch is listed for alterations in streamside or littoral vegetative covers; which is a non-pollutant form of pollution commonly linked to sediment impairment. Sluice Gulch flows 6.3 miles from the headwaters to the mouth (Rock Creek).

Physical Condition and Sediment Sources

In 2011, DEQ performed a sediment and habitat assessment at two monitoring sites on Sluice Gulch. At the upper site (SLUI 14-01) some evidence of historical grazing existed within the riparian area. A forest road paralleled the channel on river left; although, it did not appear to directly impact the stream. An old road grade existed closer to stream on river left, but it had been re-vegetated and contained many weeds.

The upper site was riffle dominated and moderately steep, with very few pools. Some entrenchment existed from downcutting, although much of the channel resembled a B4 type stream. The substrate was mainly gravel and cobbles. Pools were on steep outside meander bends or caused by LWD, which was lacking throughout the channel (only 2 individual pieces). Banks were relatively stable and recovering from historic grazing. Eroding banks were slowly eroding and well vegetated with grasses and weeds and had abundant surface protection from cobble. Eroding banks mainly occurred on outside meander bends. Some juniper understory existed, but was mostly lacking throughout the site. Mature aspen were found in the upper portion of the site, and ponderosa pine, spruce and juniper were encroaching upon the stream channel in the lower part of the site. Several weed species were noted; including thistle, mullein, and dock leafed smartweed.

Historical mining occurred both upstream from and at the lower site (SLUI 18-02). Tailings and placer workings were noted and the channel appeared to have been manipulated and channelized. The latest NHD high and mid resolution GIS layers show the stream in a different location than where it existed at the time of sampling. Some cattle grazing occurred along the riparian area, with animal crossings noted. Weeds were prevalent throughout the site.

The stream at the lower site had poorly developed features. Riffles were not well defined and a high amount of fines were noted. Pools were formed by lateral scour, with poorly developed pool tails. Some spawning gravels were noted in pool tails. Abundant algae and debris existed within the channel. The banks were stable and well vegetated, with tall grasses on both sides of the channel. Signs of grazing existed from the past year, which had created hummocky banks; however, at the time of sampling they were covered with tall grasses and appeared to be recovering. Grasses trapped silt that was released into the stream when banks were stepped on. The tall grasses and wetland vegetation covering the banks were primarily timothy grass and sedges. Some willows were present at the lower end of the site. One mature spruce tree and one mature cottonwood in the upper cells were the only canopy cover within the site. Several weed species were noted, including thistle and knapweed in the upper part of the site.

Comparison to Water Quality Targets

The existing data in comparison to the targets for Sluice Gulch are summarized in **Table 5-25**. (See **Figure 5-13** for map). Macroinvertebrate scores are found in **Table 5-26.** All bolded cells represent conditions where target values are not met.

Table 5-25. Existing Sediment-Related Data for Sluice Gulch Relative to Targets

Site ID	Target Stream Type	Field Slope (Percent)	Calculated Sinuosity	Mean BFW (ft)	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health		
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	Width/Depth Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground	Greenline % Hummocking
SLUI 14-01	B4a	2.5	1.3	6.9	**14**	2	**10**	**11.2**	1.9	**0.37**	**63**	**5**	0	0
SLUI 18-02	C4	2.0	1.2	6.9	**50**	**25**	**10**	13.6	**16.0**	**0.49**	158	**1**	0	0

Table 5-26. Sluice Gulch Macroinvertebrate Summary

Site ID - DEQ	Sample Date	Macroinvertebrates	
		O/E Score	Pass/Fail
C02SLUCG03	8/2/11	**0.78**	**Fail**
C02SLUCG02	8/2/11	**0.51**	**Fail**
C02SLUCG01	8/2/11	**0.43**	**Fail**

Figure 5-13. Sluice Gulch DEQ Assessment Sites

Summary and TMDL Development Determination

Fine sediment targets were exceeded for percent less than 6mm at riffles and pools at both sites and for fines less than 2mm in riffles at the lower site. The width to depth ratio at the upper site did not meet the target value. Residual pool depth targets were not met at either site; and the pool frequency target at the upper site was not met. Greenline understory shrub cover targets were not met at either site. Macroinvertebrates failed to meet the O/E target score. Current and historical grazing and channel manipulation on Sluice Gulch have contributed fine sediment to the stream which is likely limiting its ability to support fish and aquatic life. Because fines were notably high in field observations and field measurements showed that fine sediment targets were not being met, a sediment TMDL will be written for Sluice Gulch.

5.4.2.10 South Fork Antelope Creek MT76E002_060

South Fork Antelope Creek is listed for sedimentation/siltation on the 2012 303(d) List. In addition, South Fork Antelope Creek is listed for alterations in streamside or littoral vegetative; which is a non-pollutant form of pollution commonly linked to sediment impairment. South Fork Antelope Creek flows 2.9 miles from its headwaters to the mouth (Antelope Creek).

Physical Condition and Sediment Sources

In 2011, DEQ performed a sediment and habitat assessment at two monitoring sites on South Fork Antelope Creek. The upper site (SFAN 06-01), was located on private land. The site was in a forested area with significant grazing impacts. Hummocky banks occurred throughout the channel. Cattle were actively grazing upstream of the site. An old road existed approximately 5 to 30 feet from the stream. Upper hillslopes had been logged within the last 10 years, with some burnt slash piles just upstream of the site. Old cabins existed upstream in the grazed area.

The stream at the upper site resembled a C4b or E4b stream type, but did not have the sinuosity of an E-type stream and had a relatively high slope (4.5%). The potential stream type is likely C4b or B4. Pools were short and generally plunge type pools with LWD or boulders. Few spawning gravels existed. The stream mostly had long riffle/run sections, but resembled more of a step-pool type system in steeper sections. The lower site (cells 1 and 2) had a 4% slope, but the gradient increased to 8% in the steep middle section and was 3% in cell 5 (the flat portion of upper site). Abundant fine sediment occurred in most areas. Some LWD appeared mobile, but bigger pieces were anchored below bankfull depths. Both sides of the stream were heavily trampled by cattle throughout the entire channel, except for one section on river right between stations 244 and 356 where the bank was naturally armored with rock from a cliff above. Banks were held together with grasses and were very hummocky. This site had mostly grasses on banks but some wetland species (rushes and sedges) existed in the upper cells. A few forbs were noted, including cinquefoil in the upper site. The canopy had approximately 25% cover with lodgepole pine and spruce. Weeds were noted throughout the site, including thistle, knapweed and mullein.

The lower site (SFAN 13-01) was heavily trampled from cattle grazing. Hummocky banks existed throughout the channel, with short grazed grasses and shrubs. A culvert and road crossing existed at the bottom of the site. Slopes above the site had been logged and evidence of recent fire existed in the upper site.

The stream at the lower site was a steep (5+% slope) C4b/C5b type channel. The potential stream type was likely a B4. The channel was heavily trampled with poor riffle and pool features. Many fines existed throughout the channel. Some plunge type drops created some pool habitat. Few to minimal spawning gravels existed throughout the channel. Some LWD occurred in the form of willow clumps and dead logs from fire. Riffles were overwidened from grazing. Despite the human impacts on the stream, several fish were noted at time of sampling. Eroding banks were slowly-eroding and well-vegetated, with dense root mass. Heavy riparian grazing along the stream caused hummocky banks, which allowed the banks to slough off in places and cause fine sediment to enter the stream. Sedges were dominant throughout the site, with rushes in the upper portion. Recruitment of shrubby cinquefoil and aspen were noted in the lower cells, however, all plants were less than 2 feet tall and showed evidence of browsing by cattle. Many weeds occurred in upland areas, including thistle, knapweed and mullein.

Comparison to Water Quality Targets

The existing data in comparison to the targets for the South Fork Antelope Creek are summarized in **Table 5-27** (See **Figure 5-14** for map). All bolded cells represent conditions where target values are not met.

Table 5-27. Existing Sediment-Related Data for South Fork Antelope Creek Relative to Targets

Site ID	Target Stream Type	Field Slope (Percent)	Calculated Sinuosity	Mean BFW (ft)	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health		
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	Width/Depth Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground	Greenline % Hummocking
SFAN 06-01	B4	4.5	1.1	3.6	**29**	10	**11**	**11.6**	**5.3**	**0.37**	211	**8**	0	**95**
SFAN 13-01	B4	5.3	1.1	6.5	**41**	**18**	**21**	12.2	**4.4**	**0.48**	**116**	**11**	0	**7**

Figure 5-14. South Fork Antelope Creek DEQ Assessments

Summary and TMDL Development Determination

Fine sediment targets were exceeded for percent less than 6mm at riffles and pools at both sites and for fines less than 2mm in riffles at the lower site. The width to depth ratio target at the upper site failed to meet the target value and the entrenchment ratio at both sites did not fall within the target range. Residual pool depth targets were not met at either site; and the pool frequency target was not met at the lower site. Both sites failed to meet understory shrub target and hummocking target vales. Both instream pool habitat targets were not met. Current grazing is contributing a significant amount of fines to South Fork Antelope Creek, which is likely limiting its ability to fully support fish and aquatic life. Because fines were notably high in field observations and field measurements showed that fine sediment targets were not being met, a sediment TMDL will be written for South Fork Antelope Creek.

5.4.2.11 Upper Willow Creek MT76E002_040

Upper Willow Creek was not listed for sedimentation/siltation on the 2012 303(d) List. However, because of observations of potential sediment sources during field reconnaissance and because Upper Willow Creek is listed for alterations in streamside or littoral vegetative covers, low flow alterations, and physical substrate (which are non-pollutant forms of pollution commonly linked to sediment impairment), the stream was assessed by the DEQ. Upper Willow Creek flows 21.7 miles from its headwaters to the mouth (Rock Creek).

Physical Condition and Sediment Sources

In 2011, DEQ performed a sediment and habitat assessment at two monitoring sites on Upper Willow Creek. The upper site (UWIL 11-05) was located on private land. The channel at the upper site was in a hayfield with approximately 100 feet of uncut grass buffer on each side. Beaver had been eradicated from the area. The site was historically logged upstream and up to the stream channel. No evidence of recent grazing existed, but the site may have historically been grazed.

The stream at the upper site was a C4 type channel with some point bar development and dominated by riffle/run type habitat. Large gravels existed throughout the channel, with few fines noted. The substrate was not embedded. Few quality pools and spawning gravels existed. The channel appeared to be slightly straightened. LWD was mostly dead mature willow bunches browsed by beaver. New willows were establishing within the dead willow bunches. Eroding banks were mostly slowly-eroding and well-vegetated. Some actively eroding banks were stratified with a cobble layer below a clay layer. The banks were dominated by grass species (primarily garrison) with some wetland species (rushes and sedges). A few small willow bunches existed, with no overstory.

The lower site (UWIL 15-02) was in a hayfield, with hay cut 10 feet from the channel in places and up to 50 feet of uncut buffer in other locations. Some signs of grazing occurred at the site. Hummocky banks, sloughing, and low benches occurred in places. Upstream land use was mostly hay fields, with recent and historical logging and mining in tributary streams. A paved highway existed approximately 300 feet from the stream on river left. A bridge for hay equipment existed approximately 200 feet downstream of the bottom of the site.

At the lower site, the stream was a typical C4 type channel, with some point bar development and a consistent riffle/pool sequence. Substrate was not embedded, with few fines. Some good spawning gravels existed in pool tails. LWD was mostly comprised of willow bunches on banks. Riffles were mostly transverse-type riffles on corners, and pools were typically lateral scour. Two eroding bank types occurred, both on outside meander bends. One was an actively eroding type, with sloughing banks. The other type was a well vegetated undercut bank. Sources of erosion were cropland, grazing, and natural.

Hay grasses (brome and garrison) and reed canary grass occurred on banks throughout the site. Some understory and taller canopy of willows existed. Grasses on banks were dense, but a short (10 foot) buffer existed in places where hay was cut close to stream.

Comparison to Water Quality Targets

The existing data in comparison to the targets for Upper Willow Creek are summarized in **Table 5-28**. The macroinvertebrate bioassessment data for Upper Willow Creek is located in **Table 5-29** (See **Figure 5-15** for map). All bolded cells represent conditions where target values are not met.

Table 5-28. Existing Sediment-Related Data for Upper Willow Creek Relative to Targets

					Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health			Sediment Supply
Site ID	**Target Stream Type**	**Field Slope (Percent)**	**Calculated Sinuosity**	**Mean BFW (ft)**	**% < 6mm (mean)**	**% < 2mm (mean)**	**Pool % < 6mm (mean)**	**Width/Depth Ratio (mean)**	**Entrenchment Ratio (median)**	**Residual Pool Depth (ft)**	**Pools / Mile**	**Greenline % Shrub Cover**	**Greenline % Bare Ground**	**Greenline % Hummocking**	**RSI**
UWIL 11-05	C4	1.6	1.1	19.7	9	7		17.1	4.4	**1.08**	**32**	**18**	0	0	
UWIL 15-01	C4	0.5	2.3	21.1	11	7	**14**	16.5	10.2	2.11	74	**36**	0	0	**80**

Table 5-29. Upper Willow Creek Macroinvertebrate and Periphyton Summary

Site ID - DEQ	Sample Date	Macroinvertebrates		Periphyton	
		O/E Score	Pass/Fail	Impairment Probability	Impairment Class
UWIL 11-05	8/8/11	**0.57**	**Fail**	55.14%	Impaired
UWIL 15-01	8/8/11	**0.6**	**Fail**	37.43%	Unimpaired

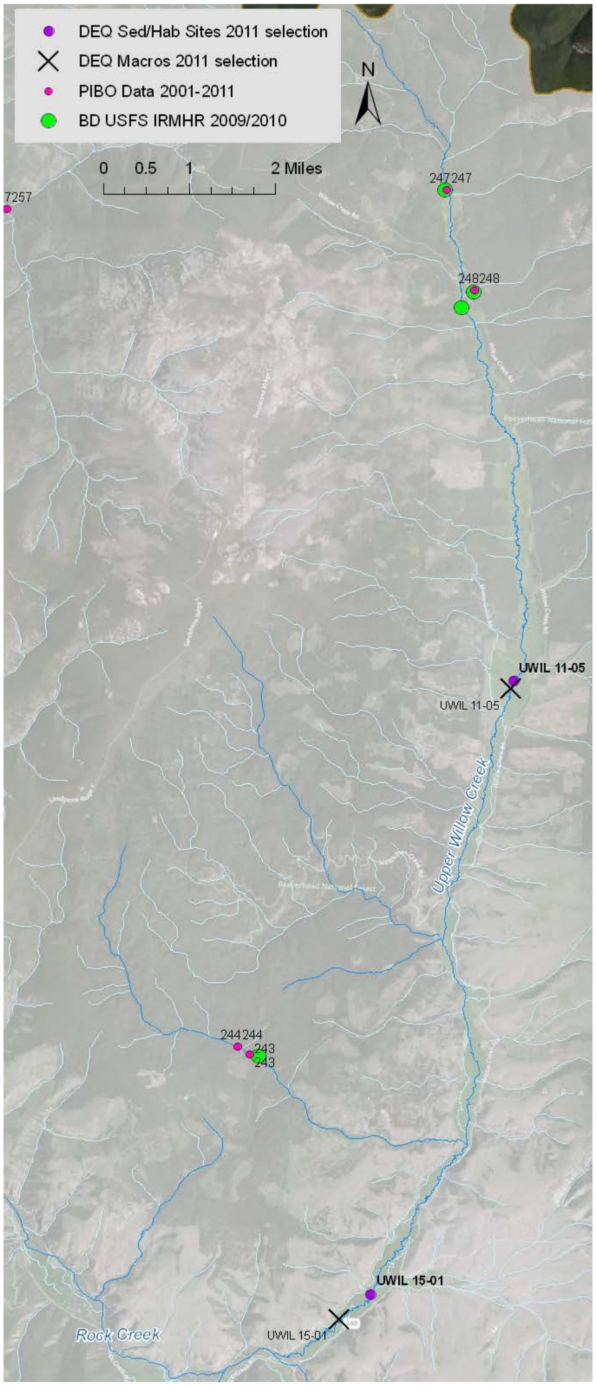

Figure 5-15. Upper Willow Creek DEQ Assessment Site and Macro Sites

Summary and TMDL Development Determination

Upper Willow Creek met most of the fine sediment targets, except for pool fines less than 6mm in the lower site. The upper site did not meet residual pool depth and pool frequency targets. Both sites did not meet the greenline understory shrub cover targets. And the lower site did not meet the RSI target. Macroinvertebrate O/E scores did not meet target values. Although Upper Willow Creek does appear to have some issues with instream and riparian habitat, the stream does not appear to have a sediment issue, therefore, a sediment TMDL will not be written for Upper Willow Creek.

5.4.2.12 West Fork Rock Creek MT76E002_030

West Fork Rock Creek was not listed for sedimentation/siltation on the 2012 303(d) List; however, because of observations of sediment sources during field reconnaissance in June of 2011, the stream was assessed by the DEQ. West Fork Rock Creek flows 25.2 miles from its headwaters to the mouth (Rock Creek).

Physical Condition and Sediment Sources

In 2011, DEQ performed a sediment and habitat assessment at three monitoring sites on West Fork Rock Creek. The upstream site (WFRK 14-03), was located on USFS land. The channel had been subjected to previous restoration attempts with numerous large logs and wood structures within the stream channel. Deep pools all had constructed wood structures that were anchored with large boulders. Many large cut logs had also been placed in the stream, some with metal rebar. The site appeared to have been historically grazed, but no evidence of grazing existed in the year of sampling. Logging and mining has likely occurred in the watershed above the sample site. A campsite existed at the lower end of the site, and debris was noted throughout the channel, including cans, bullet casings, and clay pigeons.

At the upstream site, the stream was an F5 type channel with low entrenchment values, high width/depth ratio, poor riffles, long compound pools connected by short runs, and a coarse sandy bottom (weathered granite) with some exposed gravels. Numerous pieces of LWD existed in the stream, but very few appeared natural. Some spawning sized gravels were noted. Old oxbows were evident outside of the channel. Man-made wood structures within the stream appeared to provide little benefit. More fine substrate was noted in the upper cells of the site. Streambanks were recovering from past grazing. Bank heights ranged from 1.7 to 4.6 feet and were all well vegetated, undercut and slowly eroding. There were many spots where overhanging banks had sloughed off in to the channel, leaving behind exposed banks. One large eroding bank may have been created by excavation outside of the stream channel on river right. Sedges existed on most banks, except where banks have sloughed into the channel and created grassy banks. The understory was composed of some small lodgepole pine and willow. No mature willows were noted within the site. The canopy was composed of one individual lodgepole pine. A good mix of forbs and grasses were noted outside of the stream channel.

The middle site (WFRK 27-02) was located in a forested area downstream of a bridge located on Skalkaho Road. A cabin existed on river left approximately 200 feet from the stream in cell 4. Evidence of recent grazing existed with short grasses and fresh cow dung in the upland area. The cabin area had a rock wall approximately 30 feet from the stream, with some clearing of vegetation. The site received some recreational use from fishermen. Logging had occurred in the upper watershed, and mining and ranching occurred downstream of the site.

The stream at the middle site was a B3 type channel with moderate entrenchment. At the upper cells, a step-pool system existed, but it became complicated by LWD jams and split channels in the middle cells. Compound pool habitat existed around wood jams, with short fast runs and poor riffles. Many large boulders existed with some fines accumulating in pocket water behind boulders. Pools tails did not contain many good spawning gravels. Abundant algae and vegetation were noted on rocks. The banks were well vegetated on both sides and had been undercut, allowing large trees to fall into the river during high flow. Sand had accumulated where trees have fallen into the channel. One tall bank on river left was actively eroding, but it was well armored by large cobble and boulders at the bottom of the bank. Banks were generally covered with sedges and rushes throughout the site. Many forb species were noted in the middle cells. The understory consisted of alder, birch, dogwood, and small conifers. The forest canopy consisted of mature fir and spruce, with abundant deadfall.

The downstream site (WFRK 30-02) was located on USFS land in the valley bottom. The upper cells were adjacent to the highway and had been channelized. The upper watershed (along Skalkaho Road) had been logged and mined both historically and recently. A highway bridge was within 500 feet of the top of the site. The site may have historically been grazed but showed no evidence of recent grazing. The site received minor recreational use from fishermen.

The stream at the downstream site was a typical C4b type channel in lower cells with good point bar development, good riffles, large pools, and some LWD (mostly willow clumps). The upper cells were encroached by the highway and more entrenched, similar to an F4b type channel. The stream appeared to be downcutting along the highway. Features in upper cells were not as well defined, with runs instead of riffles and increased fines. Considerable growth of aquatic vegetation and algae was noted. Eroding banks were mostly well-vegetated undercut banks, with a stratified cobble layer eroding on outside meander bends. As the cobble layer eroded and undercut, the top layer of vegetated bank slumped over and was eventually reforming banks. Banks ranged in height from 2 to 4 feet, which prevented establishment of wetland vegetation and made banks more prone to erosion. There were a few actively eroding banks with steep bank angles. The banks were well vegetated with grass species. Good understory existed with small and large willow clumps. Good wetland vegetation occurred on benches and sloughed banks, but tall banks prevented establishment of wetland vegetation, especially in entrenched areas. Some overstory existed from tall willows. Vegetation appeared stable and robust. A few noxious weeds were noted, including thistle, mullein and knapweed.

Comparison to Water Quality Targets

The existing data in comparison to the targets for West Fork Rock Creek are summarized in **Table 5-30** (See **Figure 5-16** for map). Macroinvertebrate scores are found in **Table 5-31**. All bolded cells represent conditions where target values are not met.

Table 5-30. Existing Sediment-Related Data for West Fork Rock Creek Relative to Targets

					Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health			Sediment Supply
Site ID	Target Stream Type	Field Slope (Percent)	Calculated Sinuosity	Mean BFW (ft)	% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	Width/Depth Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground	Greenline % Hummocking	RSI
WFRK 14-03	C4	1.5	3.0	28.8	**45**	**13**	**20**	22.7	**1.3**	1.66	**32**	**24**	**8**	0	
WFRK 27-02	B3	2.0	1.1	35.5	**13**	1		**21.3**	1.9	1.51	**42**	**31**	**13**	0	
WFRK 30-02	C3	1.8	1.3	44.2	7	3	0	**30.1**	**1.9**	1.73	**14**	**52**	0	0	66

Table 5-31. West Fork Rock Creek Macroinvertebrate and Periphyton Summary

Site ID - DEQ	Sample Date	Macroinvertebrates		Periphyton	
		O/E Score	Pass/Fail	Impairment Probability	Impairment Class
WFRK 14-03	8/10/11	**0.4**	**Fail**	25.49%	Unimpaired
WFRK 30-02	8/10/11	**0.43**	**Fail**	32.50%	Unimpaired

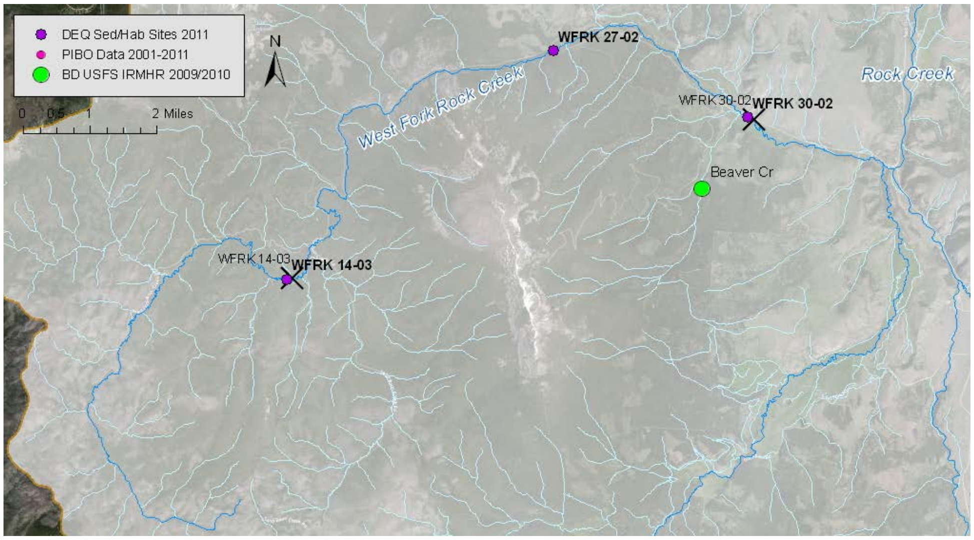

Figure 5-16. West Fork Rock Creek DEQ Assessment Site

Summary and TMDL Development Determination

Fine sediment targets were exceeded in both riffles and pools in the upstream site and fine sediment targets for percent less than 6mm were exceeded in the middle site. Width to depth ratio targets were not met in the middle and downstream sites and entrenchment ratio targets were not met in the upstream and downstream sites. Pool frequency and greenline understory shrub cover targets were not met in any of the sites. Greenline bare ground targets were exceeded in the upper and middle sites. Macroinvertebrate O/E scores also failed to meet target values. Because fines were notably high in field observations in the upper site and the existence of many sources of sediment that could continue to have a negative impact on habitat and sediment input to the stream, a sediment TMDL will be written for West Fork Rock Creek.

5.5 TMDL Development Summary

Based on the comparison of existing conditions to water quality targets, 10 sediment TMDLs will be developed in the Rock Creek TPA. **Table 5-32** summarizes the sediment TMDL development determinations and corresponds to **Table 1-1**, which contains the TMDL development status for listed waterbody segments in the Rock Creek TPA on the 2012 303(d) List.

Table 5-32. Summary of TMDL Development Determinations

Stream Segment	Waterbody ID	TMDL Development Determination (Y/N)
Antelope Creek*, headwaters to mouth (Rock Creek)	MT76E002_061	Y
Brewster Creek, East Fork to mouth (Rock Creek)	MT76E002_050	N
East Fork Rock Creek, East Fork Reservoir to mouth (Middle Fork Rock Creek)	MT76E002_020	Y
Eureka Gulch, confluence of Quartz and Basin gulches to mouth (un-named ditch)	MT76E002_090	Y
Flat Gulch, headwaters to mouth (Rock Creek)	MT76E002_120	Y
Miners Gulch, headwaters to mouth (Upper Willow Creek)	MT76E002_160	Y
Quartz Gulch, headwaters to mouth (Eureka Gulch)	MT76E002_070	Y
Scotchman Gulch, headwaters to mouth (Upper Willow Creek)	MT76E002_100	Y
Sluice Gulch, headwaters to mouth (Rock Creek)	MT76E002_110	Y
South Fork Antelope Creek, headwaters to mouth (Antelope Creek)	MT76E002_060	Y
Upper Willow Creek, headwaters to mouth (Rock Creek)	MT76E002_040	N
West Fork Rock Creek*, headwaters to mouth (Rock Creek)	MT76E002_030	Y

* Antelope Creek and West Fork Rock Creek were not on Montana's 2012 303(d) List for sediment

5.6 Source Assessment

This section summarizes the assessment approach, current sediment load estimates, and rationale for load reductions within the streams in the Rock Creek TPA that will have a sediment TMDL developed. There are no point sources in the Rock Creek TPA and therefore the focus is on the three potentially significant sediment source categories listed below and the associated controllable human-caused loading associated with each of these sediment source categories.

- streambank erosion
- upland erosion
- roads

EPA sediment TMDL development guidance for source assessments states that the basic source assessment procedure includes compiling an inventory of all sources of sediment to the waterbody and using one or more methods to determine the relative magnitude of source loading, focusing on the primary and controllable sources of loading (U.S. Environmental Protection Agency, 1999). Additionally, regulations allow that loadings "may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading" (Water quality planning and management, 40 CFR § 130.2(G)). The source assessments evaluated loading from the primary sediment sources using standard DEQ methods, but the sediment loads presented herein represent relative loading estimates within each source category, and, as no calibration has been conducted, should not be considered as actual loading values. Rather, relative estimates provide the basis for percent reductions in loads that can be accomplished via improved land management practices for each source category. These estimates of percent reduction provide a basis for setting load or wasteload allocations. As better information becomes available and the linkages between loading and instream conditions improve, the loading estimates presented here can be further refined in the future 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). The results include a mix of sediment sizes, particularly for bank erosion that involves both fine and coarse sediment loading to the receiving water; whereas loads from roads and upland erosion are predominately fine sediment.

The complete methods and results for source assessments for upland erosion, roads, and streambank erosion are located in **Appendices E, F,** and **G.** The following sections provide a summary of the load assessment results along with the basis for load reductions via improved land management practices. This load reduction basis provides the rationale for the TMDL load allocations defined in **Section 5.7**.

5.6.1 Eroding Streambank Sediment Assessment

Streambank erosion was assessed in 2011 at 22 assessment reaches discussed in **Section 5.3** to help obtain a representative dataset of existing loading conditions, causes, and the potential for loading reductions associated with improvements in land management practices. Sediment loading from eroding streambanks was assessed by performing Bank Erosion Hazard Index (BEHI) measurements and evaluating the Near Bank Stress (NBS) (Rosgen, 2006) along monitoring reaches in 2011. 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 instream energy
- natural sources
- other (typically refers to disturbance from past human activity that is not easily discernible due to elapsed time)

Based on the aerial assessment process (described in **Section 5.3**) in which each assessed stream segment is divided into different reaches, streambank erosion data from each 2011 monitoring site was used to extrapolate data and provide load estimates to the stream reach, stream segment and sub-watershed scales. Sediment load reductions were based on reducing BEHI values, assuming that implementing riparian best management practices (BMPs) practices will lead to improved streambank stability; and therefore achieve the naturally occurring condition. A more detailed description of the bank erosion assessment can be found in *Streambank Erosion Source Assessment,* which is included as **Appendix E**.

Assessment Summary

Based on the source assessment, streambank erosion contributes an estimated 7,101 tons of sediment within the streams in the Rock Creek TPA that will have a sediment TMDL developed. It is estimated that this sediment load can be reduced to 4,854 tons per year, which is a 32% reduction in sediment load from streambank erosion. Sediment loads due to streambank erosion range from 25 tons/year in Eureka Gulch to 2,880 tons per year in West Fork Rock Creek. The desired load is the estimate of the naturally occurring condition (the condition a waterbody could attain if all reasonable land, soil, and water conservation practices were put in place). The largest contribution of sediment loads due to streambank erosion in the Rock Creek TPA comes from natural sources, however, current and historical riparian grazing is the greatest anthropogenic contributor of sediment loads for most assessed sites in the Rock

Creek TPA. Bank erosion from transportation was the second largest anthropogenic contributor in many sites, where roads were confining the stream. Mining is the major source contributing to bank erosion in Eureka Gulch, but is not a primary source throughout the TPA. **Appendix E** contains additional information about sediment loads from eroding streambanks in the Rock Creek TPA by subwatershed, including all that were assessed. **Table 5-33** provides a summary of the bank erosion loads by each watershed where TMDLs are being developed in this document. **Table 5-33** also includes sediment load reduction information based on the application of BMPs. The load reduction approach and associated assumptions are described in **Appendix E**.

Table 5-33. Bank Erosion Results; Estimated Load Reduction Potential; and Resulting Loads after Application of Best Management Practices

Watershed	Total Bank Erosion Load (tons/year)	Estimated Load Reduction	Load After Application of BMPs (tons/year)
Antelope Creek (includes SF Antelope Creek)	691	40%	416
East Fork Rock Creek	984	9%	896
Eureka Gulch (includes Basin and Quartz gulches)	712	43%	407
Flat Gulch	280	58%	116
Miners Gulch	473	7%	439
Quartz Gulch	526	38%	324
Scotchman Gulch	683	31%	470
Sluice Gulch	398	46%	213
South Fork Antelope Creek	158	45%	87
West Fork Rock Creek	2880	34%	1897

5.6.2 Upland Erosion and Riparian Buffering Capacity

Upland sediment loading due to hillslope erosion was modeled using the Universal Soil Loss Equation (USLE). Sediment delivery to the stream was predicted using a sediment delivery ratio, taking into account riparian buffering. The Rock TPA riparian health assessment was used to develop a riparian health score based on the sediment reduction percentage for each individual stream segment subwatershed (See **Appendix F**). This value represents the percent reduction in sediment delivery from a nominal 100 foot wide riparian buffer under existing conditions. For the BMP scenario, it was assumed that the implementation of BMPs on those activities that affect the overall health of the vegetated riparian buffer will increase riparian health. The potential to improve riparian health was evaluated for each reach based on best professional judgment through a review of color aerial imagery from 2009 and on-the-ground reconnaissance. The USLE results are useful for source assessment as well as for determining allocations to human-caused upland erosion. This model provided an estimate of existing sediment loading from upland sources and an estimate of potential sediment loading reductions that could be achieved by applying BMPs in the uplands and in the near stream riparian area.

The sediment load allocation strategy for upland erosion sources provides for a potential decrease in loading through BMPs applied to upland land uses, as well as those land management activities that have the potential to improve the overall heath and buffering capacity of the vegetated riparian buffer. The allocation to these sources includes both present and past influences and is not meant to represent only current management practices; many of the restoration practices that address current land use will reduce pollutant loads that are influenced from historical land uses. A more detailed description of the assessment can be found in **Appendix F**.

Assessment Summary

Based on the source assessment, upland erosion contributes approximately 3,683 tons per year to the streams in the Rock Creek TPA that will have a sediment TMDL developed. The assessment indicates that rangeland grazing and hay production within the near stream riparian buffer are the most significant contributors to accelerated upland erosion. Sediment loads due to upland erosion range from 26 tons/year in the Quartz Gulch sub-watershed to 1,181 tons/year in the lower East Fork Rock Creek sub-watershed. Since this assessment was conducted at the sub-watershed scale, it is expected that larger watersheds will have greater sediment loads. A significant portion of the sediment load due to upland erosion is contributed by natural sources. **Appendix F** contains additional information about sediment loads from upland erosion in the Rock Creek TPA by subwatershed, including all 6th code HUCs in the TPA. In order to facilitate reporting of the upland sediment loading information following the allocation strategy specific to this source category the data from each sub-watershed located in the appendix was further manipulated by:

- All sources that generate < 1 ton of sediment per year were considered insignificant and were removed;
- Land use categories were lumped into these classes;
- Forest – Evergreen Forest, Wetlands, Transitional
- Range – Shrub / Scrub, Grassland / Herbaceous
- Agricultural – Pasture / Hay, Cultivated Crops
- Other – Mixed land use
- All sediment loads were rounded to the nearest ton

Table 5-34 below reports the existing loads and resulting loads after applying the BMP reductions**.** This information can be used as a basis for setting TMDL load allocations. (See **Appendix F** for more detailed information).

Table 5-34. Existing Upland Sediment Loads and Estimated Load Reduction Potential after Application of Upland and Riparian BMPs

Watershed	Estimated Existing Upland Sediment Load (tons/year)	Estimated Load Reduction Potential (% reduction)	Modeled Load After Application of Best Management Practices
Antelope Creek (includes SF Antelope Creek)	868	60%	350
East Fork Rock Creek	1181	66%	403
Eureka Gulch (includes Basin and Quartz gulches)	50	38%	31
Flat Gulch	34	38%	21
Miners Gulch	65	18%	53
Quartz Gulch	26	23%	20
Scotchman Gulch	42	33%	28
Sluice Gulch	530	60%	211
South Fork Antelope Creek	51	37%	32
West Fork Rock Creek	913	25%	689

5.6.3 Road Sediment Assessment

5.6.3.1 Erosion from Unpaved Roads

An assessment of the road network within the Rock TPA was performed as part of the development of sediment TMDLs for 303(d) listed stream segments with sediment as a documented impairment. This assessment employed GIS, field data collection, and sediment modeling to assess sediment inputs from the unpaved road network. Prior to field data collection, GIS data layers representing land ownership, road network, stream network, watersheds, and ecoregions were used to identify road crossings throughout the Rock TPA. Through GIS analysis, 339 road crossings were identified within the Rock TPA; 207 of which were identified as unpaved road crossings (gravel or native material) based on attribute information contained in the roads database (**Table 2-1**). During this initial GIS analysis, 125 crossings were identified with an 'unknown' surface type. Following the initial GIS analysis, road surface types were assigned to the 125 crossings with an 'unknown' surface type based on an assessment of proximal road segments located within the vicinity of each crossing lacking road surface type information. A total of 45 unpaved road crossings were randomly selected prior to field data collection. Thirty-four pre-selected and 7 alternative sites were visited in the field in October of 2011. Out of the 41 sites visited, 30 of the sites had a true road crossing and therefore field forms were completed at 30 sites. During field data collection, sediment inputs to stream channels from parallel road segments were not observed. Thus, no field data was collected along parallel road segments in the Rock TPA. For each unpaved crossing, a series of measurements were performed to characterize road design, maintenance level, condition, culvert size, and sediment loading potential.

Sediment loading from unpaved road crossings was estimated using the WEPP:Road soil erosion model version 2011.12.20. The WEPP:Road model was used to evaluate existing conditions at each road crossing based on the field collected data. The WEPP:Road model was also used to estimate the potential to reduce sediment loads through the application of BMPs. During field data collection, the location of potential BMPs, such as water bars and rolling dips, were identified and the distance to the stream crossing was measured. During the BMP modeling scenario, the contributing road length was reduced from the existing length to the potential BMP length based on the field measured values. A more detailed description of this assessment can be found in **Appendix G**.

Assessment Summary

Based on the source assessment, unpaved roads are contributing 1.8 tons of sediment per year to the streams in the Rock Creek TPA that will have a sediment TMDL developed. Sediment loads are all < 1 ton/year in each sub-watershed. Factors influencing sediment loads from unpaved roads at the watershed scale include the overall road density within the watershed, watershed size, and the configuration of the road network, along with factors related to road construction and maintenance. **Table 5-35** contains annual sediment loads from unpaved road crossings from the watersheds where TMDLs are developed within this document. **Table 5-35** also includes the percent load reduction by watershed based on the contributing road length BMP scenario which is further defined within **Appendix G**.

Table 5-35. Annual Sediment Load (tons/year) from Unpaved Road Crossings

Watershed	Total Estimated Existing Load (tons/year)	Percent Load Reduction After BMP Application	Total Sediment Load After BMP Application
Antelope Creek (includes SF Antelope Creek)	0.091	57%	0.039
East Fork Rock Creek	0.541	67%	0.181
Eureka Gulch (includes Basin and Quartz gulches)	0.020	50%	0.010
Flat Gulch	0.053	72%	0.015
Miners Gulch	0.199	67%	0.066
Quartz Gulch	0.013	69%	0.004
Scotchman Gulch	0.015	60%	0.006
Sluice Gulch	0.080	71%	0.023
South Fork Antelope Creek	0.021	62%	0.008
West Fork Rock Creek	0.790	62%	0.300

5.6.3.2 Culvert Failure and Fish Passage Analysis

Undersized or improperly installed culverts may be a chronic source of sediment to streams or a large acute source during failure, and they may also be passage barriers to fish. Therefore, during the roads assessment, the flow capacity and potential to be a fish passage barrier was evaluated for a subset of culverts. The flow capacity culvert analysis was performed on 27 culverts and incorporated bankfull width measurements taken upstream of each culvert to determine the stream discharge associated with different flood frequencies (e.g., 2, 5, 10, 25, 50, and 100 year) and measurements for each culvert to estimate its capacity and amount of fill material. Flood frequency refers to the probability that a flood of a certain magnitude for a given river will occur in a certain period of time. For example, a "100-year flood" event has a 1 in 100 probability of occurring in any given year or in other words, a 1% chance in any given year.

Though culvert failure represents a potential load of sediment to streams, a yearly load estimate is not incorporated into the TMDL due to the uncertainty regarding estimating the timing of such failures and a lack of monitoring information to track the occurrence of these failures.

Fish passage assessments were performed on 27 culverts. The assessment was based on the methodology defined in **Appendix G**, which is geared toward assessing passage for juvenile salmonids. Considerations for the assessment include streamflow, the culvert slope, culvert perch/outlet drop, culvert blockage, and constriction ratio (i.e., culvert width to bankfull width). The assessment is intended to be a coarse level evaluation of fish passage that quickly identifies culverts that are likely fish passage barriers and those that need a more in-depth analysis. Culverts with fish passage concerns may have elevated road failure concerns since fish passage is often linked to undersized culvert design.

Assessment Summary

Within the Rock Creek TPA, 23 of the 27 culverts assessed in the field (85%) are capable of passing the two-year flood event, while only nine of these culverts (33%) pass a 100-year flood event (see **Appendix G** for more details).

In the Rock Creek TPA, none of the culverts allowed fish passage, while 26 culverts (96%) were classified as fish passage barriers (**Appendix G**). No estimated annual load was incorporated into the TMDL due to an uncertainty of failure events and deficient monitoring information.

5.6.4 Point Sources

As of November 1, 2012, there were no Montana Pollutant Discharge Elimination System (MPDES) permitted point sources within the Rock Creek TPA.

5.7 Sediment TMDLs and Allocations

This section is organized by the following topics:

- Application of Percent Reduction and Yearly Load Approaches
- Development of Sediment Allocations by Source Categories
- Allocations and TMDLs for Each Stream
- Meeting the Intent of TMDL Allocations

5.7.1 Application of Percent Reduction and Yearly Load Approaches

The sediment TMDLs for the Rock Creek TPA will be based on a percent reduction approach discussed in **Section 4.** This approach will apply to the loading allocated among sources as well as each individual waterbody TMDLs. An implicit margin of safety will be applied as further discussed in **Section 5.8**. Cover and others (Cover et al., 2008) observed a correlation between sediment supply and instream measurements of fine sediment in riffles and pools; it is 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 attainment of the 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 best practices (i.e., 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 or 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 H**.

5.7.2 Development of Sediment Allocations by Source Categories

The percent-reduction allocations are based on the BMP scenarios for each major source type (e.g., streambank erosion, upland erosion, and roads. These BMP scenarios are discussed within **Section 5.6** and associated appendices, and 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.

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

5.7.2.1 Streambank Erosion

Sediment loads associated with bank erosion were identified by separate source categories (e.g., transportation, grazing, natural) in **Appendix E**. Because of the inherent uncertainty in extrapolating this level of detail to the watershed scale, and also because of uncertainty regarding impacts from historical land management activity, all sources of bank erosion were combined for the purpose of expressing the TMDL and allocations. Streambank stability and erosion rates are very 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.

5.7.2.2 Upland Erosion

No reductions were allocated to natural sources, which are a significant portion of all upland land use categories. 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. For all upland sources, the largest percent reduction will be achieved via riparian improvements.

5.7.2.3 Roads

The unpaved road allocation can be met by incorporating and documenting that all road crossings with potential sediment delivery to streams have the appropriate BMPs in place. Sediment loads delivered to streams from road crossings are minor and efforts in the Rock TPA to control sediment should focus on bank and upland erosion BMPs. However, routine maintenance of road 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 and, due to very low erosion potential linked to native vegetation growth on the road surface, additional BMPs may not be necessary.

5.7.3 Allocations and TMDLs for Each Stream

The following subsections present the existing quantified sediment loads, allocations and TMDL for each waterbody.

Allocation Assumptions

Sediment load reductions are given at the watershed scale, and are based on the assumption that the same sources that affect a listed stream segment affect other streams within the watershed and that a similar percent sediment load reduction can be achieved by applying BMPs throughout the watershed. However, it is acknowledged that conditions are variable throughout a watershed, and even within a 303(d) stream segment, and this affects the actual level of BMPs needed in different areas, the practicality of changes in some areas (e.g. considering factors such as public safety and cost-effectiveness), and the potential for significant reductions in loading in some areas. Also, as discussed in **Section 4.4**, note that BMPs typically correspond to all reasonable land, soil, and water conservation practices, but additional conservation practices above and beyond BMPs may be required to achieve compliance with water quality standards and restore beneficial uses.

Progress towards TMDL and individual allocation achievement can be gaged by adherence to point source permits, BMP implementation for nonpoint sources, and improvement in or attainment of water quality targets defined in **Section 5.4**. Any effort to calculate loads and percent reductions for purposes of comparison to 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 sediment TMDLs for all streams and stream segments presented below are expressed as a yearly load, and a percent reduction in the total yearly sediment loading achieved by applying the load allocation reductions identified in the associated tables (**Tables 5-36** through **5-45).** Each impaired segment's TMDL consists of any upstream allocations.

5.7.3.1 Antelope Creek (MT76E002_061)

Table 5-36. Sediment Source Assessment, Allocations and TMDL for Antelope Creek

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads	0.091	0.039	57%
Eroding Banks	691	416	40%
Upland Erosion	868	350	60%
Total Sediment Load	**1,559**	**766**	**51%**

Sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.

5.7.3.2 East Fork Rock Creek (MT76E002_020)

Table 5-37. Sediment Source Assessment, Allocations and TMDL for East Fork Rock Creek

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads	0.541	0.181	67%
Eroding Banks	984	896	9%
Upland Erosion	1181	403	66%
Total Sediment Load	**2,166**	**1,299**	**40%**

Sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.

5.7.3.3 Eureka Gulch (MT76E002_090)

Table 5-38. Sediment Source Assessment, Allocations and TMDL for Eureka Gulch

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads	0.02	0.01	50%
Eroding Banks	712	407	43%
Upland Erosion	50	31	38%
Total Sediment Load	**762**	**438**	**43%**

Sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.

5.7.3.4 Flat Gulch (MT76E002_120)

Table 5-39. Sediment Source Assessment, Allocations and TMDL for Flat Gulch

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads	0.053	0.015	72%
Eroding Banks	280	116	59%
Upland Erosion	34	21	38%
Total Sediment Load	**314**	**137**	**56%**

Sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.

5.7.3.5 Miners Gulch (MT76E002_160)

Table 5-40. Sediment Source Assessment, Allocations and TMDL for Miners Gulch

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads	0.199	0.066	67%
Eroding Banks	473	439	7%
Upland Erosion	65	53	18%
Total Sediment Load	**538**	**492**	**9%**

Sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.

5.7.3.6 Quartz Gulch (MT76E002_070)

Table 5-41. Sediment Source Assessment, Allocations and TMDL for Quartz Gulch

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads	0.013	0.004	69%
Eroding Banks	526	324	38%
Upland Erosion	26	20	23%
Total Sediment Load	**552**	**344**	**38%**

Sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.

5.7.3.7 Scotchman Gulch (MT76E002_100)

Table 5-42. Sediment Source Assessment, Allocations and TMDL for Scotchman Gulch

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads	0.015	0.006	60%
Eroding Banks	683	470	31%
Upland Erosion	42	28	33%
Total Sediment Load	**725**	**498**	**31%**

Sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.

5.7.3.8 Sluice Gulch (MT76E002_110)

Table 5-43. Sediment Source Assessment, Allocations and TMDL for Sluice Gulch

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads	0.08	0.023	71%
Eroding Banks	398	213	46%
Upland Erosion	530	211	60%
Total Sediment Load	**928**	**424**	**54%**

Sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.

5.7.3.9 South Fork Antelope Creek (MT76E002_060)

Table 5-44. Sediment Source Assessment, Allocations and TMDL for South Fork Antelope Creek

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads	0.021	0.008	62%
Eroding Banks	158	87	45%
Upland Erosion	51	32	37%
Total Sediment Load	**209**	**119**	**43%**

Sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.

5.7.3.10 West Fork Rock Creek (MT76E002_030)

Table 5-45. Sediment Source Assessment, Allocations and TMDL for West Fork Rock Creek

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads	0.79	0.3	62%
Eroding Banks	2880	1897	34%
Upland Erosion	913	689	25%
Total Sediment Load	**3,794**	**2,586**	**32%**

Sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.

5.7.4 Meeting the Intent of TMDL Allocations

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 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 historical 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. For example, a landowner or land manager that negatively impacts an existing healthy riparian area might increase sediment loading in a manner that is not consistent with the bank erosion and/or upland sediment load allocations that apply throughout the watershed.

Additional information regarding the implementation of the allocations and associated BMPs is contained in **Sections 6** and **7**.

5.8 Seasonality and Margin of Safety

Seasonality and margin of safety are both required elements of TMDL development. This section describes how seasonality and margin of safety were applied during development of the Rock Creek TPA sediment TMDLs.

5.8.1 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 as described below.

- 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 Rock Creek 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.

5.8.2 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 impacts, 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 margin of safety 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, 1999). 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.

- TMDL development was pursued for all listed streams evaluated (except for Brewster Creek), even though some streams were close to meeting all target values. This approach addresses some of the uncertainty associated with sampling variability and site representativeness, and recognizes that sediment source reduction capabilities exist throughout the watershed.
- By using standards, targets, and TMDLs that address both coarse and fine sediment delivery.
- By properly incorporating seasonality into target development, source assessments, and TMDL allocations.
- By using an adaptive management approach to evaluate target attainment and allow for refinement of load allocation, targets, modeling assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development (discussed below in **Section 5.9** and in **Sections 6** and **7**).
- 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.
- TMDLs are developed at the watershed scale addressing 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.

5.9 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 processes that can be subject to periodic modification or adjustment as new information and relationships are better understood. Within the Rock Creek TPA, adaptive management for sediment TMDLs relies on continued monitoring of water quality and stream habitat conditions, continued assessment of impacts from human activities and natural conditions, and continued assessment of how aquatic life and coldwater fish respond to changes in water quality and stream habitat conditions.

As noted in **Section 5.8.2**, adaptive management represents an important component of the implicit margin of safety. This document provides a framework to satisfy the MOS by including a section focused on TMDL implementation, monitoring and adaptive management (**Section 6**). 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 1) field data and target development and 2) 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.

5.9.1 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.

Data Collection

The stream sampling approach used to characterize water quality is described within **Appendix C**. To control sampling variability and improve accuracy, the sampling was done by trained environmental professionals using a standard DEQ procedure developed for the purpose of sediment TMDL development (Montana Department of Environmental Quality, 2012b). This procedure defines specific methods for each parameter, including sampling location and frequency to ensure proper representation and applicability of results. Prior to 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 **Appendix C**. 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 or not the appropriate sites were assessed and whether or not 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.

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 Rock Creek TPA. These differences were acknowledged within the target development discussion and taken into consideration during target setting. For each target parameter, DEQ stratified the Rock Creek 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. It is recognized 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. The goal, under these conditions, is to ensure that management activities are undertaken in a way that the achievement of targets is not significantly delayed in comparison to the natural recovery time. Also, human activity should not significantly increase the extent of water quality impacts 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 the flexibility to refine targets as necessary to ensure protection of the resource and to adapt to new information concerning target achievability.

5.9.2 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, and because of these uncertainties, conclusions may not be representative of existing conditions and achievable reductions at all locations within the watershed. Uncertainties are discussed independently for the three major source categories of bank erosion, upland erosion, and unpaved road crossings.

Bank Erosion

The load quantification approach for bank erosion is based on a standard methodology (BEHI) as defined within **Appendix E**. Field data collection was by trained environmental professionals per a standard DEQ procedure (Montana Department of Environmental Quality, 2012b). Prior to 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 **Appendix C**. The results were then extrapolated across the Rock Creek watersheds as defined in **Appendix E** to provide an estimate of the relative bank erosion loading from various streams and associated stream reaches.

Even with the above quality controls, there is uncertainty regarding the bank retreat rates, which directly influence loading rates, since it was necessary to apply bank retreat values established from Colorado by Rosgen. Even with the increased bank erosion sites, stratifying and assessing each unique reach type was not practical, therefore adding to uncertainty associated with the load extrapolation results. Also, the complexity of the BEHI methodology can introduce error and uncertainty, although this is somewhat limited by the averaging component of the measured variables.

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 is further complicated by historical human disturbances in the watershed, which could still be influencing proper channel shape, pattern and profile and thus contributing to increased bank erosion loading that may appear natural. 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 Rock Creek watershed. Evaluating bank erosion levels, particularly where best management practices 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 impact that bank erosion has on water quality throughout the Rock Creek watershed.

Upland Erosion

A professional modeler determined upland erosion loads applying a standard erosion model as defined in **Appendix F**. As with any model, there will be uncertainty in the model input parameters including uncertainties regarding land use, land cover and assumptions regarding existing levels of BMP application. For example, the model only allows one vegetative condition per land cover type (i.e., 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. To minimize uncertainty regarding existing conditions and management practices, model inputs were reviewed by stakeholders familiar with the watershed.

The upland erosion model integrates sediment delivery based on riparian health, with riparian health evaluations linked to the stream stratification work discussed above. The potential to reduce sediment loading was based on modest land cover improvements to reduce the generation of eroded sediment particles in combination with riparian improvements. The uncertainty regarding existing erosion prevention BMPs and ability to reduce erosion with additional BMPs represents a level of uncertainty. Also, the reductions in sediment delivery from improved riparian health also introduces some uncertainty, particularly in forested areas where there is uncertainty regarding the influence that historical riparian logging has on upland sediment delivery. Even with these uncertainties, the ability to reduce upland sediment erosion and delivery to nearby waterbodies is well documented in literature and the reduction values used for estimating load reductions and setting allocations are based on literature values coupled with specific assessment results for the Rock Creek watershed.

Roads

As described in **Appendix G**, the road crossings sediment load was estimated via a standardized simple yearly model developed by the U.S. Forest Service. 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 30 unpaved road crossings were evaluated in the field, representing about 9% of the total population of unpaved road crossings in the watershed. The results from these sites were extrapolated to the whole population of roads stratified by precipitation zones. The potential to reduce sediment loads from unpaved roads through the application of BMPs was assessed by reducing the existing length to the potential BMP length based on the field measured values. This approach introduces uncertainty based on how well the sites and associated BMPs represent the whole population. Although the exact percent reduction will vary by road, the analysis clearly shows the potential for sediment loading reduction by applying standard road BMPs in places where they are lacking or can be improved.

Application of Source Assessment Results

Model results should not be applied as absolute accurate sediment loading values within each watershed or for each source category because of the uncertainties discussed above. Because of the un-calibrated nature of the source assessment work, the relative percentage of the total load from each source category does not necessarily indicate its importance as a loading source. Instead, the intention is to separately evaluate source impacts within each assessment category (e.g., bank erosion, upland erosion, roads) and use the modeling and assessment results from each source category to evaluate reduction potentials based on different BMP scenarios. The process of adaptive management can help sort out the relative importance of the different source categories through time.

6.0 Temperature TMDL Components

This portion of the document focuses on temperature as an identified cause of water quality impairment in the Rock Creek TMDL Planning Area (TPA). It describes: (1) the mechanisms by which temperature affects beneficial uses of streams; (2) the specific stream segments of concern; (3) information sources used for temperature TMDL development; (4) temperature target development; (5) assessment of sources contributing to excess thermal loading; (6) TMDL development determination (7) the temperature TMDLs and allocations; (8) seasonality and margin of safety; and (9) uncertainty and adaptive management.

6.1 Temperature (Thermal) Effects on Beneficial Uses

Human influences that reduce stream shade, increase stream channel width, add heated water, or decrease the ability of the stream to regulate solar heating all increase stream temperatures. Warmer temperatures can negatively affect aquatic life and fish that depend upon cool water for survival. Coldwater fish species are more stressed in warmer water temperatures, which increase metabolism and reduce the amount of available oxygen in the water. In turn, coldwater fish, and other aquatic species, may feed less frequently and use more energy to survive in thermal conditions above their tolerance range, sometimes creating lethal conditions for a percentage of the fish population. Also, elevated temperatures can boost the ability of non-native fish to outcompete native fish if the latter are less able to adapt to warmer water conditions (Bear et al., 2007). Assessing thermal effects upon a beneficial use is an important initial consideration when interpreting Montana's water quality standard (**Appendix B**) and subsequently developing temperature TMDLs.

6.2 Stream Segments of Concern

Two waterbody segments in the Rock Creek TPA appeared on the 2012 Montana impaired waters list as having temperature limiting a beneficial use: East Fork Rock Creek (from the outlet of the reservoir to the mouth) and South Fork Antelope Creek (**Figures 6-1 and 6-2**). As discussed in **Section 3.1**, both segments are classified as B-1, which requires that the streams be maintained suitable for several uses, including salmonid fishes and associated aquatic life.

6.2.1 East Fork Rock Creek

The segment of concern is 9.74 miles long and extends from the outlet of East Fork Reservoir to the mouth (**Figure 6-1**). This stream originates in the high elevations of the Pintler Range (more than 8,000 feet above mean sea level [MSL]) and flows approximately 6 miles through the Beaverhead Deerlodge National Forest. The creek transitions from relatively steep, mountainous, coniferous forest in the headwater to more gentle, open, scrub/shrub/grassland in the lower reaches of the watershed. This transition occurs fairly dramatically just below the East Fork Reservoir, an impoundment constructed in 1938.

A siphon and a transfer pipeline were also constructed in 1939 to facilitate irrigation in the adjacent Flint Creek watershed. The Montana Department of Natural Resources and Conservation (DNRC) manages the reservoir, siphon, and transfer pipeline. Up to 200 cfs is released from the reservoir during irrigation season for diversion into the main canal. A small amount of additional flow is released from the reservoir during irrigation season to provide a minimum flow of 5 cfs in East Fork Rock Creek below the diversion. The segment (MT76E002-020) addressed in this document begins at the outlet of the dam on

East Fork Reservoir and ends at the mouth of East Fork Rock Creek (its confluence with Middle Fork Rock Creek).

The upper half of the East Fork Rock Creek watershed is primarily forested. Most of the valley bottom below the East Fork Reservoir is irrigated pasture or hay land. The 2006 National Land Cover Dataset (NLCD) erroneously identifies areas of irrigated hay and pasture as cultivated crops. The upland areas in the lower watershed are predominantly open rangeland (scrub/shrub and native grasslands).

The U.S. Forest Service owns and manages much of the watershed. The upper reaches of the East Fork Rock Creek watershed are in the Anaconda-Pintler Wilderness. Historically, timber harvest has occurred outside the wilderness area, predominantly in the Meadow Creek subwatershed, which drains to the impaired segment of East Fork Rock Creek. With the exception of two small areas in the lower half of the watershed under state ownership, the lower watershed is privately owned.

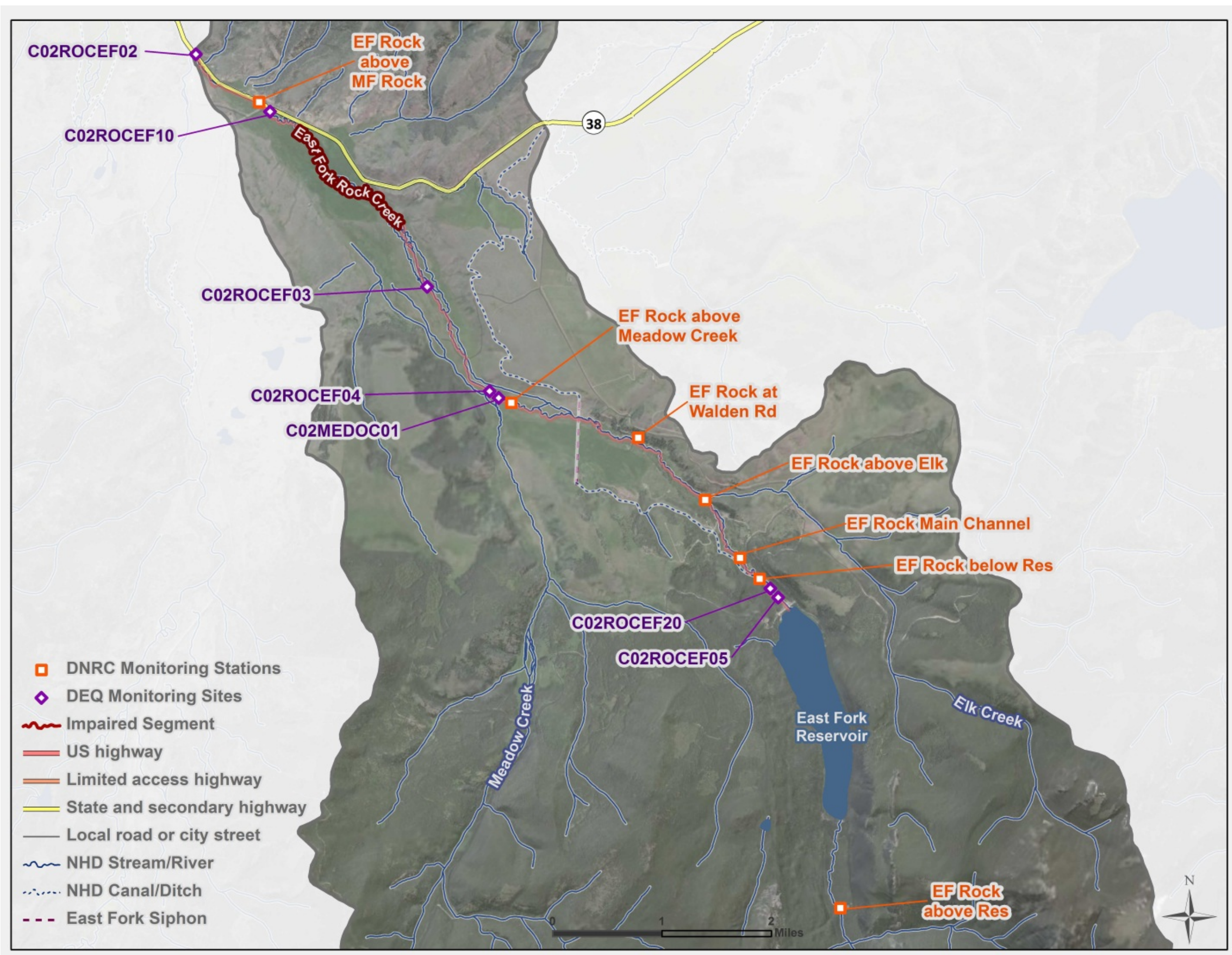

Figure 6-1. East Fork Rock Creek

6.2.2 South Fork Antelope Creek

The segment of concern is 2.9 miles long and extends from the headwaters to the mouth (**Figure 6-2**). Roughly half of the South Fork Antelope Creek watershed is forested. The remaining area is either shrub or grassland, exhibiting various stages of regrowth from timber harvesting. Approximately two-thirds of the watershed is privately owned. The remainder is owned by the U.S. Bureau of Land Management.

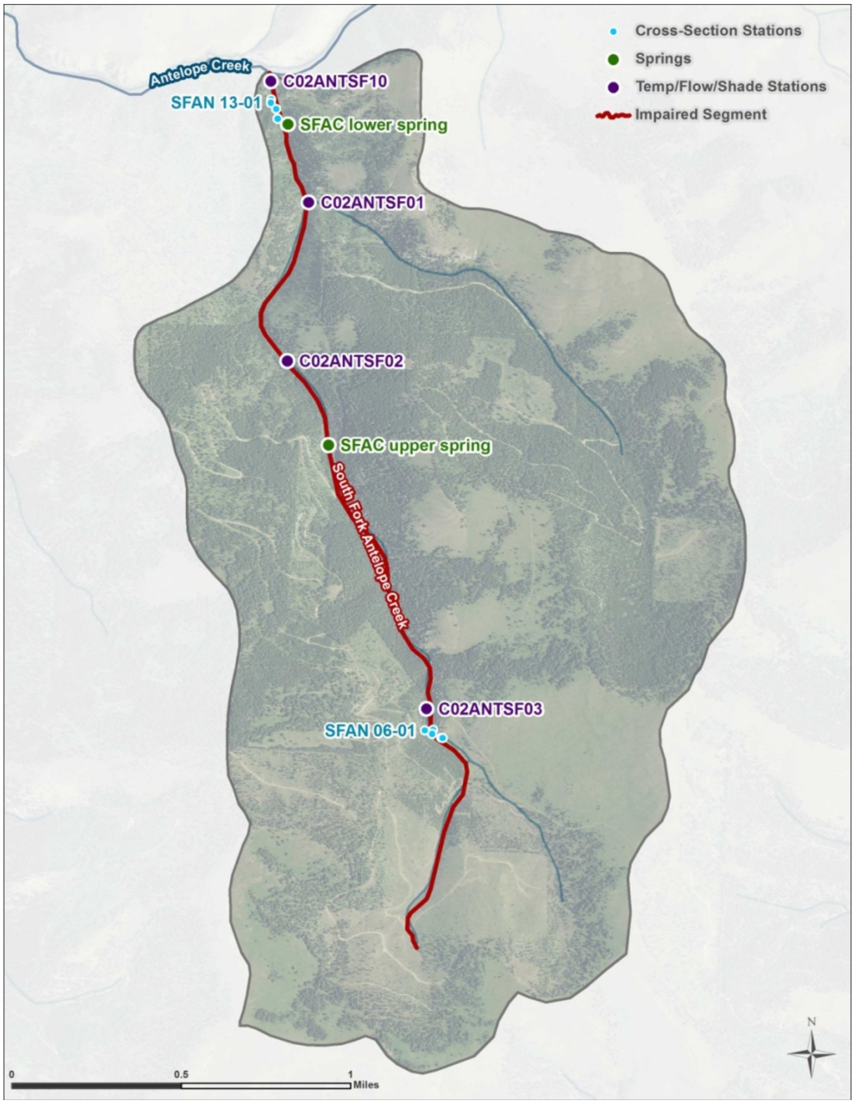

Figure 6-2. South Fork Antelope Creek watershed

6.3 Information Sources and Data Collection

As part of this TMDL project, DEQ used several information and data sources to analyze and assess the stream segments of concern.

6.3.1 Fish Populations & Specific Temperatures of Concern

To help understand potential thermal effects on aquatic life, information on fish populations along with information on temperatures that may cause harm to these fish populations was collected and is summarized below.

6.3.1.1 Fish Populations in East Fork Rock and South Fork Antelope Creeks

Based on a query of Montana Fisheries Information System (MFISH), brook trout, brown trout, and sculpin are year round residents in East Fork Rock Creek below the reservoir. Additionally, bull trout, westslope cutthroat trout, rainbow trout, and mountain whitefish are all common resident populations in East Fork Rock Creek. Longnose sucker are rare and longnose dace are also present in the stream with an unknown abundance. During shade monitoring and sediment and habitat field work, many fish were noted throughout East Fork Rock Creek.

According to a query of MFISH, South Fork Antelope Creek contains an abundant and year round resident population of native westslope cutthroat trout. Several 6” trout were observed at the confluence of South Fork Antelope and Antelope Creeks during a site visit on 8/1/2011.

6.3.1.2 Temperature Levels of Concern

Bull trout are listed as threatened under the U.S. Endangered Species Act. upper incipient lethal temperature (UILT) for Bull Trout is 68.5°F (20.3°C) (Selong et al., 2001). The LD10 for bull trout is 74°F (23.4°C) (McCullough and Spalding, 2002). Bull trout have maximum growth near 59.5°F (15.3°C) (McCullough and Spalding, 2002).

Special temperature considerations are warranted for the westslope cutthroat trout, which are listed in Montana as a species of concern. Research by Bear et al., (2007) found westslope cutthroat maximum growth around 56.5° F (13.6° C) with an optimum growth range, based on 95% confidence intervals, from 50.5° F to 62.6° F (10.3-17.0° C). Rainbow trout were found to have a similar optimum growth temperature; however, rainbow trout were predicted to grow better over a wider range of temperatures than cutthroat trout, with growth significantly better at temperatures above 44.2° F and below 69.4° F (6.8-20.8° C), possibly allowing for increased competition with cutthroat trout in lower-elevation (warmer) streams.

Additionally, the average 60 day UILT for westslope cutthroat trout is 67.5° F (20.0° C). The 7-day UILT was found to be 75.4° F (Bear et al., 2007). The UILT is the temperature considered to be survivable indefinitely by 50% of the population over a specified time period. The lethal concentration (LD10) for westslope cutthroat is 73.0° F (22.8° C), which is the temperature that, on a sustained basis, will kill 10% of the population in a 24-hour period (Lines and Graham, 1988).

Brown trout better tolerate temperature increases than the native westslope cutthroat species; however, high temperatures can negatively affect the brown trout population as well. Studies conducted by Elliott (1981) and Brett (1952) found a range of 7-day UILT between 76.5° and 80.1° F. The upper lethal concentration for juvenile brown trout is 75.4° F, as presented in Beschta et al. (1987). The critical thermal maximum (CTM) is the arithmetic mean of collected thermal points at which locomotor activity becomes disorganized such that the organism loses its ability to escape lethal conditions (Cowells and Bogert, 1944). The CTM for brown trout, according to Elliott and Elliott (1995), is 85.8° F.

6.3.2 DEQ Assessment Files

DEQ maintains assessment files that provide a summary of available water quality and other existing condition information, along with a justification for impairment determinations. This information was compiled in 2006 during DEQ’s most recent formal assessment of streams in the Rock Creek TPA. Below is a short review and general characterization of stream conditions in relation to temperature impairment determinations DEQ made in 2006.

6.3.2.1 East Fork Rock Creek

The most recent assessment performed by the DEQ’s Monitoring and Assessment section for East Fork Rock Creek (EFRC) occurred in 2006. According to the records in the assessment file:

EFRC contains bull trout, westslope cutthroat trout, rainbow trout, brook trout, brown trout, sculpin, mountain whitefish, longnose sucker, and longnose dace. EFRC is an Northwest Power & Conservation Council fisheries protected area because it is essential spawning habitat for Rock Creek. This stretch of EFRC contains high infection rates of whirling disease and very high numbers of tubifex worms. The macroinvertebrate fauna collected in EFRC in 2005 suggested low diversity; nutrient enrichment; potentially elevated temperatures; excess fine sediment deposition; and simplified instream habitats at the local and reach scales. DEQ derived mountain metric scores indicated nonsupport of aquatic life. Chlorophyll-*a* was sampled at two locations in 2004; results at both locations suggested excess algal growth limiting beneficial uses.

Fine sediment levels were observed to be appropriate below the dam where flows were adequate, but near the mouth the stream channel was clogged with fine sediments. Percent grid fines in pool tails were 37%, fines in riffles less than 2mm comprised 29%, and fines in riffles less than 6mm comprised 31%. RSI indexes were calculated in 2004 and found to be ~70% below the dam, denoting riffles on the threshold of dynamic equilibrium and intermediate state, with riffles somewhat loaded with sediment. Near the mouth, the RSI was ~98%; indicative of riffles with increased loading of excess sediment, reducing pool volume and relative pool abundance. Width to depth and entrenchment ratios increased in the downstream direction. The majority of the reach was in a C4 channel type.

Road density was moderate in the watershed, but a large percentage of these roads were located in close proximity to the stream channel and crossed the stream channel frequently (almost all crossings had culverts). East Fork dam was built in 1936 to provide irrigation water in the Flint Creek drainage and acts as a fish migration barrier. The 2006 assessment determined that the operation of the dam, and associated diversion structures, resulted in direct loss of bull trout from the system (into the ditch system) and that during times of high demand for irrigation water, the natural channel was nearly absent of water flow. Reduced flows in the EFRC downstream of the dam was resulting in elevated levels of fine sediment, high water temperatures, alteration of riparian vegetation communities and simplification of instream habitats.

The 2006 assessment indicated that downstream of the dam, the majority of the watershed had been altered from natural conditions by human activities. On national forest lands, pool habitat was reduced, streambanks were less stable and instream fine sediment levels were elevated. Cursory inspection of private lands revealed a lack of riparian vegetation and unstable stream channels. An integrated assessment of species and habitat conditions rated EFRC as functioning at unacceptable risk. Private land uses were primarily for raising livestock, including grazing lands and irrigated lands used for hay production. Large-scale sub-division of ranchlands had begun and may become an increasingly important issue if the trend continues. Water temperatures were elevated above the peak growth rate for bull trout during the summer months and was most likely limiting the fishery. There was a major diversion just below the dam and additional withdrawls downstream. Land uses and altered flows downstream of the dam (a result of irrigation withdrawls) resulted in substantially warmer water entering Rock Creek. Flows near the mouth in 2004 were 17% of the total water released from the dam.

EFRC was included on the 1996 impaired water list as having the cold-water fishery beneficial use threatened due to siltation and thermal modifications from agriculture, irrigated crop production, logging road construction/maintenance, and pasture land. In 2000, the DEQ assessed the data quantity and quality to be insufficient to make an impairment determination. At the time of the 2006 assessment, siltation was causing impairment below the major irrigation diversion just downstream of the dam. There were also numerous signs that temperatures were elevated in the summer time; therefore thermal modifications remained a cause of impairment.

6.3.2.2 South Fork Antelope Creek

The most recent assessment performed by the DEQ's Monitoring and Assessment section for South Fork Antelope Creek (SFAC) occurred in 2006. According to the records in the assessment file:

> The macroinvertebrate fauna collected in SFAC in 2005 suggested warmer water temperatures; elevated nutrient concentrations; intact instream habitats; and year-round flows. Scrapers were rare, expressing the lack of algae growth in the channel. Overall, using DEQ mountain metrics a score of 62% was derived, demonstrating partial support of aquatic life. Little plant growth was demonstrated in the low level of detected chlorophyll-*a*, 4.7 mg/m2.
>
> Vegetation was lacking diversity and age classes, from past management abuse. The stream channel was out of balance and very unstable, with large erosional and sediment depositional areas and filled pools. The channel was incised but, starting to form meanders within the incised channel. There was little woody vegetation present to stabilize the banks. Bank vegetation was dominated by sedges, with little willows present compared to potential. The substrate was dominated by fine gravels, sand, and silt. Riffle and pool spacing had no regular frequency, and most pools were step pools partially filled with sand and sediment. Fish cover was rated as sparse to moderate, with overhanging vegetation and woody debris, but few deep pools and undercut banks. One culvert was observed and it was perched; making it difficult for small fish to migrate through. Photos showed a very simplified stream channel with thick herbaceous growth, but very little woody vegetation regeneration. There was an abundance of sand choking the channel and many of the banks were eroding. The stream channel was not in a stable state, but it still had attributes of a "B5" channel type. Wolman pebble counts indicated substrate dominated by sands and fine gravels.
>
> The only mines listed in this drainage were high in the headwaters; one of which was the Ant mine and the other was the Mountain Ram Mine. Both produced gold, but current status at the time of assessment was unknown. The Ant mine had a significant road system within 1/2 a mile of the stream. The stream showed moderate disturbance from logging and associated roads from approximately 10 years from the time of assessment. At the time of the assessment, there was a new owner on the property, and the stream was starting to recover, however much more time is needed. Based on the 2006 assessment results, SFAC remained on the 305(b) report for temperature, nutrients, sediment and other habitat alterations.

6.3.3 TMDL Data Collection

DEQ's methods for temperature TMDL development on East Fork Rock and South Fork Antelope Creeks included a combination of characterizing water temperatures throughout the summer and collecting additional vegetation, channel condition, shade, and streamflow data; which were used to model stream temperature. As described in **Appendix I and J**, the QUAL2K temperature model was calibrated to existing flow, shade, and temperature conditions, with the ability to evaluate temperature impacts from differing riparian health (shade) and streamflow conditions. Thus TMDL data collection can be grouped into three categories: (1) temperature data collection used to characterize water quality throughout the summer; (2) field data collection of flow, shade, riparian health, and channel geometry; and (3) relevant data from outside sources.

6.3.3.1 Temperature Data Collection

In 2010 continuous temperature measurements were conducted in East Fork Rock and South Fork Antelope Creeks from late July through late September. The study examined stream temperatures during the period when streamflows tend to be the lowest and water temperatures the warmest; therefore, the negative effects to the coldwater fishery and aquatic life beneficial uses are likely most pronounced. Temperature monitoring consisted of placing temperature data logging devices at 6 sites in EFRC and at 4 sites in SFAC. In addition, a temperature data logging device was placed on Meadow Creek, a tributary stream to EFRC. Temperature monitoring sites were selected to bracket stream reaches with similar hydrology, riparian vegetation type, valley type, stream aspect, and channel width (**Figures 6-1 and 6-2**).

For East Fork Rock Creek, data loggers recorded temperatures every half hour for 2 months between July 27 and 28, 2010, and September 26 and 27, 2010. Field parameters (including water temperature) were collected during data logger deployment and retrieval. The upstream-most site was below the East Fork Dam, upstream of the canal diversion (C02ROCEF05). Maximum recorded temperatures generally increased in a downstream direction ranging from 58.0 °F below the dam (C02ROCEF05) to a maximum of 64.4 °F approximately one mile below the confluence with Meadow Creek (C02ROCEF03). With one exception, the between-site variability in daily maximum temperatures was relatively constant throughout the 2010 monitoring period. The exception was that the maximum daily temperatures at the two uppermost sites (C02ROCEF05 and C02ROCEF20) were lower than those recorded at the downstream sites between the beginning of the monitoring period and mid-August. For the monitoring period, the maximum temperatures in Meadow Creek were among the highest (i.e., 63.8 °F). The most striking observation with the 2010 data was the difference in maximum daily temperatures between the upstream and downstream monitoring sites between the beginning of the monitoring period and mid-August. This suggests some kind of warming influence downstream from site C02ROCEF20. While this could be a natural phenomenon as the streamflows through the more open valley downstream, potential anthropogenic influences are irrigation withdrawals and returns, degradation of the riparian vegetation, and altered stream morphology.

For South Fork Antelope Creek, loggers recorded temperatures every half hour for 2 months between July 15 and 16, 2010, and September 23 and 24, 2010 (i.e., 70 days). Daily maximum temperatures were the coolest and varied the least (between approximately 44.0 and 55.0 °F) at the site that was most downstream (C02ANTSF10). The highest maximum temperatures were at the site that was most upstream (C02ANTSF03) and ranged from approximately 44.0 to 61.0 °F. The largest range of maximum daily temperatures was also observed at the site that is most upstream (C02ANTSF03). South Fork Antelope Creek is a small, shallow mountain stream. The coolest recorded stream temperatures were observed at the station that is most downstream, which corresponds to the lowest effective shade. The warmest recorded maximum temperatures were observed at the most upstream station where effective shade values are among the highest. This may be related to the increased influence of cooler groundwater in the lower portion of the stream or could suggest that ambient air temperature is an influencing factor affecting instream temperature. The headwaters of the creek (site C02ANSF03) are very shallow, and instream temperatures directly correspond to the ambient air temperature. Temperatures logged in the lower segments of the South Fork of Antelope Creek also typically vary with ambient air temperature, but are generally cooler than the headwaters segments during the day and warmer than the headwaters during the night.

6.3.3.2 Field Data Collection

The following section describes measurements collected by a team from WET and DEQ on East Fork Rock and South Fork Antelope Creeks in the late summer of 2011 to characterize meteorological data (e.g. air temperature, dew point, wind speed, and cloud cover), channel geometry, additional flow measurements, and/or shade variables in support of the modeling effort. Additional information was obtained from a local weather station within the Remote Automated Weather Station (RAWS) program.

Sites for streamflow, shade, and channel geometry monitoring were selected by DEQ. Shade characterization sites were identified by assessment of aerial and color infrared images and by approved access from private landowners. In total, six mainstem locations on EFRC and four mainstem sites on SFAC were monitored in the field for vegetative shade and nine of these sites were also monitored with a Solar Pathfinder ™.

6.3.3.2.1 Streamflow

Flow was measured at the sites on EFRC and SFAC by DEQ in July, August and September of 2010. Flow was also measured by DEQ in 2011 for use in model development and in the water balance inclusion of Elk Creek and Trail Creek tributaries.

A water balance was determined from the provided DEQ dataset and described in the QAPP (Water & Environmental Technologies, 2011). Additional uncharacterized surface water flow was determined to be significant on the EFRC watershed and was measured in the 2011 field effort. These flows include Elk Creek and Trail Creek. Trail Creek was measured at a location parallel with Skalkaho Road just above a driveway on private property. It appears that the flow as measured on Trail Creek is further divided toward three center pivot sprinklers and may be used for irrigation. The point of surface contact between Trail Creek and EFRC was not able to be determined without landowner approval.

6.3.3.2.2 Riparian Shading

Riparian vegetation data were assessed in the field to characterize direct solar radiation losses from topography and vegetative shade. The following measurements were collected at three transects at each site to support the modeling efforts: (1) bankfull and wetted channel width (BFW and WCW), (2) vegetation/canopy height, (3) canopy density and vegetative cover percent, (4) channel overhang, and (5) percent shade at specified transects. A fiberglass-tape, range-finder, clinometer, canopy densiometer, and Solar Pathfinder™ were used to acquire these attributes. The riparian vegetation information (BFW/WCW, height, density, overhang, and % shade) was inputted into the Shadev3.0.xls Model (Washington State Department of Ecology, 2012). The Solar Pathfinder instrument was used to determine the amount of effective shade at a specific site to gage riparian shade effectiveness for various vegetative communities and riparian conditions. The Shadev3.0.xls Model yielded shade estimates at a finer scale than the available Solar Pathfinder data (i.e., every 15 meters along the stream compared with three sites along the stream). The Shade.xls site specific results, as compared with the Solar Pathfinder results, are displayed in **Figures 6-3 and 6-4**.

DEQ collected vegetation/canopy height, canopy density, vegetative cover percent, and channel overhang at three transects at all six of its sampling locations on East Fork Rock Creek in 2011 (**Figure 6-1**). **Figure 6-3** presents shade estimates from both the Solar Pathfinder and Shadev3.0.xls Model. As estimated by the Shadev3.0.xls Model, shade varied over a large range above river mile 7 and varied over fairly constant ranges from river mile 7 to the mouth. The effective shade derived using the Shadev3.0.xls Model was compared to the field measurements from the Solar Pathfinder, aerial imagery, and site photographs. The Shadev3.0.xls output was found to be reasonably accurate (i.e., within 10 percent or less at all sites with Solar Pathfinder data; see **Figure 6-3**). Additional plots of these data sets are presented in **Appendix I**.

An analysis of aerial imagery showed that shading along South Fork Antelope Creek was highly variable because of timber harvest and changes in elevation along the stream. Therefore, riparian vegetation data for South Fork Antelope Creek was collected at three transects at four sites (C02ANTSF03, C02ANTSF02, C02ANTSF01, and C02ANTSF010) in 2011 and Solar Pathfinder data was collected at three sites (C02ANTSF10, C02ANTSF01, and C02ANTSF02). **Figure 6-4** presents shade estimates from both the Solar Pathfinder and Shade.xls Model. As estimated by the Shade Model.xls, shade varied over a large range above river mile 2.0, varied over a constant range from river mile 2.0 to river mile 0.2, and decreased considerably from river mile 0.2 to the mouth. The effective shade derived using the spreadsheet tool Shadev3.0.xls was compared to the field measurements from the Solar Pathfinder, aerial imagery, and site photographs. The Shadev3.0.xls output was found to be reasonably accurate (i.e., within 10 percent or less at all sites with Solar Pathfinder data; see **Figure 6-4**). Additional plots of these data sets are presented in **Appendix J**.

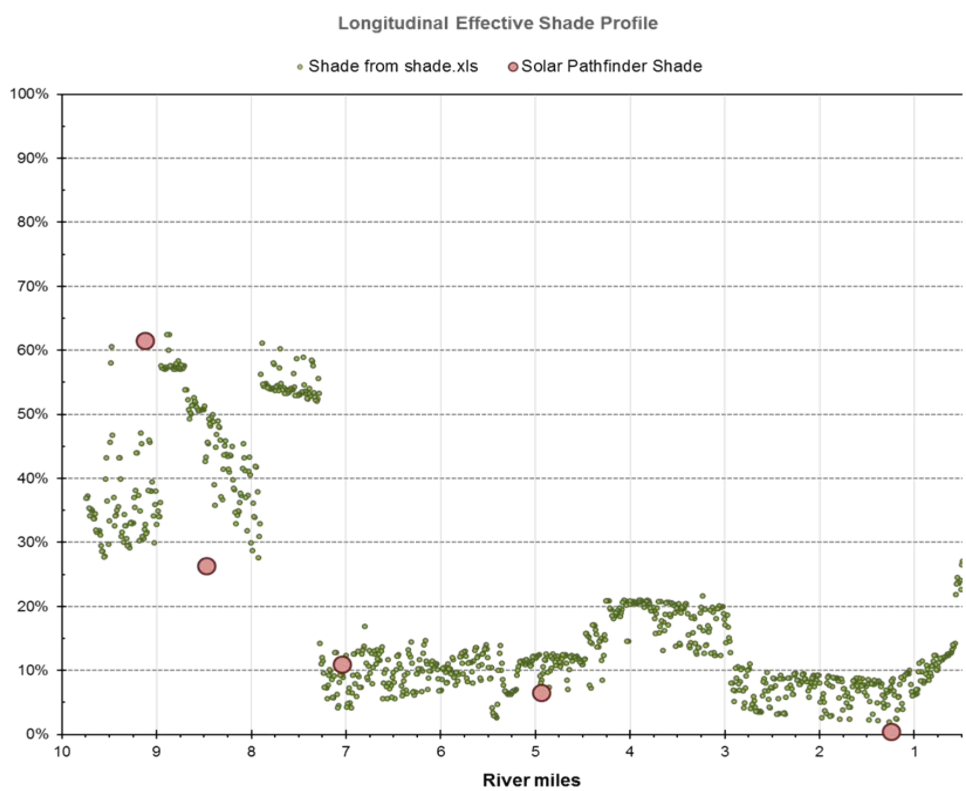

Figure 6-3. Effective shade output for EFRC from Shadev3.0.xls and Solar Pathfinder data

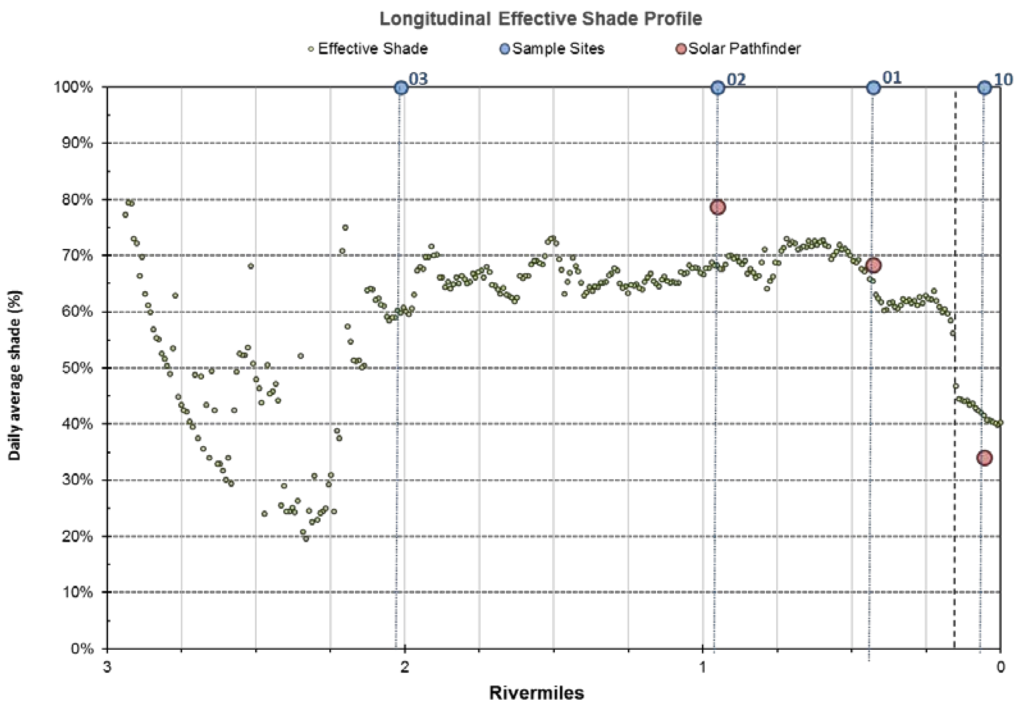

Figure 6-4. Effective shade output for SFAC from Shadev3.0.xls and Solar Pathfinder data

6.3.3.2.3 Channel Geometry

Although not a direct measure of thermal effect on the stream, channel geometry can influence the rate of thermal loading. Wide, shallow streams transfer heat energy faster than narrow, deep streams. Therefore, channel geometry can be used to identify areas that may be destabilized, and may be more prone to rapid thermal loading, particularly in locations where shading is minimal.

Channel morphology measurements were taken at five cross-sections at two sites on East Fork Rock Creek (EFRK 01-02 and EFRK 03-03) during the DEQ sediment and habitat assessment in 2011. Representative bankfull width to depth ratios for the two sites are based on the reach average of those measurements, which averaged 22.2 at the upper site (EFRK 01-02) and 14.3 at the lower site (EFRK 03-03). Field observations were that the channel is overwidened at some discrete locations. However, both of the average reach values are within the acceptable and expected values for East Fork Rock Creek; therefore, no altered channel morphology scenario will be completed in the model to assess the influence of physical geometry on the overall heat balance of the stream.

Channel morphology measurements were taken at five cross-sections at two sites on South Fork Antelope Creek (SFAN 06-01 and SFAN 13-01) during the DEQ sediment and habitat assessment in 2011. Representative bankfull width to depth ratios for the two sites are based on the reach average of those measurements, which averaged 11.6 at the upper site (SFAN 06-01) and 12.2 at the lower site (SFAN 13-01). Field observations were that the channel was impacted by cattle and the creek channel had avulsed into hoof tracks and pockets of slower moving water. However, both of the average reach values are within the acceptable and expected values for South Fork Antelope Creek; therefore, no altered channel morphology scenario will be completed in the model to assess the influence of physical geometry on the overall heat balance of the stream.

Channel geometry inputs for QUAL2K for reaches A, B, C, and D (**Figure 6-5**) were derived using field-measured data and DEQ's cross-sections (Water & Environmental Technologies, 2011). No channel geometry data were available upstream of sample site C02ANTSF03.

Data from the 2011 DEQ sediment and habitat sites was used to derive channel geometry for the QUAL2K model. Manning's roughness coefficient (n) was estimated during a field visit (Water & Environmental Technologies, 2011). Channel slope was calculated using field-collected elevation data (Water & Environmental Technologies, 2011). Stream bottom width and the sides of the trapezoidal cross-section assumed for modeling were estimated using cross-sectional profile data collected during field work (Water & Environmental Technologies, 2011).

6.3.3.2.4 Meteorological Data
At all 2011 DEQ sites air temperature, dew point, wind speed, and cloud cover were sampled to assist in characterizing weather in the watershed. However, for the QUAL2K model, weather inputs were compiled from the closest station recording the necessary data. These data were used as model input for the July 29, 2010 critical date (the day with the warmest water temperatures within the warmest and driest week of the summer) for East Fork Rock Creek and the July 16, 2010 critical date for South Fork Antelope Creek. Air temperature, wind speed, relative humidity, and solar radiation data were obtained from the Philipsburg RAWS, which is at an elevation of 5,280 feet. Air temperature and dew point temperature data from this station were corrected to account for the elevation difference between the station and the impaired stream. Wind speed was corrected for the height differences of the sensor at Philipsburg RAWS (reported as 20 feet) and the assumed height in QUAL2K (7 meters, which is approximately 23 feet). Cloud cover was estimated on the basis of available hourly data at the Butte municipal airport (WBAN 24135) weather station that is operated by the National Weather Service, which is the closest weather station that measures cloud cover. Zero percent cloud cover was observed at the Butte municipal airport on July 16 and 29, 2010; therefore, zero percent was input for all 24 hours in the QUAL2K model.

6.3.3.2.5 Springs on SFAC
On the SFAC watershed, one spring was noted between C02ANTSF10 and C02ANTSF01 and another was noted between C02ANTSF02 and C02ANTSF03. Instantaneous water temperature was measured with the wet bulb thermometer of the sling phsychrometer in the spring and in the main SFAC channel both above and below the spring (**Table 6-1**). The temperature readout was not as accurate as a digital thermometer and should be used for comparison only. Flow of each spring was minimal.

Table 6-1. Instantaneous water temperature measurements on spring fed seeps into SFAC

Location	Date	Latitude	Longitude	Temperature of Spring (F)	Temperature of SFAC above spring (F)	Temperature of SFAC below spring (F)
Upper Spring	8/31/2011	46.2467	-113.4571	43.5	45.3	44.5
Lower Spring	8/31/2011	46.2603	-113.4606	44.1	45.5	Not recorded.

6.3.4 Other Information Sources
The following sections describe data used in the analysis of East Fork Rock and South Fork Antelope Creeks outside of the DEQ.

6.3.4.1 Additional Flow Data (DNRC)
The hydrology of East Fork Rock Creek is significantly affected by anthropogenic flow modification. In 1938, the stream was dammed and a transfer pipeline (siphon) was constructed to move the impounded water to the Flint Creek drainage. The East Fork Rock Creek Dam is owned by DNRC and operated by the Flint Creek Water Users Association. It is an earthen embankment dam, 88 feet high and 1,083 feet long. The reservoir stores 16,040 acre-feet at normal pool covering 390 acres (Montana Department of Natural Resources and Conservation, 2012).

The transfer pipeline diverts about one-quarter of a mile below the dam and follows a northwesterly direction to Trout Creek, which is used as a carrier for the diversion of water by other canals in the Flint Creek valley below (State Engineers Office, 1959). The canal has a maximum capacity of 200 cubic feet per second cfs; (Norberg, M., personal communication 2012). On the basis of flow data collected by DNRC in 2010 and 2011, water is typically diverted into the canal from late May through September with flow rates in the range of 50 to 150 cfs (Norberg, M., personal communication 2012). In 2010, the canal diverted between 34 and 98 percent (median 94 percent) of the flow discharged from East Fork Reservoir.

Montana DNRC has maintained continuously recording gages on East Fork Rock Creek for most years starting in 1994 at four locations (EF Rock above Res, EF Rock below Res, EF Rock Main Channel, and EF Rock above Elk). According to DNRC, after spring snowmelt, flow in the creek decreases considerably as much of the flow is diverted to the irrigation canal. Flows are always lowest just below the irrigation canal diversion. The stream gains between 24 and 32 cfs from just below the irrigation diversion canal to the mouth. Flow occasionally decreases or remains relatively constant in the lower half of the creek; this might be because of the cumulative effect of multiple small irrigation withdrawals, which divert to pivot and some flood irrigation (Norberg, M., personal communication 2012).

6.3.4.2 Climatic Data
In addition to the field-measured values for the East Fork Rock and South Fork Antelope Creeks, climatic data inputs for the QUAL2K model were obtained from the Western Regional Climate Center station in Philipsburg, MT, and included air temperature, dew point temperature, and wind speed.

6.4 Target Development
The following section describes 1) the framework for interpreting Montana's temperature standard; 2) the selection of indicator parameters used for target TMDL development; 3) how target values were developed; and 4) a summary of the temperature target values for East Fork Rock and South Fork Antelope Creeks.

6.4.1. Framework for Interpreting Montana's Temperature Standard
As discussed in **Section 4.1**, the TMDL targets represent attainment of applicable water quality standards. Montana's water quality standard for temperature is narrative in that it specifies a maximum allowable increase above the "naturally occurring" temperature in order to protect the existing thermal regime for fish and aquatic life. For waters classified as B-1, a 1°F maximum increase above naturally occurring water temperature is allowed within the range of 32°F to 66°F; within the naturally occurring range of 66°F to 66.5°F, no discharge is allowed which will cause the water temperature to exceed 67°F; and where the naturally occurring water temperature is 66.5°F or greater, the maximum allowable increase in water temperature is 0.5°F [ARM 17.30.623(2)(e)]. Note that under Montana water quality

law, naturally occurring temperatures incorporate natural sources, yet may also include human sources with reasonable land, soil, and water conservation practices that protect current and reasonably anticipated beneficial uses.

Evaluating the extent that human activities are influencing stream temperatures is important. For the both the East Fork Rock and South Fork Antelope Creeks, a model (QUAL2K) was used to estimate the extent of human influence on temperature by evaluating the temperature deviation when existing conditions of riparian health and associated shade, channel geometry, and streamflow were compared with naturally occurring conditions for these parameters. Per the above water quality standard, human activity leading to increased temperature deviations from 0.5° F to 1.0° F (depending on the baseline naturally occurring condition) would be consistent with the existing impairment determinations for East Fork Rock and South Fork Antelope Creeks.

To help evaluate the extent and implications of impairment, it is useful to evaluate the degree to which existing temperatures affect fish populations or other aquatic life. For example, as discussed in **Section 6.3.3.1**, the existing temperatures within the East Fork Rock Creek have maximum values ranging from 58.0° F to 64.4° F for the lower portion of the stream. The maximum temperatures at several sites are just above optimum growth range for Westslope cutthroat trout (**Section 6.3.1.2**). Maximum temperatures in South Fork Antelope Creek range from 54.9° F to 61.2° F **(Section 6.3.3.1)**, which are levels within the optimal growth range for Westslope cutthroat trout (**Section 6.3.1.2**).

6.4.2 Selection of Indicator Parameters for TMDL Target Development

Naturally occurring temperatures can be estimated for a given set of conditions using QUAL2K or other modeling approaches. Because naturally occurring temperatures can significantly vary throughout the summer, as well as from year to year, the quantified temperature targets include those indicator parameters that influence temperature and can be linked to human causes. These target or indicator parameters include riparian health and associated shade, channel geometry, and improved streamflow conditions where applicable.

6.4.3 Developing Target Values

Values are developed for each target parameter and are set at levels that result in attainment of Montana's temperature standard under all seasonal and yearly variability. The goal is to set most of the target values at levels that would contribute to naturally occurring temperature conditions, while ensuring that any variability from naturally occurring conditions is less than that allowed by the standard. Although the resulting target values are protective of fish and 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.

6.4.3.1 Riparian Canopy and Shade Target Values

Increased shading from riparian vegetation reduces sunlight hitting the stream and, thus, reduces heat load to the stream. Riparian vegetation also reduces near-stream wind speed and traps air against the water surface, which reduces heat exchange with the atmosphere. In addition, lack of established riparian areas can lead to bank instability, which could result in overwidened streams. Human influences affecting riparian canopy cover in the East Fork Rock Creek include current and historical agricultural activities (grazing and irrigated hay production) and some limited areas of recreational activity and residential development in the watershed. Human influences affecting riparian canopy cover in South Fork Antelope Creek include timber harvest and grazing.

DEQ uses a reference approach to define naturally occurring conditions for riparian health. 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 past and current land-use activities. The riparian canopy cover targets for East Fork Rock Creek and South Fork Antelope Creek are based on measurements made in the field from sites (**Section 6.3.3.2.2**) with good to moderate riparian conditions to represent a potential reference condition for each stream. The effective shade outputs derived using the Shadev3.0.xls Model were averaged from 7:00 am to 8:00 pm in order to arrive at the reach average effective shade throughout the day (based on sunrise and sunset times at the time of sampling - (National Oceanic and Atmospheric Administration, 2013)).

The target for a healthy riparian corridor for the valley section of East Fork Rock Creek (reaches A through F on **Figure 6-5**) is a minimum of 42% effective shade, which is the average riparian shade as measured from sites defined with moderate willow and shrub riparian canopy as discussed in **Section 6.3.3.2.2** and represents a potential reference condition for this section of the stream. For the upper part of East Fork Rock Creek (reaches G, H, and I on **Figure 6-6**) the target is a minimum of 63% effective shade, based on the average riparian shade as measured from sites with moderate mixed high level and coniferous riparian vegetation, representing a potential reference condition for this stream.

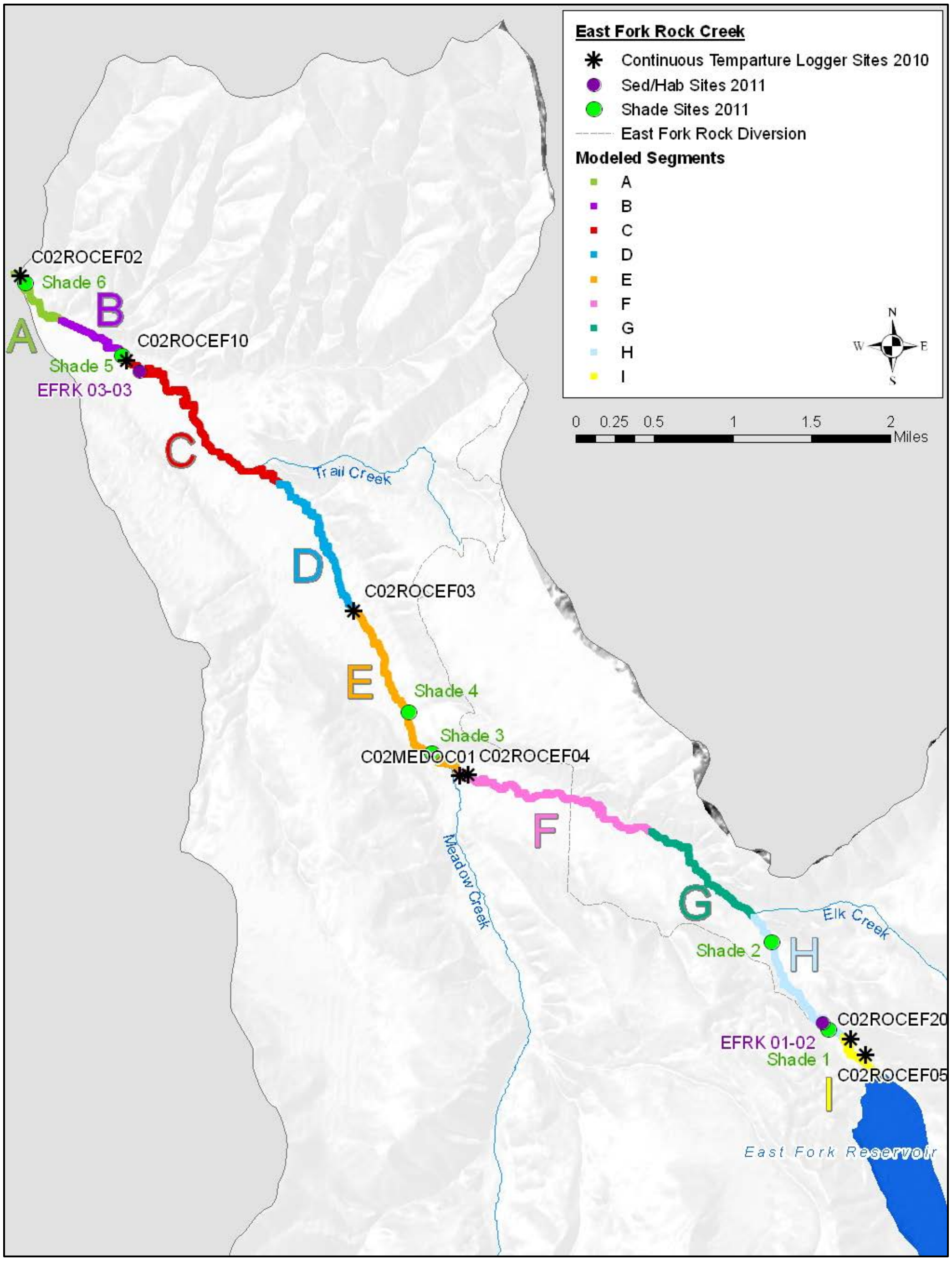

Figure 6-5. Model segmentation and sample sites along East Fork Rock Creek

The riparian canopy cover target for South Fork Antelope Creek is based on measurements made in the field from sites with good to moderate riparian conditions to represent a potential reference condition for this stream. The target for a healthy riparian corridor for all of South Fork Antelope Creek (reaches A through D) is a minimum of 76% effective shade, which is the average riparian shade as measured from sites defined with moderate riparian canopy as discussed in **Section 6.3.3.2.2.**

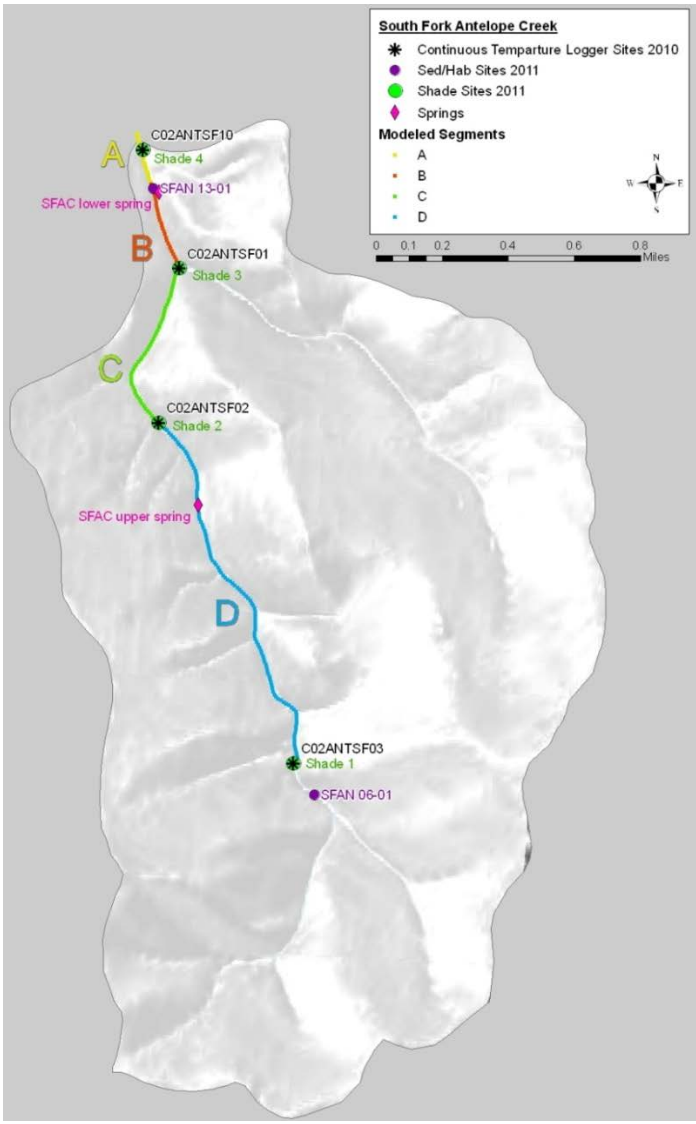

Figure 6-6. South Fork Antelope Creek Modeling Segments and Monitoring Sites

6.4.3.2 Width-to-Depth Ratio Target Values

A lower width-to-depth ratio equates to a deeper, narrower channel that has a smaller contact area with warm afternoon air and is slower to absorb heat. Also a lower width-to-depth ratio will increase the effectiveness of shading produced by the riparian canopy. Much of the stream channel widening in the East Fork Rock and South Fork Antelope Creeks is a result of destabilized streambanks from present or past agricultural activities (mostly riparian area grazing, although other human-related activities also have an impact).

Channel dimensions were not altered in the QUAL2K model scenarios; however, a channel geometry target has been developed for the dimensionless width-to-depth ratios in association with sediment TMDLs for the Rock Creek TPA (< 16 for B stream types, < 23 for C stream types, and < 12 for E stream types). East Fork Rock is a type C/E stream and South Fork Antelope is a type B stream. Width-to-depth ratio target values are used because a smaller width-to-depth ratio indicates a stream with stable channels and healthy riparian areas, directly affecting temperature. Width-to-depth target values are currently being met at the sites sampled in 2011 in East Fork Rock Creek and at the sites sampled in South Fork Antelope Creek in 2011.

The target values are not intended to be specific to every given point on the stream, the intent rather, is to achieve an average width-to-depth ratio that meets target values as a general trend throughout the East Fork Rock Creek and South Fork Antelope Creek corridors. Generally, improved riparian areas will lead to gradual improvements in width-to-depth ratio values over time. However, improvement in both riparian health and channel morphology need significant time before changes are visible. Changes in land management practices and a commitment to those practices have occurred in some locations along both creeks and should continue to be implemented throughout both creeks in order to meet goals for temperature.

6.4.3.3 Instream Discharge (Streamflow Conditions) Target Values

Larger volumes of water take longer to heat up during the day. Therefore, when flow is reduced, streams can reach higher maximum daily stream temperatures. In East Fork Rock Creek, the majority of streamflow reduction is attributed to a diversion about one quarter of a mile below the East Fork Rock Creek Dam for use in the neighboring Flint Creek watershed for irrigation purposes.

Instream discharge in East Fork Rock Creek is complicated by the inter-basin transfer of water via a significant irrigation diversion; and the relationships to groundwater and water rights both in the Flint Creek and East Fork Rock Creek watersheds. Thorough investigations into irrigation infrastructure improvements, water management (including the possibility of appropriating water for instream use), and relationships to groundwater were not conducted for this TMDL. However, for modeling purposes, a scenario was run to estimate all reasonable land, soil, and water conservation practices that included a 15% water savings from improved irrigation delivery and application efficiencies, and allowing that conserved water to flow down East Fork Rock Creek downstream from the point of the diversion of the East Fork Rock Creek canal. The focus of the 15% water savings is on the main diversion because the majority of flow released from the dam is being diverted during July and August, which is the time period of concern for instream temperatures. The 15% may be an over or under estimation of what is achievable and should be studied further, however, 15% is a reasonable value with which to start the discussion. Per Montana's water quality law, TMDL development cannot be construed to divest, impair, or diminish any water right recognized pursuant to Title 85 (MCA §75-5-705). Therefore, any voluntary water savings and subsequent instream flow augmentation must be done in a way that protects water rights.

The 15% water savings could be achieved through best management practices including delivery system upgrades, irrigation scheduling, and application management (Waskom, 1994). The DNRC has proposed an East Fork Rock Creek Main Canal Lining Project. The DNRC identified seepage loss in the reach of the canal from the headgate to the East Fork Siphon as high as 30 acre-feet per day, with a seasonal average of 15 to 20 acre-feet per day. According to DNRC, this water is lost through the highly pervious canal berm, and the seepage dissipates into the ground with no beneficial use. According to the DNRC, lining the canal would help to eliminate the loss of water to seepage; conserve, and put to beneficial use water captured in the East Fork reservoir; keep more water in the system, which benefits farmers and ranchers, fish and wildlife and sportsman and recreationists; and protect from excessive seepage water the recently installed 4,000 foot long East Fork siphon. In addition to improving water delivery, improvements in application efficiencies could also contribute to the 15% water savings. The U.S. Department of Agriculture (1997) has documented improvements to gravity flood systems that increase typical system efficiencies from 40%-65% up to 80%-90%. Similar efficiency improvements for gravity systems have been reported by the Montana DNRC (2008a), the Economic Research Station (1997), and Negri et al (1989). The DEQ recognizes that not all water savings from improved efficiencies are necessarily available for flow augmentation.

Water users in the East Fork Rock Creek and Flint Creek watersheds are encouraged to work with the USDA Natural Resource Conservation Service, the Montana Department of Natural Resources & Conservation, the local conservation district, and other local land management agencies to review their systems and practices.

6.4.4 Target Values Summary

The allowable temperatures defined via Montana's temperature standard represent the primary target that must be attained.

Alternatively, compliance with the temperature standard can be achieved by meeting all other targets for shade, channel width-to-depth ratio, and streamflow. In this approach, if all reasonable land, soil, and water conservation practices are installed or practiced, state standards are met. These targets, which need to be met in combination, are referred to as "temperature-influencing targets." **Table 6-2** presents a summary of the temperature influencing targets for East Fork Rock Creek and South Fork Antelope Creek. Note that an instream discharge target is not applicable to South Fork Antelope Creek because of the lack of irrigation diversions.

Table 6-2. Temperature TMDL Targets for East Fork Rock and South Fork Antelope Creeks

Target Parameter	Target Value	Existing Condition
Maximum allowable increase over naturally occurring temperature	For waters classified as B-1, a 1°F maximum increase above naturally occurring water temperature is allowed within the range of 32°F to 66°F; within the naturally occurring range of 66°F to 66.5°F, no discharge is allowed which will cause the water temperature to exceed 67°F; and where the naturally occurring water temperature is 66.5°F or greater, the maximum allowable increase in water temperature is 0.5°F [ARM 17.30.623(2)(e)].	• Calibrated QUAL2K model results are compared to restoration scenario results. • Modeling conclusions indicate Montana's temperature standard is not being met in East Fork Rock Creek (increased temperature deviation of 3.9° F), but is being met in South Fork Antelope Creek (increased temperature deviation of 0.3° F).
OR meet ALL of the temperature influencing restoration targets below		
Riparian Health - Shade	• East Fork Rock Creek: minimum 42% average effective shade for valley willow and shrub cover (Reaches A through F on **Figure 6-5**) and 63% for mixed high level and coniferous riparian areas (Reaches G through I on **Figure 6-5**) • South Fork Antelope Creek: minimum 76% average effective shade	• East Fork Rock Creek: Of the nine sites measured, effective shade was 42%, 24%, 21%, 36%, 29%, and 25% for valley willow and shrub cover and 63%, 63%, and 55% for mixed high level and coniferous riparian areas. • South Fork Antelope Creek: Of the four sites measured, effective shade was 76%, 79%, 75%, and 59%.
Width to Depth Ratio	• East Fork Rock Creek: o C stream type: < 23 o E stream type: < 12 • South Fork Antelope Creek: o B stream type: < 16	• East Fork Rock Creek: Of the two sites measured, both sites (type C) are meeting the W/D target (22.1 and 14.3) • South Fork Antelope Creek: Of the two sites measured, both sites are meeting the W/D target (11.6 and 12.2)

Instream Discharge	East Fork Rock Creek: 15% water savings from improved irrigation delivery and application efficiencies, and allowing that water savings to flow down East Fork Rock Creek downstream from the point of the diversion of the East Fork Rock Creek canal (any voluntary water savings and subsequent in stream flow augmentation must be done in a way that protects water rights). • South Fork Antelope Creek: Not applicable because of lack of irrigation withdrawals in area of concern	East Fork Rock Creek (EFRC): Instream discharge in EFRC is complicated by the inter-basin transfer of water via a significant irrigation diversion; and the relationships to groundwater and water rights both in the Flint Creek and East Fork Rock Creek watersheds. The 15% water savings could be achieved through best management practices including delivery system upgrades, irrigation scheduling, and application management (i.e. the proposed lining of the East Fork Rock Creek Main Canal). Thorough investigations into irrigation infrastructure improvements, water management, and relationships to groundwater would need to be conducted.

6.5 Source Assessment – QUAL2K Model and Modeling Scenarios

As discussed above, source assessment for East Fork Rock and South Fork Antelope Creeks involved QUAL2K temperature modeling (**Appendices I and J**). Water temperature, flow, channel dimension, and riparian shade data were incorporated in a QUAL2K water quality model to characterize existing temperature conditions and to evaluate differing land management scenarios for East Fork Rock and South Fork Antelope Creeks. This section provides a summary of the QUAL2K modeling presented in **Appendices I and J**, including a description of the model and the modeling scenarios used to evaluate human influences on both streams.

The QUAL2K model was used to determine the extent that human-caused disturbances within East Fork Rock and South Fork Antelope Creeks have increased the water temperature above the naturally occurring level. QUAL2K is a one-dimensional river and stream water quality model that assumes the channel is well-mixed vertically and laterally. The QUAL2K model uses steady state hydraulics that simulates non-uniform steady flow. Within the model, water temperatures are estimated based on climate data, riparian shading, and channel conditions. For this assessment, the QUAL2K model was used to evaluate maximum summer water temperatures in East Fork Rock and South Fork Antelope Creeks.

The water temperature data collected in East Fork Rock and South Fork Antelope Creeks (**Section 6.3.3**), along with climate data (**Section 6.3.4.2**), was incorporated into the model and used to calibrate to existing conditions. A number of various scenarios were then modeled to investigate the potential influences of human activities on temperatures in East Fork Rock and South Fork Antelope Creeks. The following sections describe those modeling scenarios. A more detailed report of the development and results of the QUAL2K models and scenarios are included in **Appendices I and J**.

6.5.1 QUAL2K - East Fork Rock Creek

6.5.1.1 Baseline Scenario

The baseline scenario represents the existing conditions within the East Fork Rock Creek during July 29, 2010, which was determined to be the hottest period for water temperatures on the stream in the 2010 summer. To inform the model, this scenario used the measured field data to represent temperature, flow, and shade. When field data was unavailable, reasonable assumptions and extrapolation were used. The model was then run and compared with measured conditions. Hydraulic output in the model accurately reflected measured conditions, indicating that water routing and channel morphology were adequately calibrated. To assure consistency when evaluating the potential to reduce stream temperatures, subsequent model scenarios were compared with the existing-conditions results of the baseline model and not to the field-measured values.

6.5.1.2 Low Flow Scenario

In this scenario, the flow inputs to the QUAL2K model are decreased to represent low-flow conditions, simulating the stream dynamics during an exceptionally dry season. DNRC, which manages East Fork Reservoir and the diversion to the Flint Creek watershed, maintains at least 5 cfs below the diversion. In this scenario, the water balance was altered such that 5 cfs of flow was present in the model just below the diversion. This low-flow condition scenario resulted in slightly higher temperatures along most of the stream. Daily maximum temperatures increased between 0.1 and 0.3 °F.

6.5.1.3 Full Potential Shade Scenario

The full potential shade scenario uses the existing conditions model and increases shading along the creek depending on the vegetation present in each reach. The shade in reaches A through F was set equivalent to the 24-hour shade input in reach A. The shade in reach G remained the same, and the shade in reaches H and I was set equivalent to the 24-hour shade input in reach H (see **Figure 6-5**). These full potential shade assignments are based on the review of the vegetation data and aerial photos. It appears that vegetation conditions similar to the EFRC Shade 1, which is characterized by medium conifer in the overstory with dense willows and shrubs in the understory, would be achievable in East Fork Rock Creek below East Fork Reservoir, in reaches H and I. According to site EFRC Shade 2, the potential cover is mixed high level for reach G. The potential cover for reaches A through F is based on site EFRC Shade 6, which appears to be medium willow and shrub; however, most of the stream along these reaches is below this potential condition. This scenario resulted in cooler water temperatures along most of East Fork Rock Creek. Daily maximum temperatures decreased between 0.0 and 1.8 °F.

6.5.1.4 Full Potential Shade with Low Flow Conditions Scenario

The full potential shade scenario using low-flow conditions is a combination of the scenarios presented in **Sections 6.5.1.3** and **6.5.1.4**. Flow conditions were designed to replicate a dry season, and shading was increased to approximate a mature riparian corridor. This scenario resulted in cooler water temperatures along the lower portions of East Fork Rock Creek. Daily maximum temperatures changed between –1.6 and 0.2 °F.

6.5.1.5 Increased Flow Scenario

The increased flow scenario is used to describe the potential thermal effect of water savings and flow augmentation on water temperatures in East Fork Rock Creek. This scenario assumes that improved water delivery and application efficiency could create a water savings of 15% and that the conserved water could be allowed to flow down East Fork Rock Creek past the main diversion, thereby increasing instream flow. For modeling purposes, the diversion flow rate was reduced by 15 percent, and the additional water was allowed to flow down East Fork Rock Creek. This scenario resulted in cooler water temperatures along most of East Fork Rock Creek. Daily maximum temperatures decreased between 0.6 and 2.5 °F.

6.5.1.6 Naturally Occurring Scenario (Full Application of BMPs with Current Land Use)

The naturally occurring scenario represents water temperature conditions resulting from implementing all reasonable land, soil, and water conservation practices as outlined in ARM 17.30.602. This scenario identifies the naturally occurring temperature in waterbodies of interest and establishes the temperatures to which a 1° F temperature increase is allowable. In turn, this can be used to identify the impairment status of a waterbody and forms the basis for the allocations and temperature TMDLs in this document. The naturally occurring scenario used the conditions included in the full potential shade scenario (**Section 6.5.1.3**) and the increased flow scenario (**Section 6.5.1.5**). **Figure 6-7** presents the results for both the existing condition (baseline scenario) and the naturally occurring scenario. This scenario resulted in cooler water temperatures along most of East Fork Rock Creek. Daily maximum temperatures decreased between 0.6 and 3.9 °F.

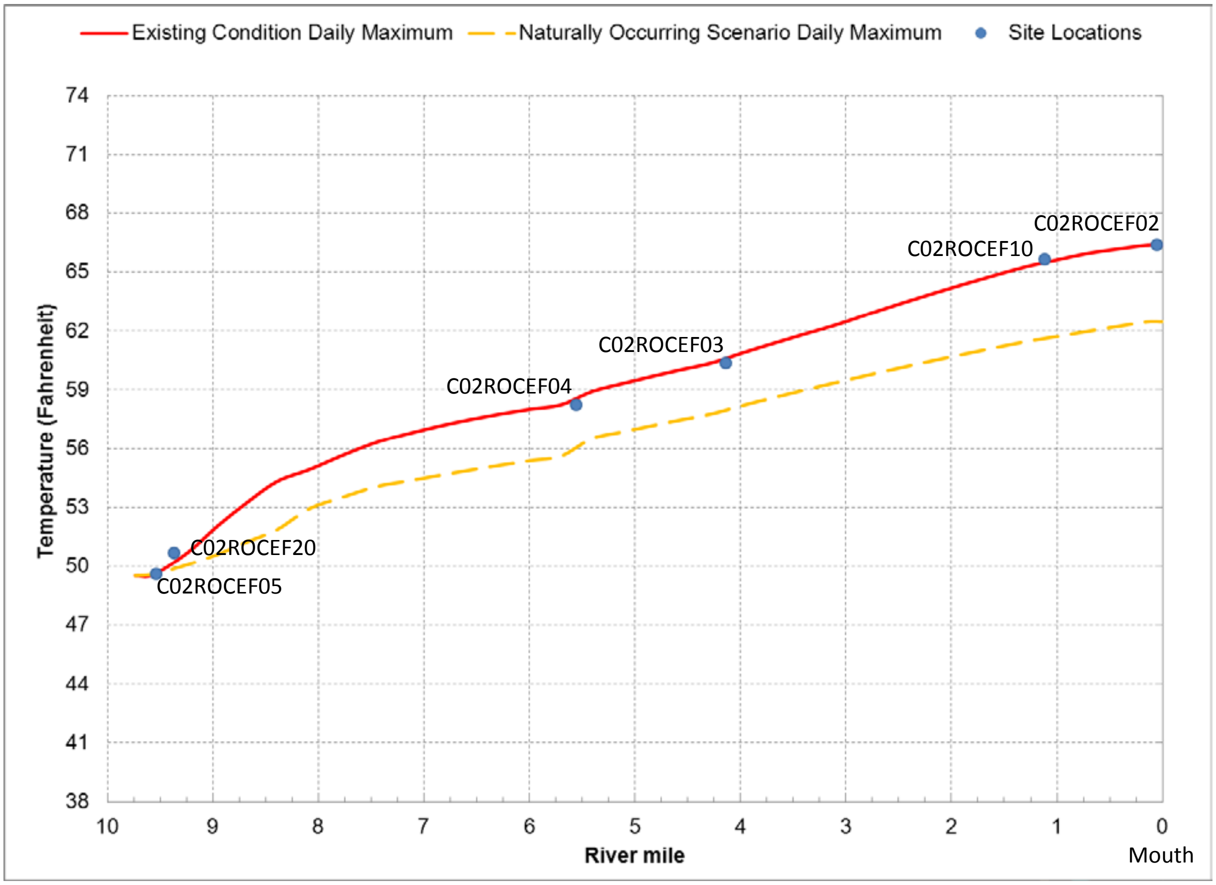

Figure 6-7. Comparison between Existing Condition Daily Maximums and Naturally Occurring Scenario Daily Maximums in East Fork Rock Creek

6.5.2 QUAL2K – South Fork Antelope Creek

6.5.2.1 Baseline Scenario

The baseline scenario represents the existing conditions within South Fork Antelope Creek on July 16, 2010, which was determined to the hottest period for water temperatures on the stream in the 2010 summer. To inform the model, this scenario used the measured field data to represent temperature, flow, and shade. When field data was unavailable, reasonable assumptions and extrapolation were used. The model was then run and compared with measured conditions. Hydraulic output in the model accurately reflected measured conditions, indicating that water routing and channel morphology were adequately calibrated. To assure consistency when evaluating the potential to reduce stream temperatures, subsequent model scenarios were compared with the existing-conditions results of the baseline model and not to the field-measured values.

6.5.2.2 Low Flow Scenario

In this scenario, the flow inputs to the QUAL2K model are decreased to represent critical low-flow conditions, simulating the stream dynamics during an exceptionally dry season. An evaluation of monthly flows at the closest USGS gaging station on the Middle Fork Rock Creek near Philipsburg, Montana (12332000) showed that low-flow conditions (represented by the monthly 25th percentile flow - Calculation Period: 1938-2011) were 37 percent smaller than the average conditions (represented by the monthly mean flow for that same calculation period) for July. An evaluation of monthly flows during the year 2010 revealed that the July through August time period was representative of the average flows for those 3 particular months (**Figure 6-8**). Therefore, the headwaters inflow, diffuse flow (i.e., groundwater) and springs' inflow were reduced by 37 percent. The low-flow condition scenario resulted in higher daily-maximum and daily-mean temperatures along the entire stream, with a greater increase in temperature corresponding to a greater decrease in flow. A uniform decrease in minimum temperatures may be related to the increased influence of cooler groundwater during low-flow conditions.

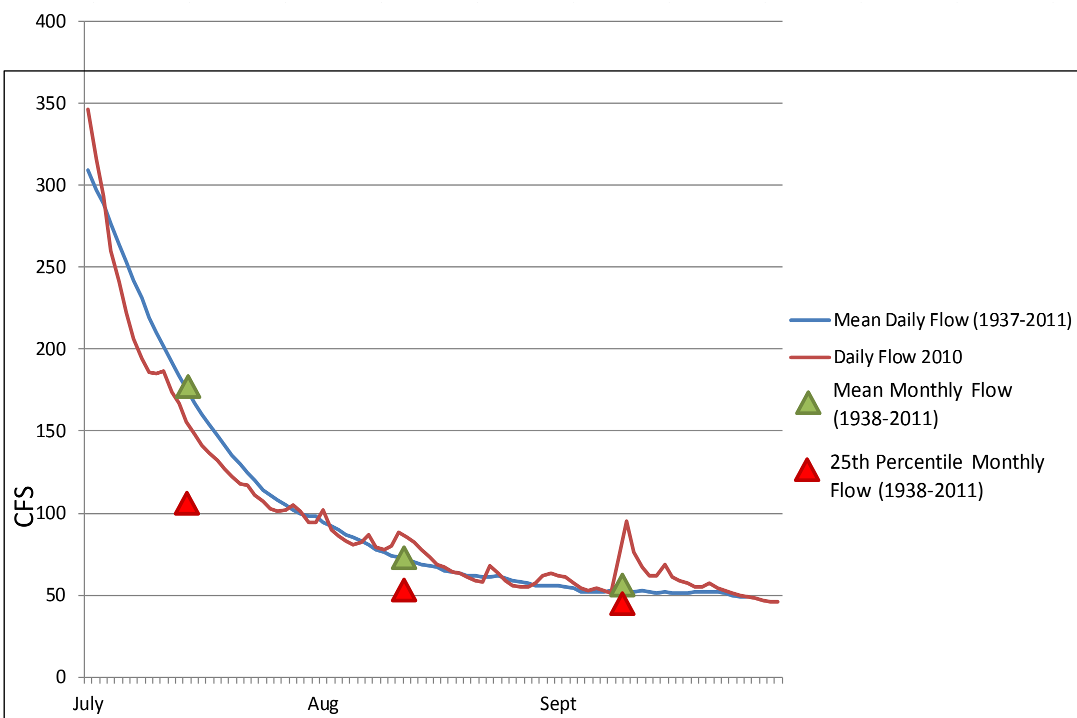

Figure 6-8. Flow comparison on the Middle Fork Rock Creek USGS gaging station

6.5.2.3 Full Potential Shade Scenario

The full potential shade scenario uses the existing conditions model and increases shading along the creek depending on the vegetation present in each reach. In this scenario, the shading of all the reaches was increased to the level of shading in the reach with the highest levels of estimated shading. The 24-hour shade input for reaches A, B, and C were set to the same as the 24-hour shade input for reach D (**Figure 6-6**). This full potential shade scenario had a minimal effect on water temperatures along South

Fork Antelope Creek, with small decreases of maximum daily water temperatures in the lower half of the watershed. Daily maximum temperatures decreased between 0°F and 0.3 °F.

6.5.2.4 Full Potential Shade with Low Flow Conditions Scenario

The full potential shade scenario using low-flow conditions is a combination of the scenarios presented in **Sections 6.5.2.2** and **6.5.2.3**. Flow conditions were designed to replicate a dry season, and shading was increased to approximate a mature riparian corridor. Daily maximum temperatures were lower, as compared to daily maximum temperatures in the low flow condition scenario, but still increased between 0.0 and 1.0 °F.

6.5.2.4 Naturally Occurring Scenario (Full Application of BMPs with Current Land Use)

The naturally occurring scenario represents water temperature conditions resulting from implementing all reasonable land, soil, and water conservation practices as outlined in ARM 17.30.602. This scenario identifies the naturally occurring temperature in waterbodies of interest and establishes the temperatures to which a 1° F temperature increase is allowable. In turn, this can be used to identify the impairment status of a waterbody and forms the basis for the allocations and temperature TMDLs in this document. The naturally occurring scenario used the conditions included in the full potential shade scenario (**Section 6.5.2.3**). Daily maximum temperatures decreased, as compared to the existing condition scenario, between 0.0°F and 0.3 °F. **Figure 6-9** presents the results for both the existing condition (baseline scenario) and the naturally occurring scenario. Again, this full potential shade scenario had a minimal effect on water temperatures along South Fork Antelope Creek.

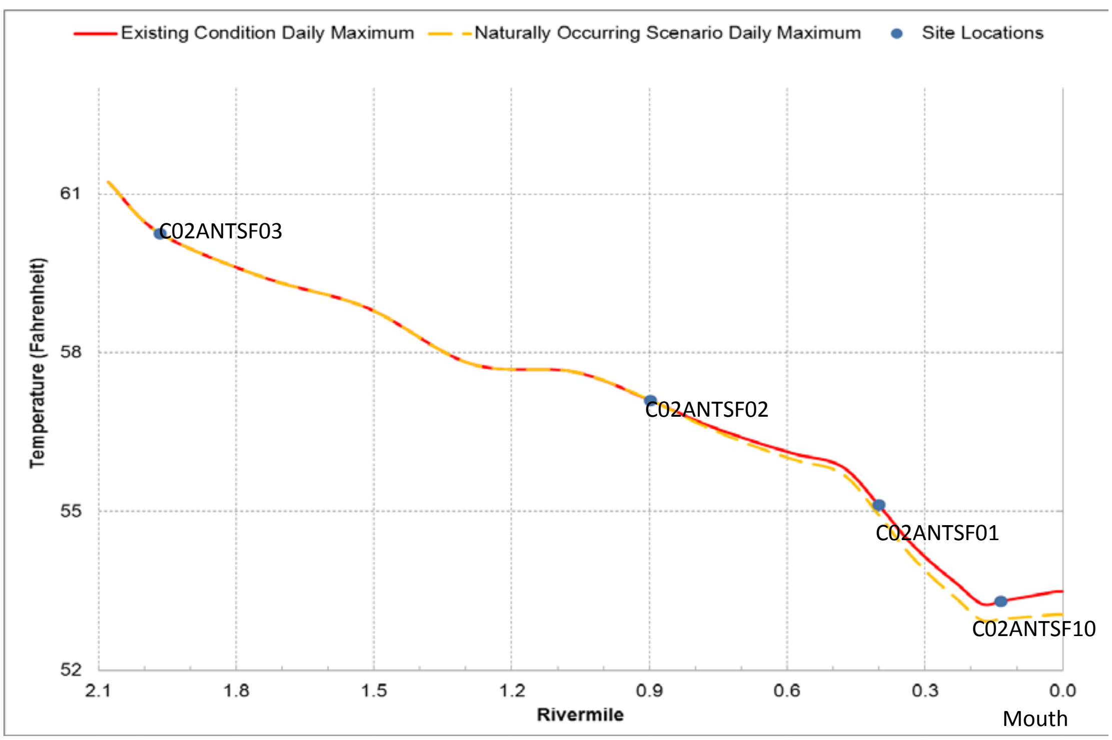

Figure 6-9. Comparison between Existing Condition Daily Maximums and Naturally Occurring Scenario Daily Maximums in South Fork Antelope Creek

6.6 TMDL DEVELOPMENT DETERMINATION

Modeling is used to determine temperature conditions that relate to Montana's temperature standard. The model is calibrated to existing conditions and then used to simulate stream temperatures by applying temperature influencing conditions that represent a naturally occurring setting. These simulated temperatures determine the appropriate allowable increase specified by the standard (0.5°F or 1°F). The need for a TMDL is determined by comparing current conditions to a condition representing all reasonable land, soil, and water conservation practices (naturally occurring condition).

6.6.1 South Fork Antelope Creek

Based on the comparison of the existing conditions to the naturally occurring conditions (full application of BMPs with current land use) a temperature TMDL will not be written for South Fork Antelope Creek. Scenarios were developed in QUAL2K to evaluate the impacts of various factors that could affect instream water temperatures in South Fork Antelope Creek. Increasing shade to replicate the effect of re-vegetation after timber harvest resulted in a small change when compared to both the existing condition scenario (≤ 0.3°F) and the natural low-flow scenario (≤ 0.4°F) (**Figures 6-10 and 6-11**).

Because South Fork Antelope Creek is classified as B-1, and the naturally occurring temperatures for South Fork Antelope Creek are less than 66°F, the maximum allowable increase over the naturally occurring temperature is 1°F. Currently, the estimated maximum increase over the naturally occurring temperature is 0.3°F; therefore, no temperature TMDL will be written for South Fork Antelope Creek.

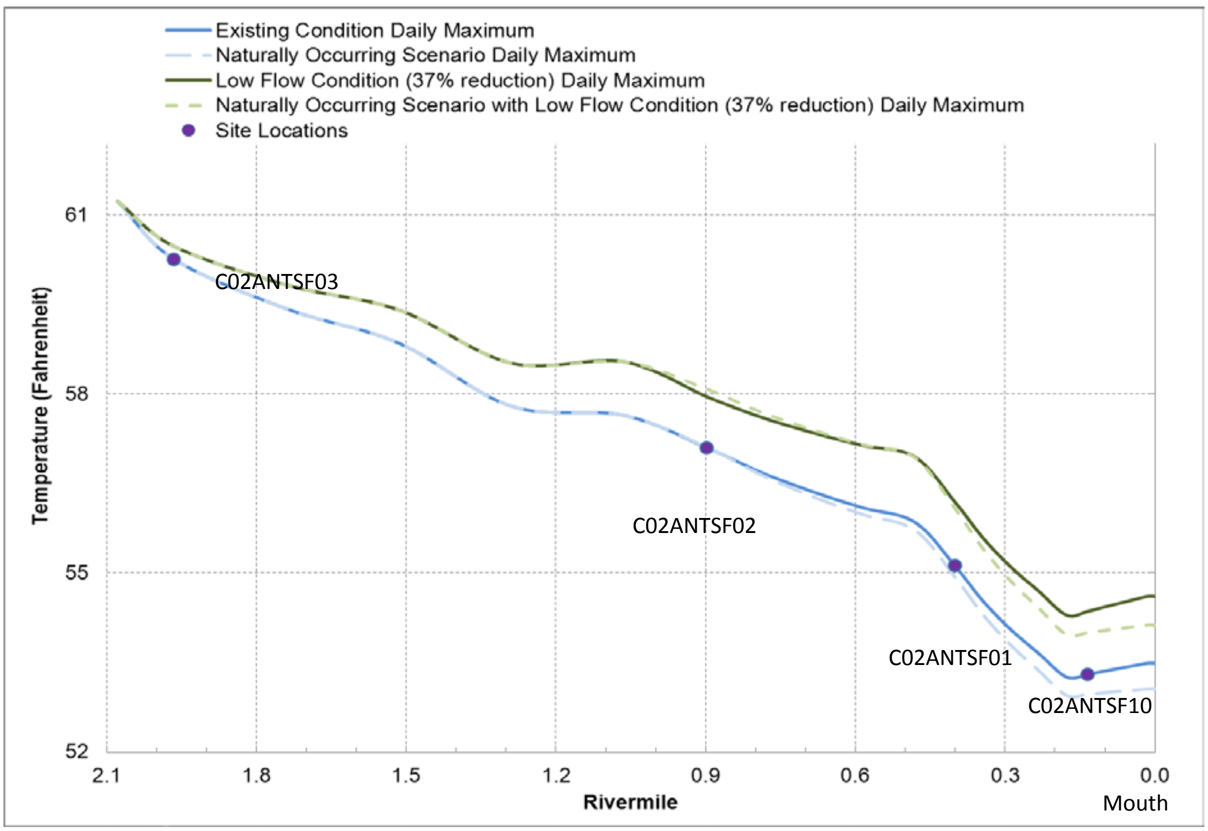

Figure 6-10. Comparison of Existing and Low Flow Conditions with Naturally Occurring Scenario

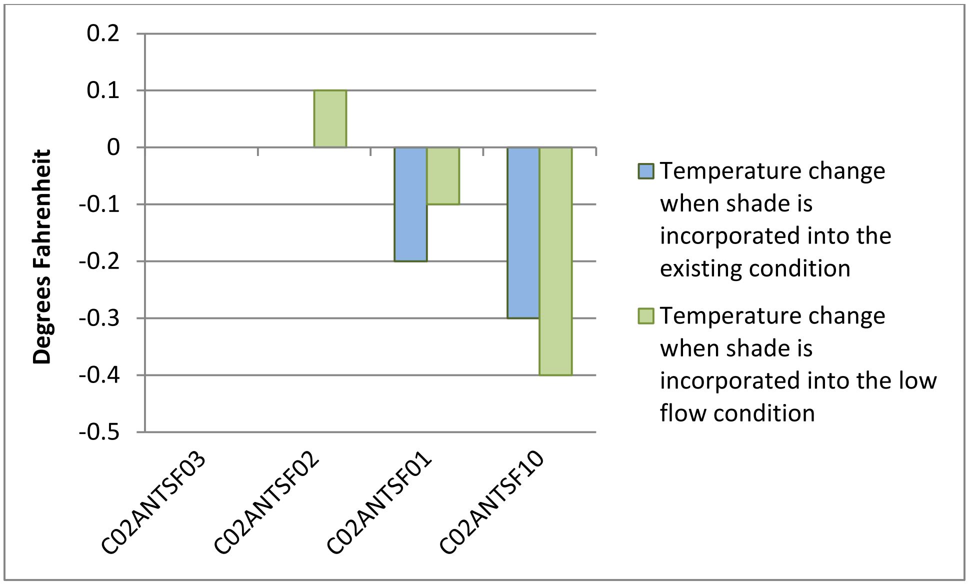

Figure 6-11. Change in Temperature when Naturally Occurring Scenario (full potential shade) is Incorporated into both the Existing and Low Flow Conditions

6.6.2 East Fork Rock Creek

Based on the comparison of existing conditions to naturally occurring conditions (full application of BMPs with current land use) and temperature influencing TMDL targets, a temperature TMDL will be developed for East Fork Rock Creek. Scenarios were developed in QUAL2K to evaluate the impacts of various factors that might affect instream water temperatures in East Fork Rock Creek. Reducing flow such that only 5 cfs was present in East Fork Rock Creek below the main diversion resulted in higher instream temperatures, which increased up to 0.3 °F. Increasing shade to replicate the effect of re-vegetation lowered stream temperatures by as much as 1.8 °F. Increasing shade with low-flow conditions resulted in higher instream temperatures in some parts of East Fork Rock Creek and cooler temperatures in other parts. Creating a water savings from improved irrigation delivery and application efficiencies, and allowing that conserved water to flow down East Fork Rock Creek downstream from the point of the diversion of the East Fork Rock Creek canal, lowered temperatures by as much as 2.5 °F. Increasing instream flow and increasing to full potential shade, which is considered to be the naturally occurring condition, lowered instream temperatures by as much as 3.9 °F.

Because East Fork Rock Creek is classified as B-1, and the naturally occurring temperatures for East Fork Rock Creek are less than 66°F, the maximum allowable increase over the naturally occurring temperature is 1°F. Currently, the estimated maximum increase over the naturally occurring temperature is 3.9°F; therefore, a temperature TMDL will be written for East Fork Rock Creek.

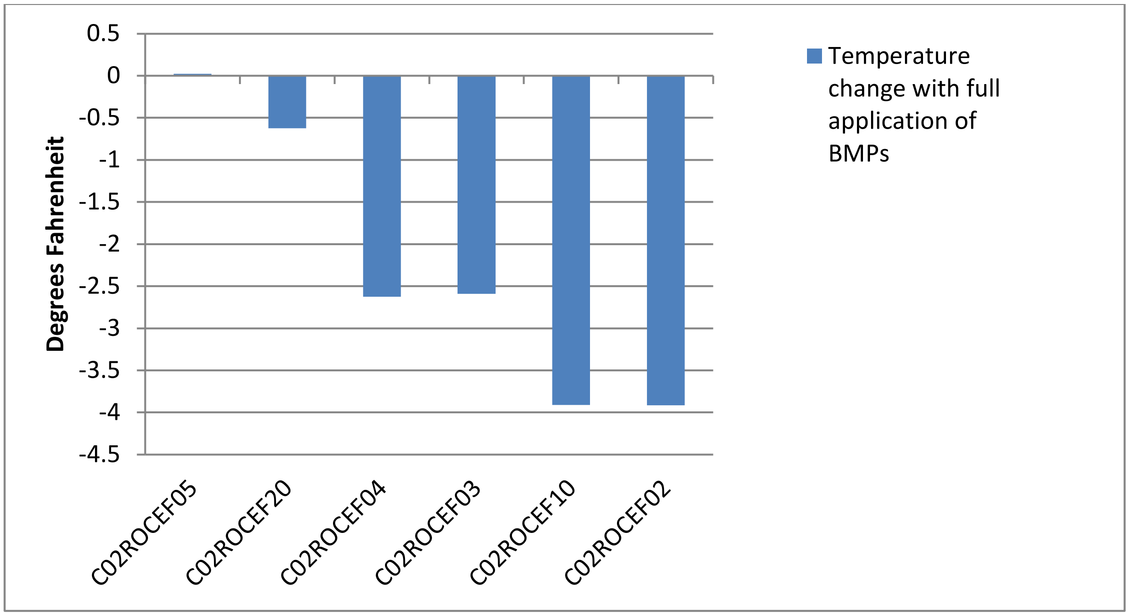

Figure 6-12. Change in Temperature when Naturally Occurring Scenario (full potential shade and instream flow augmentation) is Incorporated into the Existing Condition

6.7 East Fork Rock Creek Temperature TMDL and Allocations

Total maximum daily loads (TMDLs) are a measure of the maximum load of a pollutant a particular waterbody can receive and still maintain water quality standards (see **Section 4.0**). A TMDL is the sum of wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources. A TMDL includes a margin of safety (MOS) to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving stream. Allocations represent the distribution of allowable load applied to those factors that influence loading to the stream. In the case of temperature, thermal loading is assessed.

6.7.1. Temperature TMDL East Fork Rock Creek (MT76E002_020)

Because of the dynamic temperature conditions throughout the course of a day, the temperature TMDL is the thermal load, at an instantaneous moment, associated with the stream temperature when in compliance with Montana's water quality standards. As stated earlier, the temperature standard for East Fork Rock Creek is defined as follows: For waters classified as B-1, the maximum allowable increase over the naturally occurring temperature is 1° F, if the naturally occurring temperature is less than 66° F. Within the naturally occurring temperature range of 66° F to 66.5° F, the allowable increase cannot exceed 67° F. If the naturally occurring temperature is greater than 66.5° F, the maximum allowable increase is 0.5° F. Montana's temperature standard for B1 classified waters, relative to naturally occurring temperatures, is depicted in **Figure 6-13**.

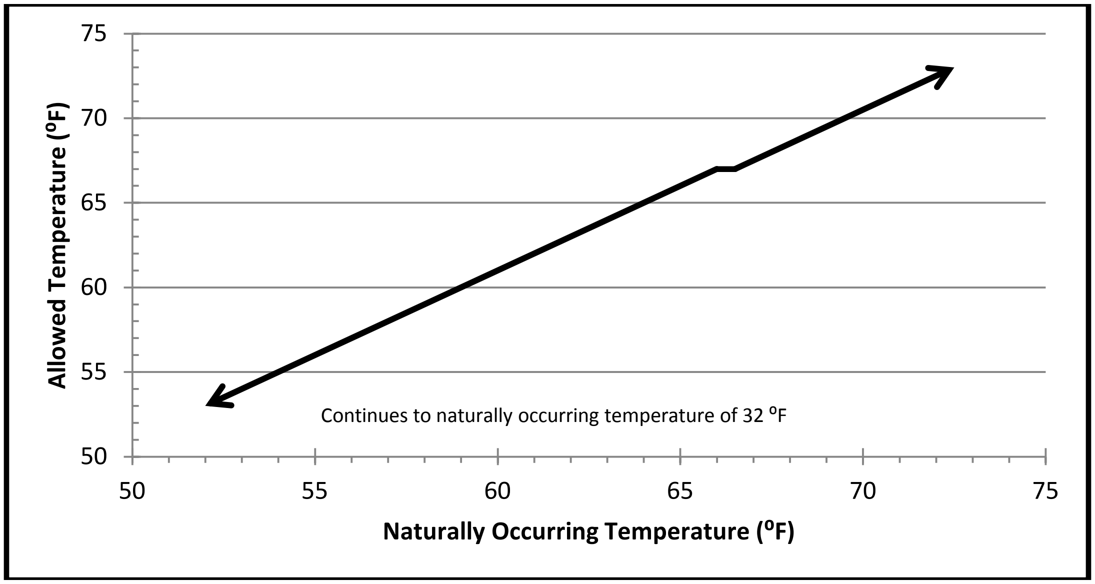

Figure 6-13. Instream Temperatures Allowed by Montana's B-1 Classification Temperature Standard

An instantaneous load is computed by the second and applied at all times. The allowed temperature can be calculated using Montana's B-1 classification standards (**Figure 6-13**) and using a modeled, measured, or estimated naturally occurring instantaneous temperature. The allowable instantaneous total maximum load (per second) at any location in the waterbody is provided by **Equation 6-1**. This equates to the kCal increase associated with the warming of the water from 32° F to the temperature that represents compliance with Montana's temperature standard, as determined from **Figure 6-13**.

Equation 6-1: $TMDL = [(T_n+A)-32]*Q*(15.6)$

Where:
T_n = naturally occurring water temperature (°F)
A = allowable increase above naturally occurring temperature (°F)
Q = streamflow (cfs)
15.6 = conversion factor (°F to kCal)
TMDL = allowable thermal load expressed as kilocalories per second above 32°F

The use of a load per second to define the temperature TMDL is appropriate to address the most sensitive summer afternoon timeframe when fish are most distressed by temperatures and when human-caused thermal loading would have the most effect. Providing thermal loads based upon an average daily temperature does not protect fish because diurnal shifts in temperature create average daily conditions. Streams with significant shade loss can be warmer than natural during the day and cooler than natural at night, resulting in circumstances that do not deviate from Montana's temperature standard when averaged over a daily timeframe. Evaluating impairment and expressing the TMDL using a short time step provides proper fishery use protection.

6.7.2 Temperature TMDL Allocations for East Fork Rock Creek (MT76E002_020)

While **Equation 6-1** provides a translation of allowable instantaneous temperature to an allowable instantaneous thermal load, the development of the TMDL allocations based on this variable thermal load does not readily translate to on-the-ground management.

Furthermore, the challenge in deriving a Total Maximum Daily Load for a parameter such as temperature is in defining the naturally occurring temperature at any given point during the day. In the case of East Fork Rock Creek, a model was used to investigate the likelihood of temperatures above the allowable limit described by the state standard. Although not a perfect representation of the complex interactions that occur in the watershed, the model has shown that human-caused activities have elevated temperatures. In addition, on-the-ground information tells us that not all reasonable land, soil, and water conservation practices (human activity under naturally occurring conditions) are currently being practiced in the watershed. Thus, in lieu of developing allocations based on quantified temperatures or thermal loads that apply under a specific set of conditions, we can express the TMDL and associated allocations through surrogate indicators of local conditions that would comply with the temperature standard. Therefore, the allocations necessary to achieve the TMDL are described using the restoration targets (**Section 6.4.4**). Linking achievement of these targets to land management activities where the application of all reasonable land, soil, and water conservation practices would achieve the state temperature standard.

Thermal conditions affecting East Fork Rock Creek are complex and influenced by many inter-related factors throughout the stream. Although all of these relationships have not been completely analyzed during the assessment of East Fork Rock Creek, field data and water quality modeling do indicate that temperatures in East Fork Rock Creek are influenced by human activity, that temperature increases are likely harmful to aquatic life during certain periods of the summer, and that improvements in vegetative canopy cover and augmenting instream flow during summer months will reduce water temperatures throughout most of the stream, from below the reservoir to the mouth.

The temperature TMDL allocations for East Fork Rock Creek are conveyed via surrogate allocations based on the temperature-related water quality targets described in **Section 6.4.4**. These surrogate TMDL allocations define conditions that will ensure compliance with Montana's temperature standard. The surrogate allocations applicable to East Fork Rock Creek are presented in **Table 6-3**. Naturally occurring conditions will be achieved via meeting the nonpoint source load allocations.

Table 6-3. Temperature TMDL Allocations for East Fork Rock Creek (MT76E002_020) from the East Fork Reservoir to the mouth (Middle Fork Rock Creek)

Source Type	Allocation
Land uses and practices that reduce riparian health and shade provided by near-stream vegetation along East Fork Rock Creek	Load Allocation: The thermal load to the stream segment when there is a minimum average effective shade of 42% along reaches A through F (**Figure 6-5**) and a minimum average effective shade of 63% for reaches G through I (**Figure 6-5**)
Land uses and practices that result in the overwidening of the stream channel such that widths are increased, depths are decreased, and thermal loading is accelerated	Load Allocation: The thermal load to the stream when there is an average width-to-depth ratio < 23 throughout East Fork Rock Creek on C channels and < 12 on E channels

Table 6-3. Temperature TMDL Allocations for East Fork Rock Creek (MT76E002_020) from the East Fork Reservoir to the mouth (Middle Fork Rock Creek)

Source Type	Allocation
Majority of streamflow in East Fork Rock Creek is diverted during summer months to provide water for irrigation.	Load Allocation: 15% water savings from improved irrigation water delivery and application efficiencies, and allowing that conserved water to flow down East Fork Rock Creek downstream from the point of the diversion of the East Fork Rock Creek canal (any voluntary water savings and subsequent in stream flow augmentation must be done in a way that protects water rights). This allocation does not imply an inherent inefficient use of water throughout the watershed, but rather calls on water users to identify their practices, determine if more efficient means are possible and practical given various economic and resource constraints, and apply those improvements wherever possible to limit the effects of practices on temperatures in the East Fork Rock Creek.

6.7.3 Achieving Temperature Allocations

Improvement in riparian health needs significant time before changes can be seen. DEQ does not expect these targets to be met in the short-term; however, changes in land management practices and a commitment to those practices would need to be implemented to start meeting goals for temperature in East Fork Rock Creek. In addition, the targets and allocations presented represent the desired conditions that would be expected in most areas along a stream, but DEQ acknowledges that all sites may not be able to achieve them. The targets and allocations are not intended to be specific to every given point on the stream; the intent, rather, is to achieve these goals as a typical condition throughout the East Fork Rock Creek watershed. (Note that some areas may also be able to achieve conditions greater than the target, and the best possible condition given all reasonable land, soil, and water conservation practices should be strived for in all circumstances.)

6.8 Margin of Safety and Seasonality

TMDL development must incorporate a margin of safety into the allocation process to account for uncertainties in pollutant sources and other watershed conditions, and ensure (to the degree practicable) that the TMDL components and requirements are sufficiently protective of water quality and beneficial uses. In addition, all TMDL/Water Quality Restoration Planning documents must consider the seasonal variability, or seasonality, on water quality impairment conditions, maximum allowable pollutant loads in a stream, and load allocations. This section describes, in detail, considerations of a margin of safety and seasonality in the temperature TMDL development process.

The margin of safety (MOS) is addressed in several ways as part of this section:

- MOS is implicit in each of the temperature TMDLs; they incorporate methods and assumptions that account for local conditions and assess outcomes under all reasonable land, soil, and water conservation practices, but do not ignore or prohibit current anthropogenic activity
- Montana's water quality standards are applicable to any timeframe and any season. The temperature modeling analysis for East Fork Rock Creek investigated temperature conditions during the heat of the summer, when the temperature standards are most likely to heat the stream the most and creates the most detrimental effects on aquatic life.
- The assessment and subsequent allocation scenarios addressed streamflow influences that affect the streams dissipative and volumetric heat capacity.

- Compliance with targets and refinement of load allocations are all based on an adaptive management approach (**Section 6.8**) that relies on future monitoring and assessment for updating planning and implementation efforts.

Seasonal considerations are significant for temperature. Obviously, with high temperatures being a primary limiting factor for salmonids, summer temperatures are a paramount concern. Therefore, focusing on summer thermal regime is an appropriate approach. Seasonality addresses the need to ensure year round beneficial-use support. Seasonality is addressed in this TMDL document as follows:

- Temperature monitoring occurred during the summer season, which is the warmest time of the year. Modeling simulated heat of the summer conditions when instream temperatures are most stressful to the fishery. The fishery is the most sensitive use in regard to thermal conditions. Effective shade was collected during August, which is during the typical hottest time period of the year.
- Temperature targets, the TMDL, and load allocations apply year round, but it is likely that exceedances occur mostly during summer conditions.
- Restoration approaches will help to stabilize stream temperatures year round.

6.9 Uncertainty and Adaptive Management

Uncertainties in the accuracy of field data, source assessments, water quality models, loading calculations and other considerations are inherent when evaluating environmental variables for TMDL development. While uncertainties are an undeniable fact of TMDL development, mitigation and reduction of uncertainty through adaptive management approaches is a key component of ongoing TMDL implementation activities. Uncertainties, assumptions and considerations are applied throughout this document and point to the need for refining analyses when needed or living with the uncertainty when more effort is likely unnecessary to restore uses by easily identified sources.

The process of adaptive management is predicated on the premise that TMDLs, allocations and their supporting analyses are not static, but are processes which are subject to periodic modification and adjustment as new information and relationships are better understood. As further monitoring and assessment is conducted, uncertainties with present assumptions and consideration may be mitigated via periodic revision or review of the assessment which occurred for this document.

As part of the adaptive management approach, changes in land and water management that affect temperature should be tracked. As implementation of restoration projects which reduce thermal input or new sources that increase thermal loading arise, tracking should occur. Known changes in management should be the basis for building future monitoring plans to determine if the thermal conditions meet state standards.

The TMDLs and allocations established in this section are meant to apply to recent conditions of natural background and natural disturbance. Under some periodic but extreme natural conditions, it may not be possible to satisfy all targets, loads, and allocations because of natural short term affects to temperature. The goal is to ensure that management activities are undertaken to achieve loading approximate to the TMDLs within a reasonable time frame and to prevent significant longer term excess loading during recovery from significant natural events.

Any influencing factors that increase water temperatures, including global climate change, could impact thermally sensitive fish species in Montana. The assessments and technical analysis for the temperature

TMDLs considered a worst case scenario reflective of current weather conditions, which inherently accounts for any global climate change to date. Allocations to future changes in global climate are outside the scope of this project but could be considered during the adaptive management process if necessary.

Uncertainties in environmental assessments should not paralyze, but should point to the need for flexibility in our understanding of complex systems and to adjust our current thinking and future analysis. Implementation and monitoring recommendations presented in **Section 10.2 and 10.3** provide a basic framework for reducing uncertainty and further understanding of the complex issues TMDLs undertake.

7.0 Nutrient TMDL Components

This section focuses on nutrients (nitrogen and phosphorus forms) as a cause of water quality impairment in the Rock Creek TMDL Planning Area (TPA). It includes 1) a discussion on nutrient impairment of beneficial uses; 2) identification of the specific stream segments of concern; 3) currently available data on nutrient impairment assessment in the watershed, including target development and a comparison of existing water quality targets; 4) quantification of nutrient sources based on recent studies; and 5) identification of and justification for nutrient TMDLs and TMDL allocations.

7.1 Effects of Excess Nutrients on Beneficial Uses

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

Human activities can increase the biologically available supply of nitrogen and phosphorus. An overabundance of these nutrients in aquatic ecosystems accelerates the process known as eutrophication. Eutrophication is the enrichment of a waterbody, usually by nitrogen and phosphorus, leading to increased aquatic plant production (including algae). The increased aquatic plant or algal growth can reach nuisance levels and harm multiple beneficial uses of the waterbody. Respiration rates from nuisance algal can deplete the oxygen supply available for other aquatic organisms, potentially to levels that can kill fish and other forms of aquatic life. Nuisance algae can shift the macroinvertebrate community structure, which may affect fish that feed on macroinvertebrates (U.S. Environmental Protection Agency, 2010). Nuisance algae can also reduce water clarity, negatively affect waterbody aesthetics, and increase treatment costs of drinking water. Additionally, nuisance algae can cause changes in water clarity, fish community structure, and aesthetics. Changes in aesthetics can harm recreational uses, such as fishing, swimming, and boating (Suplee et al., 2009).

Nuisance algae can pose health risks if ingested in drinking water (World Health Organization, 2003). It can also lead to blue-green algae blooms (Priscu, 1987), which can produce toxins lethal to aquatic life, wildlife, livestock, and humans. Excess nitrogen in the form of dissolved ammonia (which is typically associated with human sources) can be toxic to aquatic life, and excess nitrogen in the form of nitrates in drinking water can inhibit normal hemoglobin function in infants.

7.2 Stream Segments of Concern

A total of 6 waterbody segments in the Rock Creek TPA appeared on the 2012 Montana 303(d) List for nutrient (phosphorus and/or nitrogen) impairments. These impairments occur on the East Fork of Rock Creek, South Fork of Antelope Creek, Scotchman’s Gulch, Sluice Gulch and Flat Gulch. Brewster Creek is also included on the 2012 303(d) List as impaired for nutrients. As noted in **Section 7.4.4, Table 7-13**, DEQ has concluded that Brewster Creek not impaired for nutrients after collection and assessment of additional data. 15-16 samples were collected for total nitrogen (TN), total phosphorous (TP) and

NO_3+NO_2. All sample results were non-detect with the exception of 1 TN sample. Also assessed for nutrient impairment through the TMDL development process was Miner Gulch. Miners Gulch was not listed on the 303(d) list, and was found to not be impaired for nutrients. **Table 7-1** identifies the original 6 waterbodies with 8 nutrient impairment causes from the 2012 303(d) List. Refer to **Map A-1** for the location of these waterbodies. This table differs slightly from **Table 7-13**, which identifies those TMDLs that will be developed through this document. **Section 7.4.3** will discuss those reasons for derivation from the original listing.

Table 7-1. Nutrient Impaired Streams from the 2012 303(d) List

Stream Segment	Waterbody ID	Nutrient Pollutant Listing*
EAST FORK ROCK CREEK, East Fork Reservoir to mouth (Middle Fork Rock Creek)	MT46E002_020	Nitrogen, Nitrate **
BREWSTER CREEK, East Fork to Mouth (Rock Creek)	MT46E002_050	Total Phosphorous
SOUTH FORK ANTELOPE CREEK, Headwater to mouth(Antelope Creek)	MT46E002_060	Total Phosphorous, Nitrate + Nitrite**
SCOTCHMAN GULCH, Headwater to mouth (Upper Willow Creek)	MT46E002_100	Total Phosphorous
SLUICE GULCH, Headwater to mouth (Rock Creek)	MT46E002_110	Nitrate + Nitrite**
FLAT GULCH, Headwaters to mouth (Rock Creek)	MT46E002_120	Total Phosphorous, Total Nitrogen

* Since creation of the 2012 303(d) List, DEQ has reassessed all six streams identified in **Table 7-1**. **Section 7.4** provides a summary of the assessment results with updated nutrient impairment determinations.
* *These two pollutant listings represent the same cause of impairment: Nitrate + Nitrite; generally referred to as NO_3+NO_2 throughout this document.

7.3 Information Sources

To assess nutrient conditions for TMDL development, DEQ compiled nutrient data and undertook additional monitoring. The following data sources represent the primary information used to characterize water quality for the six streams identified in **Table 7-1**.

1) **DEQ TMDL Sampling**. DEQ conducted water quality sampling from 2009 through 2011 to update impairment determinations and assist with the development of nutrient TMDLs. In 2009, water quality samples were collected and analyzed for nutrients on three streams through three events during the algal growing season (July–September). In 2010, all six streams were sampled through three events during the growing season. In 2011, sampling took place on three streams during two events during the growing season.

   Sample locations bracketed tributaries and changes in land-use type or management. In addition to water quality samples, algal samples were collected during growing season sampling in 2009, 2010, and 2011. Algae samples were analyzed for Chlorophyll-*a* concentration and ash free dry weight (AFDW). AFDW is a measurement that captures living and dead algal biomass and is particularly helpful for streams where some or all of the algae are dead (because chlorophyll-*a* measures only living algae). Macroinvertebrate data were collected on all streams between 2000 and 2011 to aid in nutrient impairment determinations. **Figure 7-1** shows the sample locations for the five streams that were identified as the nutrient impaired on the 2012 303(d) List and subsequently determined impaired after performing updated assessments as discussed below in **Section 7.4.3**.

2) **DEQ Assessment Files**. The files contain information used to make nutrient impairment determinations for the 2012 303(d) List. These determinations were made prior to 2006 and thus did not involve any of the recently collected data described above.

Growing-season nutrient data used for impairment assessment purposes and TMDL development are included in **Appendix K**. This and other nutrient data from the watershed is publicly available through EPA's STORET water quality database and DEQ's EQuIS water quality database.

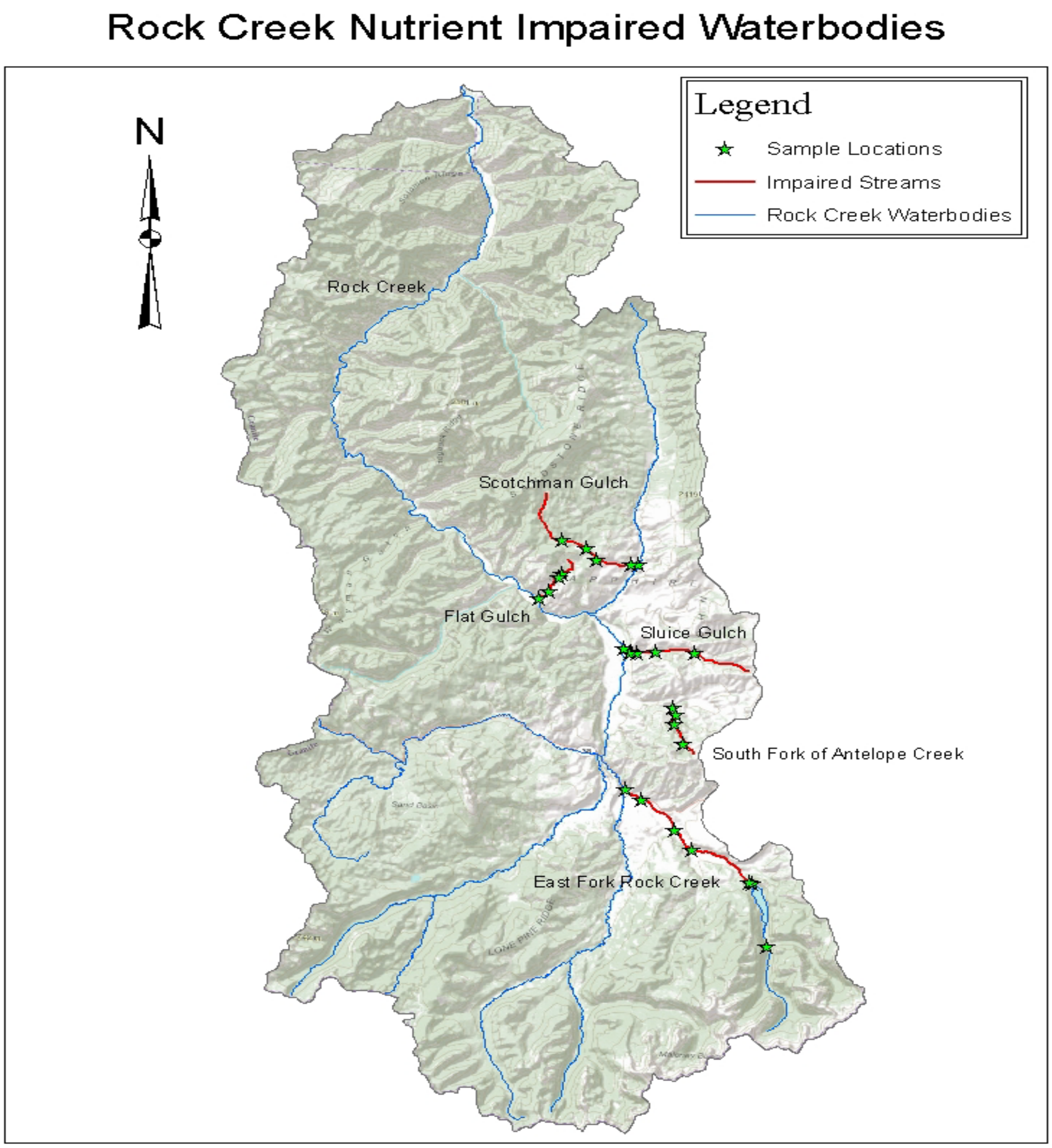

Figure 7-1. Nutrient impaired streams (based on post-2012 assessments) and associated sampling locations.

Additional sources of information used to develop TMDL components (**Section 4.0**) include the following:

- Additional chemical, physical, and biological water quality monitoring results collected during nutrient assessment work

- Streamflow data
- GIS data layers
- Outside agency and university websites and documentation
- Land-use information

The above information and water quality data are used to compare existing conditions to waterbody restoration goals (targets), to assess nutrient pollutant sources, and to help determine TMDL allocations.

7.4 Water Quality Targets

TMDL water quality targets are numeric indicator values used to evaluate whether water quality standards have been met. These are discussed in **Section 4.0**. This section presents nutrient water quality targets and compares them with recently collected nutrient data in the Rock TPA following DEQ's draft assessment methodology (Suplee and Sada de Suplee, 2011). To be consistent with DEQ's draft assessment methodology, and because of improvements in analytical methods, only data from the past 10 years are included in the review of existing data.

7.4.1 Nutrient Water Quality Standards

Montana's water quality standards for nutrients (nitrogen and phosphorous) are narrative and are addressed via narrative criteria. Narrative criteria require state surface waters to be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will: 1) produce conditions that create concentrations or combinations of material toxic or harmful to aquatic life, and 2) create conditions that produce undesirable aquatic life (ARM 17.30.637 (1) (d-e)). DEQ is currently developing numeric nutrient criteria that will be established at levels consistent with narrative criteria requirements. These numeric criteria are the basis for the nutrient TMDL targets and are consistent with EPA's guidance on TMDL development and federal regulations (40 CFR Section 122.44(d)).

7.4.2 Nutrient Target Values

Nutrient water quality targets include nutrient concentrations in surface waters and measures of benthic algae (a form of aquatic life that at elevated concentrations is undesirable) chlorophyll-*a* concentrations and AFDW. The target concentrations for nitrogen and phosphorus are established at levels believed to prevent the harmful growth and proliferation of excess algae. Since 2002, DEQ has conducted studies in order to develop numeric criteria for nutrients (N and P forms). DEQ is developing draft numeric nutrient standards for total nitrogen (TN) and total phosphorus (TP) based on 1) public surveys defining what level of algae was perceived as "undesirable" and 2) the outcome of nutrient stressor-response studies that determine nutrient concentrations that will maintain algal growth below undesirable and harmful levels (Suplee et al., 2008a).

Nutrient targets for TN and TP (which are also draft numeric criteria), chlorophyll-*a*, and AFDM are based on Suplee and Watson (2013) and can be found in **Table 7-2**. The nitrate target is based on research by Suplee et al. (2008b) and can also be found in **Table 7-2**. DEQ has determined that the values for nitrate, TN, and TP provide an appropriate numeric translation of the applicable narrative nutrient water quality standards based on existing water quality data in the Rock Creek TPA and on the type of typical coldwater wadeable streams addressed by nutrient TMDL development in this document. These targets are appropriate for the Level IV Ecoregions that comprise the Rock Creek TPA (Rattlesnake-Blackfoot-South Swan-Northern Garnet- Sapphire Mountains, Deer Lodge-Philipsburg-Avon

Grassy Intermontane Hills and Valleys, Flint Creek Anaconda Mountains and Eastern Batholith). The target values are based on the most sensitive uses; therefore, the nutrient TMDLs are protective of all designated uses. When the draft criteria for TN and TP become numeric standards they will be in DEQ's DEQ-12 circular.

A macroinvertebrate biometric (Hilsenhoff's biotic index (HBI) score) is also considered in further evaluation of compliance with nutrient targets **Table 7-2**. An HBI score of greater than 4.0 is used to indicate nutrient impairment.

Because numeric nutrient chemistry is established to maintain algal levels below target chlorophyll-*a* concentrations and AFDM, target attainment applies and is evaluated during the summer growing season (July 1–September 30 for the Middle Rockies Level III Ecoregion) when algal growth will most likely affect beneficial uses. Targets listed here have been established specifically for nutrient TMDL development in the Rock Creek TPA and may or may not be applicable to streams in other TMDL project areas. The target values for nitrate, TN, and TP will be used to develop TMDLs. See **Section 7.6** for the adaptive management strategy as it relates to nutrient water quality targets.

Table 7-2. Nutrient Targets for the Rock Creek TPA

Parameter	Target Value
Nitrate	≤ 0.100 mg/L(1)
Total Nitrogen	≤ 0.300 mg/L(2)
Total Phosphorus	≤ 0.030 mg/L(2)
Chlorophyll-*a*	≤ 120 mg/m^2(2)
Ash Free Dry Mass	≤ 35 g /m^2(2)
Hilsenhoff's Biotic Index	< 4.0

(1) Value is from Suplee et al. (2008b).
(2) Value is from Suplee and Watson (2013).

7.4.3 Existing Conditions and Comparison with Targets

To evaluate whether nutrient targets have been met, the existing water quality conditions in each waterbody segment are compared to the water quality targets in **Table 7-2** using the methodology in the DEQ draft guidance document "2011 Assessment Methodology for Determining Wadeable Stream Impairment due to Excess Nitrogen and Phosphorus Levels" (Suplee and Sada de Suplee, 2011). This approach provides DEQ with updated impairment determinations used for TMDL development decisions. Because the original impairment listings are based on old data or were listed before developing the numeric criteria, each stream segment is evaluated for impairment from NO_3+NO_2, TN, and TP using data collected within the past 10 years. As previously noted, assessment results for Brewster Creek showed no nutrient impairments, therefore, nutrient TMDLs are not developed for this stream and assessment information is not included in this document.

The assessment methodology uses two statistical tests (Exact Binomial Test and the One-Sample Student's T-test for the Mean) to evaluate water quality data for compliance with established target values. In general, compliance with water quality targets is <u>not</u> attained when nutrient chemistry data shows a target exceedance rate of >20% (Exact Binomial Test), when mean water quality nutrient chemistry exceeds target values (Student T-test), or when a single chlorophyll-*a* exceeds benthic algal target concentrations (120 mg/m^2 or 35 g AFDW/m^2). Where water chemistry and algae data do not provide a clear determination of impairment, or where other limitations exist, macroinvertebrate biometrics (HBI >4.0) are considered in further evaluating compliance with nutrient targets. Lastly, inherent to any impairment determination is the existence of human sources of pollutant loading. Human-caused sources of nutrients must be present for a stream to be considered impaired. Note: to ensure a higher degree of certainty for removing an impairment determination and making any new impairment determination, the statistical tests are configured differently for an unlisted nutrient form than for a listed nutrient form. This can result in a different number of allowable exceedances for nutrients within a single stream segment. Such tests help assure that assessment reaches do not vacillate between listed and delisted status by the change in results from a single additional sample.

Simple summary statistics are provided in tables in each of the subsequent sections. These tables show the minimum, maximum , mean and 80th percentile values of the data sets for each perspective waterbody. Percentile is the value below which the percent of the observations may be found. For example , if a score is in the 80th percentile, then this score mark is higher than 80 percent of the other values. The 80th percentile is shown to give the reader an idea of where the majority of the data lies. The use of the 80th percentile is also consistent with the 20% allowable exceedance rate within the Exact Binomial Test.

7.4.3.1 East Fork Rock Creek

East Fork Rock Creek appears on the 2012 303(d) List as impaired for nitrate (equivalent to NO_3+NO_2 for all practical purposes). The impaired segment of the East Fork of Rock Creek originates at the East Fork Reservoir and ends at the mouth. Tributaries to the East Fork Reservoir, including the upper portion of the East Fork Rock Creek, originate at the continental divide in the Anaconda-Pintler Wilderness. The East Fork of Rock Creek flows north-northwest from the East Fork Reservoir dam for about 10.2 miles to the confluence with the Middle Fork of Rock Creek. The confluence of the Middle Fork and the East Fork are the origins of Rock Creek.

Summary nutrient data statistics and assessment method evaluation results for the East Fork of Rock Creek are provided in **Tables 7-3 and 7-4,** respectively. Between 2004 and 2010, numerous samples were collected in the East Fork of Rock Creek. The samples are broken out as follows: 13 samples for TN, 15 samples for NO_3+NO_2 and 15 samples for TP. No NO_3+NO_2 or TN samples collected during this time exceeded target values. Only one TP sample collected during this time was above target values.

Chlorophyll-*a* data was collected from 2007 to 2010. No samples collected during this time exceeded the target criteria (>120 mg/m^2). AFDW data was collected from 2009 to 2011; 3 values exceeded target criteria (>35g/m^2). On July 26, 2010, AFDW was measured as 70.42 g/m^2, 72.59 g/m^2 and 125.5 g/m^2 at three independent sampling sites (C2ROCEF10, C2ROCEF03, C2ROCEF04 respectively). HBI data was collected in 2004. All samples collected were higher than target values, providing additional indication of impairment.

Field data sheets were reviewed to rule out irregularities in collection methods or sample QC/QC. Laboratory methods and Quality Assurance/Quality Control (QA/QC) criteria were also reviewed to ensure these values were accurate. Nothing was found to indicate the result was an anomaly. As a result of the initial listing for nitrate, elevated AFDW and elevated HBI scores DEQ will continue with TMDL development for TN. This conclusion is consistent with DEQ’s assessment method whereby elevated algal results and elevated HBI scores provide a strong indication of nutrient impairment even in the absence of elevated nutrient concentrations. The lack of elevated nutrient concentrations in the water column could be due to consumption of nitrogen and phosphorus for algal growth, and there is uncertainty as to whether the problem is mainly from elevated nitrogen or phosphorus. As such, DEQ has also made the determination to develop TN and TP TMDL. The TN TMDL will be developed because a nitrogen species was previously identified as a cause of impairment, then a nitrogen species will remain as a cause of impairment per DEQ's assessment method. In this type of situation, TN is the preferred nitrogen species for impairment determination and subsequent TMDL development.

Table 7-3. Nutrient Data Summary for East Fork Rock Creek (East Fork Reservoir to Mouth)

Nutrient Parameter	Sample Timeframe	Sample Size	Min	Max	Mean	80th percentile
Nitrate+Nitrite, mg/L	2004, 2007, 2010	15	0.010	0.040	0.012	0.010
TN, mg/L	2004, 2007, 2010	13	0.010	0.110	0.062	0.086
TP, mg/L	2004, 2007, 2010	15	0.005	0.031	0.012	0.016
Chlorophyll-*a*, mg/m^2	2010	4	10.2	17.6	15.4	16.46
AFDW, g/m^2	2010	4	18.3	125.5	71.5	93.7
Macroinvertebrate HBI	2004	3	5.45	5.83	5.46	5.68

Table 7-4. Assessment Method Evaluation Results for the East fork of Rock Creek (East Fork Reservoir to Mouth)

Nutrient Parameter	Sample Size	Target Value (mg/l)	Samples Above Target	Binomial Test Result	T-test Result	AFDW Test Results	Chl-*a* Test Result	HBI Results	TMDL Required
NO_3+NO_2	15	0.100	0	PASS	PASS				NO
TN	13	0.300	0	PASS	PASS	FAIL	PASS	FAIL	Yes
TP	15	0.030	1	PASS	PASS				Yes

7.4.3.2 South Fork of Antelope Creek

The South Fork of Antelope Creek appears on the 2012 303(d) List as impaired for Nitrate + Nitrite ($N0_3$+$N0_2$) and Total Phosphorous (TP). The South Fork of Antelope Creek originates from the southwest side of the John Long Mountains. The streamflows north northwest, and its total length is about 2.8 miles from the origin to the confluence with Antelope Creek. Antelope Creek is a tributary to Rock Creek and joins Rock Creek approximately 3.8 miles downstream from the origin of Rock Creek. The likely cause of nutrient impairment in the South Fork of Antelope Creek is grazing. There are a number of federally allotted grazing units and private cattle grazing operations in this watershed.

Summary nutrient data statistics and assessment method evaluation results for the South Fork of Antelope Creek are provided in **Tables 7-5 and 7-6,** respectively. From 2004 to 2011, numerous high-flow and low-flow samples were collected in the South Fork of Antelope Creek for TP and $N0_3$+$N0_2$. TP samples exceeded target values three times out of 16 samples. From 2004 to 2011 15 growing season samples for Total Nitrogen (TN) were collected. In addition, one sample for each NO_3+NO_2, and TP were collected in 2004. All TN and NO_3+NO_2 samples collected during this time frame exceeded target values.

Chlorophyll-*a* data was collected in 2010. No samples collected during this time exceeded the target criteria (>120 mg/m^2). AFDW data was collected in 2010 as well; no values exceeded target criteria (>35g/m^2). In 2004 and 2011 4 macro invertebrate samples were collected. Two of the 4 samples collected exceeded the target criteria (>4 HBI). As a result of the initial 2012 303(d) impairment causes for TP and $N0_3$+$N0_2$ along with elevated HBI scores, DEQ will continue with TMDL development for TP, $N0_3$+$N0_2$. Also, the2004 through 2011 sampling results justify TN as an impairment cause, as such DEQ will develop a TMDL for TN for the South Fork of Antelope Creek as well.

Table 7-5. Nutrient Data Summary for South Fork of Antelope Creek

Nutrient Parameter	Sample Timeframe	Sample Size	Min	Max	Mean	80th percentile
Nitrate+Nitrite, mg/L	2004,2010-2011	16	0.240	0.620	0.471	0.550
TN, mg/L	2010-2011	15	0.380	1.480	0.659	0.806
TP, mg/L	2004, 2010-2011	16	0.005	0.063	0.020	0.030
Chlorophyll-*a*, mg/m^2	2009-2011	3	7.0	30.27	17.57	25.19
AFDW, g/m^2	2009-2010	2	4.4	6.88	5.64	6.38
Macroinvertebrate HBI	2004, 2011	4	2.78	6.10	3.76	4.92

Table 7-6. Assessment Method Evaluation Results for South Fork of Antelope Creek

Nutrient Parameter	Sample Size	Target Value (mg/l)	Samples Above Target	Binomial Test Result	T-test Result	AFDW Test results	Chl-*a* Test Result	HBI Results	TMDL Required
NO_3+NO_2	16	0.100	16	FAIL	FAIL				YES
TN	15	0.300	15	FAIL	FAIL	PASS	PASS	FAIL	YES
TP	16	0.030	3	FAIL	PASS				YES

7.4.3.3 Sluice Gulch

Sluice Gulch appears on the 2012 303(d) List as impaired for NO_3+NO_2. Sluice Gulch is located in the south central portion of the Rock TPA on the southwestern-most extent of the John Long Mountains. It originates in the John Long Mountains east of Rock Creek and North of Antelope Creek. The total stream length is about 5.8 miles from its origin to the confluence with Rock Creek. The direction of flow is to the north and west. The likely cause of the elevated nutrient values in Sluice Gulch is the result of cattle grazing and historical mining practices in the area.

Summary nutrient data statistics and assessment method evaluation results for Sluice Gulch are provided in **Tables 7-7 and 7-8**. From 2004 through 2011, numerous growing season samples were collected for NO_3+NO_2, TN and TP. Between 2010 and 2011, 15 samples were collected for TN, 16 for both NO_3+NO_2, and TP. 14 out of 15 samples for TN were above target criteria; fourteen out of 16 samples for NO_3+NO_2 were above the target criteria; no TP samples were above target criteria. These results can be seen in **Table 7-8**.

Chlorophyll-*a* and AFDW data were collected in 2010, none of which exceeded the target criteria of >120 mg/m^2 and >35g/m^2, respectively. In 2011, three macroinvertebrate samples were collected, and two were above the target criteria (>4 HBI). Elevated HBI scores support the nutrient impairments identified through the water quality sampling discussed above. The initial listing of NO_3+NO_2 and its associated impairment cause will be addressed through a TMDL for NO_3+NO_2. 2004 through 2011 sampling results also justify TN as a parameter of impairment; therefore, a TMDL for TN will also be developed for Sluice Gulch.

Table 7-7. Nutrient Data Summary for Sluice Gulch

Nutrient Parameter	Sample Timeframe	Sample Size	Min	Max	Mean	80th percentile
Nitrate+Nitrite, mg/L	2004-2011	16	0.06	0.5	0.365	0.45
TN, mg/L	2010-2011	15	0.27	0.67	0.42	0.53
TP, mg/L	2004-2011	16	0.010	0.19	0.0135	0.017
Chlorophyll-*a*, mg/m^2	2010	3	20.7	34.22	24.4	30.29
AFDW, g/m^2	2010	2	8.43	12.69	10.56	11.84
Macroinvertebrate HBI	2011	3	3.92	5.33	4.76	5.10

Table 7-8. Assessment Method Evaluation Results for Sluice Gulch

Nutrient Parameter	Sample Size	Target Value (mg/l)	Samples Above Target	Binomial Test Result	T-test Result	AFDW Test Result	Chl-*a* Test Result	HBI Results	TMDL Required
NO_2+NO_3	16	0.1	14	FAIL	FAIL	PASS	PASS	FAIL	YES
TN	15	0.3	14	FAIL	FAIL				YES
TP	16	0.03	0	PASS	PASS				NO

7.4.3.4 Scotchman Gulch

Scotchman Gulch appears on the 2012 303(d) List as impaired for TP. Scotchman Gulch is located in the central portion of the Rock TPA. Scotchman Gulch originates from Sandstone Ridge that separates the Beaverhead Deerlodge National Forest from the Lolo National Forest. Scotchman Gulch flows off the southeast side of Sandstone Ridge, and is located north of Flat Gulch and south of Miners Gulch. The total stream length is about 7.0 miles from the origin to the confluence with Upper Willow Creek. Willow creek is a tributary to Rock Creek, and joins Rock Creek downstream of the confluence of the East, West and Middle forks. The likely cause of the nutrient impairment is the result of cattle grazing.

Summary nutrient data statistics and assessment method evaluation results for Scotchman Gulch are provided in **Tables 7-9 and 7-10.** From 2004 through 2011, a total of 26 growing season samples were collected for NO_3+NO_2 and TP. No NO_3+NO_2 samples were above the target criteria. Eight of 24 TN samples were above target criteria, 24 of 26 TP samples were above target criteria.

Chlorophyll-*a* and AFDW data were collected from 2009 to 2011. No Chlorophyll-*a* samples exceeded the target criteria of >120 mg/m^2. No AFDW samples exceeded the criteria of >35g/m^2. In 2004 and 2009, 12 macroinvertebrate samples were collected and three were above the target criteria (>4 HBI). As a result of this assessment and the 2012 303(d) listing, DEQ will develop a TMDL for TP for Scotchman Gulch. The assessment methodology results also justify TN as a parameter of impairment; therefore, a TMDL for TN will also be developed for Scotchman gulch.

Table 7-9. Nutrient Data Summary for Scotchman Gulch

Nutrient Parameter	Sample Timeframe	Sample Size	Min	Max	Mean	80th percentile
Nitrate+Nitrite, mg/L	2004-2011	26	0.005	0.095	0.0125	0.023
TN, mg/L	2007-2011	24	0.15	0.71	0.25	0.398
TP, mg/L	2004-2011	26	0.001	0.115	0.056	0.066
Chlorophyll-*a*, mg/m^2	2009,2011	11	2.29	14.29	4.16	7.15
AFDW, g/m^2	2011	3	3.98	13.82	4.16	9.96
Macroinvertebrate HBI	2004,2009	12	2.63	6.37	3.56	4.23

Table 7-10. Assessment Method Evaluation Results for Scotchman Gulch

Nutrient Parameter	Sample Size	Target Value (mg/l)	Sample Above Target	Binomial Test Result	T-test Result	AFDW Test Results	Chl-*a* Test Result	HBI Results	TMDL Required
NO_3+NO_2	26	0.1	0	PASS	PASS	PASS	PASS	FAIL	NO
TN	24	0.3	8	FAIL	FAIL				YES
TP	26	0.03	24	FAIL	PASS				YES

7.4.3.5 Flat Gulch

Flat Gulch appears on the 2012 303(d) List as impaired for TN and TP. Flat Gulch is located in the central portion of the Rock TPA. Flat Gulch originates from Sandstone Ridge that separates the Beaverhead Deerlodge National Forest from the Lolo National Forest. Flat Gulch flows off the southwest side of Sandstone Ridge, and is located south of Scotchman Gulch. The total stream length is about 3.0 miles from the origin to the confluence with Rock Creek. The likely cause of the nutrient impairment is the result of cattle grazing.

Summary nutrient data statistics and assessment method evaluation results for Flat Gulch are provided in **Tables 7-11 and 7-12.** From 2004 through 2011, numerous samples were collected for NO_3+NO_2, TN and TP. From 2009-2011 16 samples were collected for TN. Fifteen of 16 TN samples were above target criteria, 17 of 17 TP samples were above target criteria and one NO_3+NO_2 sample was above target criteria.

Chlorophyll-*a* and AFDW data were collected in 2004, 2009 to 2011. No Chlorophyll-*a* samples exceeded the target criteria of >120 mg/m^2. No AFDW samples exceeded the criteria of >35g/m^2. In 2009, 6 macroinvertebrate samples were collected and all were above the target criteria (>4 HBI). As a result of the 2012 303(d) listing and the assessment findings mentioned above, DEQ will develop a TMDL for TN and TP for Flat Gulch.

Table 7-11. Nutrient Data Summary for Flat Gulch

Nutrient Parameter	Sample Timeframe	Sample Size	Min	Max	Mean	80th percentile
Nitrate+Nitrite, mg/L	2004-2011	17	0.005	0.136	0.0375	0.052
TN, mg/L	2009-2011	16	0.229	1.23	0.464	1.04
TP, mg/L	2004-2011	17	0.078	0.402	0.211	0.31
Chlorophyll-*a*, mg/m^2	2009,2011	10	5.54	25.2	10.705	17.204
AFDW, g/m^2	2011	3	2.61	4.14	2.97	3.696
Macroinvertebrate HBI	2009	6	4.68	5.79	5.16	5.76

Table 7-12. Assessment Method Evaluation Results for Flat Gulch

Nutrient Parameter	Sample Size	Target Value (mg/l)	Samples Above Target	Binomial Test Result	T-test Result	AFDW Test Results	Chl-*a* Test Result	HBI Result	TMDL Required
NO_3+NO_2	17	0.1	1	PASS	PASS	PASS	PASS	FAIL	NO
TN	16	0.3	15	FAIL	FAIL				YES
TP	17	0.03	17	FAIL	FAIL				YES

7.4.4 Nutrient TMDL Development Summary

Table 7-13 summarizes the 2012 nutrient 303(d) listings for the Rock TPA, along with the summary of the nutrient pollutants for which TMLDs will be prepared based on DEQ's updated assessment for these stream. The changes from the 2012 303(d) List are because of limited data collection at the time the waterbody segments were initially listed (1994 through 2006) and the improved assessment method along with significant data collection since original impairment determinations. The updated impairment determinations will be reflected in the 2014 Water Quality Integrated Report. Note that as Per **Table 7-13** a total of 11 separate nutrient TMDLs will be developed for the 5 stream segments that still have nutrient impairment causes. No nutrient TMDLs will be developed for Brewster Creek since DEQ concluded that Brewster Creek in not impaired for nutrients per recent assessment results.

Table 7-13. Summary of Nutrient TMDL Development Determinations

Stream Segment	Waterbody ID	2012 303(d) Nutrient Impairment(s)	TMDLs Prepared
EAST FORK ROCK CREEK, East Fork Reservoir to mouth (Middle Fork Rock Creek)	MT46E002_020	Nitrogen, Nitrate	Total Nitrogen, Total Phosphorous
BREWSTER CREEK, East Fork to Mouth (Rock Creek)	MT46E002_050	Total Phosphorous	NA
SOUTH FORK ANTELOPE CREEK, Headwater to mouth (Antelope Creek)	MT46E002_060	Total Phosphorous, Nitrate + Nitrite	Total Phosphorous, Nitrate + Nitrite, Total Nitrogen
SCOTCHMAN GULCH, Headwater to mouth (Upper Willow Creek)	MT46E002_100	Total Phosphorous	Total Phosphorous, Total Nitrogen
SLUICE GULCH, Headwater to mouth (Rock Creek)	MT46E002_110	Nitrate + Nitrite	Total Nitrogen, Nitrate + Nitrite
FLAT GULCH, Headwaters to mouth (Rock Creek)	MT46E002_120	Total Phosphorous, Total Nitrogen	Total Phosphorous, Total Nitrogen

7.5 Nutrient Sources, TMDLs, and Allocations

As described in **Section 7.4**, exceedances of water quality targets in the Rock TPA include Total Phosphorous (TP), nitrogen fractions; (TN), and (NO_3+NO_2). Data results show TN target exceedances on South Fork of Antelope Creek, Sluice Gulch, Scotchman Gulch and Flat Gulch are sufficient to conclude impairment and require TN TMDL development for these streams. Data results also show NO_3+NO_2 target exceedances in South Fork of Antelope Creek and Sluice Gulch. TP exceedances were documented in the South Fork of Antelope Creek, Scotchman Gulch and Flat Gulch.

Assessment of existing nutrient sources is needed to develop load allocations to specific source categories. Water quality sampling conducted from 2004 through 2011 provides the most recent data for determining existing nutrient water quality conditions in the Rock Creek watershed. DEQ collected samples from 24 sampling sites with the objective of 1) evaluating attainment of water quality targets and 2) assessing load contributions from nutrient sources within the Rock Creek watershed. These investigations form the primary dataset from which existing water quality conditions were evaluated and from which nutrient loading estimates are derived. Data used to conduct analyses and loading estimations is publicly available at http://deq.mt.gov/wqinfo/datamgmt/MTEWQX.mcpx.

This section characterizes the type, magnitude, and distribution of sources contributing to TP, TN and NO_3+NO_2 loading to impaired streams, provides loading estimates for significant source types, and establishes TMDLs and allocations to specific source categories. Source types include natural and human-caused sources and are described in further detail for each stream. Source characterization links nutrient sources loading to streams, and water quality response, and supports the formulation of the load allocation portion of the TMDL. As described in **Section 7.4.2**, TP, TN, and NO_3+NO_2 water quality targets are applicable during the summer growing season (i.e., July 1–Sept 30). Consequently, source characterizations are focused mainly on sources and mechanisms that influence nutrient contributions during this period. Similarly, loading estimates and subsequent load allocations are established for the growing season time period and are based on observed water quality data and typical flow conditions.

Source characterization and assessment was conducted primarily using extensive monitoring data collected in the watershed from 2004 through 2011 to determine temporal and spatial patterns in nutrient concentrations, loads, and biological response.

Land uses in the Rock Creek watershed are primarily agriculture, silviculture and historical mining practices. None of the nutrient impaired waterbodies in the Rock Creek watershed has contributing nutrient sources from sites with permits from the Montana Pollutant Discharge Elimination System (MPDES). Nutrient sources therefore consist primarily of 1) natural sources derived from airborne deposition, vegetation, soils, and geologic weathering; and 2) human-caused sources (agriculture, silviculture, historical mining practices). These sources may include a variety of discrete and diffuse pollutant inputs related to agricultural and mining runoff.

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

- East Fork Rock Creek
- South Fork Antelope Creek
- Sluice Gulch
- Scotchman Gulch
- Flat Gulch

7.5.1 East Fork Rock Creek (MT46E002_020)

The East Fork of Rock Creek originates at the Continental Divide in the Pintler Wilderness. The East Fork of Rock Creek flows for approximately 5.7 miles before it joins with Page Creek. After the confluence with Page Creek the streamflow for another 1.3 miles before it releases into the East Fork Reservoir. The East Fork of Rock Creek flows for another 10 miles prior to it reaching the confluence with the Middle Fork of Rock Creek, which then forms the mainstem of Rock Creek. The last 10 miles of the East Fork of Rock Creek (the lower segment) is the impaired section. For the purpose of TMDL development and this document the lower segment of the East Fork of Rock Creek will be referred to as the East Fork of Rock Creek.

Land use along the East Fork of Rock Creek consists primarily of cattle grazing in the lower segment and some limited cattle grazing and general silvicultural activities throughout the upper segments of the watershed. As determined in **Section 7.4.3.1,** the East Fork of Rock Creek did not exceeded nutrient water quality targets for NO_3+NO_2, TN, and TP. However, on one day, three AFDM samples exceeded target criteria (>35 g/m^2). On July 26, 2010, AFDW was measured as 70.42 g/m^2, 72.59 g/m^2 and 125.5 g/m^2 at sampling sites C2ROCEF10, C2ROCEF03 and C2ROCEF04 respectively. As a result of the initial listing and elevated AFDW DEQ has chosen to continue with TMDL development for TN and TP.

Complicating estimation of TN, and TP loads in the East Fork of Rock Creek is instream assimilation and retention of these nutrient loads by algae. High algal mass was observed through several reaches during the assessment process. High algal mass likely indicates that NO_3+NO_2, TN, and TP load is being taken up by algal growth and converted to biomass. This suggests that actual loads to East Fork Rock Creek may be greater than the loads measured instream.

7.5.1.1 East Fork of Rock Creek Source Assessment

The source assessment for the East fork of Rock Creek includes the evaluation of TN and TP concentrations as well as flow and loading data along the whole length of the East Fork of Rock Creek. This is followed by the quantification of natural background and the most significant human caused sources of nutrients. Human caused nutrient sources in the East Fork of Rock Creek are most likely the result of cattle grazing.

DEQ sampled water quality on the East Fork of Rock Creek during the growing season of 2010 and samples were analyzed for TN and TP. The data set for TN was limited, as the majority of the analytical results were non-detect. No values were provided for those samples that were reported as below the detection limit. For the purpose of data analysis a detection limit of 0.05 mg/L was used where data were reported as non-detect. The detection limit is well below the target value of 0.30 mg/L.

The data set for TP contained one data point that was above the target value of 0.030 mg/L. The primary reason for TMDL development for TP is the elevated AFDW and HBI scores. **Table 7-14** and **Table 7-15**, and **Figures 7-2** and **7-3** present summary statistics of TN and TP concentrations at sampling sites in the East Fork of Rock Creek. Due to the use of the detection limit in TN data analysis, the graphic representation of the data set is slightly distorted. This is exemplified in the lack of variability in the data for the sample site CO2ROCEF05 and CO2ROCEF20. This can also be seen in the closeness of some of the statistical results. For example the TN minimum and 25th percentile values for C2ROCEF05, C2ROCEF04, CO2ROCEF20 and C2ROCEF03 are almost identical. Similar lack of variability can be seen in the **Table 7-15** and **Figure 7-3**. Only one sample was collected at CO2ROCEF20, this sample exceeded the water quality target, however the lack of additional data points for this monitoring site limits the ability to conduct any relative statistics.

Table 7-14. Growing season TN Summary Statistics for sampling sites on the East Fork of Rock Creek (units in mg/L)

Site	n	min	max	mean	25th percentile	median	75th percentile
CO2ROCEF05	3	0.050	0.050	0.050	0.050	0.050	0.050
CO2ROCEF20	1	0.050	0.050	0.050	0.050	0.050	0.050
CO2ROCEF04	3	0.050	0.090	0.0667	0.055	0.060	0.075
CO2ROCEF03	3	0.050	0.090	0.0633	0.050	0.050	0.070
CO2ROCEF10	5	0.010	0.110	0.0650	0.046	0.065	0.875

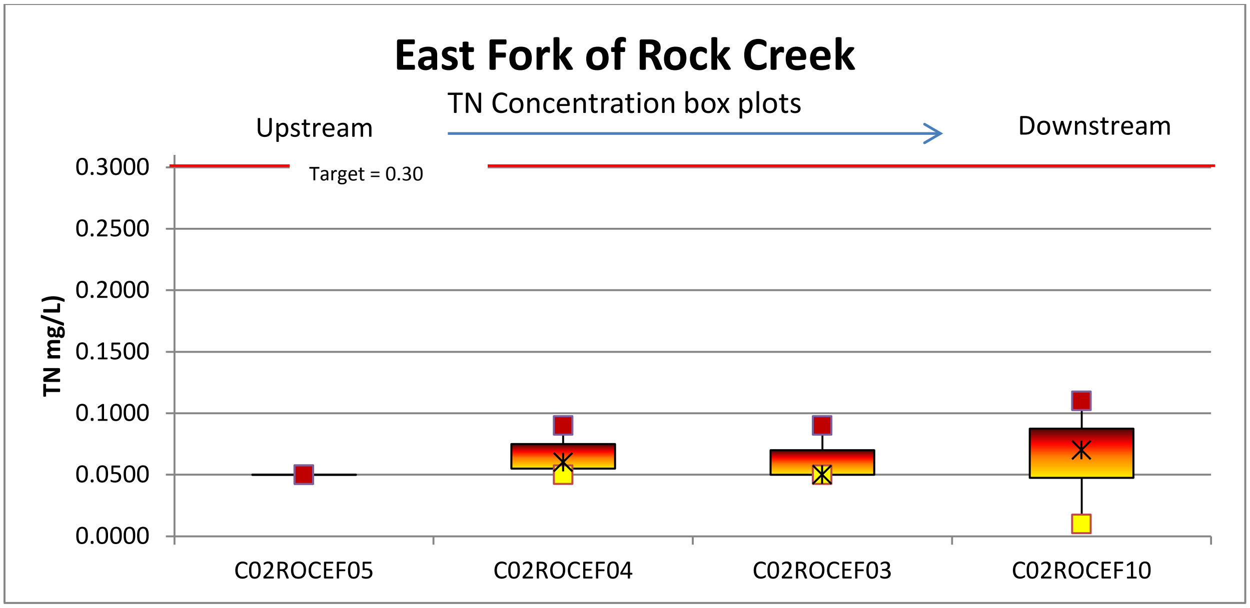

Figure 7-2. TN Concentration Box plots: East Fork of Rock Creek

Table 7-15. Growing season TP Summary Statistics for sampling sites on the East Fork of Rock Creek (units in mg/L)

Site	n	min	max	mean	25th percentile	median	75th percentile
CO2ROCEF05	3	0.0050	0.0070	0.0060	0.0055	0.0060	0.0065
CO2ROCEF20	1	0.0310	0.0310	0.0310	0.0310	0.0310	0.0310
CO2ROCEF04	3	0.0070	0.0090	0.0077	0.0070	0.0070	0.0080
CO2ROCEF03	3	0.0070	0.0080	0.0077	0.0075	0.0080	0.0080
CO2ROCEF10	5	0.0120	0.0240	0.0170	0.0150	0.0150	0.0210

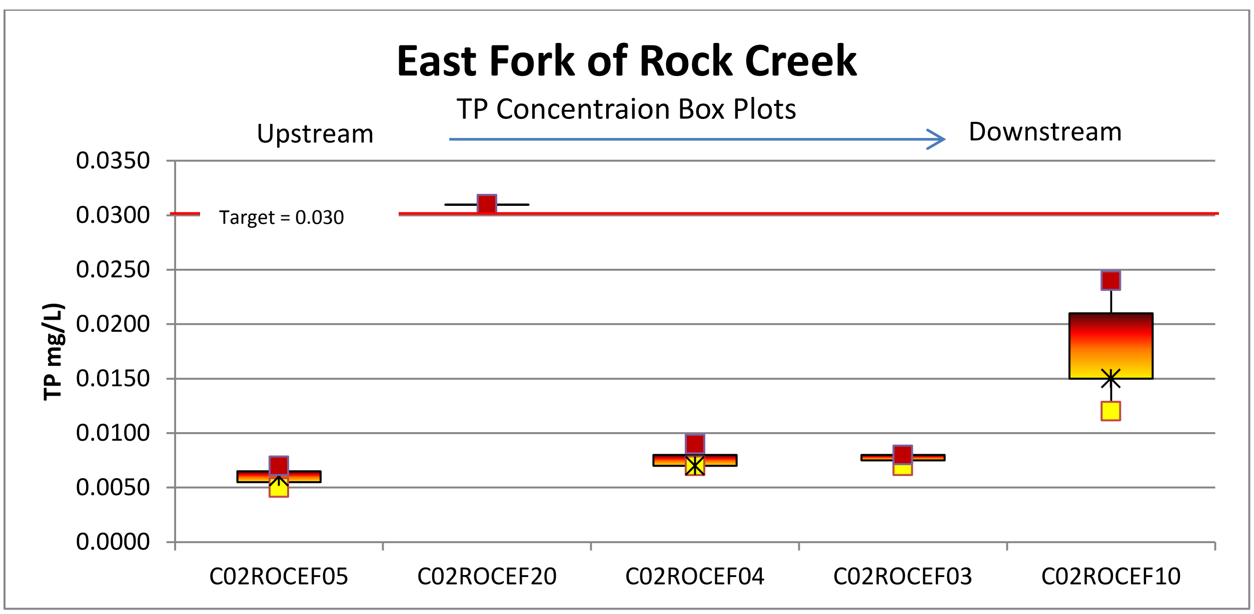

Figure 7-3. TP Concentration Box plots: East Fork of Rock Creek

Average growing season TN loads are highest in the headwater. TN load drops off significantly from monitoring location CO2ROCEF05 to CO2ROCEF20. Load gradually increases at each monitoring location from CO2ROCEF20 to that last monitoring location. There is an overall decrease from 17.7 lbs/day in the headwaters at monitoring location CO2ROCEF05 to 15.2 lbs/day at the downstream CO2ROCEF10 monitoring location. This is an average decrease of 2.5 lbs/day as is noted in **Figure 7-4**.

The initial TP loads decrease significantly between monitoring location CO2ROCEF05 and CO2ROCEF04 and then increase from CO2ROCEF04 to CO2ROCEF10 **Figure 7-5**. The total average growing season TP loads are lower at monitoring location CO2ROCEF05 (1.98 lb/day) and increase at the downstream CO2ROCEF10 monitoring location (2.66 lb/day). This is an average increase of 0.68 lbs/day.

Streamflow volume increases as you move from the headwaters to the mouth. With the exception of the upstream most monitoring location TN load increase parallels the increase in flow throughout the length of the stream. The limited tributary network in this area suggests that much of this increased flow may be via groundwater. The increased loading may be due to TN within this groundwater and/or may be linked to increased direct surface water nutrient input from cattle and other sources. TP concentrations tend to remain relatively constant along the East Fork Rock Creek as you move down stream. With the exception of one sample, all sample results are below water quality targets.

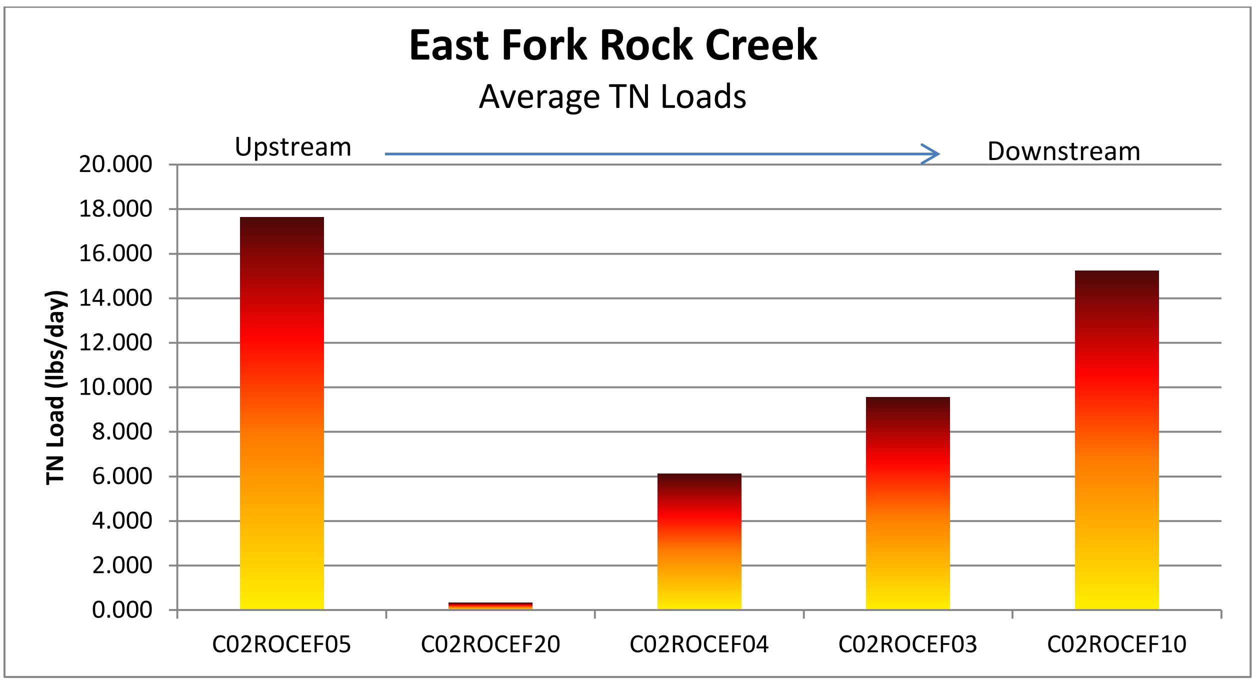

Figure 7-4 TN Load within East Fork Rock Creek

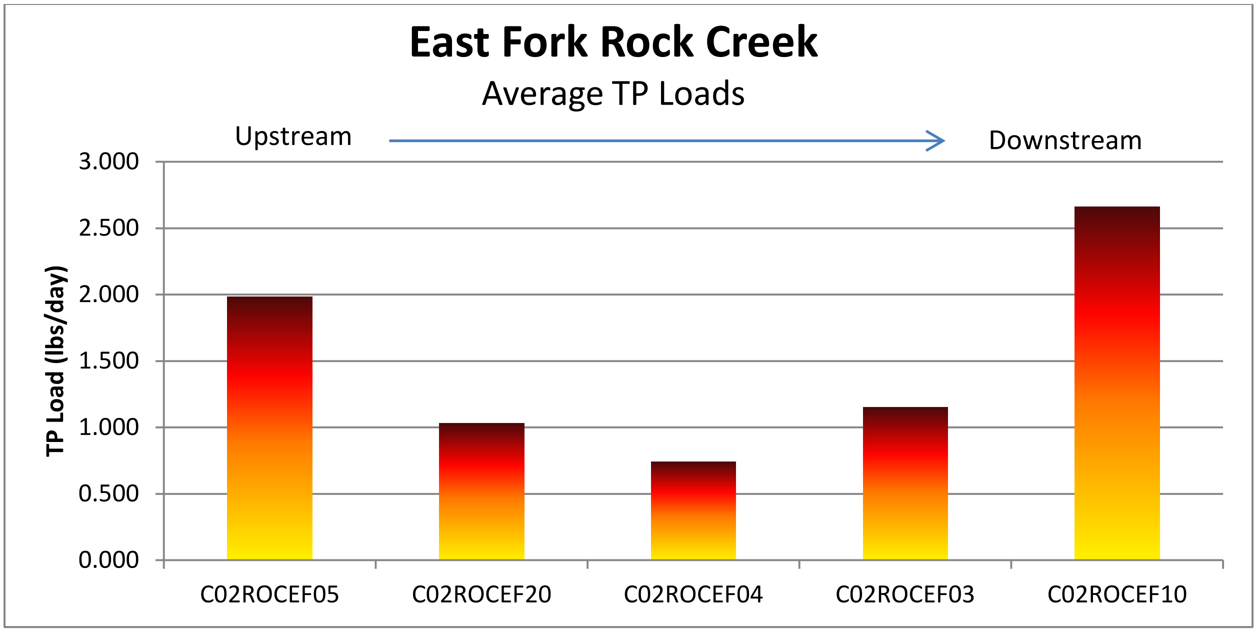

Figure 7-5. TP Load within East Fork Rock Creek

Natural background Nutrient loading

Natural background sources of nitrogen include a variety of natural processes and sources and likely include: soils and local geology, natural vegetative decay, wet and dry airborne deposition, wild animal waste, and other biochemical processes that contribute nitrogen to this system. DEQ did not sample the headwaters in the East Fork of Rock Creek. Consequently, no certain background water quality data was collected for the East Fork of Rock Creek. Given the lack of data in East Fork of Rock Creek and lack of data in the Rock Creek TPA, DEQ has decided to use values from reference streams in the Level III Middle Rockies Ecoregion for background concentrations.

Background TN concentrations derived from (Suplee et al., 2008a) were 0.065 mg/L, 0.085 mg/L, and 0.175 mg/L for the 25th, 50th, and 75th percentiles, respectively. DEQ will use the 50th percentile value (0.085 mg/L) since it represents the central tendency for the data sets used and is a likely representation of background water quality. Assuming a natural background concentration for TN of 0.085 mg/L and a median growing season flow of 34.1 cfs, the average background TN load to the segment is calculated to be approximately 15.6 lbs/day.

Agricultural Nutrient Loading

Cattle are periodically grazed within Fork of Rock Creek watershed, during the algal growing season. The USDA Forest Service (USFS) accounts for two allotments in the East Fork of Rock Creek Watershed. These allotments are the Meadow Creek allotment and the Georgetown/Elk Creek allotment. The Meadow Creek allotment is comprised of 17,608 acres, and is grazed by 100 head of cattle from June, 21 through October, 15. The Georgetown/Elk Creek allotment spans both the East Fork of Rock Creek and the Georgetown Lake watersheds. The Elk Creek portion of this allotment is within the East Fork of Rock Creek watershed and is comprised of 5,747 acres and is capable of supporting 83 head of cattle. This allotment is currently not in use, and was last grazed in 2003. There are approximately 1,120 acres of state land within the East Fork of Rock Creek watershed. Of these 1,120 acres approximately 1,015 acres are actively grazed at a rate of 400 Animal Unit Month (AUM). AUM is a grazing descriptor which is calculated by multiplying the number of animal units by the number of months of grazing. AUM provides a useful indicator of the amount of livestock use a particular segment of land receives.

The remaining portion of the East Fork of Rock Creek is private land. There is a significant difficulty in determining the number of cattle grazed on private land in this watershed. However, the DEQ will assume that cattle are being grazed on private land within the watershed. A conservatively low methodology for determining the number of cattle being grazed is to apply an AUM of 0.1 to 0.15 per acres to the approximate 11,420 acres of private land (Phone conversation with Bret Bledso of the NRCS). This would indicate that this land was capable of supporting 1,142 to 1,713 cattle if they were grazed sustainably.

There are several possible mechanisms for the transport of nutrients from agricultural land to surface water during the growing season. The potential pathways include 1) direct loading via the breakdown of excrement 2) delivery from grazed forest and rangeland during the growing season and 3) the effect of grazing on vegetative health and its ability to uptake nutrients and minimize erosion in upland and riparian areas. As noted by the sediment assessment results in **Section 5.4.2.3,** vegetation, habitat, and sediment deposition in the East Fork of Rock Creek have been negatively impacted via grazing. These negative impacts contribute to a lack of riparian buffering as a significant contributor towards elevated nutrient loading along with direct loading from cattle excrement given their proximity to the stream.

7.5.1.2 East Fork Rock Creek Total Maximum Daily Loads: Total Nitrogen (TN) and Total Phosphorous (TP)

TN and TP Total Maximum Daily Loads are presented here for the East Fork Rock Creek (MT41E002_020). The TMDLs (lbs/day) for TN and TP are calculated using the water quality target values established in **Section 7.4**. The TMDL loads for TN and TP apply during the summer growing season (normally July 1–Sept. 30). The TMDL for TN is based on an instream target value of 0.30 mg/L TN and streamflow (**Figure 7-6**). The TMDL for TP is based on an instream target value of 0.03 mg/L TN and streamflow (**Figure 7-7**).

TMDL calculations for TN and TP are based on the following formula:

TMDL = (X) (Y) (5.393)

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 cubic feet per second
5.393 = conversion factor

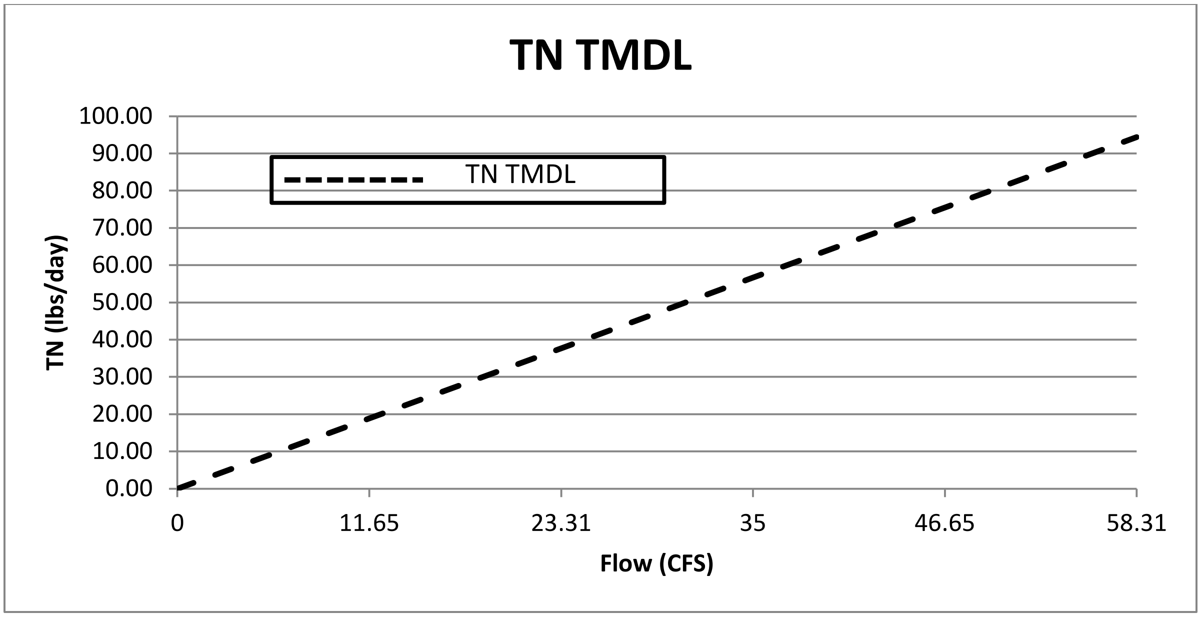

Figure 7-6. TMDL for TN as a function of flow: East Fork of Rock Creek

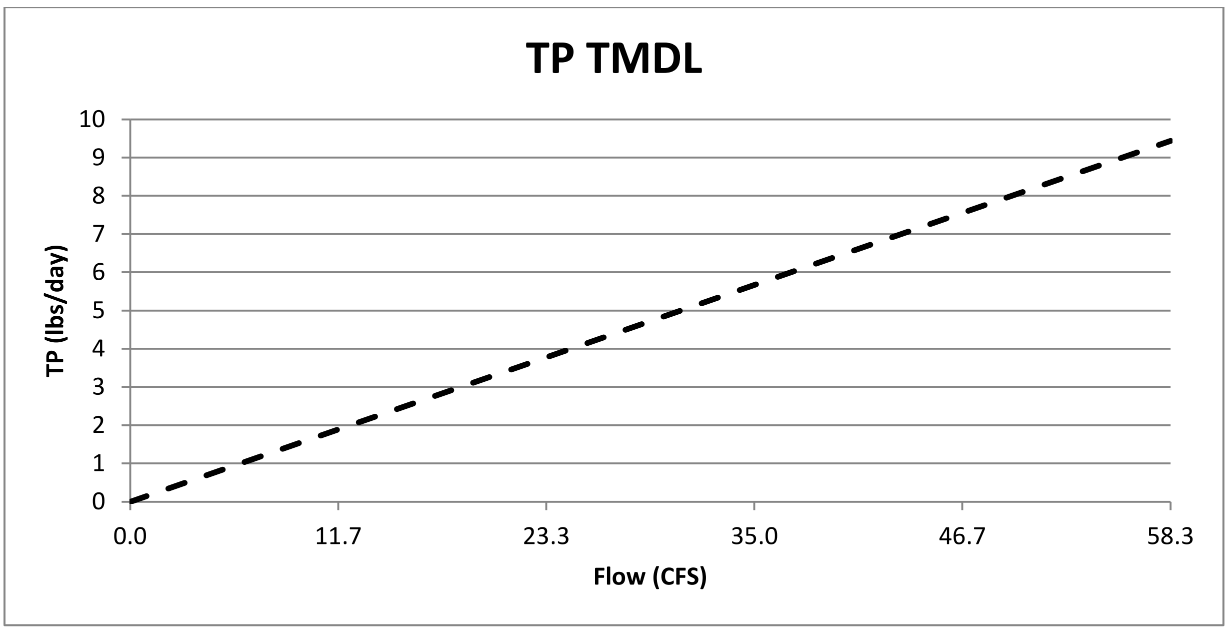

Figure 7-7 TMDL for TP as a function of flow: East Fork of Rock Creek

7.5.1.3 East Fork of Rock Creek Total Nitrogen (TN) and Total Phosphorous (TP) Allocations

TMDLs are allocated to point (wasteload) and nonpoint (load) TN and TP sources. A TMDL comprises the sum of all point sources and nonpoint sources (natural and human-caused), plus a margin of safety (MOS) that accounts for uncertainties in loading and receiving water analyses. An implicit MOS is defined within **Section 4.4,** is applied toward the East Fork of Rock Creek TMDL. In addition to pollutant load allocations, a TMDL must also take into account the seasonal variability of pollutant loads and adaptive management strategies in order to address uncertainties inherent in environmental analyses.

7.5.1.3.1 Total Nitrogen (TN) Allocation

For The East Fork of Rock Creek the TMDL for TN comprises the sum of the load allocations to individual source categories. There are no MPDES discharges to The East Fork of Rock Creek that would require wasteload allocations, and relevant TN nonpoint sources include natural background sources and agricultural land use. Load allocations are therefore provided for 1) natural background sources and 2) agricultural land use. In the absence of individual WLAs and an explicit MOS, the TMDL for TN in is equal to the sum of the individual load allocations as follows:

$TMDL = LA_{NB} + LA_{ag}$

LA_{NB} = Load Allocation to natural background sources
LA_{ag}= Load Allocation to agricultural land use

Natural Background Source

Load allocations for natural background sources are based on a natural background TN concentration of 0.085 mg/L (**see Section 7.5.1.1**) and are calculated as follows:

$LA_{NB} = (X)\ (Y)\ (5.393)$

LA_{NB}= TN load allocated to natural background sources
X= 0.085 mg/L natural background concentration
Y= streamflow in cubic feet per second
5.393 = conversion factor

Agricultural Source

The load allocation to the agricultural sources is calculated as the difference between the allowable daily load (TMDL) and the natural background load:

LA_{AG}= TMDL - LA_{NB}

TN Load Allocation

TN load allocations (**Table 7-16**) are provided for The East Fork of Rock Creek and include allocations to the following source categories: 1) natural background (LA_{NB}) and 2) agriculture (LA_{AG}). The TN TMDL is presented graphically in **Figure 7-8.**

Table 7-16. TN load allocation descriptions, East Fork of Rock Creek

Source Category	Load Allocation Descriptions	LA Calculation
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.	**$LA_{NB} = (X)\ (Y)\ (5.393)$**
Agricultural Land Use	• domestic animal waste • loss of riparian and wetland vegetation along streambanks	**LA_{AG} = TMDL - LA_{NB}**

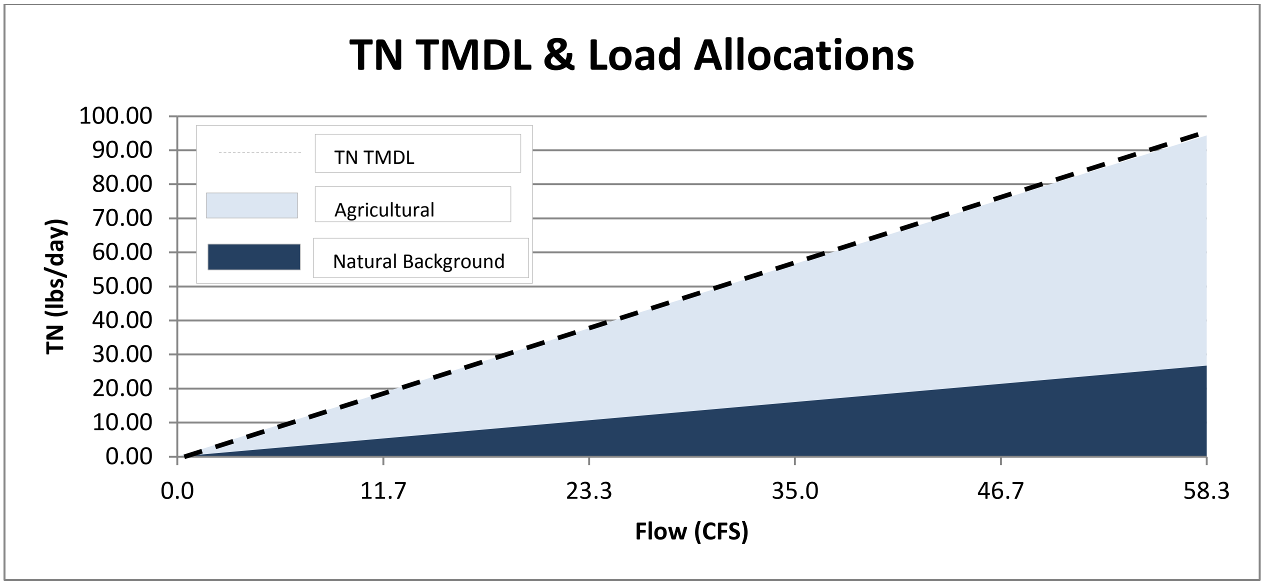

Figure 7-8. TMDL for TN and Load Allocations, the East Fork of Rock Creek

Because measured instream TN concentrations are within natural background conditions and below target concentrations, water quality data precludes calculating TN load reductions to specific source categories using empirical data. Load allocations, however, incorporate allowed loading from general source categories and establish allowable TN loads. **Table 7-17** presents example TMDLs and TN load allocations as a function of streamflow in accordance with the allocation scheme presented in **Table 7-16**; load allocations are presented at growing season flow conditions in the East Fork of Rock Creek.

Reducing nitrate loads from agricultural sources will likely mitigate the effects of nutrient impairment (algal growth, macroinvertebrate impairment) although the uncertainty regarding background conditions and nutrient contributions from agricultural sources makes it difficult to predict the extent of necessary nitrate reduction to reduce excess algal growth and increase macro invertebrate populations.

Table 7-17. The East Fork of Rock Creek Example TN load allocations and TMDL*

Source Category	Allocation & TMDL (lbs/day)*
Natural Background	15.6
Agriculture	39.6
TMDL	**55.2**

**based on a median growing season flow of 34.1 cfs*

7.5.1.3.2 Total Phosphorous (TP) Allocation

For the East Fork of Rock Creek the TMDL for TP comprises the sum of the load allocations to individual source categories. There are no MPDES discharges to the East Fork of Rock Creek that would require wasteload allocations, and relevant TP nonpoint sources include natural background sources and agricultural land use. Load allocations are therefore provided for 1) natural background sources and 2) agricultural land use. In the absence of individual WLAs and an explicit MOS, the TMDL for TP in is equal to the sum of the individual load allocations as follows:

TMDL = LA_{NB} + LA_{ag}

LA_{NB} = Load Allocation to natural background sources

LA_{ag}= Load Allocation to agricultural land use

LA_{NB} = (X) (Y) (5.393)

LA_{NB}= TP load allocated to natural background sources
X= 0.030 mg/L natural background concentration
Y= streamflow in cubic feet per second
5.393 = conversion factor

Agricultural Source

The load allocation to the agricultural sources is calculated as the difference between the allowable daily load (TMDL) and the natural background load:

LA_{AG}= TMDL - LA_{NB}

TP Load Allocation

TP load allocations (**Table 7-18**) are provided for The East Fork of Rock Creek and include allocations to the following source categories: 1) natural background (LA_{NB}) and 2) agriculture (LA_{AG}). The TP TMDL is presented graphically in **Figure 7-9.**

Table 7-18. TP load allocation descriptions, East Fork of Rock Creek

Source Category	Load Allocation Descriptions	LA Calculation
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.	**LA_{NB} = (X) (Y) (5.393)**
Agricultural Land Use	• domestic animal waste • loss of riparian and wetland vegetation along streambanks	**LA_{AG} = TMDL - LA_{NB}**

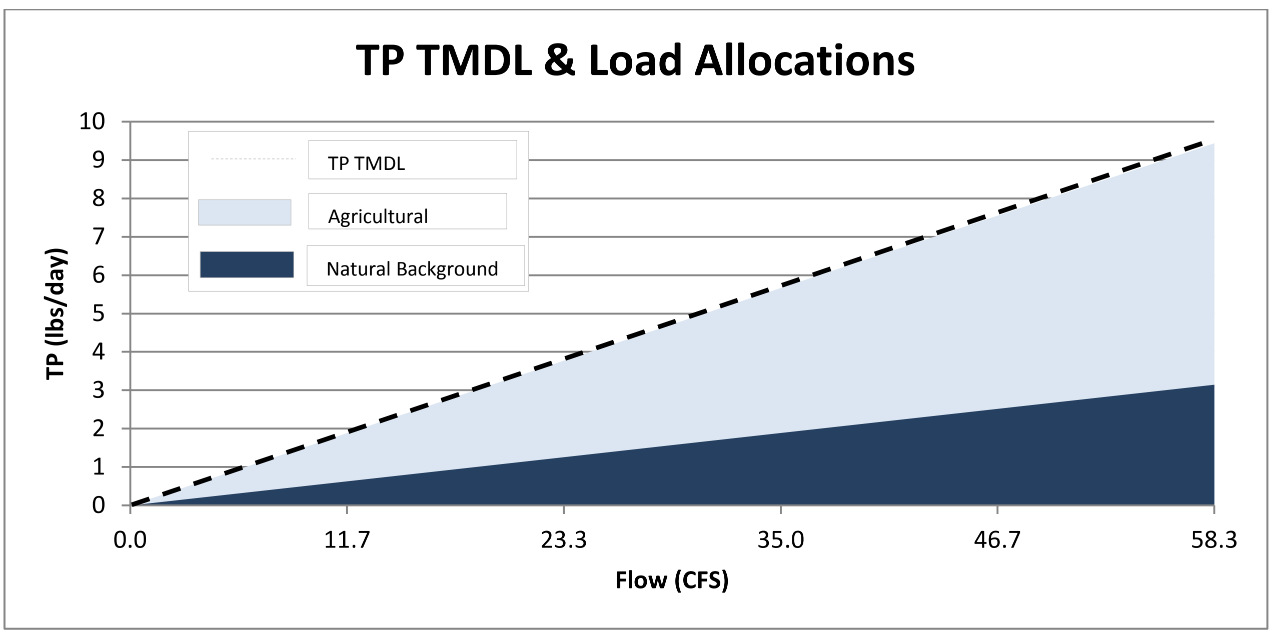

Figure 7-9. TMDL for TP and Load Allocations, the East Fork of Rock Creek

Table 7-19 provides an example TMDL and example allocations for typical summer baseflow conditions. The TP load allocations and the TP TMDL are a function of streamflow and are developed in accordance with the TMDL and allocation approaches presented above. **Table 7-19** also provides existing loading values for the source categories along with the required percent reductions to satisfy the allocations and TMDL. Typically TMDLs are developed by basing the existing load on the 80th percentile of instantaneous loads. Instantaneous loads are calculated from water quality data used in the assessment process and a corresponding streamflow volume. The 80th percentile of these loads is then used as the existing load. The existing load in this example TMDL was developed based on the one time water quality exceedance and associated flow measurement. DEQ has chosen to utilize this load because it represents the condition of the East Fork of Rock Creek at the time of the water quality target exceedance and is conservative estimate and will be protective of water quality.

Table 7-19. East Fork Rock Creek Example TP, load allocations and TMDL

Source Category	Existing Load (lbs/day)**	Allocation & TMDL (lbs/day)*	Percent Reduction
Natural Background	1.00	1.00	0
Agricultural and Silvicultural Land Use	9.3	4.51	51.5
	Total = 10.3	**TMDL = 5.51**	**Total = 46.5**

**based on a median growing season flow of 34.1 cfs*
***based on the one time water quality target exceedance concentration 0.31 mg/L and flow of 6.18 cfs*

The source assessment conducted for the East Fork Rock Creek has led DEQ to determine that agricultural sources are the most current and prominent sources of nutrients in the watershed. DEQ maintains that reducing loads from agricultural sources in the East Fork Rock Creek and its tributaries will result in lower TP concentrations throughout the length of East Fork Rock Creek. Reducing loads of this nature will mitigate elevated TP loads.

7.5.2 South Fork of Antelope Creek (MT46E002_060)

The South Fork of Antelope Creek flows into Antelope Creek which in turn flows into Rock Creek. Antelope Creek enters Rock Creek approximately 3.6 miles downstream from the confluence of the East Fork and West Fork. Area land use is primarily agricultural and some light historical mining in the upper reaches. There has also been limited silviculture (logging) activity within the watershed. As determined in **Section 7.4.3.2** the South Fork of Antelope Creek exceeded nutrient water quality targets for Nitrate + Nitrite ($N0_3$+$N0_2$), Total Nitrogen (TN) and Total Phosphorous (TP). TMDLs will be developed for $N0_3$+$N0_2$, TN and TP.

7.5.2.1 South Fork of Antelope Creek Source Assessment

The source assessment for the South Fork of Antelope Creek includes an evaluation of $N0_3$+$N0_2$, TN and TP concentrations, flow and loading data along the whole length of the South Fork. This is followed by quantification of natural background and the two most significant human-caused sources of nutrients. The two human-caused nutrient sources include agriculture (grazing) and historical mining practices.

Instream $N0_3$+$N0_2$, TN and TP concentrations exceeded water quality targets at a number of sampling locations during different growing season events. $N0_3$+$N0_2$, TN and TP concentrations were higher in the headwaters and decrease as you move down stream. **Table 7-20** and **Figure 7-10** present summary statistics of $N0_3$+$N0_2$ concentrations at sampling sites in the South Fork. **Table 7-21** and **Figure 7-11** present summary statistics of TN concentrations at sampling sites in the South Fork. **Table 7-22** and **Figure 7-12** present the summary statistics of TP concentrations at sampling sites in the South Fork.

Table 7-20. Growing season NO_3+NO_2 Summary Statistics for Sampling Sites on the South Fork of Antelope Creek (units in mg/L)

Site	n	min	max	mean	25th percentile	median	75th percentile
C02ANTSF03	5	0.490	0.620	0.549	0.490	0.540	0.604
C02ANTSF02	5	0.460	0.560	0.518	0.480	0.540	0.550
C02ANTSF10	6	0.240	0.430	0.364	0.360	0.375	0.412

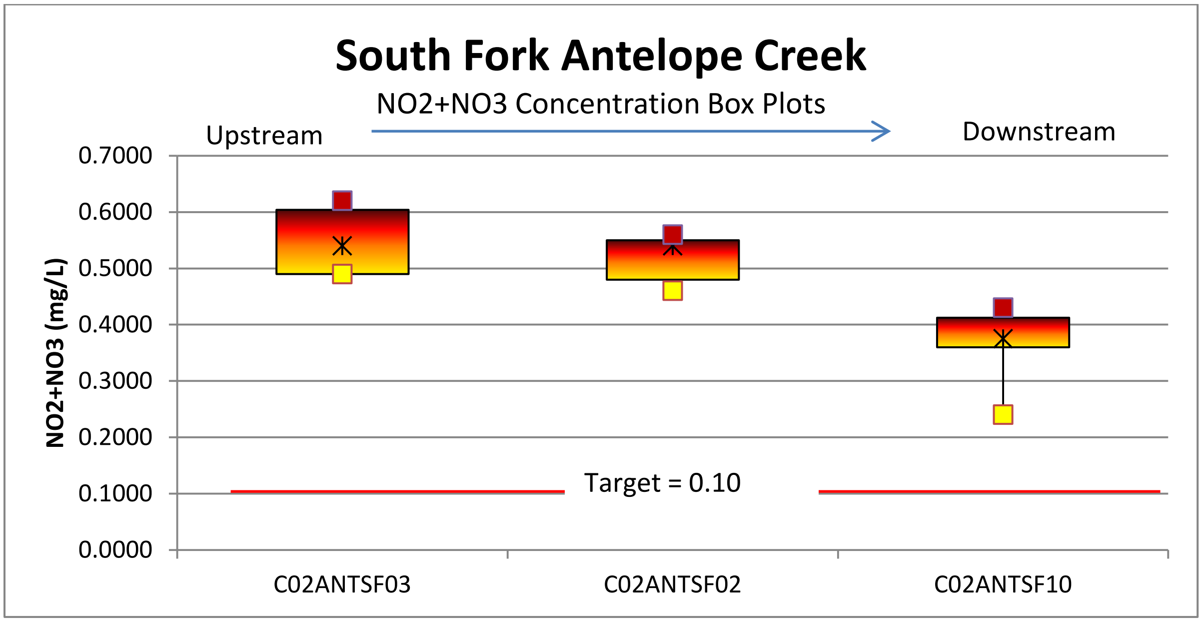

Figure 7-10. N03+N02 Concentration Box plots: South Fork of Antelope Creek

Table 7-21. Growing season TN Summary Statistics for sampling sites on the South Fork of Antelope Creek (units in mg/L)

Site	n	min	max	mean	25th percentile	median	75th percentile
C02ANTSF03	5	0.58	1.48	0.88	0.67	0.79	0.870
C02ANTSF02	5	0.54	1.08	0.67	0.54	0.56	0.62
C02ANTSF10	5	0.38	0.47	0.43	0.42	0.43	0.45

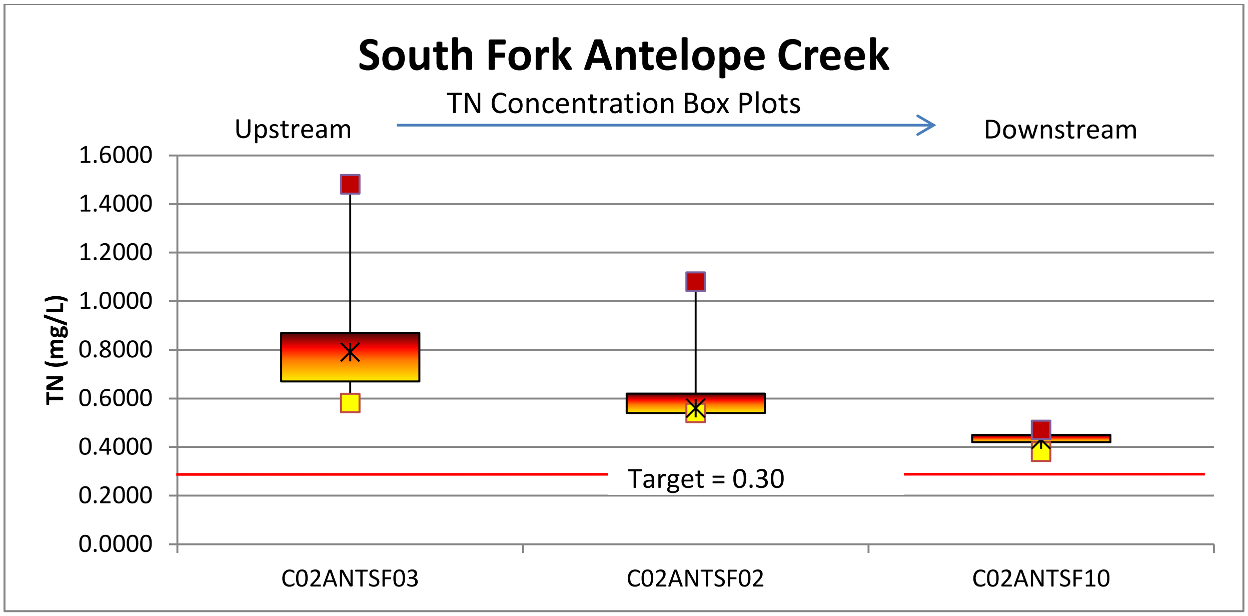

Figure 7-11. TN Concentration Box Plots: South Fork Antelope Creek

Table 7-22. Growing season TP Summary Statistics for sampling sites on the South Fork of Antelope Creek (units in mg/L)

Site	n	min	max	mean	25th percentile	median	75th percentile
C02ANTSF03	5	0.010	0.630	0.035	0.160	0.030	0.056
C02ANTSF02	5	0.007	0.016	0.012	0.013	0.013	0.013
C02ANTSF10	6	0.005	0.035	0.015	0.0103	0.0115	0.0143

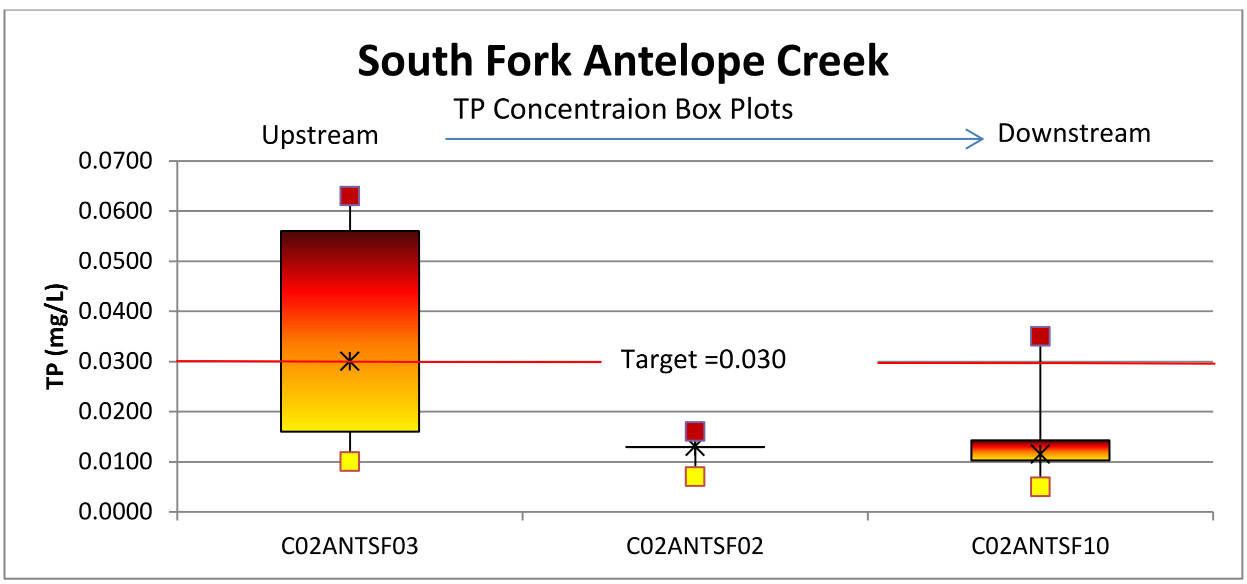

Figure 7-12. TP Concentration Box Plots: South Fork Antelope Creek

$N0_3$+$N0_2$, TN and TP loads calculated from the 2004 and 2010–2011 sampling events are depicted in **Figure 7-10, 7-11 and 7-12**, respectively. Average growing season $N0_3$+$N0_2$ loads increase from 0.68 lbs/day at monitoring location CO2ANTSF03 to 1.47 lbs/day at the downstream CO2ANTSF02 monitoring location, an average increase of 0.79 lbs/day **Figure 7-10**. From monitoring location CO2ANTSF02 to CO2ANTSF10 loads decrease slightly from 1.47 to 1.37 lbs/day.

Average growing season TN loads increase from 0.95 lbs/day at monitoring location CO2ANTSF03 to 1.97 lbs/day at the downstream CO2ANTSF02 monitoring location, an average increase of 1.02 lbs/day **Figure 7-11** From monitoring location CO2ANTSF02 to CO2ANTSF10 loads decease slightly from 1.97 to 1.5 lbs/day, an average decrease of 0.47 lbs/day.

Average growing season TP loads decrease slightly from 0.041 lb/day at monitoring location CO2ANTSF03 to 0.031 lb/day at the downstream CO2ANTSF02 monitoring location **Figure 7-12**. This is an average decrease of 0.010 lbs/day. Average low-flow TP loads remained relatively constant at approximately 0.031 lb/day between monitoring locations CO2ANTSF02 and CO2ANTSF10.

Streamflow volume increases as you move from the headwaters to the mouth. The $N0_3$+$N0_2$, and TN load increase parallels the increase in flow throughout the length of the stream. The limited tributary network in this area suggests that much of this increased flow is via groundwater. The increased loading is likely due to $N0_3$+$N0_2$ and TN within this groundwater and/or may be linked to increased direct surface water nutrient input from cattle and other sources. Additionally the $N0_3$+$N0_2$, TN and TP concentrations **(Tables 7-20, 7-21 and 7-22)** tend to decrease along the South Fork of Antelope Creek as you move down stream. This could be because the $N0_3$+$N0_2$, TN and TP concentrations in the groundwater are lower than (cleaner than) the concentrations in the South Fork. The decreased $N0_3$+$N0_2$, TN and TP concentrations could also indicate some algal nutrient uptake. The high AFDW results along the South Fork during the majority of sample events suggests that there was significant algae uptake at the time of the sampling events.

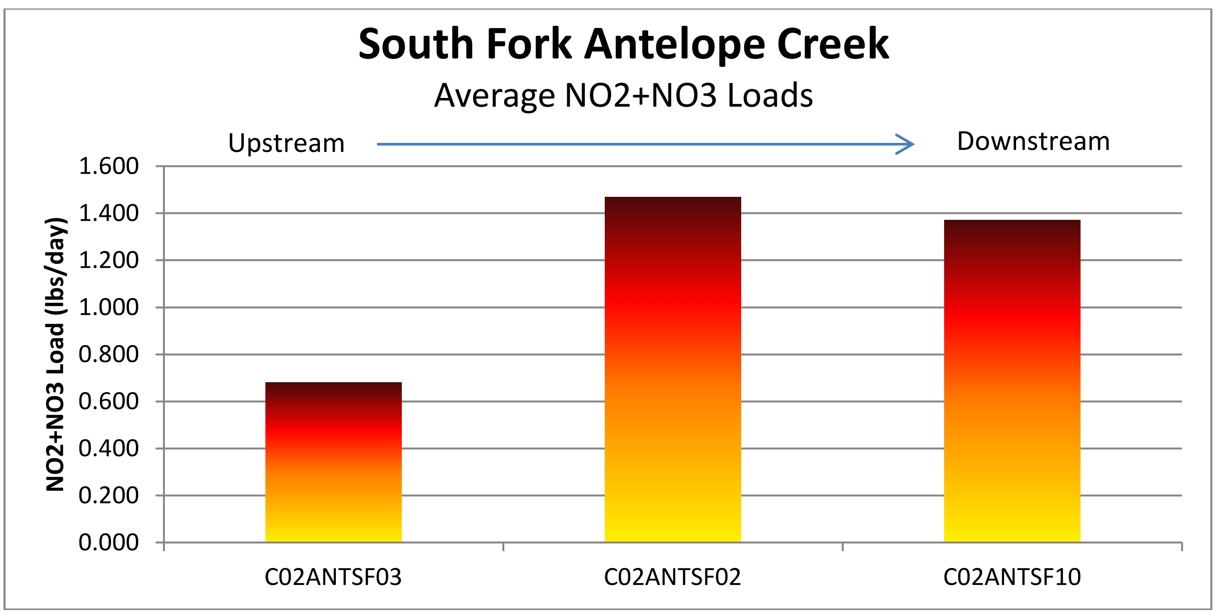

Figure 7-13. $N0_3$+$N0_2$ Load within South Fork Antelope Creek

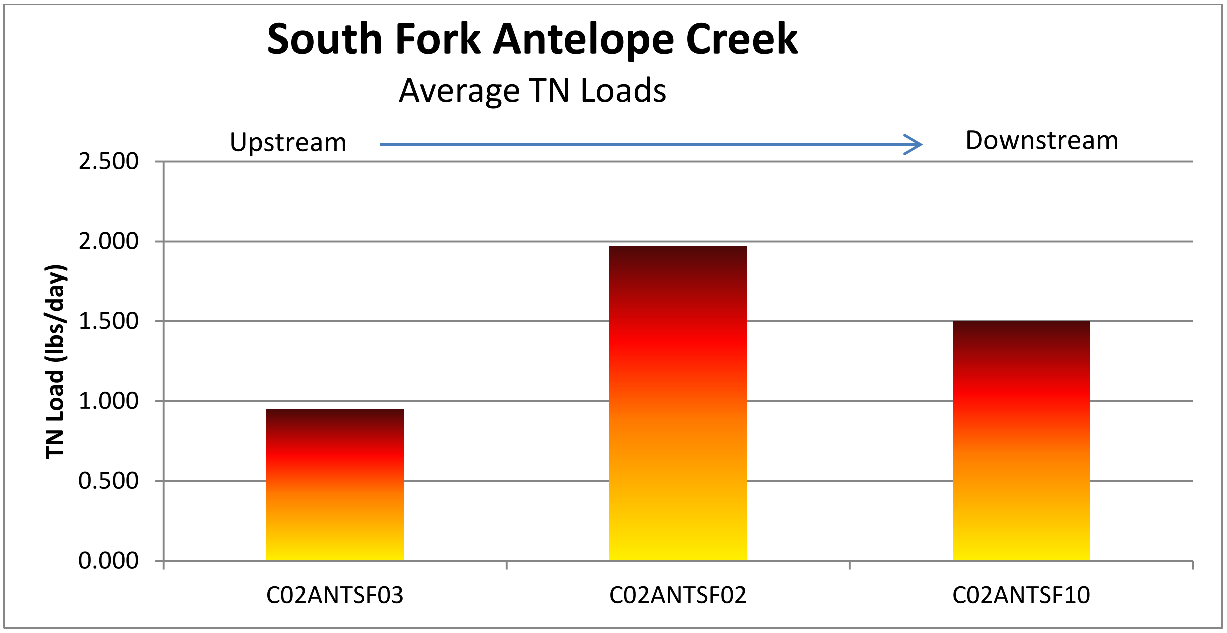

Figure 7-14. TN Load within South Fork Antelope Creek

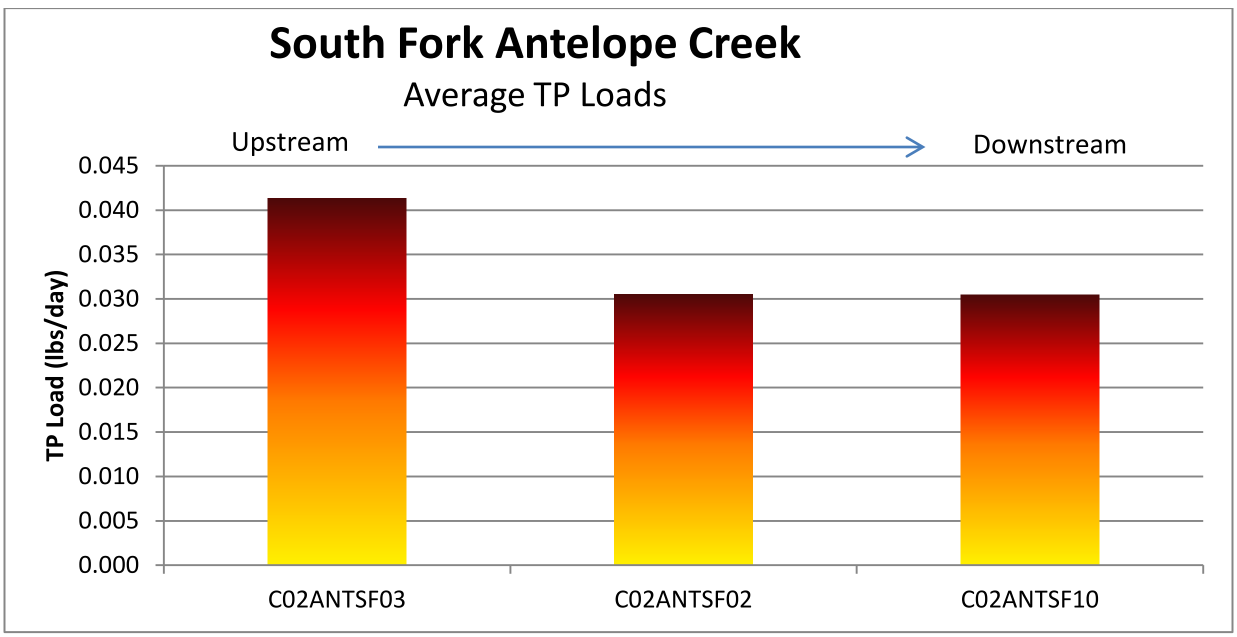

Figure 7-15. TP Load within South Fork Antelope Creek

Natural Background Nutrient Loading

Natural background sources of nitrogen include a variety of natural processes and sources and likely include: soils and local geology, natural vegetative decay, wet and dry airborne deposition, wild animal waste, and other biochemical processes that contribute nitrogen to this system. No background water quality data was available for the South Fork of Antelope Creek.

Given this lack of data, and lack of data from reference streams in the Rock TPA, DEQ has decided to use values from reference streams in the Level III Middle Rockies Ecoregion. In a study to develop nutrient criteria for streams in Montana, (Suplee et al., 2008a) provides the 25th, 50th, and 75th percentile of the all-season reference dataset from wadeable streams to represent background conditions.

This translates to background $N0_3$+$N0_2$ values ranging from 0.005 mg/L, 0.020 mg/L, and 0.042 mg/L at the 25th, 50th, and 75th percentiles, respectively. DEQ will use the 50th percentile value (0.020 mg/L) since it represents the central tendency for the data sets used and is a likely representation of background water quality. Assuming a natural background concentration for TN of 0.020 mg/L and a median growing season flow of 0.57 cfs, the estimated background TN load to the segment is calculated to be approximately 0.061 lbs/day.

Background TN values derived from (Suplee et al., 2008a) ranging from 0.065 mg/L, 0.085 mg/L, and 0.175 mg/L at the 25th, 50th, and 75th percentiles, respectively. DEQ will use the 50th percentile value (0.085 mg/L) since it represents the central tendency for the data sets used and is a likely representation of background water quality. Assuming a natural background concentration for TN of 0.085 mg/L and a median low-flow baseflow of 0.57 cfs, the average background TN load to the segment is calculated to be approximately 0.26 lbs/day.

Background TP values derived from (Suplee et al., 2008a) for wadeable streams ranged from 0.008 mg/L, 0.010 mg/L, and 0.020 mg/L at the 25th, 50th, and 75th percentiles, respectively. DEQ will use the 50th percentile value (0.010mg/L) since it represents the central tendency for the data sets used and is a likely representation of background water quality. Assuming a natural background concentration for TP of 0.010 mg/L and a median low-flow baseflow of 0.57 cfs, the average background TP load to the segment is calculated to be approximately 0.031 lb/day.

Agricultural Nutrient Loading

Cattle are periodically grazed within the South Fork of Antelope Creek watershed, during the algal growing season. The Bureau of Land Management (BLM) accounts for three allotments in the South Fork of Antelope Creek watershed. The Antelope East, Antelope South and the Duck point allotments. These allotments are approximately 180, 386 and 58 acres respectively. Total number of livestock in these allotments is 4, 12 and 4 respectively. The South Fork of Antelope Creek watershed is approximately 1,650 acres in size, 624 acres (38 %) is in authorized BLM allotments. These allotments are used from June 15 through October 14.

The remaining portion of the South fork of Antelope Creek is private land. There is a significant difficulty in determining the number of cattle grazed on private land in this watershed. As noted by the sediment assessment results in **Section 5.6,** vegetation, habitat, and sediment deposition health in the South Fork of Antelope Creek has been negatively impacted eroding streambanks like associated with riparian grazing. These negative impacts contribute to a lack of riparian buffering as a significant contributor towards elevated nutrient loading along with direct loading from cattle excrement give their proximity to the stream. A conservative approach to determining the number of cattle being grazed is to apply an Animal Unit Month (AUM) of 0.1 to 0.15/ acre to the remaining 1,026 acres of private land (phone conversation with Bret Bledso, NRCS). This would indicate that this land was capable of providing forage for 102-154 cattle if they were grazed sustainably.

There are several possible mechanisms for the transport of nutrients from agricultural land to surface water during the growing season. The potential pathways include 1) direct loading via the breakdown of excrement and surface runoff and subsurface pathways, 2) delivery from grazed forest and rangeland during the growing season and 3) the effect of grazing on vegetative health and its ability to uptake nutrients and minimize erosion in upland and riparian areas. As noted by the sediment assessment results in **Section 5.4.2.1,** vegetation, habitat, and sediment deposition in Sluice Gulch have been negatively impacted via grazing. These negative impacts contribute to a lack of riparian buffering as a significant contributor towards elevated nutrient loading along with direct loading from cattle excrement given their proximity to the stream.

Silvicultural Practices

Silvicultural (timber harvest) practices inevitably cause some measure of downstream effects that may or may not be significant over time. Changes in land cover will change the rate at which water evapotranspires which will affect 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) and this will have an affect the hydrologic cycle. Changes in the biomass uptake and soil conditions will affect the nutrient cycle. Elevated nitrate concentrations result from increased leaching from the soil as mineralization is enhanced. Nutrient uptake by biomass is also greatly reduced after timber harvest, leaving more nutrients available for runoff.

There have been some historical silvicultural activities in the South Fork of Antelope Creek. Some small scale timber sales occurred in 1991, 2005 and 2006. In 1991, 189 acres were harvested for a total of 1,602,000 board feet of product. In 2005, 152 acres were harvest for a total of 794,000 board feet of product. In 2006, 12 acres were harvested for 76,000 board feet of product. Nutrient loading from harvest areas are generally linked to runoff event and lack of timber harvest best management practices. Because of grazing in the upper portions of the Rock watershed, it is difficult to use the sample results to partition grazing impacts from Silviculture impacts. DEQ data for areas with timber harvest and limited or no cattle grazing or other agricultural land management activity has routinely shown that timber harvest is typically a negligible source of elevated nutrients during the algal growing season.

Historical Mining Nutrient Loading

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. Concentration of potential contaminants depends on the timing of when mining has taken place, mechanism of chemical release, streamflow, and water chemistry.

Two known mining operations have existed in the South Fork of Antelope Creek. The Ant Mine and the Ram Mountain Mine. The Ant mine was last investigated by the DEQ in 1993. At the time of the investigation there was no visible mine tailings, however, an estimated 2,300 cubic yards of waste rock were documented. There was one mine adit that contained water. pH measured in this water was 2.9 S.U. Three other open adits were identified during this investigation. The South Fork of Antelope Creek is approximately 450 feet away from the mine remnants.

The Ram Mountain mine was originally active in the early 1900's. This mine was opened for exploration in the mid 1980's. During this time several underground working were opened, roads were constructed and improved and drilling took place at a number of locations. No mining occurred during this time.

Nutrient pollution is likely not a result of the mining in the South fork of Antelope Creek, considering the time that has lapsed since the mining has taken place in this watershed and remedial efforts on the existing sites.

7.5.2.2 South Fork of Antelope Creek Total Maximum Daily Loads: Nitrate plus Nitrite (NO_3 + NO_2), Total Nitrogen (TN) and Total Phosphorous (TP)

$N0_3$+$N0_2$, TN and TP Total Maximum Daily Loads are presented here for the South Fork of Antelope Creek (MT41E002_060). The TMDLs (lbs/day) for $N0_3$+$N0_2$, TN and TP are calculated using the water quality target values established in **Section 7.4**. The TMDL loads for TN and TP apply during the summer growing season (normally July 1–Sept. 30). The TMDL for $N0_3$+$N0_2$ is based on an instream target value of 0.10 mg/L TN and streamflow (**Figure 7-16**).The TMDL for TN is based on an instream target value of 0.30 mg/L TN and streamflow (**Figure 7-17**). The TMDL for TP is based on an instream target value of 0.03 mg/L TN and streamflow (**Figure 7-18**).

TMDL calculations for $N0_3$+$N0_2$, TN and TP are based on the following formula:

TMDL = (X) (Y) (5.393)

TMDL= Total Maximum Daily Load in lbs/day
X= water quality target in mg/L ($N0_3$+$N0_2$ = 0.10, TN =0.30 mg/L or TP =0.030 mg/L)
Y= streamflow in cubic feet per second
5.393 = conversion factor

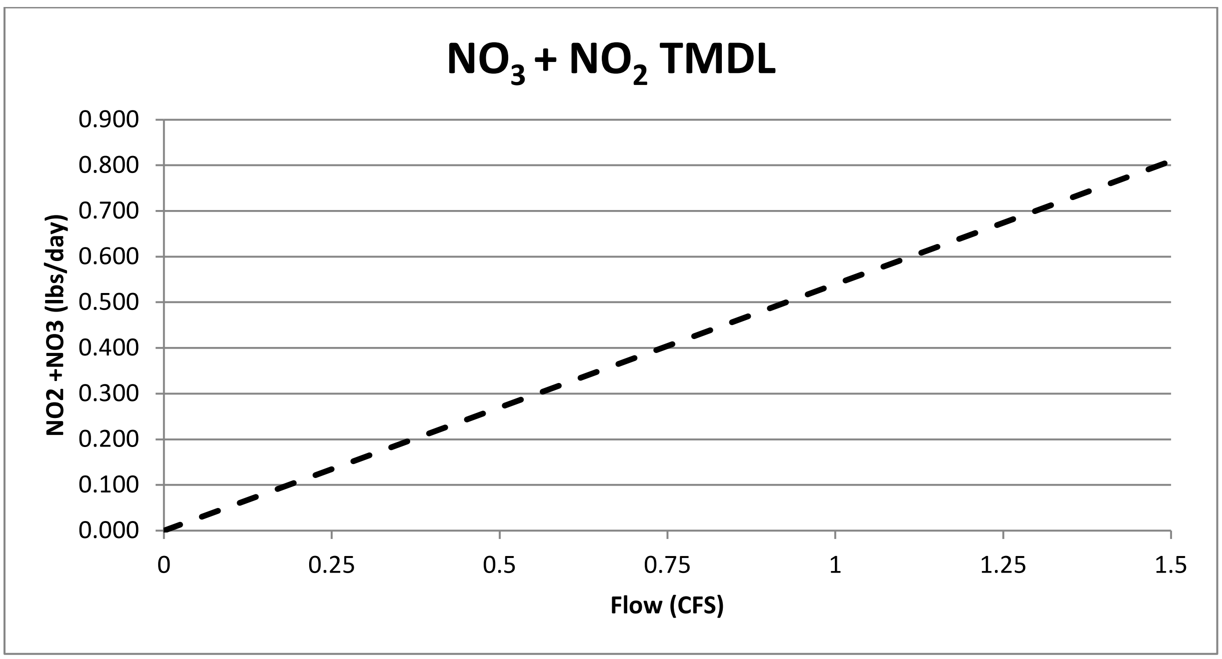

Figure 7-16. TMDL for NO_2 +NO_3 as a function of flow: South Fork of Antelope Creek

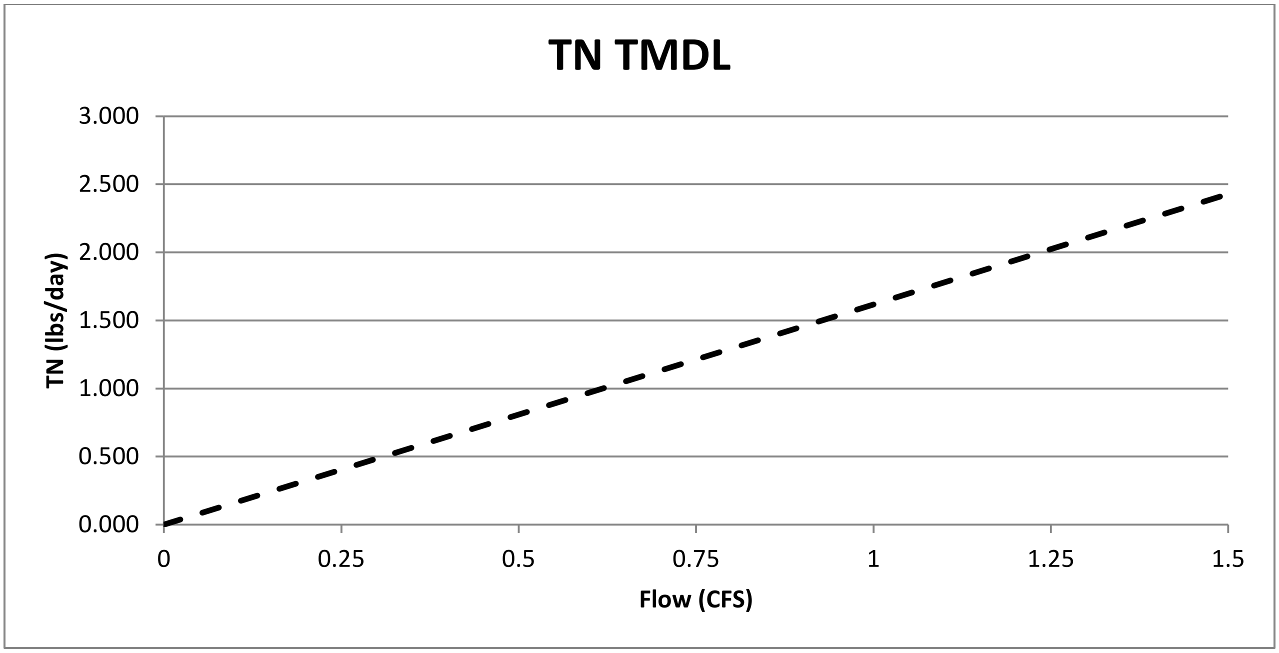

Figure 7-17. TMDL for TN as a function of flow: South Fork of Antelope Creek

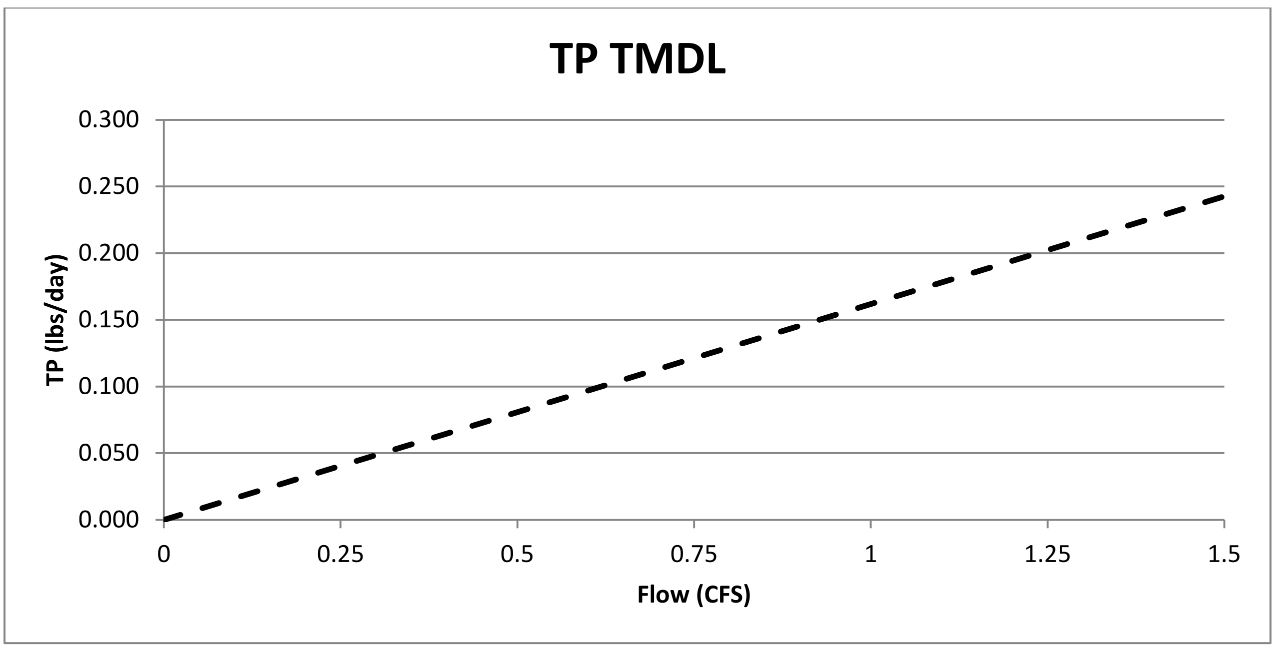

Figure 7-18. TMDL for TP as a function of flow: South Fork of Antelope Creek

7.5.2.3 South Fork of Antelope Creek Nitrate plus Nitrite (NO_2 +NO_3), Total Nitrogen (TN) and Total Phosphorus (TP) Allocations

TMDLs are allocated to point (wasteload) and nonpoint (load) $N0_3$+$N0_2$, TN and TP sources. The TMDL comprises the sum of all point sources and nonpoint sources (natural and human-caused), plus a margin of safety that accounts for uncertainties in loading and receiving water analyses. In addition to pollutant load allocations, the TMDL must also take into account the seasonal variability of pollutant loads and adaptive management strategies in order to address uncertainties inherent in environmental analyses.

7.5.2.3.1 Nitrate plus Nitrite (NO_3 +NO_2) Allocations

The South Fork of Antelope Creek TMDL for $N0_3$+$N0_2$, comprises the sum of the load allocations to individual source categories. There are no MPDES discharges to the reach requiring wasteload allocations. Relevant $N0_3$+$N0_2$, nonpoint sources include natural background sources, agricultural, silvicultural and historical mining sources.

Due to the difficulty in determining the contribution of each potential source load allocations from each source will be composited. Load allocations are therefore provided for 1) natural background sources and 2) the combination of agricultural and silvicultural land use. In the absence of individual WLAs and an explicit MOS, TMDLs for $N0_3$+$N0_2$, in the watershed are equal to the sum of the individual load allocations as follows:

TMDL = LA_{NB} + $LA_{AG+SILV}$

LA_{NB} = Load Allocation to natural background sources

$LA_{AG+\ SILV}$ = Load Allocation to the combination of agricultural and silvicultural land use sources

Natural Background Source

Load allocations for natural background sources are based on a natural background $N0_3$+$N0_2$, concentration of 0.020 mg/L (**see Section 7.5.1.1**) and are calculated as follows:

LA_{NB} = (X) (Y) (5.393)

LA_{NB}= $N0_3$+$N0_2$, load allocated to natural background sources

X= 0.020 mg/L natural background concentration

Y= streamflow in cubic feet per second

5.393 = conversion factor

Agriculture and Silvicultural Sources

The load allocations are to the combination of agricultural and silvicultural sources are calculated as the difference between the allowable daily load (TMDL) and the natural background load:

$LA_{AG+SIIV}$= TMDL - LA_{NB}

$N0_3$+$N0_2$ Load Allocation

$N0_3$+$N0_2$ load allocations are provided for South Fork Antelope Creek and include allocations to the following source categories: 1) natural background (LA_{NB}) and 2) the combination of agricultural and silvicultural land-use sources ($LA_{AG+SILV}$). $N0_3$+$N0_2$, load allocations are summarized in **Table 7-23**. The TMDL is depicted graphically in **Figure 7-19.**

Table 7-23. $N0_3$+$N0_2$, load allocation descriptions, South Fork of Antelope Creek

Source Category	Load Allocation Descriptions	LA Calculation
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.	**LA_{NB} = (X) (Y) (5.393)**

Table 7-23. $N0_3$+$N0_2$, load allocation descriptions, South Fork of Antelope Creek

Source Category	Load Allocation Descriptions	LA Calculation
Combination of Agricultural and Silvicultural Land Use	• domestic animal waste • loss of riparian and wetland vegetation along streambanks • limited nutrient uptake due to loss of overstory	**LA_{AG}+SILV = TMDL - LA_{NB}**

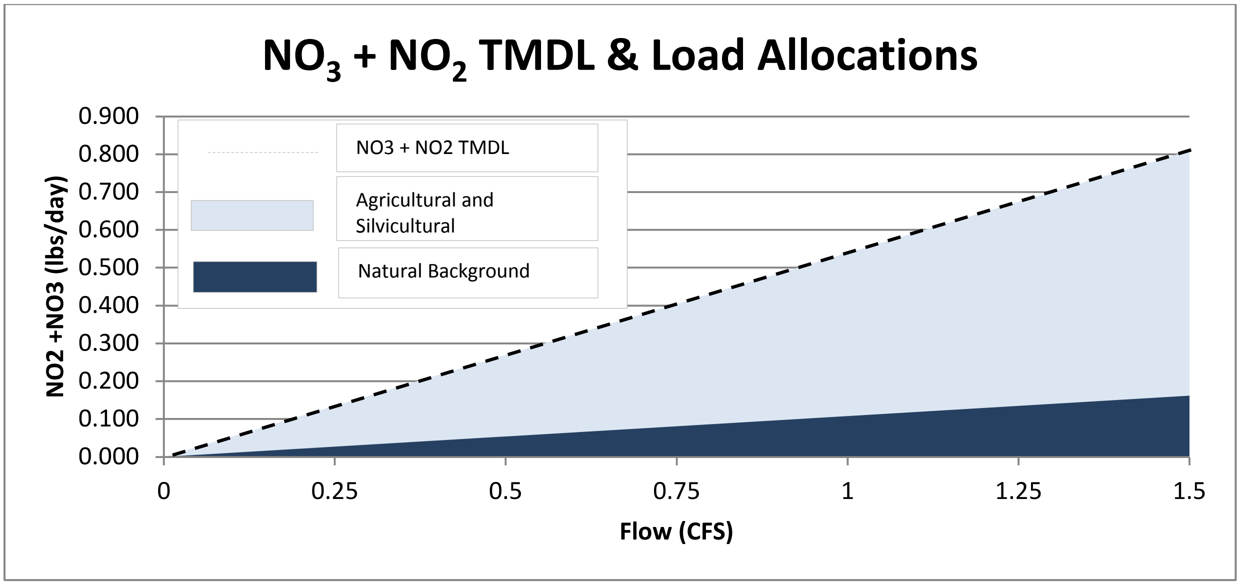

Figure 7-19. TMDL for $N0_3$+$N0_2$ and Load Allocations, South Fork Antelope Creek

Table 7-24 provides an example TMDL and example allocations for a typical summer baseflow condition. The $N0_3$+$N0_2$ load allocations and the $N0_3$+$N0_2$ TMDL are a function of streamflow and are developed in accordance with the TMDL and allocation approaches presented above. **Table 7-24** also provides existing loading values for the source categories along with the required percent reductions to satisfy the allocations and TMDL. Estimation of natural background load is explained previously in this section. The existing load is the 80th percentile of instantaneous loads calculated from water quality data used in the assessment process and discussed in **Section 7.4.3**. For each water quality sample that has a corresponding flow measurement, a load is calculated. The 80th percentile of these loads is then used as the existing load.

Table 7-24. South Fork of Antelope Creek Example $N0_3$+$N0_2$, load allocations and TMDL*

Source Category	Existing Load (lbs/day)	Allocation & TMDL (lbs/day)*	Percent Reduction
Natural Background	0.047	0.047	0%
Agricultural and Silvicultural Land Use	1.25	0.19	84.8%
	Total = 1.30	**TMDL = 0.24**	**Total =81.5%**

**based on a median growing season flow of 0.44 cfs*

The example TMDL for $N0_3$+$N0_2$ in the South Fork of Antelope Creek is calculated to be 0.24 lbs/day. Existing $N0_3$+$N0_2$ loading to the South Fork of Antelope Creek is estimated at 1.30 lbs/day, requiring a total load reduction of 81.5% in order to meet the TMDL for $N0_3$+$N0_2$ in the South Fork of Antelope Creek. Load allocations and load reductions are specifically designated to the composite load of agricultural and silvicultural land uses, along with the existing load, make up an estimated 96% of the

$N0_3$+$N0_2$ load within the South Fork of Antelope Creek. Load reductions should focus on limiting and controlling $N0_3$+$N0_2$ loads from the variety of sources associated with agricultural land use, primarily grazing impacts along the South Fork of Antelope Creek.

Because of grazing in the upper portions of the Rock watershed, it is difficult to use water quality sample results to partition the impacts from grazing impacts from impacts from Silviculture activities. The source assessment conducted for the South Fork of Antelope Creek has led DEQ to determine that agricultural sources are the most current and prominent sources of nutrients in the watershed. DEQ maintains that reducing loads from agricultural sources in the South Fork of Antelope Creek and its tributaries will result in lower $N0_3$+$N0_2$ concentrations throughout the length of Antelope Creek. Reducing loads of this nature will mitigate elevated $N0_3$+$N0_2$ loads. Meeting load allocations may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 8.0**.

7.5.2.3.2 Total Nitrogen (TN) Load Allocations

The South Fork of Antelope Creek TMDL for TN comprises the sum of the load allocations to individual source categories. There are no MPDES discharges to the reach requiring wasteload allocations. Relevant nonpoint source contributions include 1) natural background sources and 2) the combination of agricultural and silvicultural land-use sources. In the absence of individual WLAs and an explicit MOS, TMDLs for TP in the watershed are equal to the sum of the individual load allocations as follows:

TMDL = LA_{NB} + LA_{AG}

LA_{NB} = Load Allocation to natural background sources

$LA_{AG+SILV}$ = Load Allocation to the combination of agricultural and silvicultural land use sources

Natural Background Source

Load allocations for natural background sources are based on a natural background TN concentration of 0.085mg/L (**see Section 7.5.1.1**) and are calculated as follows:

LA_{NB} = (X) (Y) (5.393)

LA_{NB}= TN load allocated to natural background sources

X= 0.085 mg/L natural background concentration

Y= median growing season streamflow in cubic feet per second

5.393 = conversion factor

Agriculture and silvicultural Land use Sources

The load allocation to the combination of agricultural and silvicultural land use sources is calculated as the difference between the allowable daily load (TMDL) and the natural background load:

$LA_{AG+SILV}$= TMDL - LA_{NB}

TN Load Allocation

TN load allocations are provided for South Fork Antelope Creek (**Table 7-25**) and include allocations to the following source categories: 1) natural background (LA_{NB}) and 2) the combination of agricultural and silvicultural land-use sources ($LA_{AG+SILV}$). The TMDL is depicted graphically in **Figure 7-20.**

Table 7-25. TN load allocation descriptions, South Fork Antelope Creek

Source Category	Load Allocation Descriptions	LA Calculation
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.	**LA_{NB} = (X) (Y) (5.393)**
Combination of Agricultural and Silvicultural Land Use	• domestic animal waste • loss of riparian and wetland vegetation along streambanks • limited nutrient uptake	**$LA_{AG+SILV}$ = TMDL - LA_{NB}**

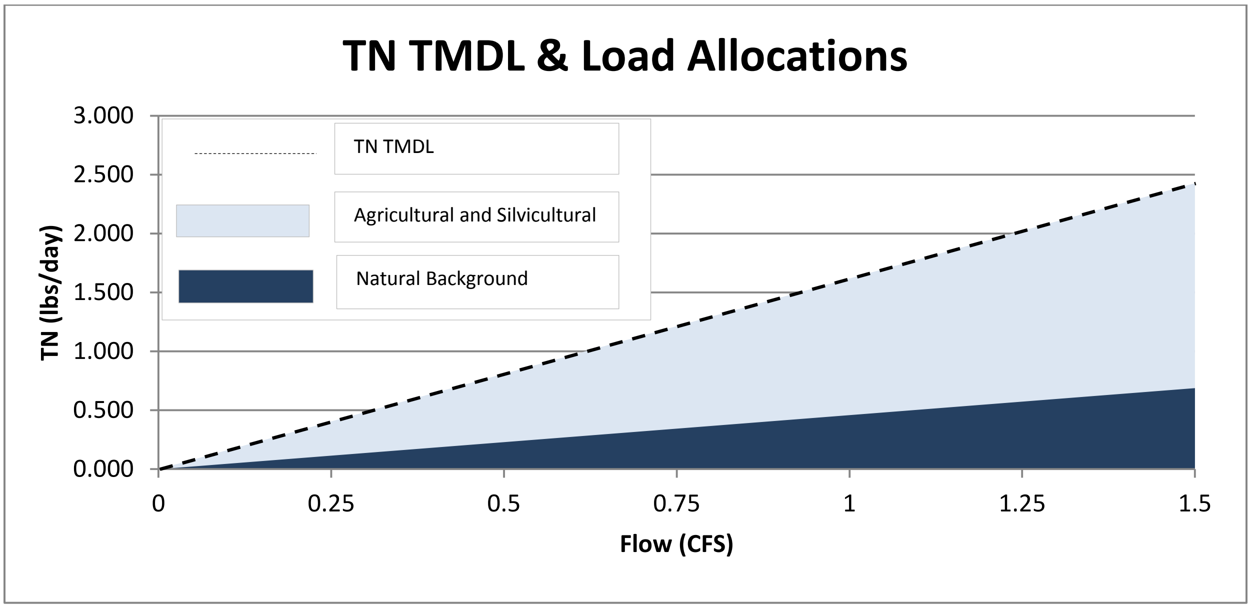

Figure 7-20. TMDL for TN and Load Allocations, South Fork Antelope Creek

Table 7-26 provides an example TMDL and example allocations for a typical summer baseflow condition. The TN load allocations and the TN TMDL are a function of streamflow and are developed in accordance with the TMDL and allocation approaches presented above. **Table 7-26** also provides existing loading values for the source categories along with the required percent reductions to satisfy the allocations and TMDL. Estimation of natural background load is explained previously in this section. The existing load is the 80th percentile of instantaneous loads calculated from water quality data used in the assessment process and discussed in **Section 7.4.3**. For each water quality sample that has a corresponding flow measurement, a load is calculated. The 80th percentile of these loads is then used as the existing load.

Table 7-26. South Fork Antelope Creek Example TN load allocations and TMDL*

Source Category	Existing Load (lbs/day)	Allocation & TMDL (lbs/day)*	Percent Reduction
Natural Background	0.20	0.20	0%
Agricultural and Silvicultural Land Use Sources	2.19	0.51	76.7%
	Total = 2.39	**TMDL = 0.71**	**Total = 70.3%**

**based on a median growing season of 0.44 cfs*

The TMDL for TN in the South Fork of Antelope Creek is calculated to be 0.71 lbs/day. Existing TN loading to the South Fork of Antelope is estimated at 2.39 lbs/day, requiring a total load reduction of 70.3% in order to meet the TMDL for TN in the South Fork of Antelope Creek. Load allocations and load reductions are specifically designated to agricultural and silvicultural land uses which make up 92% of the TN load within the South Fork of Antelope Creek. Load reductions should focus on limiting and controlling TN loads from the variety of sources associated with agricultural land use, primarily grazing impacts along the South Fork of Antelope Creek.

The source assessment conducted for the South Fork of Antelope Creek has led DEQ to determine that agricultural sources are the most current and prominent sources of nutrients in the watershed. DEQ maintains that reducing loads from agricultural sources in the South Fork of Antelope Creek and its tributaries will result in lower TN concentrations throughout the length of Antelope Creek. Reducing loads of this nature will mitigate elevated TN loads. Meeting load allocations may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 8.0**.

7.5.2.3.2 Total Phosphorus (TP) Load Allocations

The South Fork of Antelope Creek TMDL for TP comprises the sum of the load allocations to individual source categories. There are no MPDES discharges to the reach requiring wasteload allocations. Relevant nonpoint source contributions include 1) natural background sources and 2) the combination of agricultural and silvicultural sources. In the absence of individual WLAs and an explicit MOS, TMDLs for TP in the watershed are equal to the sum of the individual load allocations as follows:

$$\mathbf{TMDL = LA_{NB} + LA_{AG+SILV}}$$

LA_{NB} = Load Allocation to natural background sources

$LA_{AG+SIIV}$ = Load Allocation to the combination of agricultural and silvicultural land use sources.

Natural Background Source

Load allocations for natural background sources are based on a natural background TP concentration of 0.010mg/L (**see Section 7.5.1.1**) and are calculated as follows:

$$LA_{NB} = (X)\,(Y)\,(5.393)$$

LA_{NB}= TP load allocated to natural background sources

X= 0.010 mg/L natural background concentration

Y= median growing season streamflow in cubic feet per second

5.393 = conversion factor

Agriculture and Silvicultural Sources

The load allocations are to the combination of agricultural and silvicultural sources are calculated as the difference between the allowable daily load (TMDL) and the natural background load:

$$\mathbf{LA_{AG} = TMDL - LA_{NB}}$$

TP Load Allocation

TP load allocations are provided for South Fork Antelope Creek (**Table 7-27**) and include allocations to the following source categories: 1) natural background (LA_{NB}) and 2) the combination of agricultural and silvicultural land-use sources ($LA_{AG+SILV}$). The TMDL is depicted graphically in **Figure 7-21.**

Table 7-27. TP load allocation descriptions, South Fork Antelope Creek

Source Category	Load Allocation Descriptions	LA Calculation
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.	**LA_{NB} = (X) (Y) (5.393)**
Combination of Agricultural and Silvicultural Land Use	• domestic animal waste • loss of riparian and wetland vegetation along streambanks • limited nutrient uptake	**$LA_{AG+SILV}$ = TMDL - LA_{NB}**

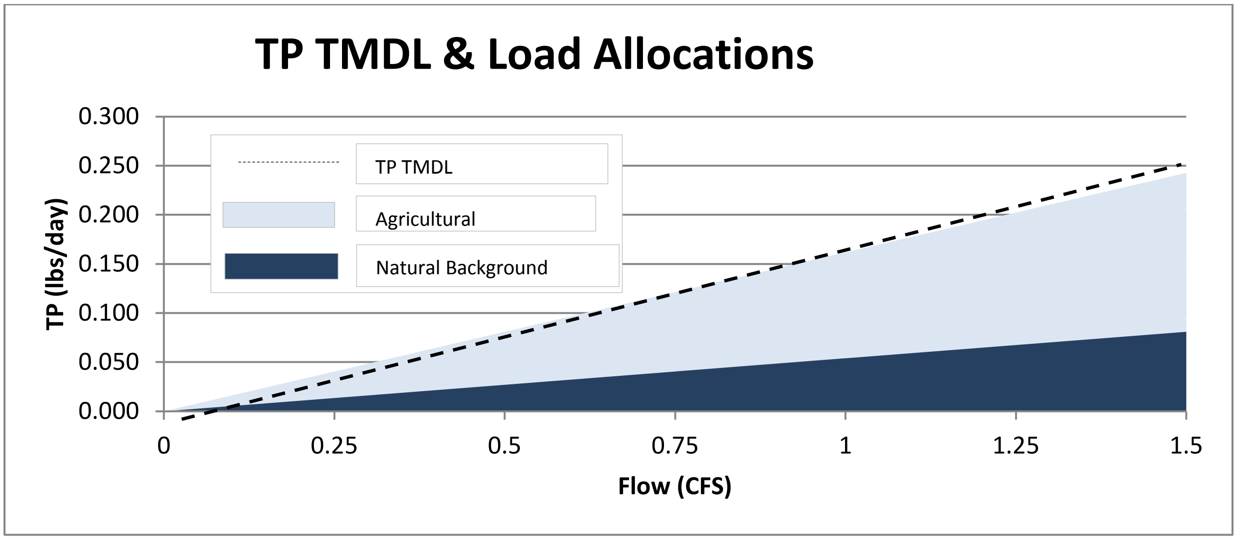

Figure 7-21. TMDL for TP and Load Allocations, South Fork Antelope Creek

Because measured instream TP concentrations are not wholly within natural background conditions and above target concentrations, water quality data warrants calculation of TP load reductions to specific source categories. Load allocations incorporate allowed loading from general source categories and establish allowable TP loads. **Tables 7-28 and 7-29** presents example TP load allocations as a function of streamflow in accordance with the allocation scheme presented in **Table 7-27**; load allocations are presented at growing season flow conditions in the South Fork of Antelope Creek. The existing load is the 80th percentile of instantaneous loads calculated from water quality data used in the assessment process and discussed in **Section 7.4.3**. For each water quality sample that has a corresponding flow measurement, a load is calculated. The 80th percentile of these loads is then used as the existing load.

Table 7-28. Primary calculations of the South Fork Antelope Creek example TP load allocations and TMDL*

Source Category	Existing Load (lbs/day)	Allocation & TMDL (lbs/day)*	Percent Reduction
Natural Background	0.024	0.024	0%
Agricultural and Silvicultural Land Use Sources	0.23	0.047	0%
	Total = 0.047	**TMDL = 0.071**	**Total = 0%**

**based on a median growing season flow of 0.44 cfs*

The example TMDL for TP in the South Fork of Antelope Creek is calculated to be 0.071 lbs/day. Existing TP loading to the South Fork of Antelope is estimated at 0.047 lbs/day, that TP is currently meeting the TMDL for TP. There are a number of factors that contribute to the %0 load allocation.

DEQ's assessment method utilizes a binomial test which, in order to calculate both false positive and false negative rates, includes a value referred to as effect size. The ramification of the effect size is that an exceedance rate of something less than 20% is needed for removing a nutrient impairment cause. The amount that the allowable exceedance rate is below 20% is in part a function of sample size, and as sample size increases the allowable exceedance rate approaches 20%. Because the percent reductions in **Table 7-25** are determined using the 80th percentile of the data, this can lead to zero percent reduction to meet the TMDL when in fact a reduction is necessary based on the margin of safety inherently incorporated into the binomial portion of the assessment method. This condition is exemplified in the South Fork Antelope Creek TP assessment results where 3 of 16 (18.8%) of the samples exceeded the criteria, whereas the allowable number of exceedances is 1 (6.25%). For this number of samples (16), the 94th percentile of the data would need to be equal to or less than the TP target value of 0.030 mg/l.

This exampled is compounded by the flow values used to calculate load. Load is calculated by flow measurements and corresponding TP concentrations collected during the low flow summer growing season. The 80th percentile of these loads is then used in determining the total existing load from the waterbody. Summer growing season flow measurements are typically low. Higher concentrations occur during the period of the year that experiences the lowest flows (growing season). The 80th percentile for loading will tend to miss these exceedances using the approach mentioned above.

Table 7-26 shows load reduction based on the 94th percentile of the TP concentration data and the median growing season flow of 0.44 cfs. The 94th percentile of the concentration data is 0.057 mg/L, which yields a load of 0.135 lbs/day. This suggests a 47.4% reduction in total loading would be necessary to satisfy the target conditions.

Table 7-29. Secondary Calculations of the example South Fork Antelope Creek TP load allocations and TMDL*

Source Category	Existing Load (lbs/day)*	Allocation & TMDL (lbs/day)*	Percent Reduction
Natural Background	0.024	0.024	%0
Agricultural and silvicultural Land Use Sources	0.111	0.047	57.7%
	Total = 0.135	**TMDL = 0.071**	**Total =47.4 %**

**based on a median growing season flow of 0.44 cfs*

Load allocations and load reductions are specifically designated to the combination of agricultural and silvicultural land uses which make up 82% of the TP load within the South Fork of Antelope Creek. Load reductions should focus on limiting and controlling TN loads from the variety of sources associated with agricultural land use, primarily grazing impacts along the South Fork of Antelope Creek.

The source assessment conducted for the South Fork of Antelope Creek has led DEQ to determine that agricultural sources are the most current and prominent sources of nutrients in the watershed. DEQ maintains that reducing loads from agricultural sources in the South Fork of Antelope Creek and its tributaries will result in lower TN concentrations throughout the length of Antelope Creek. Reducing loads of this nature will mitigate elevated TN loads. Meeting load allocations may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 8.0**.

7.5.3 Sluice Gulch (MT46E002_110)

Sluice Gulch flows into Rock Creek. Sluice Gulch enters Rock Creek 6.2 miles downstream from the confluence of the East Fork and West Fork. Area land use is primarily agricultural and historical mining. Land use is primarily heavy grazing and past mining practices. Sluice Gulch appears on the 2012 303(d) List as impaired for NO_3+NO_2. As determined in **Section 7.4.3.3** Sluice Gulch exceeded nutrient water quality targets for Nitrate + Nitrite ($N0_3$+$N0_2$) and Total Nitrogen (TN). Source assessment was conducted for $N0_3$+$N0_2$ and TN.

7.5.3.1 Sluice Gulch Source Assessment

The source assessment for Sluice Gulch includes an evaluation of $N0_3$+$N0_2$ and TN concentrations, flow and loading data along the whole length of Sluice Gulch. This is followed by quantification of natural background and the two most significant human-caused sources of nutrients. The two human-caused nutrient sources include agriculture (grazing) and historical mining practices.

Instream concentrations exceeded water quality targets at all sampling locations during different low-flow events. Only one sample collected for $N0_3$+$N0_2$ and only one sample collected for TN were below target criteria. Both of these samples were collected at the downstream most sampling location (CO2SLUCG01).

$N0_3$+$N0_2$, and TN concentrations were higher in the head waters and decrease as you move down stream. **Table 7-30** and **Figure 7-22** present summary statistics of $N0_3$+$N0_2$ concentrations at sampling sites in Sluice Gulch. **Table 7-31** and **Figure 7-23** present summary statistics of TN concentrations at sampling sites in Sluice Gulch.

Table 7-30. Growing season $N0_3$+$N0_2$ Summary Statistics for Sampling Sites on Sluice Gulch (units in mg/L)

Site	n	min	max	mean	25th percentile	median	75th percentile
C02SLUCG03	5	0.360	0.500	0.46	0.410	0.490	0.490
C02SLUCG02	5	0.250	0.450	0.356	0.280	0.370	0.430
C02SLUCG01	5	0.090	0.380	0.262	0.240	0.290	0.310

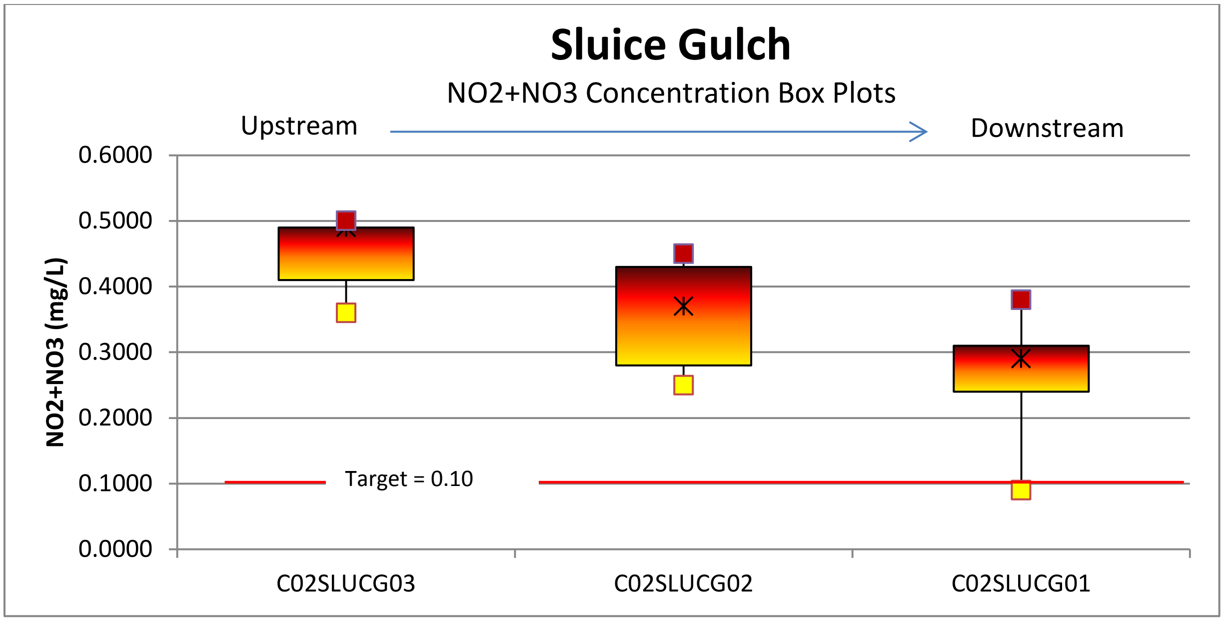

Figure 7-22. NO_3+NO_2 Concentration Box plots: Sluice Gulch

Table 7-31. Growing season TN Summary Statistics for sampling sites on Sluice Gulch (units in mg/L)

Site	n	min	max	mean	25th percentile	median	75th percentile
C02ANTSF03	5	0.420	0.670	0.550	0.520	0.550	0.560
C02ANTSF02	5	0.330	0.500	0.412	0.410	0.410	0.410
C02ANTSF10	5	0.270	0.460	0.370	0.330	0.340	0.450

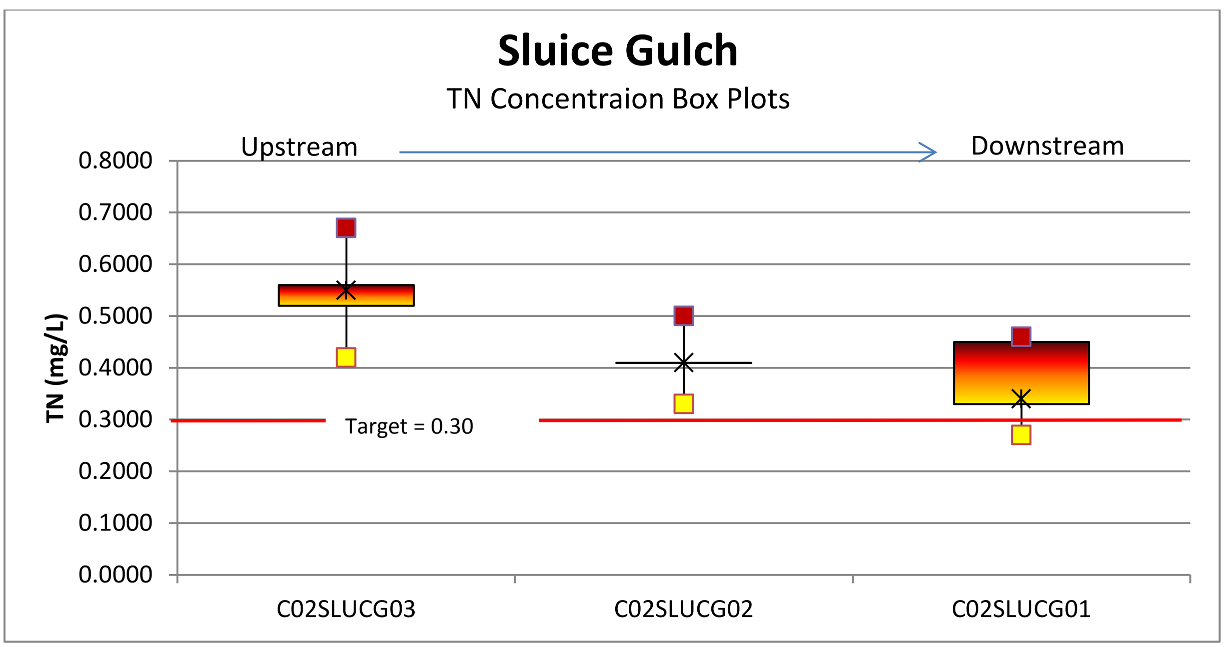

Figure 7-23. TN Concentration Box Plots: Sluice Gulch

NO_3+NO_2 and TN loads calculated from the 2004 and 2010–2011 sampling events are depicted in **Figures 7-24 and 7-25**, respectively. Average NO_3+NO_2 and TN loads decrease moving downstream from the headwaters of the Sluice Gulch to the mouth. The decrease in loading is due to the decrease in $N0_3$+$N0_2$ and TN concentrations and decrease in volume of streamflow in Sluice Gulch.

Average low-flow $N0_3$+$N0_2$ loads decrease from 3.75 lbs/day at monitoring location CO2SLUCG03 to 1.67 lbs/day at the downstream CO2SLUCG01 monitoring location, an average decrease of 2.08 lbs/day. Average low-flow TN loads decreased from 4.21 lb/day at monitoring location CO2SLUCG03 to 2.34 lb/day at the downstream CO2SLUCG01 monitoring location. This is an average decrease of 1.87 lbs/day.

The Decrease in concentration of $N0_3$+$N0_2$ and TN as you move down stream is a likely a result of the sources of $N0_3$+$N0_2$ and TN being located closer to the headwaters of Sluice Gulch. Sluice Gulch is subject to grazing approximately 2-3 months of the year, on 285 allotment acres.

Streamflow volume decreases as you move from the headwaters to the mouth. Average flow volumes decrease from 1.45 cubic feet per second (cfs) to 1.27 cfs to 1.16 cfs at the monitoring sites CO2SLUCG03, CO2SLUCG02 and CO2SLUCG01, respectively. The load decrease parallels the decrease in flow throughout the length of the stream.

The tributary network to Sluice Gulch suggests that the supply of water for this creek is adequate to maintain flow volumes. However, much of the flow volume is lost over its length, which suggests there is an overall loss of surface water to groundwater along Sluice Gulch. This idea is supported by the Belt Series Carbonate geology that is present for the length of Sluice Gulch.

The decreased $N0_3$+$N0_2$ and TN concentrations could also indicate some algal nutrient uptake, although the relatively low Chlorophyll-*a* (live algae) and AFDW results along Sluice Gulch during the majority of sample events suggests that there was not significant algae uptake at the time of the sampling events. **Figures 7-24 and 7-25** shows the decreasing $N0_3$+$N0_2$ and TN loading trends.

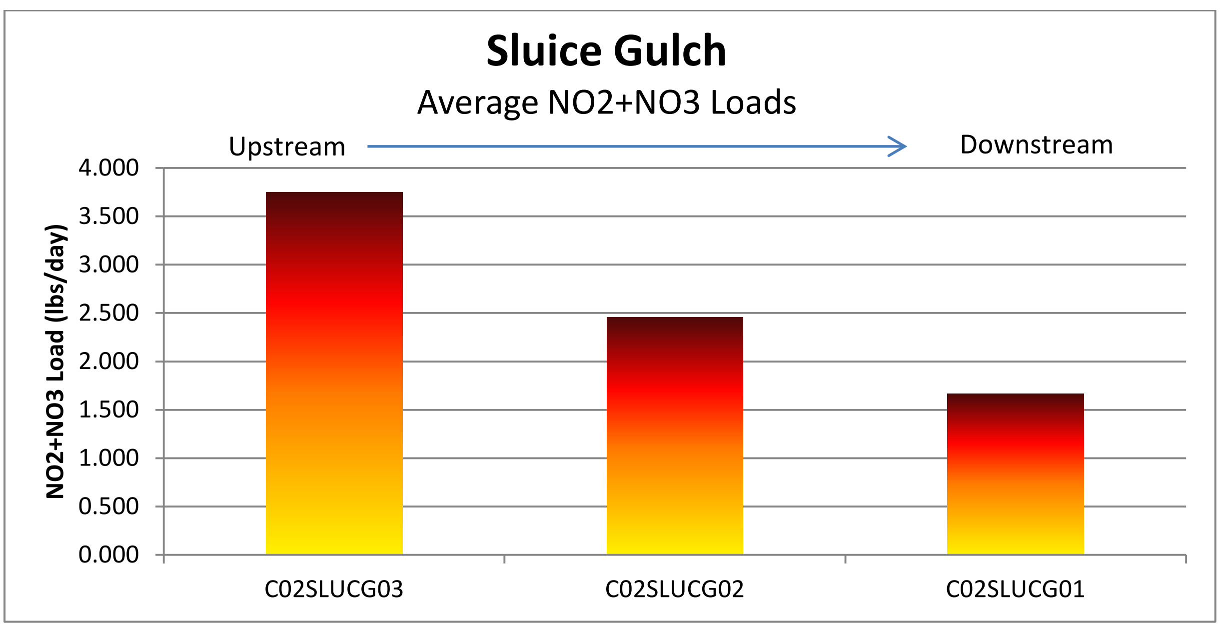

Figure 7-24. $N0_3$+$N0_2$ Load within Sluice Gulch

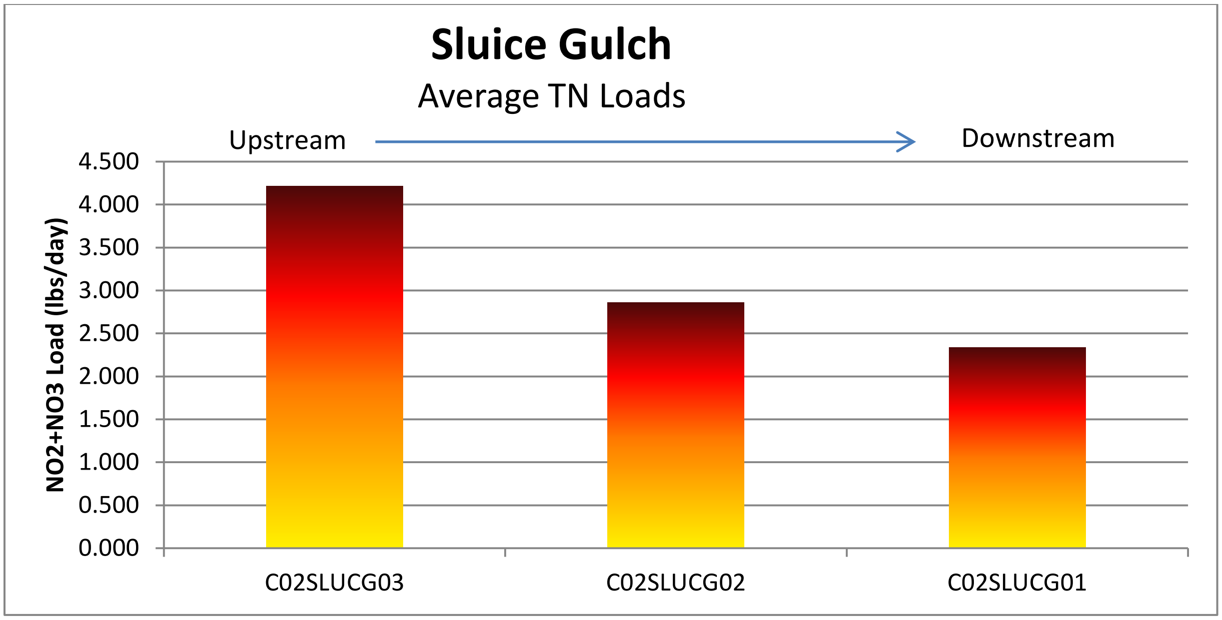

Figure 7-25. TN Load within Sluice Gulch

Natural Background Nutrient Loading

Natural background sources of nitrogen include a variety of natural processes and sources and likely include: soils and local geology, natural vegetative decay, wet and dry airborne deposition, wild animal waste, and other biochemical processes that contribute nitrogen to this system. No background water quality data was available for Sluice Gulch.

Given this lack of data, and lack of data from reference streams in the Rock TPA, DEQ has decided to use values from reference streams in the Level III Middle Rockies Ecoregion. In a study to develop nutrient criteria for streams in Montana, (Suplee et al., 2008a) provides the 25th, 50th, and 75th percentile of the all-season reference dataset from wadeable streams to represent background conditions.

This translates to background $N0_3$+$N0_2$ values ranging from 0.005 mg/L, 0.020 mg/L, and 0.042 mg/L at the 25th, 50th, and 75th percentiles, respectively. DEQ will use the 50th percentile value (0.020 mg/L) since it represents the central tendency for the data sets used and is a likely representation of background water quality. Assuming a natural background concentration for $N0_3$+$N0_2$ of 0.020 mg/L and a median low-flow baseflow of 1.27 cfs, the average background $N0_3$+$N0_2$ load to the segment is calculated to be approximately 0.14 lbs/day.

Background TN values derived from (Suplee et al., 2008a) ranging from 0.065 mg/L, 0.085 mg/L, and 0.175 mg/L at the 25th, 50th, and 75th percentiles, respectively. DEQ will use the 50th percentile value (0.085 mg/L) since it represents the central tendency for the data sets used and is a likely representation of background water quality. Assuming a natural background concentration for TN of 0.085 mg/L and a median low-flow baseflow of 1.27 cfs, the average background TN load to the segment is calculated to be approximately 0.58 lbs/day.

Agricultural Nutrient Loading

A large number of cattle are periodically grazed along and in the headwaters of Sluice Gulch, sometimes during the algal growing season. Sluice Gulch is approximately 5,532 acres, of which 240 acres are state land, and 300 acres are Bureau of Land Management (BLM) land. The BLM has a total of 285 allotted acres in the Sluice Gulch watershed. This acreage is split between two allotments. These allotments are Papoose Gulch and Sluice Gulch allotments. The BLM allows 50 cattle between the two allotments.

The remaining portion of Sluice Gulch (approximately 4992 acres) is private land. The DEQ will assume that cattle are being grazed on private land within the watershed. A conservative approach to determining the number of cattle being grazed is to apply an Animal Unit Month (AUM) of 0.1 to 0.15 to the remaining 4992 acres of private land. This would indicate that this land was capable of providing forage for 499-749 cattle if they were grazed sustainably.

There are several possible mechanisms for the transport of nutrients from agricultural land to surface water during the growing season. The potential pathways include 1) direct loading via the breakdown of excrement 2) delivery from grazed forest and rangeland during the growing season via surface water and subsurface pathways 3) the effect of grazing on vegetative health and its ability to uptake nutrients and minimize erosion in upland and riparian areas. As noted by the sediment assessment results in **Section XX,** vegetation, habitat, and sediment deposition in Sluice Gulch have been negatively impacted primarily via grazing. These negative impacts contribute to a lack of riparian buffering as a significant contributor towards elevated nutrient loading along with direct loading from cattle excrement given their proximity to the stream.

Historical Mining Loading

The Montana Bureau of Mines and Geology (MBMG) abandoned mines database lists two inactive mines in the Sluice Gulch drainage: the Silver King Mine and the Lori No. 13. The Silver King is a former gold and silver lode mine occupying about 18 acres on the south flank of Sluice Gulch where the drainage enters the Upper Willow Creek Valley. The mine consists of access roads, operating benches, 5 adit openings, and 30,000 cubic yards of waste rock in several dumps. A 1993 field assessment reported one of the adits discharging at about 50 gallons per minute. Approximately one mile upstream of the Silver King Mine is the Lori No. 13 that consists of a single dry adit and a revegetated waste rock dump containing about 700 cubic yards (Pioneer Technical Services, Inc., 1995). The mine disturbs about 9 acres on the north side of the gulch and is about 800 feet from Sluice Gulch surface water. Both the Silver King and Lori N. 13 are ranked as priority mine sites that have potential human health and safety hazards.

Sluice Gulch is listed in the 2012 Integrated Report (Montana Department of Environmental Quality, 2012c) as being impaired due to arsenic, sediment, nitrite plus nitrate nitrogen, and alteration in streamside vegetative covers. The recent water quality dataset for Sluice Gulch contains 8 metals analysis records for samples collected in 2004 and 2010. All 8 results for arsenic exceeded the human health criterion of 10 µg/L. One in 8 results for both aluminum and copper exceeded the chronic aquatic life criterion. Other water column metals concentrations are either less than detectable concentrations, or at or below metals target values.

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. Concentration of contaminants depends on the mechanism of chemical release, streamflow, and water chemistry. Nitrates may be present in mine discharge water as a result of 1) residuals from ammonium nitrate and fuel oil (ANFO) used in blasting, 2) microbial mediates cyanide degradation, 3) leaching of ANFO contamination from waste rock or from rock with natural background nitrate, and 4) residuals from fertilizer used in reclamation (Environmental Protection Agency,1996). Some nitrate may be the result of nitric acid commonly used in the recovery process.

Nitrate pollution is likely not a result of ANFO, considering the time that has lapsed since these chemicals were used in the mining process. However, given the presence of large amounts of disturbed areas, and acid mine drainage from adits, nitrate pollution may be attributable to nitrate leaching from waste rock or to the breakdown of cyanide from leaching. Nitrate polluted groundwater in the area is another possible source of nitrates. Depending on the hydrogeologic flow regime, groundwater affected by historical mining activities may be upwelling in the area and contributing to nitrates in Sluice Gulch.

Surface water quality data collected for the purposes of assessing the current conditions of Sluice Gulch **(Section 7.7.1.1)** indicate $N0_3$+$N0_2$ and TN concentration decrease as you move downstream. Flow volumes also decrease as you move downstream, which intern causes an overall decrease in $N0_3$+$N0_2$ and TN loads. Monitoring data did not indicate a dramatic increase in concentration or load downstream of the Silver King and Lori N. 13 mines. The monitoring data did not indicate that there is a direct contribution of nutrients from the mines as such the DEQ cannot assign an individual load allocation and will assign a composite load allocation to this potential source. This composite load allocation will include both agricultural (grazing) and Mining sources throughout the watershed.

7.5.3.2 Sluice Gulch Total Maximum Daily Loads: Nitrate Plus Nitrite ($N0_3$+$N0_2$) and Total Nitrogen (TN)

$N0_3$+$N0_2$ and TN Total Maximum Daily Loads are presented here for Sluice Gulch (MT41E002_110). The TMDLs (lbs/day) for $N0_3$+$N0_2$ and TN are calculated using the water quality target values established in **Section 7.4**.X.X The TMDL loads for $N0_3$+$N0_2$ and TN apply during the summer growing season (normally July 1–Sept. 30). The TMDL for $N0_3$+$N0_2$ is based on an instream target value of 0.10 mg/L TN and streamflow (**Figure 7-26**). The TMDL for TN is based on an instream target value of 0.30 mg/L TN and streamflow (**Figure 7-27**).

TMDL calculations for $N0_3$+$N0_2$ and TN are based on the following formula:

TMDL = (X) (Y) (5.393)

TMDL= Total Maximum Daily Load in lbs/day
X= water quality target in mg/L ($N0_3$+$N0_2$ *=0.10 mg/L or TN =0.30 mg/L)*
Y= streamflow in cubic feet per second
5.393 = conversion factor

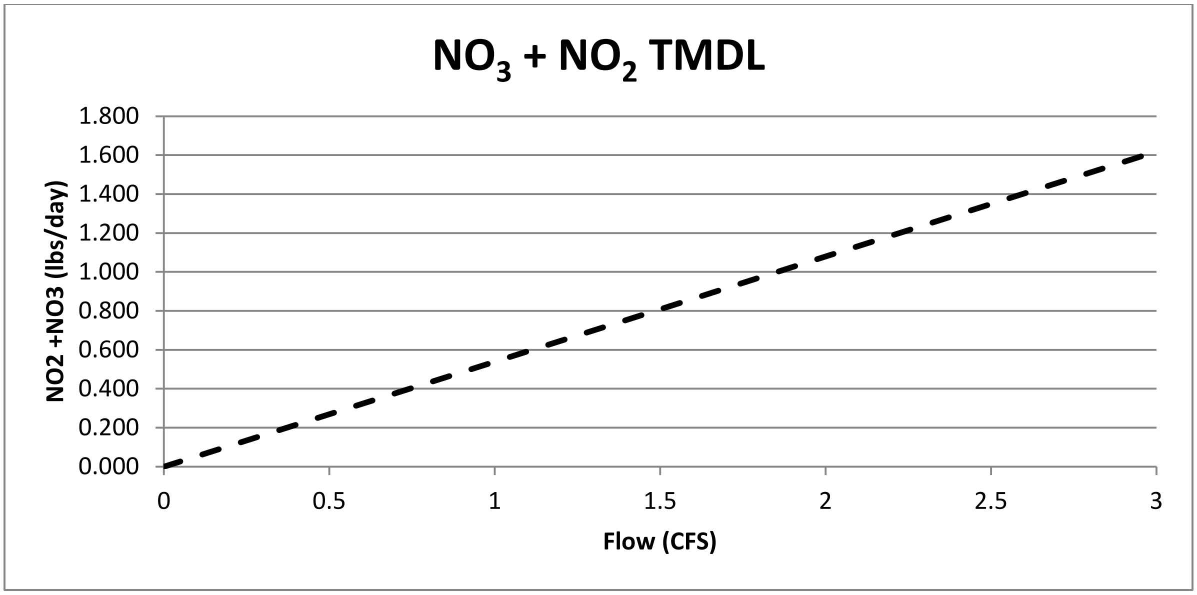

Figure 7-26. TMDL for $NO_2 + NO_3$ as a function of flow: Sluice Gulch

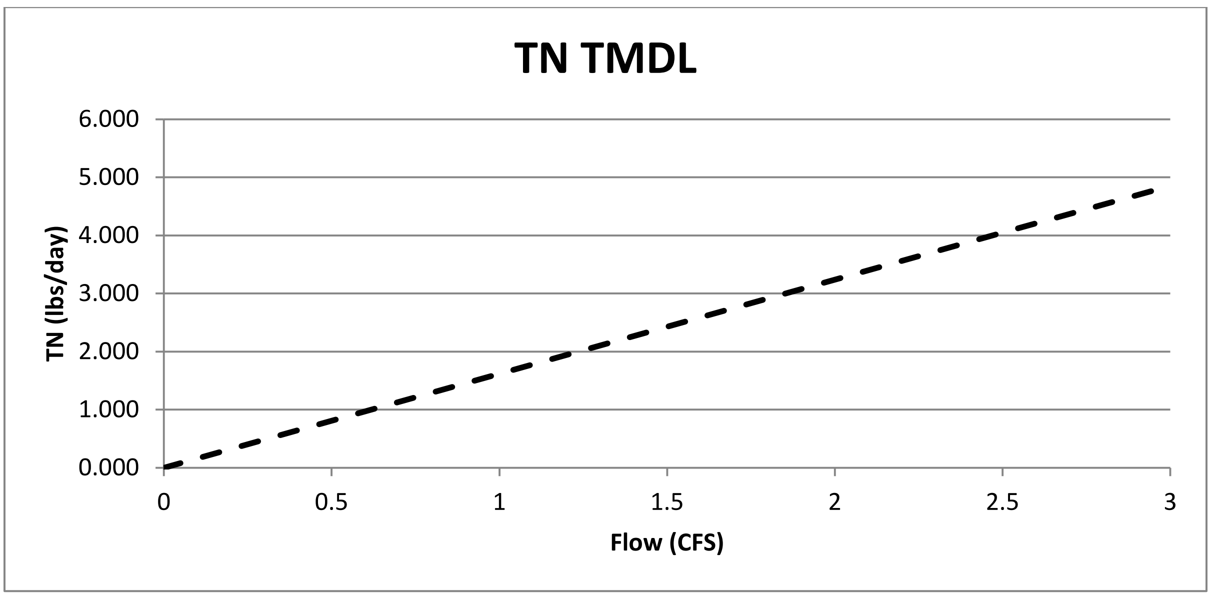

Figure 7-27. TMDL for TN as a function of flow: Sluice Gulch

7.5.3.3 Sluice Gulch Nitrate Plus Nitrite ($N0_3$+$N0_2$) and Total Nitrogen (TN) Allocations

TMDLs are allocated to point (wasteload) and nonpoint (load) $N0_3$+$N0_2$ and TN sources. The TMDL comprises the sum of all point sources and nonpoint sources (natural and human-caused), plus a margin of safety that accounts for uncertainties in loading and receiving water analyses. In addition to pollutant load allocations, the TMDL must also take into account the seasonal variability of pollutant loads and adaptive management strategies in order to address uncertainties inherent in environmental analyses.

7.5.3.3.1 Nitrate Plus Nitrite ($N0_3$+$N0_2$) Allocations

Sluice Gulch's TMDL for $N0_3$+$N0_2$ comprises the sum of the load allocations to individual source categories. There are no MPDES discharges to the reach requiring wasteload allocations. Relevant $N0_3$+$N0_2$ nonpoint sources include natural background sources and agricultural and historical mining practices. Load allocations are therefore provided for 1) natural background sources and 2) the combination of agricultural and historical mining land-use sources. In the absence of individual WLAs and an explicit MOS, TMDLs for $N0_3$+$N0_2$ in the watershed are equal to the sum of the individual load allocations as follows:

TMDL = LA_{NB} + $LA_{AG+MINE}$

LA_{NB} = Load Allocation to natural background sources

$LA_{AG+MINE}$ = Load Allocation to the combination of agricultural and historical mining land-use sources

Natural Background Source

Load allocations for natural background sources are based on a natural background $N0_3$+$N0_2$ concentration of 0.020 mg/L (**see Section 7.5.1.1**) and are calculated as follows:

LA_{NB} = (X) (Y) (5.393)

LA_{NB}= $N0_3$+$N0_2$ load allocated to natural background sources

X= 0.020 mg/L natural background concentration

Y= streamflow in cubic feet per second

5.393 = conversion factor

Agriculture and Historical Mining

The load allocation of composite agricultural and mining sources is calculated as the difference between the allowable daily load (TMDL) and the natural background load:

$LA_{AG+MINE}$= TMDL - LA_{NB}

$N0_3$+$N0_2$ load allocations are summarized in **Table 7-32** and depicted graphically in **Figure 7-28.**

Table 7-32. $N0_3$+$N0_2$ load allocation descriptions, Sluice Gulch

Source Category	Load Allocation Descriptions	LA Calculation
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.	**LA_{NB} = (X) (Y) (5.393)**
Combination of Agricultural Land Use and Historical Mining	• domestic animal waste • loss of riparian and wetland vegetation along streambank • Runoff from exposed rock with containing natural background nitrate • Residual chemicals left over from mining practices	**$LA_{AG+MINE}$ = TMDL - LA_{NB}**

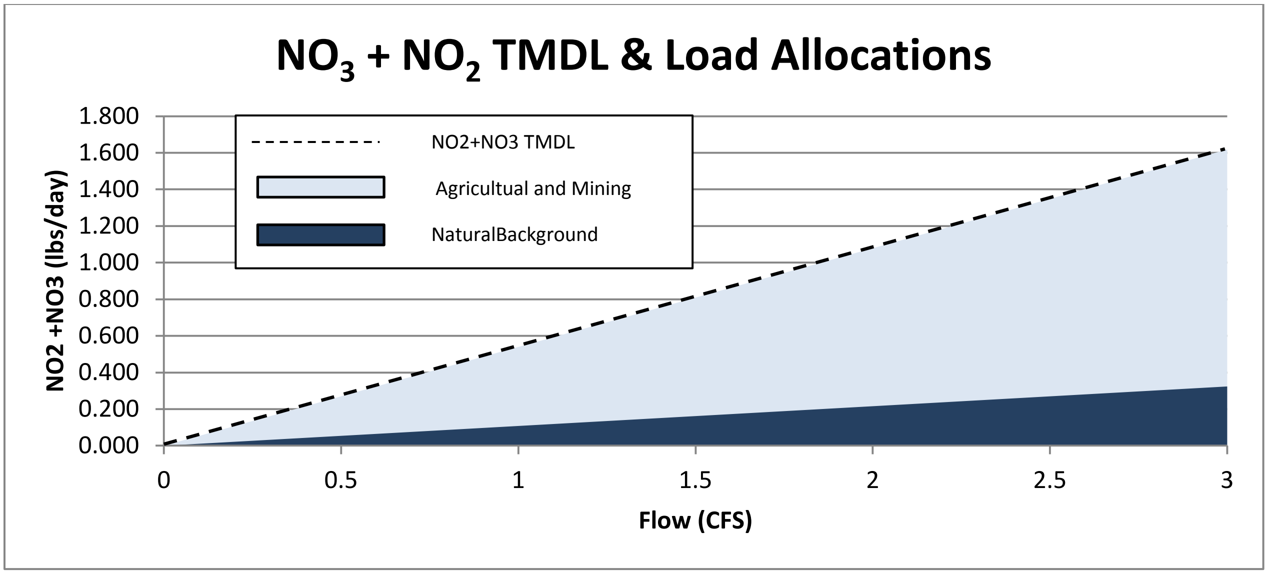

Figure 7-28. TMDL for NO_3+NO_2 and Load Allocations, Sluice Gulch

Table 7-33 provides an example TMDL and example allocations for a typical summer baseflow condition. The $N0_3$+$N0_2$ load allocations and the $N0_3$+$N0_2$ TMDL are a function of streamflow and are developed in accordance with the TMDL and allocation approaches presented above. **Table 7-33** also provides existing loading values for the source categories along with the required percent reductions to satisfy the allocations and TMDL. Estimation of natural background load is explained previously in this section. The existing load is the 80th percentile of instantaneous loads calculated from water quality data used in the assessment process and discussed in **Section 7.4.3**. For each water quality sample that has a corresponding flow measurement, a load is calculated. The 80th percentile of these loads is then used as the existing load.

Table 7-33. Sluice Gulch example $N0_3$+$N0_2$ load allocations and TMDL*

Source Category	Existing Load (lbs/day)	Allocation & TMDL (lbs/day)*	Percent Reduction
Natural Background	0.14	0.14	0%
Agricultural Land-Use and Historical Mining Sources	3.06	0.54	82.4%
	Total = 3.20	**TMDL = 0.68**	**Total = 78.8%**

**based on a median growing season flow of 1.27 cfs*

The TMDL for $N0_3$+$N0_2$ in Sluice Gulch is calculated to be 0.68 lbs/day. Existing $N0_3$+$N0_2$ loading to Sluice Gulch is estimated at 2.81 lbs/day, requiring a total load reduction of 78.8% in order to meet the TMDL for $N0_3$+$N0_2$ in Sluice Gulch. Load allocations and load reductions are specifically designated to the combination of agricultural land use and historical mining which makes up an estimated 96% of the $N0_3$+$N0_2$ load measured within Sluice Gulch. Load reductions should focus on limiting and controlling $N0_3$+$N0_2$ loads from the variety of sources associated with agricultural land use and historical mining impacts along Sluice Gulch.

The source assessment conducted for the Sluice Gulch has led DEQ to determine that agricultural sources are the most current and prominent sources of nutrients in the watershed. DEQ maintains that reducing loads from agricultural sources in the Sluice Gulch and its tributaries will result in lower $N0_3$+$N0_2$ concentrations throughout the length of Sluice Gulch. Reducing loads of this nature will mitigate elevated $N0_3$+$N0_2$ loads. Meeting load allocations may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 8.0**.

7.5.3.3.1 Total Nitrogen (TN) Allocations

The Sluice Gulch TMDL for TN comprises the sum of the load allocations to individual source categories. There are no MPDES discharges to the reach requiring wasteload allocations. Relevant TN nonpoint sources include natural background sources and the combination of agricultural and historical mining sources. Load allocations are therefore provided for 1) natural background sources and 2) the combination of agricultural and historical mining land-use sources. In the absence of individual WLAs and an explicit MOS, TMDLs for TN in the watershed are equal to the sum of the individual load allocations as follows:

$$\mathbf{TMDL = LA_{NB} + LA_{AG+MINE}}$$

LA_{NB} = Load Allocation to natural background sources

$LA_{AG+MINE}$ = Load Allocation to the combination of agricultural and historical mining land-use sources

Natural Background Source

Load allocations for natural background sources are based on a natural background TN concentration of 0.085 mg/L (**see Section 7.5.1.1**) and are calculated as follows:

$$LA_{NB} = (X)\ (Y)\ (5.393)$$

LA_{NB}= TN load allocated to natural background sources

X= 0.085 mg/L natural background concentration

Y= streamflow in cubic feet per second

5.393 = conversion factor

Agriculture and Historical Mining

The load allocation of agricultural sources is calculated as the difference between the allowable daily load (TMDL) and the natural background load:

$$\mathbf{LA_{AG+MINE} = TMDL - LA_{NB}}$$

TN load allocations are summarized in **Table 7-34** and depicted graphically in **Figure 7-29**.

Table 7-34. TN load allocation descriptions, Sluice Gulch

Source Category	Load Allocation Descriptions	LA Calculation
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.	**LA_{NB} = (X) (Y) (5.393)**
Combination of Agricultural and Mining Land Use	• domestic animal waste • loss of riparian and wetland vegetation along streambanks • Runoff from exposed rock with containing natural background nitrate • Residual chemicals left over from mining practices	**$LA_{AG+MINE}$ = TMDL - LA_{NB}**

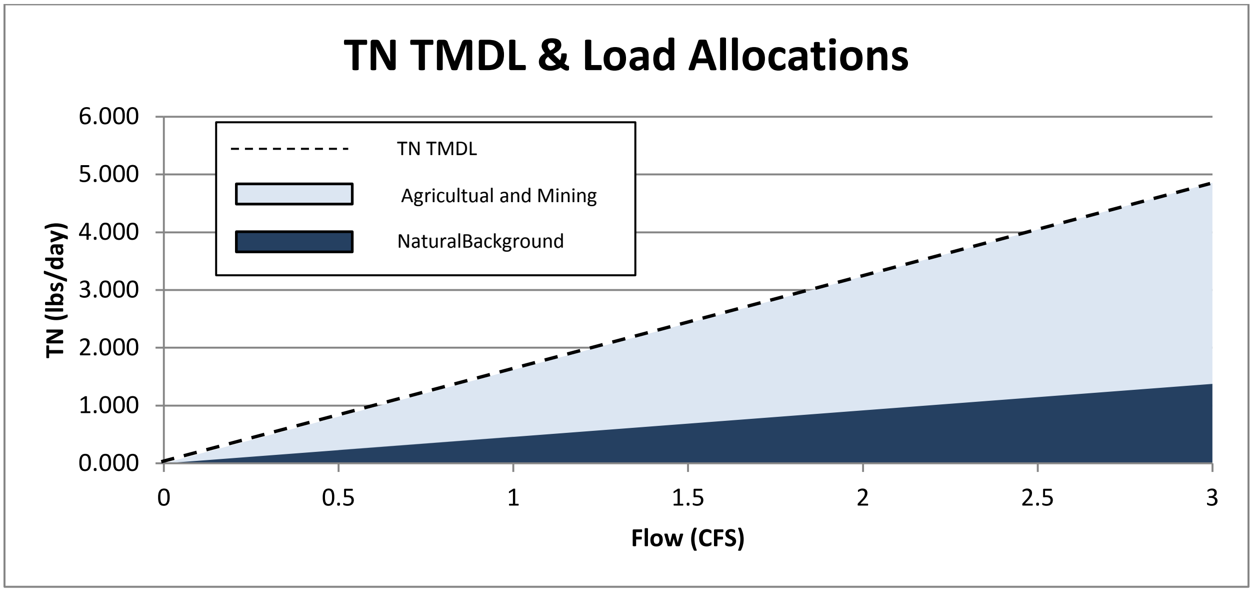

Figure 7-29. TMDL for TN and Load Allocations, Sluice Gulch

Table 7-35 provides an example TMDL and example allocations for a typical summer baseflow condition. The TN load allocations and the TN TMDL are a function of streamflow and are developed in accordance with the TMDL and allocation approaches presented above. **Table 7-35** also provides existing loading values for the source categories along with the required percent reductions to satisfy the allocations and TMDL. Estimation of natural background load is explained previously in this section. The existing load is the 80th percentile of instantaneous loads calculated from water quality data used in the assessment process and discussed in **Section 7.4.3**. For each water quality sample that has a corresponding flow measurement, a load is calculated. The 80th percentile of these loads is then used as the existing load.

Table 7-35. Sluice Creek example TN load allocations and TMDL*

Source Category	Existing Load (lbs/day)	Allocation & TMDL (lbs/day)*	Percent Reduction
Natural Background	0.58	0.58	0%
Agricultural Land-Use Sources and Historical Mining	3.57	1.48	58.5%
	Total = 4.15	**TMDL** = 2.06	**Total = 50.4%**

**based on a median growing season flow of 1.27 cfs*

The TMDL for TN in Sluice Gulch is calculated to be 2.06 lbs/day. Existing TN loading to Sluice Gulch is estimated at 4.15 lbs/day, requiring a total load reduction of 50.4% in order to meet the TMDL for TN. Load allocations and load reductions are specifically designated to the combination of agricultural and mining land use which makes up an estimated 86% of the TN load within Sluice Gulch. . Load reductions should focus on limiting and controlling $N0_3$+$N0_2$ loads from the variety of sources associated with agricultural land use and historical mining impacts along Sluice Gulch.

The source assessment conducted for the Sluice Gulch has led DEQ to determine that agricultural sources are the most current and prominent sources of nutrients in the watershed. DEQ maintains that reducing loads from agricultural sources in the Sluice Gulch and its tributaries will result in lower TN concentrations throughout the length of Sluice Gulch. Reducing loads of this nature will mitigate elevated TN loads. Meeting load allocations may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 8.0**.

7.5.4 Scotchman Gulch (MT46E002_100)

Scotchman Creek is a tributary of Upper Willow Creek. Scotchman Creek enters Upper Willow Creek approximately 3.7 mile up from the confluence with Rock Creek. Area land use is primarily agricultural, silviculture and some historical mining. Agriculture land use consist primarily of cattle operations, silvicultural use is comprised of timber harvesting and thinning operations. Other impacts to surface water quality in Scotchman Gulch include those from past mining practices. Scotchman Gulch appears on the 2012 303(d) List as impaired for Total Phosphorous (TP). As determined in **Section 7.4.3.4**, Scotchman Gulch exceeded nutrient water quality targets for TP and Total Nitrogen (TN). Source assessment was conducted for TP and TN.

7.5.4.1 Scotchman Gulch Source Assessment

The source assessment for Scotchman Gulch includes an evaluation of TN and TP concentrations, flow and loading data along the whole length of Scotchman Gulch. This is followed by quantification of natural background and discussion of the three most potentially significant human-caused sources of nutrients. The three human-caused nutrient sources include agriculture (grazing), silviculture and historical mining practices.

In stream concentrations exceeded water quality targets at all sampling locations during different low-flow events. Six of the 23 samples collected (26%) for TN were above the target criteria of 0.30 mg/L TN. The majority of TP samples collected were above target criteria, only 2 samples were below the target criteria of 0.030 mg/L TP. These values were observed at CO2SCTMG01 and CO2SCTMG03.
As a whole, both TN and TP concentrations were lower in the head waters and increased as you move down stream. The highest concentration observed for both parameters were seen at the downstream most sampling location. **Table 7-36** and **Figure 7-30** present summary statistics of TN concentrations at sampling sites in Scotchman Gulch. **Table 7-37** and **Figure 7-31** present summary statistics of TP concentrations at sampling sites in Scotchman Gulch.

Table 7-36. Growing season TN Summary Statistics for Sampling Sites on Scotchman Gulch (units in mg/L)

Site	n	min	max	mean	25th percentile	median	75th percentile
CO2SCTMG01	5	0.104	0.380	0.220	0.188	0.200	0.228
CO2SCTMG10	6	0.152	0.412	0.265	0.225	0.238	0.297
CO2SCTMG02	6	0.156	0.431	0.270	0.228	0.258	0.280
CO2SCTMG03	6	0.154	0.707	0.384	0.301	0.350	0.410

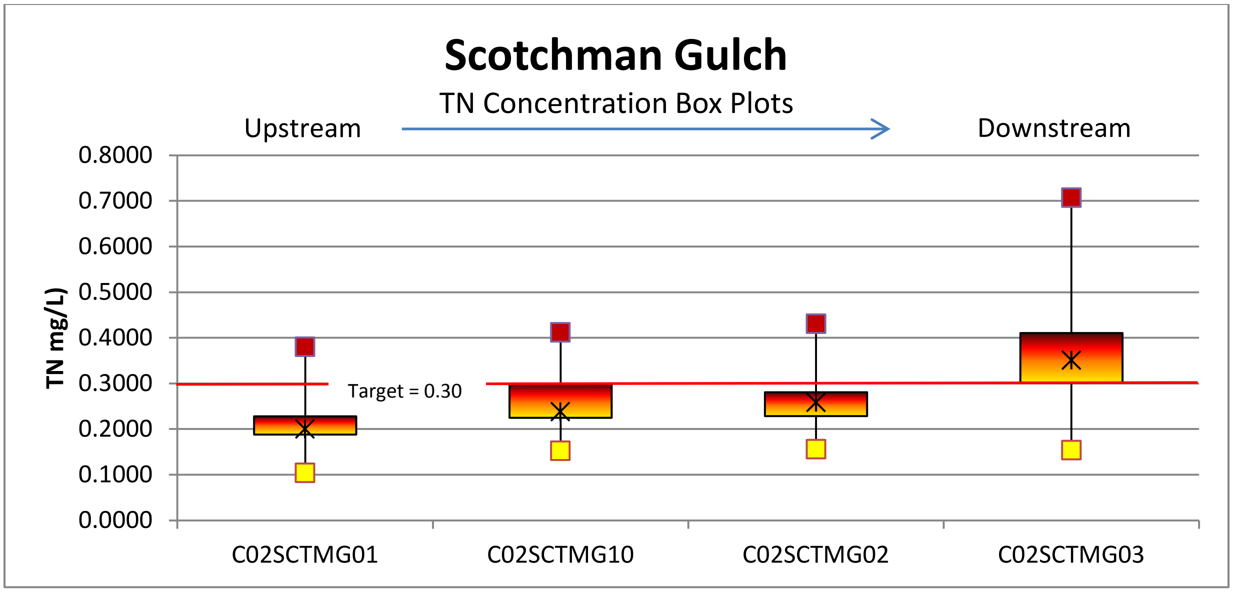

Figure 7-30. TN Concentration Box Plots: Scotchman Gulch

Table 7-37. Growing season TP Summary Statistics for sampling sites on Scotchman Gulch (units in mg/L)

Site	n	min	max	mean	25th percentile	median	75th percentile
CO2SCTMG01	5	0.028	0.046	0.035	0.031	0.032	0.036
CO2SCTMG10	7	0.036	0.064	0.051	0.043	0.047	0.062
CO2SCTMG02	6	0.045	0.074	0.056	0.047	0.054	0.063
CO2SCTMG03	6	0.001	0.115	0.063	0.048	0.056	0.091

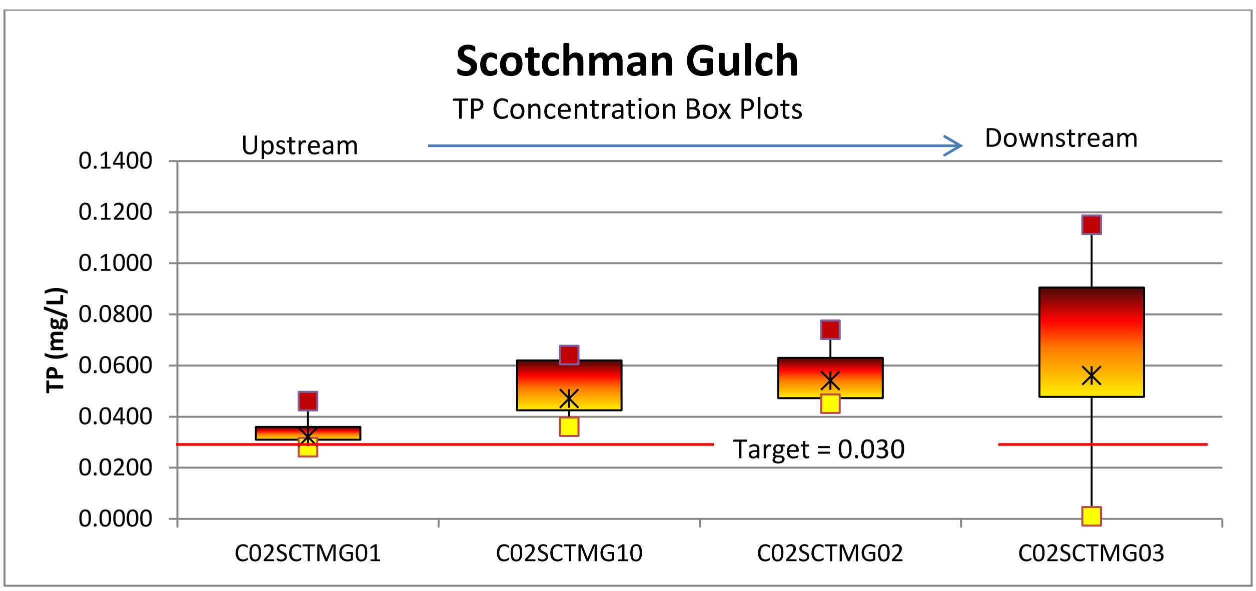

Figure 7-31. TP Concentration Box Plots: Scotchman Gulch

TN and TP loads calculated from the 2004 and 2009–2011 sampling events are depicted in **Figures 7-32 and 7-33**, respectively. As a whole, average TN and TP loads increase moving downstream from the headwaters of the Scotchman Gulch to the mouth. For example, the average low-flow TN loads increase from 0.45 lbs/day at the upstream monitoring location CO2SCTMG01 to 0.62 lbs/day at the downstream CO2SCTMG03 monitoring location, an average increase of 0.17 lbs/day. Average low-flow TP loads increase from 0.064 lb/day at monitoring location CO2SLUCG01 to 0.10 lb/day at the downstream CO2SLUCG02 monitoring location. This is an average decrease of 0.041 lbs/day. The TP load then decreases by 0.007 lbs/day from CO2SLUCG02 to CO2SLUCG03. The increase in loading is due to the increase in TN and TP concentrations and increase in volume of streamflow in Scotchman Gulch. The increase in concentration of TN and TP as you move down stream is a likely a result of the sources of TN and TP being located throughout Scotchman Gulch.

Streamflow volume increase slightly as you move from the headwater to the mouth. Average flow volumes increase from 0.33 cfs, 0.34 cfs to 0.44 cfs at the monitoring sites CO2SCTMG01, CO2SCTMG101 and CO2SCTMG02, respectively. There is a slight decrease in average flow of 0.05 cfs from CO2SCTMG02 to CO2SCTMG03.

While flow volumes in the upper segments of Scotchman Gulch are relatively constant, the extensive drainage area and land type through which Scotchman Gulch flows, suggests that the supply of water for this creek should provide increased flow volumes. A portion of the flow volume is lost between the last two sampling sites. The constant and loosing flow volumes suggest surface water may be contributing to the groundwater system in the upper segments and especially between the last two sampling locations. This idea is supported by the Belt Series Carbonate geology that is present for the length of Scotchman Gulch.

The Increased TN and TP concentrations indicate increased TN and TP contributions in the downstream segments of Scotchman Gulch. Low Chlorophyll-*a* (live algae) and AFDW results along Scotchman Gulch during the majority of sample events suggests that there was not significant uptake by algae at the time of the sampling events.

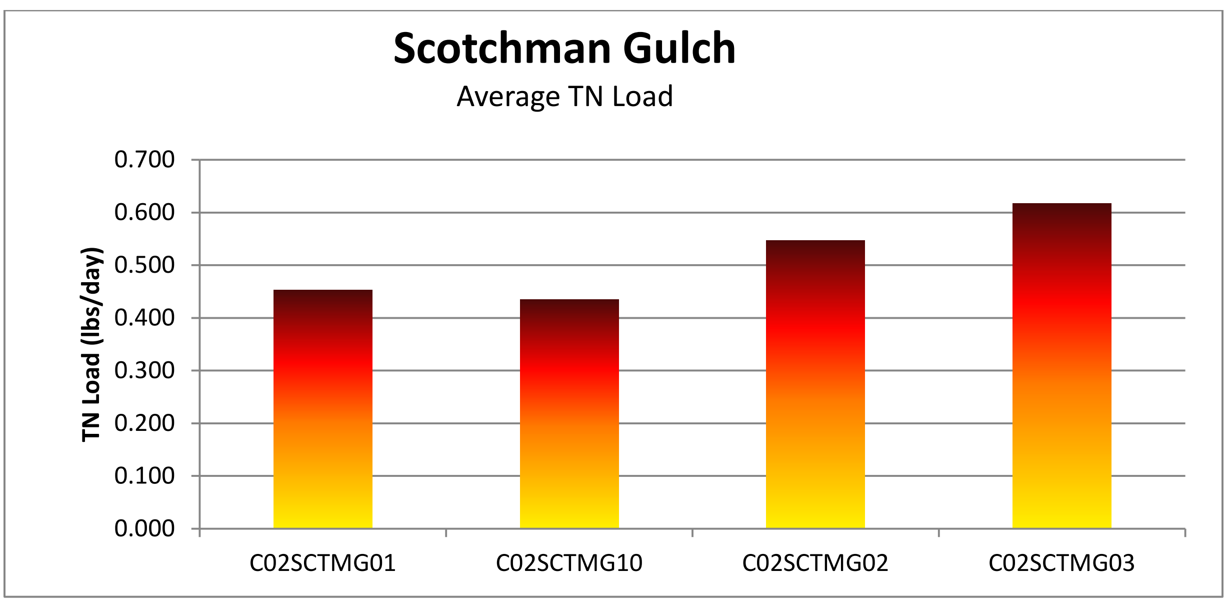

Figure 7-32. TN Load within Scotchman Gulch

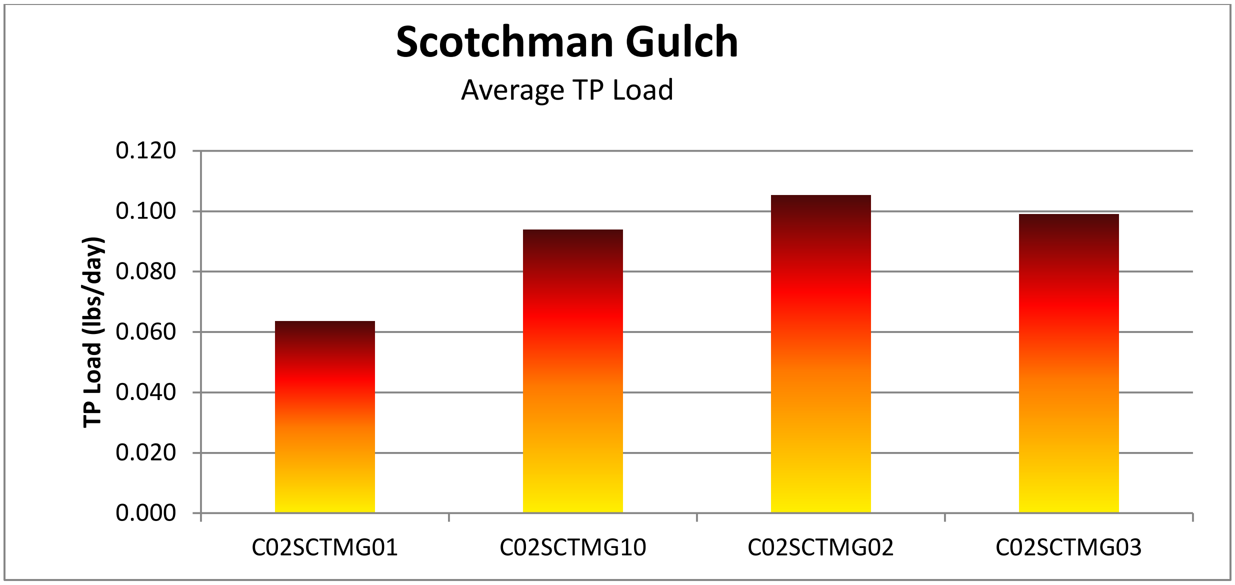

Figure 7-33. TP Load within Scotchman Gulch

Natural Background Nutrient Loading

Natural background sources of nitrogen include a variety of natural processes and sources and likely include: soils and local geology, natural vegetative decay, wet and dry airborne deposition, wild animal waste, and other biochemical processes that contribute nitrogen to this system. No background water quality data was available for Scotchman Gulch.

Given this lack of data, and lack of data from reference streams in the Rock TPA, DEQ has decided to use values from reference streams in the Level III Middle Rockies Ecoregion. In a study to develop nutrient criteria for streams in Montana, (Suplee et al., 2008a) provides the 25th, 50th, and 75th percentile of the all-season reference dataset from wadeable streams to represent background conditions.

This translates to background TN values ranging from 0.065 mg/L, 0.085 mg/L, and 0.175 mg/L at the 25th, 50th, and 75th percentiles, respectively. DEQ will use the 50th percentile value (0.085 mg/L) since it represents the central tendency for the data sets used and is a likely representation of background water quality. Assuming a natural background concentration for TN of 0.085 mg/L and a median low-flow baseflow of 0.39 cfs,, the average background TN load to the segment is calculated to be approximately 0.18 lbs/day.

Background TP values derived from (Suplee et al., 2008a) ranging from 0.008 mg/L, 0.010 mg/L, and 0.020 mg/L at the 25th, 50th, and 75th percentiles, respectively. DEQ will use the 50th percentile value (0.010 mg/L) since it represents the central tendency for the data sets used and is a likely representation of background water quality. Assuming a natural background concentration for TN of 0.010 mg/L and a median low-flow baseflow of 0.39 cfs, the average background TN load to the segment is calculated to be approximately 0.021 lbs/day.

Agricultural Nutrient Loading

A significant number of cattle are grazed in the Scotchman Gulch watershed, typically this takes place sometime during the algal growing season. Scotchman Gulch is approximately 4,300 acres, of which approximately 1,870 acres are Forest Service (FS) land, and 1,600 acres are Bureau of Land Management (BLM) land. The BLM has a total of 1,440 allotted acres in the Scotchman Gulch watershed. This is part of the Ram Mountain allotment. The BLM allows 160 cattle to graze this allotment from May 20 through October 15. The FS has a small allotment (approximately 845 acres) that allows 15 head of cattle from July 1 through October 15.

The remaining portion of Scotchman Gulch (approximately 830 acres) is private land. The DEQ will assume that cattle are being grazed on private land within the watershed. A conservative approach to determining the number of cattle being grazed is to apply an Animal Unit Month (AUM) of 0.1 to 0.15 to the remaining 830 acres of private land. This would indicate that this land was capable of providing forage for 83-125 cattle if they were grazed sustainably.

There are several possible mechanisms for the transport of nutrients from agricultural land to surface water during the growing season. The potential pathways include 1) direct loading via the breakdown of excrement 2) delivery from grazed forest and rangeland during the growing season via surface water and subsurface pathways 3) the effect of grazing on vegetative health and its ability to uptake nutrients and minimize erosion in upland and riparian areas. As noted by the sediment assessment results in **Section 5.4.2.8,** vegetation, habitat, and sediment deposition in Scotchman Gulch have been negatively impacted primarily by streambank erosion, likely associated with riparian grazing. These negative impacts contribute to a lack of riparian buffering as a significant contributor towards elevated nutrient loading along with direct loading from cattle excrement given their proximity to the stream. There have been some recent efforts recently by the Bureau of Land Management (BLM) to control cattle access to a few segments of the headwaters reaches of Scotchman Gulch. The BLM has recently installed fencing around several segments of stream channel in an attempt to alleviate grazing in these areas. Best management practices such as these are likely to contribute to reducing nutrient concentrations and loads in Scotchman Gulch.

7.5.4.2 Scotchman Gulch Total Maximum Daily Loads: Total Nitrogen (TN) and Total Phosphorous (TP)

TN and TP Total Maximum Daily Loads are presented here for Scotchman Gulch (MT41E002_100). The TMDLs (lbs/day) for TN and TP are calculated using the water quality target values established in **Section 7.X.X.X** The TMDL loads for TN and TP apply during the summer growing season (normally July 1–Sept. 30). The TMDL for TN is based on an instream target value of 0.30 mg/L TN and streamflow (**Figure 7-34**). The TMDL for TP is based on an instream target value of 0.030 mg/L TN and streamflow (**Figure 7-35**).

TMDL calculations for TN and TP are based on the following formula:

TMDL = (X) (Y) (5.393)

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 cubic feet per second
5.393 = conversion factor

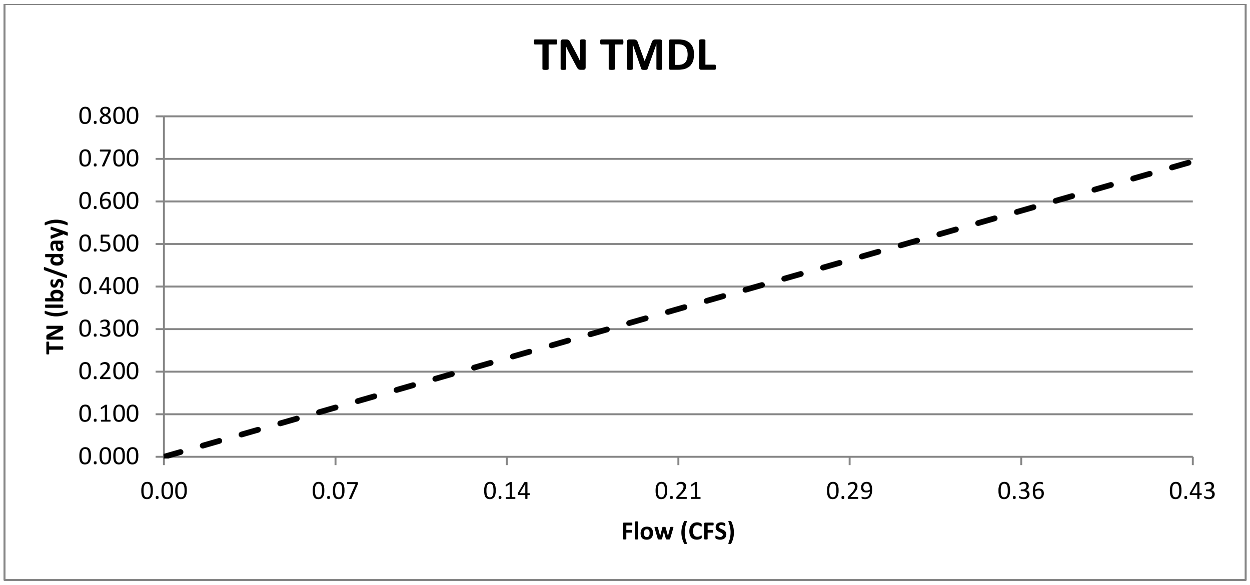

Figure 7-34. TMDL for TN as a function of flow: Scotchman Gulch

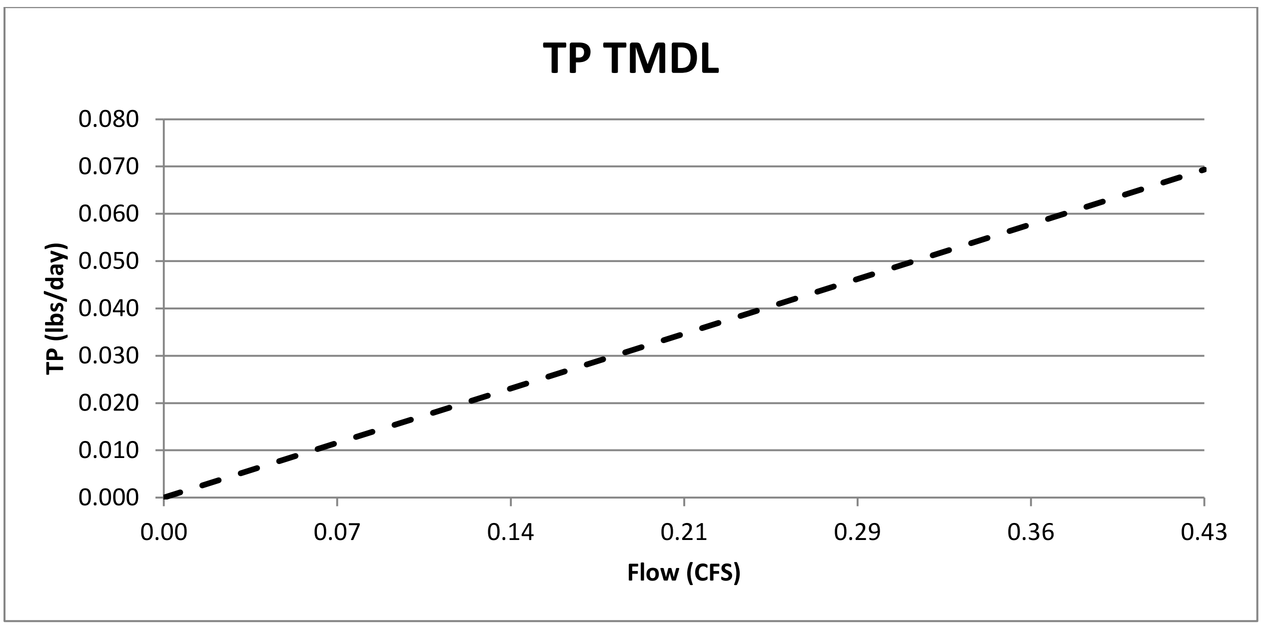

Figure 7-35. TMDL for TP as a function of flow: Scotchman Gulch

7.5.4.3 Scotchman Gulch: Total Nitrogen (TN) and Total Phosphorous (TP) Allocations

TMDLs are allocated to point (wasteload) and nonpoint (load) TN and TP sources. The TMDL comprises the sum of all point sources and nonpoint sources (natural and human-caused), plus a margin of safety that accounts for uncertainties in loading and receiving water analyses. In addition to pollutant load allocations, the TMDL must also take into account the seasonal variability of pollutant loads and adaptive management strategies in order to address uncertainties inherent in environmental analyses.

7.5.4.3.1 Total Nitrogen (TN) Allocations

Scotchman Gulch TMDL for TN comprises the sum of the load allocations to individual source categories. There are no MPDES discharges to the reach requiring wasteload allocations. Relevant TN nonpoint sources include natural background and agricultural sources. Load allocations are therefore provided for 1) natural background sources and 2) agricultural land-use sources. In the absence of individual WLAs and an explicit MOS, TMDLs for TN in the watershed are equal to the sum of the individual load allocations as follows:

$$\mathbf{TMDL = LA_{NB} + LA_{AG}}$$

LA_{NB} = Load Allocation to natural background sources
LA_{AG} = Load Allocation to agricultural land-use sources

Natural Background Source
Load allocations for natural background sources are based on a natural background TN concentration of 0.085 mg/L (**see Section 7.5.1.1**) and are calculated as follows:

$$LA_{NB} = (X)\,(Y)\,(5.393)$$

LA_{NB}= TN load allocated to natural background sources
X= 0.085 mg/L natural background concentration
Y= streamflow in cubic feet per second
5.393 = conversion factor

Agriculture
The load allocation of agricultural sources is calculated as the difference between the allowable daily load (TMDL) and the natural background load:

$$\mathbf{LA_{AG} = TMDL - LA_{NB}}$$

TN load allocations are summarized in **Table-38** and depicted graphically in **Figure 7-36**.

Table 7-38. TN load allocation descriptions, Scotchman Gulch

Source Category	Load Allocation Descriptions	LA Calculation
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.	**LA_{NB} = (X) (Y) (5.393)**
Agricultural Land Use	• domestic animal waste • loss of riparian and wetland vegetation along streambank	**LA_{AG} = TMDL - LA_{NB}**

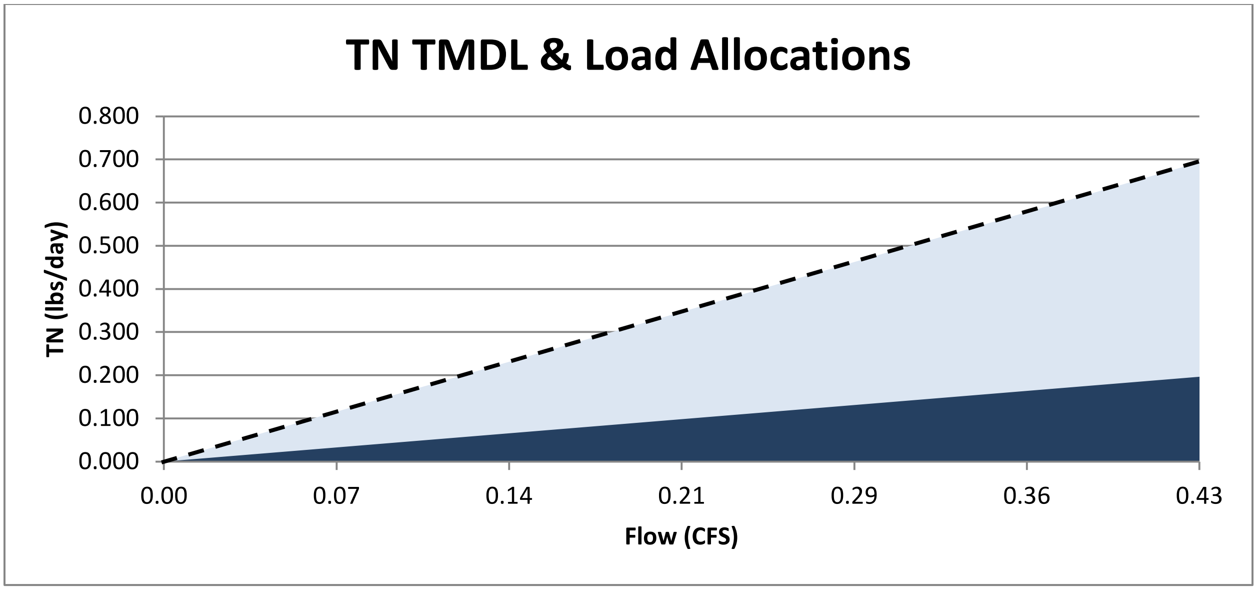

Figure 7-36. TMDL for TN and Load Allocations, Scotchman Gulch

Table 7-39 provides an example TMDL and example allocations for a typical summer baseflow condition. The TN load allocations and the TN TMDL are a function of streamflow and are developed in accordance with the TMDL and allocation approaches presented above. **Table 7-39** also provides existing loading values for the source categories along with the required percent reductions to satisfy the allocations and TMDL. Estimation of natural background load is explained previously in this section. The existing load is the 80th percentile of instantaneous loads calculated from water quality data used in the assessment process and discussed in **Section 7.4.3**. For each water quality sample that has a corresponding flow measurement, a load is calculated. The 80th percentile of these loads is then used as the existing load.

Table 7-39. Scotchman Gulch example TN load allocations and TMDL*

Source Category	Existing Load (lbs/day)	Allocation & TMDL (lbs/day)*	Percent Reduction
Natural Background	0.18	0.18	0%
Agricultural Land-Use Sources	1.13	0.45	60.1%
	Total = 1.31	**TMDL = 0.63**	**Total =51.9 %**

**based on a growing season flow of 0.39 cfs*

The TMDL for TN in Scotchman Gulch is calculated to be 0.63 lbs/day. Existing TN loading to Scotchman Gulch is estimated at 1.31 lbs/day, requiring a total load reduction of 51.9% in order to meet the TMDL for TN in Scotchman Gulch. Load allocations and load reductions are specifically designated to the agricultural land use which makes up an estimated 86% of the TN load within Scotchman Gulch. Load reductions should focus on limiting and controlling TN loads from the variety of sources associated with agricultural land use impacts along Scotchman Gulch.

The source assessment conducted for the Scotchman Gulch has led DEQ to determine that agricultural sources are the most current and prominent sources of nutrients in the watershed. DEQ maintains that reducing loads from agricultural sources in the Scotchman Gulch and its tributaries will result in lower TN concentrations throughout the length of Scotchman Gulch. Reducing loads of this nature will mitigate elevated TN loads. Meeting load allocations may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 8.0**.

7.5.4.3.1 Total Phosphorous (TP) Allocations

The Scotchman Gulch TMDL for TP comprises the sum of the load allocations to individual source categories. There are no MPDES discharges to the reach requiring wasteload allocations. Relevant TP nonpoint sources include natural background sources and agricultural land use sources. Load allocations are therefore provided for 1) natural background sources and 2) agricultural land-use sources. In the absence of individual WLAs and an explicit MOS, TMDLs for TP in the watershed are equal to the sum of the individual load allocations as follows:

$$\mathbf{TMDL = LA_{NB} + LA_{AG}}$$

LA_{NB} = Load Allocation to natural background sources
LA_{AG} = Load Allocation to agricultural land-use sources

Natural Background Source

Load allocations for natural background sources are based on a natural background TP concentration of 0.010 mg/L (**see Section 7.5.1.1**) and are calculated as follows:

$$LA_{NB} = (X)\,(Y)\,(5.393)$$

LA_{NB}= TP load allocated to natural background sources
X= 0.010 mg/L natural background concentration
Y= streamflow in cubic feet per second
5.393 = conversion factor

Agriculture

The load allocation of agricultural sources is calculated as the difference between the allowable daily load (TMDL) and the natural background load:

$$\mathbf{LA_{AG} = TMDL - LA_{NB}}$$

TP load allocations are summarized in **Table 7-40** and depicted graphically in **Figure 7-37**.

Table 7-40. TP load allocation descriptions, Scotchman Gulch

Source Category	Load Allocation Descriptions	LA Calculation
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.	LA_{NB} = (X) (Y) (5.393)
Agricultural Land Use	• domestic animal waste • loss of riparian and wetland vegetation along streambanks	LA_{AG} = TMDL - LA_{NB}

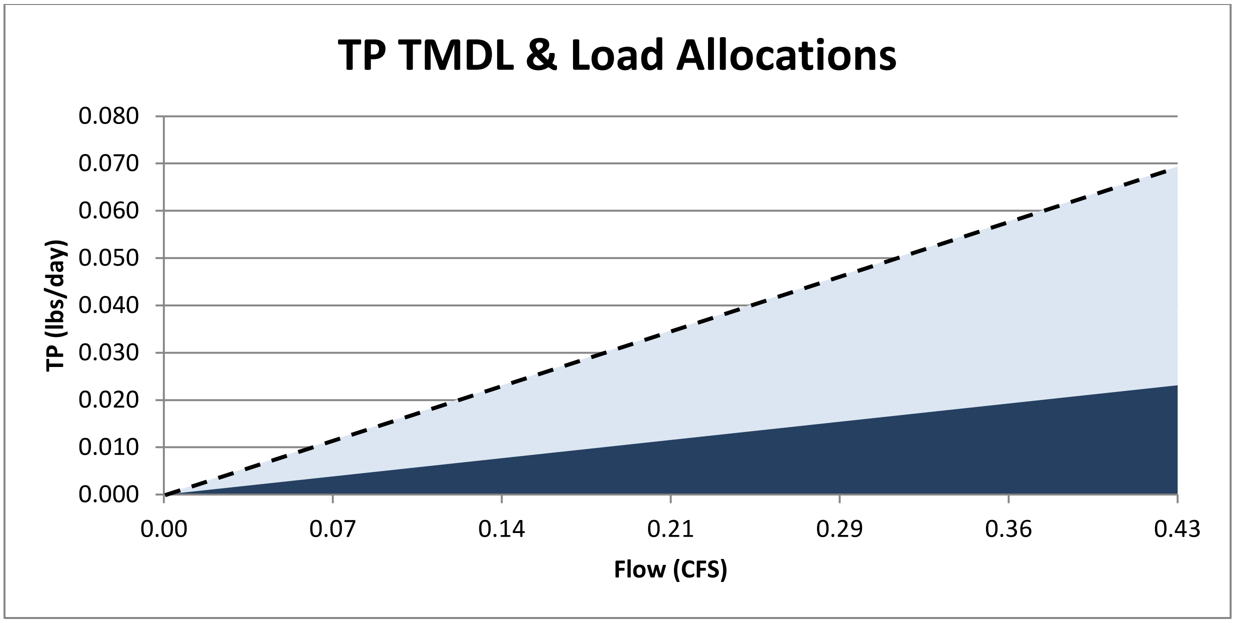

Figure 7-37. TMDL for TP and Load Allocations, Scotchman Gulch

Table 7-41 provides an example TMDL and example allocations for a typical summer baseflow condition. The TP load allocations and the TP TMDL are a function of streamflow and are developed in accordance with the TMDL and allocation approaches presented above. **Table 7-41** also provides existing loading values for the source categories along with the required percent reductions to satisfy the allocations and TMDL. Estimation of natural background load is explained previously in this section. The existing load is the 80th percentile of instantaneous loads calculated from water quality data used in the assessment process and discussed in **Section 7.4.3**. For each water quality sample that has a corresponding flow measurement, a load is calculated. The 80th percentile of these loads is then used as the existing load.

Table 7-41. Scotchman Gulch example TP load allocations and TMDL*

Source Category	Existing Load (lbs/day)	Allocation & TMDL (lbs/day)*	Percent Reduction
Natural Background	0.021	0.013	0%
Agricultural Land-Use Sources	0.129	0.050	61.2%
	Total = 0.15	**TMDL =0.063**	**Total = 58%**

**based on a median growing season flow of 0.39 cfs*

The TMDL for TP in Scotchman Gulch is calculated to be 0.063 lbs/day. Existing TP loading to Scotchman Gulch is estimated at 0.15 lbs/day, requiring a total load reduction of 58% in order to meet the TMDL for TP. Load allocations and load reductions are specifically designated to agricultural land use which makes up an estimated 86% of the TP load within Scotchman Gulch. Load reductions should focus on limiting and controlling TP loads from the variety of sources associated with agricultural land use, primarily grazing impacts along Scotchman Gulch.

The source assessment conducted for the Scotchman Gulch has led DEQ to determine that agricultural sources are the most current and prominent sources of nutrients in the watershed. DEQ maintains that reducing loads from agricultural sources in the Scotchman Gulch and its tributaries will result in lower TP concentrations throughout the length of Scotchman Gulch. Reducing loads of this nature will mitigate elevated TP loads. Meeting load allocations may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 8.0**.

7.5.5 Flat Gulch (MT46E002_120)

The Flat Gulch is a direct tributary to Rock Creek. Flat Gulch enters Rock Creek approximately 35 miles upstream from the confluence of Rock Creek and the Clark Fork River. Area land use is primarily agricultural and silviculture. Agriculture land use consist primarily of cattle operations, silvicultural use is comprised of timber harvesting and thinning operations. Flat Gulch appears on the 2012 303(d) List as impaired for total nitrogen (TN) and Total Phosphorous (TP). As determined in **Section 7.4.3.5** Flat Gulch exceeded nutrient water quality targets for TN and TP. Source assessment was conducted for TN and TP.

7.5.5.1 Flat Gulch Source Assessment

The source assessment for Flat Gulch includes an evaluation of TN and TP concentrations, flow and loading data along the whole length of Flat Gulch. This is followed by quantification of natural background and the most significant human-caused sources of nutrients. The two most likely human-caused nutrient sources include agriculture (grazing) and silviculture.

In stream concentrations exceeded water quality targets at all sampling locations during different low-flow events. Fifteen of the sixteen samples collected (94%) for TN were above the target criteria of 0.30 mg/L TN. All TP (100%) samples collected were above target criteria of 0.030 mg/L TP. As a whole, both TN and TP concentrations were lower in the head waters and increased as you move down stream. Concentrations were the highest at CO2FLATG10, and decrease slightly as you move to CO2FLATG02. The highest concentration observed for both parameters were seen at the sampling location at the midpoint in the drainage (CO2FLATG10). **Table 7-42** and **Figure 7-38** present summary statistics of TN concentrations at sampling sites in Flat Gulch. **Table 7-43** and **Figure 7-39** present summary statistics of TP concentrations at sampling sites in Flat Gulch. Only one sample was collected at sampling site CO2FLATG04, as such there in no variation in statistical representation of the data.

Table 7-42. Growing season TN Summary Statistics for Sampling Sites on Flat Gulch (units in mg/L)

Site	n	min	max	mean	25th percentile	median	75th percentile
CO2FLATG04	1	0.384	0.384	0.384	0.384	0.384	0.384
CO2FLATG01	5	0.330	0.984	0.506	0.333	0.397	0.488
CO2FLATG10	6	0.429	1.230	0.793	0.456	0.774	1.077
CO2FLATG02	4	0.229	1.110	0.599	0.293	0.530	0.836

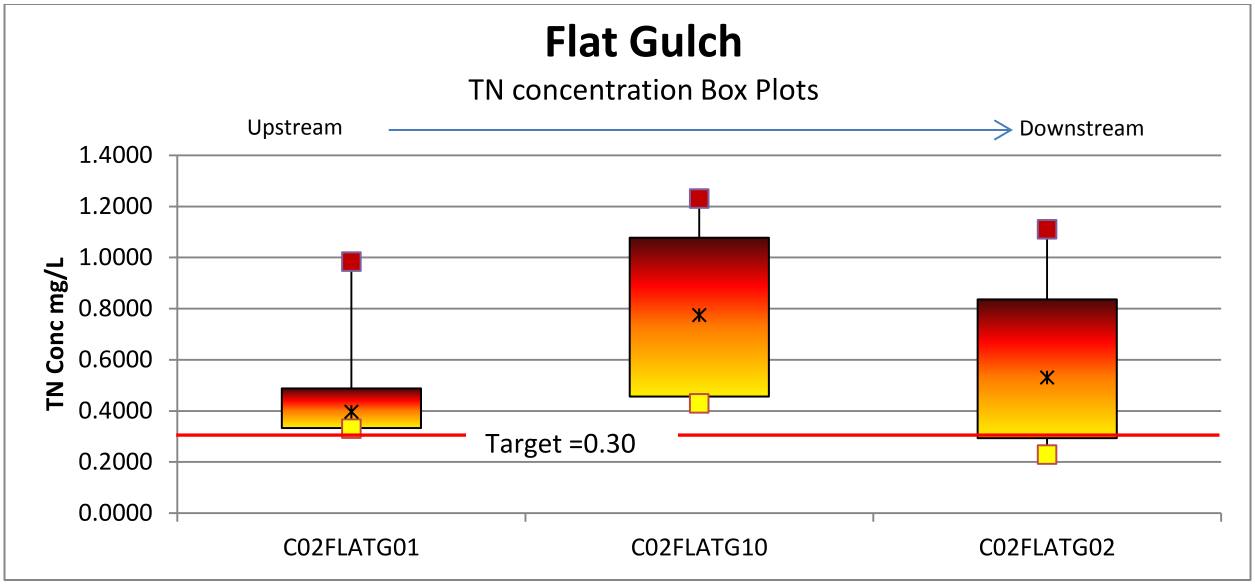

Figure 7-38. TN Concentration Box Plots: Flat Gulch

Table 7-43. Growing season TP Summary Statistics for sampling sites on Flat Gulch (units in mg/L)

Site	n	min	max	mean	25th percentile	median	75th percentile
CO2FLATG04	1	0.095	0.095	0.095	0.095	0.095	0.095
CO2FLATG01	5	0.078	0.182	0.119	0.088	0.089	0.160
CO2FLATG10	7	0.174	0.402	0.280	0.212	0.295	0.320
CO2FLATG02	4	0.115	0.324	0.240	0.189	0.261	0.312

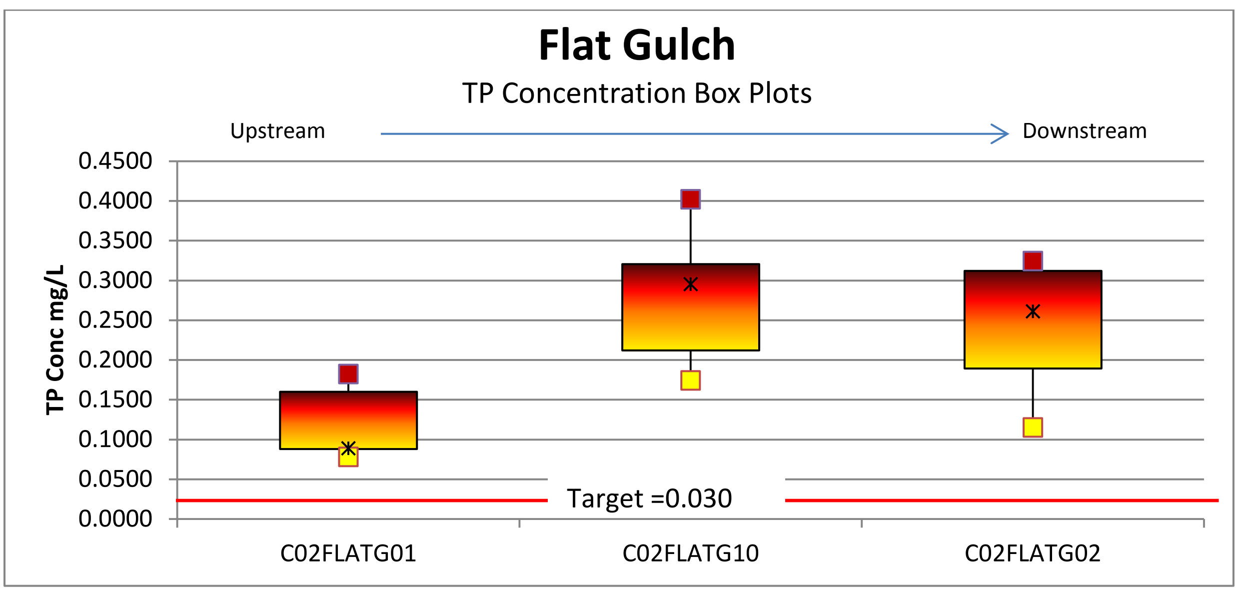

Figure 7-39. TP Concentration Box Plots: Flat Gulch

TN and TP loads calculated from the 2004 and 2010–2011 sampling events are depicted in **Figure 7-40 and 7-41**, respectively. Average low-flow TN loads increase from 0.37lbs/day at monitoring location CO2FLATG01 to 0.63 lbs/day at the downstream CO2FLATG02 monitoring location, an average decrease of 0.26 lbs/day. Average low-flow TP loads decreased from 0.08 lb/day at monitoring location

CO2FLATG01 to 0.26 lb/day at the downstream CO2FLATG10 monitoring location. This is an average decrease of 0.18 lbs/day.

Average TP and TN loads increase as you move downstream from the headwaters to the mouth. The increasing in loading is due to the increase in TN and TP concentrations and the slight increase in volume of streamflow in Flat Gulch. The increase in concentration of TN and TP as you move down stream is a likely a result of the sources of TN and TP being located closer to the midsection and mouth of Flat Gulch.

Streamflow volumes generally increase as you move from the headwater to the mouth. Average flow volumes increase from 0.11 cfs to 0.15 cfs at the monitoring sites CO2FLATG01, CO2FLATG10 2, respectively. Flows decrease slightly from CO2FLATG10 to CO2FLATG10. As a result, the load decrease parallels the decrease in flow throughout this segment of stream.

The tributary network to Flats Gulch suggests that the supply of water for this creek is adequate to maintain flow volumes. However, there is a volume of flow that is lost between CO2FLATG10 to CO2FLATG10, which suggests there is an overall loss of surface water to groundwater between these two sample locations. This idea is supported by the alluvial geology that is present at the mouth of Flat Gulch.

The TN and decreased TP concentrations could also indicate some algal nutrient uptake, although the relatively low Chlorophyll-*a* (live algae) and AFDW results along Flat Gulch during the majority of sample events suggests that there was not significant algae uptake at the time of the sampling events. **Figures 7-40 and 7-41** show this TN and decrease in TP loading.

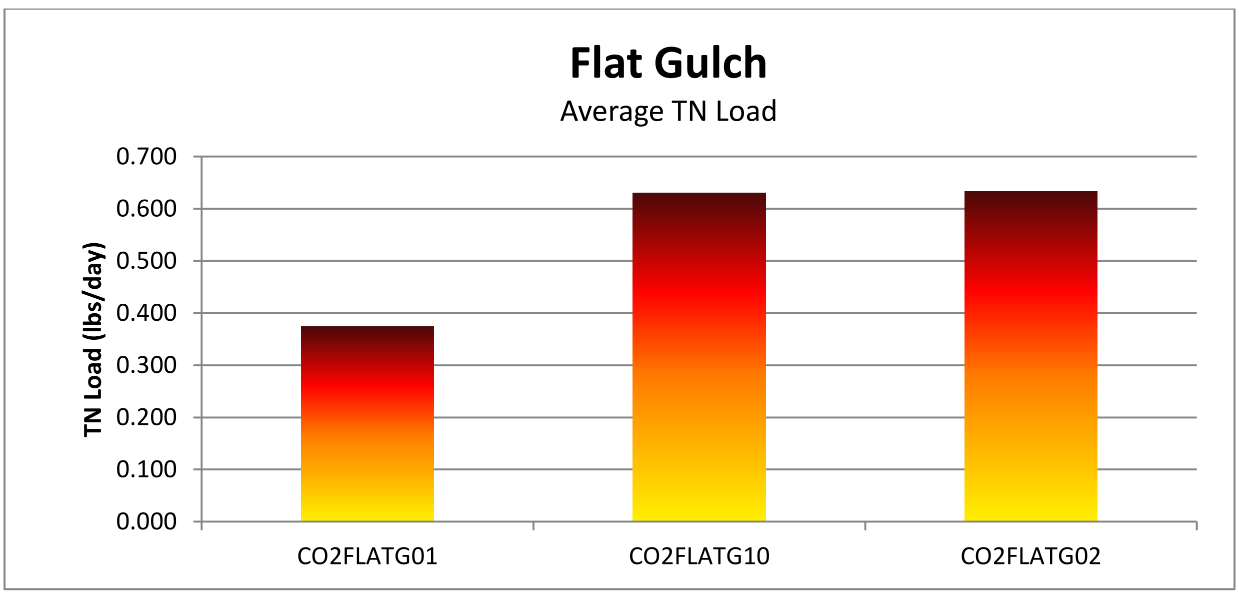

Figure 7-40. TN Load within Flat Gulch

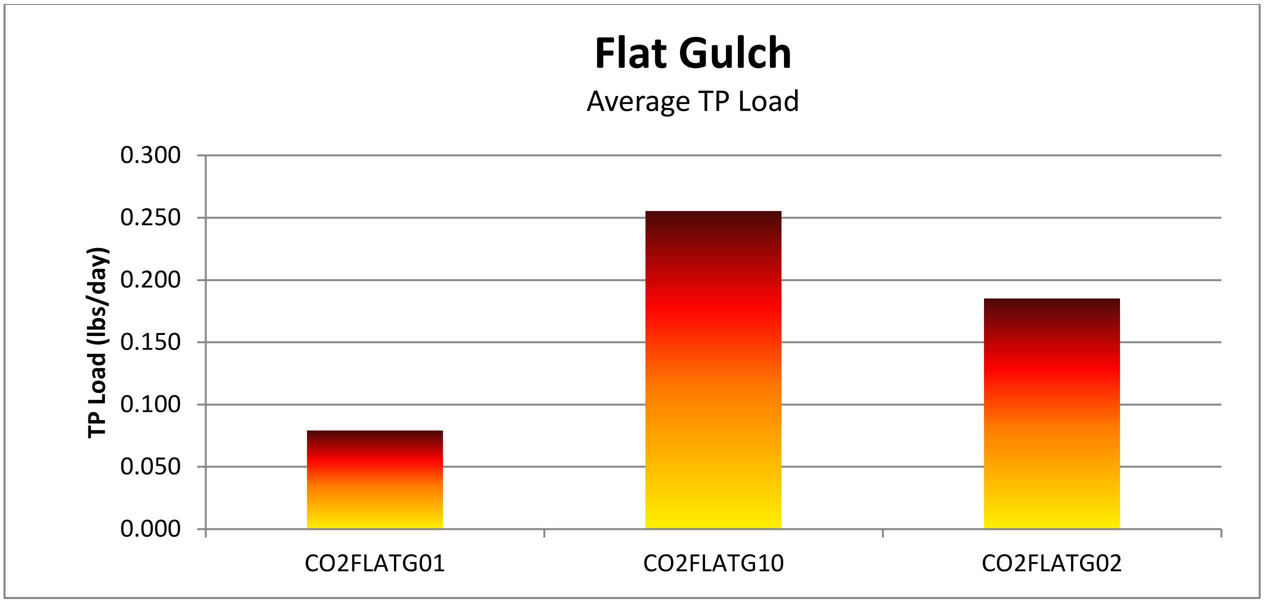

Figure 7-41. TP Load within Flat Gulch

Natural Background Nutrient Loading

Natural background sources of nitrogen include a variety of natural processes and sources and likely include: soils and local geology, natural vegetative decay, wet and dry airborne deposition, wild animal waste, and other biochemical processes that contribute nitrogen to this system. No background water quality data was available for Flat Gulch.

Given this lack of data, and lack of data from reference streams in the Rock TPA, DEQ has decided to use values from reference streams in the Level III Middle Rockies Ecoregion. In a study to develop nutrient criteria for streams in Montana, (Suplee et al., 2008a) provides the 25th, 50th, and 75th percentile of the all-season reference dataset from wadeable streams to represent background conditions.

This translates to background TN values ranging from 0.065 mg/L, 0.085 mg/L, and 0.175 mg/L at the 25th, 50th, and 75th percentiles, respectively. DEQ will use the 50th percentile value (0.085 mg/L) since it represents the central tendency for the data sets used and is a likely representation of background water quality. Assuming a natural background concentration for TN of 0.085 mg/L and a median low-flow baseflow of 0.12 cfs, the average background TN load to the segment is calculated to be approximately 0.06 lbs/day.

Background TP values derived from (Suplee et al., 2008a) ranging from 0.008 mg/L, 0.010 mg/L, and 0.020 mg/L at the 25th, 50th, and 75th percentiles, respectively. DEQ will use the 50th percentile value (0.010 mg/L) since it represents the central tendency for the data sets used and is a likely representation of background water quality. Assuming a natural background concentration for TP of 0.010 mg/L and a median low-flow baseflow of 0.12 cfs, the average background TN load to the segment is calculated to be approximately 0.006 lbs/day.

Agricultural Nutrient Loading

A significant number of cattle are grazed in the Flat Gulch watershed, typically this takes place sometime during the algal growing season. Flat Gulch is approximately 1,780 acres, of which approximately 205 acres are Forest Service (FS) land, and 1090 acres are Bureau of Land Management (BLM) land. The BLM has a total of 1,440 allotted acres in the Ram Mountain allotment. This allotment is split between Scotchman Gulch and Flat Gulch. 160 cattle are allowed on the Ram mountain allotment from June, 20 through October, 15. The FS has a small allotment (approximately ¾ of one section) near the mouth of Flat gulch. Approximately 160 head of cattle are allowed on this allotment From May, 5 through May, 30.

The remaining portion of Flat Gulch (approximately 485 acres) is private land. The DEQ will assume that cattle are being grazed on private land within the watershed. A conservative approach to determining the number of cattle being grazed is to apply an Animal Unit Month (AUM) of 0.1 to 0.15 to the remaining 485 acres of private land. This would indicate that this land was capable of providing forage for 49-73 cattle if they were grazed sustainably.

There are several possible mechanisms for the transport of nutrients from agricultural land to surface water during the growing season. The potential pathways include 1) direct loading via the breakdown of excrement, 2) delivery from grazed forest and rangeland during the growing season via surface runoff and subsurface pathways and 3) the effect of grazing on vegetative health and its ability to uptake nutrients and minimize erosion in upland and riparian areas. As noted by the sediment assessment results in **Section 5.4.2.5,** vegetation, habitat, and sediment deposition in Flat Gulch have been negatively impacted primarily by streambank erosion influenced by riparian grazing. These negative impacts contribute to a lack of riparian buffering as a significant contributor towards elevated nutrient loading along with direct loading from cattle excrement given their proximity to the stream.

Silvicultural Practices

There have been some historical silvicultural activities in Flat Gulch. One notable small scale timber sale occurred in 2010. This timber sale took place on 69 acres of land and produced a total of 296,000 board feet of product. Some more extensive timbering operations were conducted in the 1980’s.

Silvicultural practices inevitably cause some measure of downstream effects that may or may not be significant over time. Changes in land cover will change the rate at which water evapotranspires which will affect 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) and this will have an affect the hydrologic cycle. Changes in the biomass uptake and soil conditions will affect the nutrient cycle. Elevated nitrate concentrations result from increased leaching from the soil as mineralization is enhanced. Nutrient uptake by biomass is also greatly reduced after timber harvest, leaving more nutrients available for runoff.

Nitrate pollution is likely not a result of timber operations, considering the limited acreage of the most recent timber operations, and the amount of time that has passed since the timber operations of the 1980’s. As such this potential source will not be given an individual or composite load allocation.

7.5.5.2 Flat Gulch Total Maximum Daily Loads: Total Nitrogen (TN) and Total Phosphorous (TP)

TN and TP Total Maximum Daily Loads are presented here for Flat Gulch (MT41E002_120). The TMDLs (lbs/day) for TN and TP are calculated using the water quality target values established in **Section 7.4**. X.X.X The TMDL loads for TN and TP apply during the summer growing season (normally July 1–Sept. 30).

The TMDL for TN is based on an instream target value of 0.30 mg/L TN and streamflow (**Figure 7-42**). The TMDL for TP is based on an instream target value of 0.030 mg/L TN and streamflow (**Figure 7-43**).

TMDL calculations for TN and TP are based on the following formula:

TMDL = (X) (Y) (5.393)

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 cubic feet per second
5.393 = conversion factor

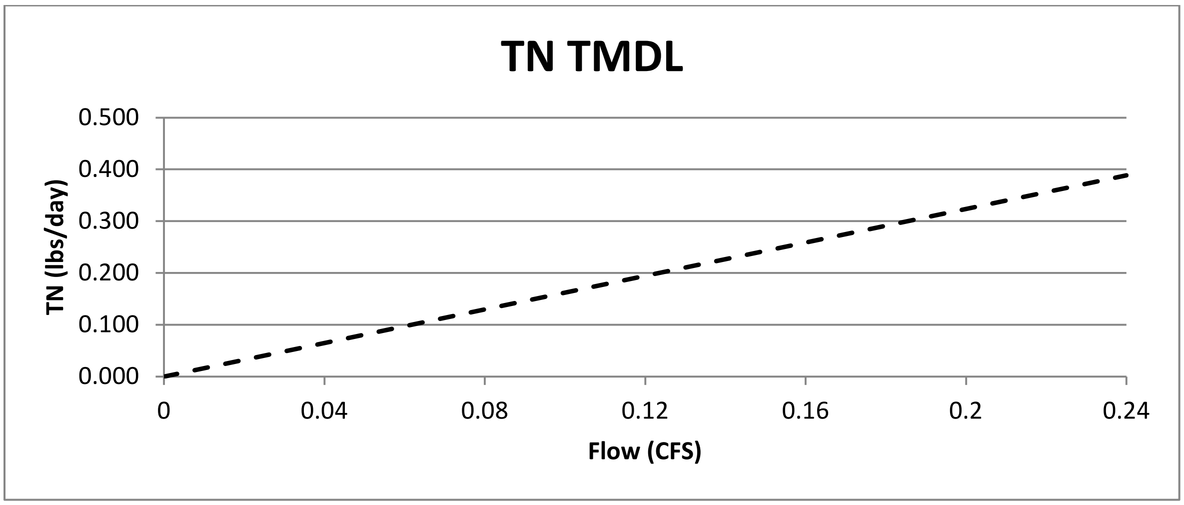

Figure 7-42. TMDL for TN as a function of flow: Flat Gulch

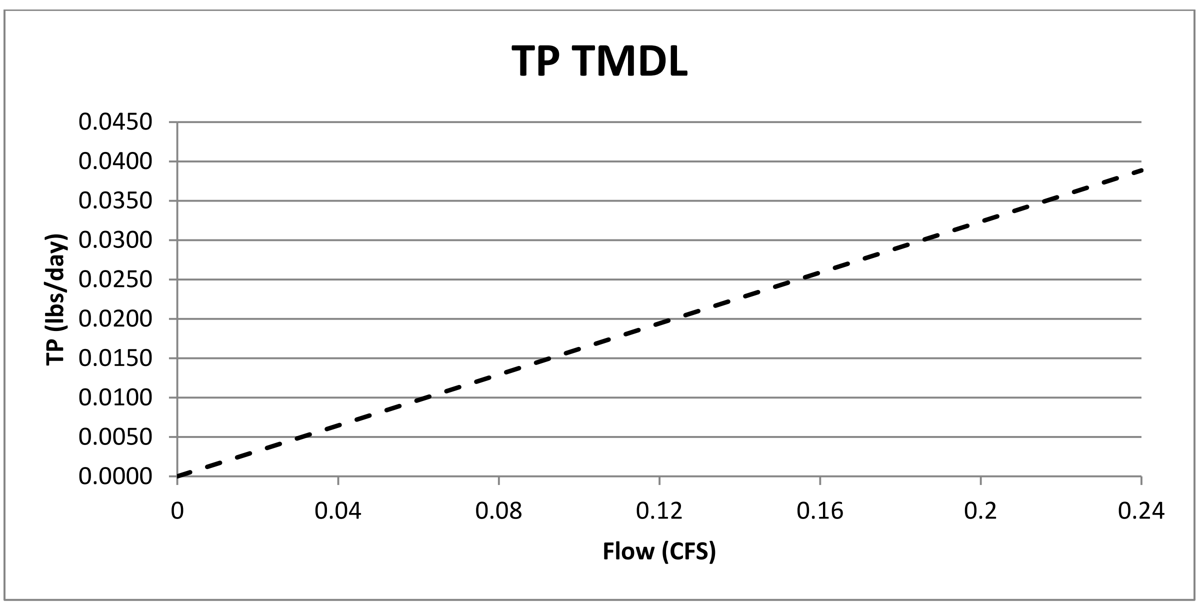

Figure 7-43. TMDL for TP as a function of flow: Flat Gulch

7.5.5.3 Flat Gulch: Total Nitrogen (TN) and Total Phosphorous (TP) Allocations

TMDLs are allocated to point (wasteload) and nonpoint (load) TN and TP sources. The TMDL comprises the sum of all point sources and nonpoint sources (natural and human-caused), plus a margin of safety that accounts for uncertainties in loading and receiving water analyses. In addition to pollutant load allocations, the TMDL must also take into account the seasonal variability of pollutant loads and adaptive management strategies in order to address uncertainties inherent in environmental analyses.

7.5.5.3.1 Total Nitrogen (TN) Allocations

Flat Gulch TMDL for TN comprises the sum of the load allocations to individual source categories. There are no MPDES discharges to the reach requiring wasteload allocations. Relevant TN nonpoint sources include natural background and agricultural sources. Load allocations are therefore provided for 1) natural background sources and 2) agricultural land-use sources. In the absence of individual WLAs and an explicit MOS, TMDLs for TN in the watershed are equal to the sum of the individual load allocations as follows:

$$\mathbf{TMDL = LA_{NB} + LA_{AG}}$$

LA_{NB} = Load Allocation to natural background sources
LA_{AG} = Load Allocation to agricultural land-use sources

Natural Background Source

Load allocations for natural background sources are based on a natural background TN concentration of 0.085 mg/L (**see Section 7.5.1.1**) and are calculated as follows:

$$\boldsymbol{LA_{NB} = (X)\,(Y)\,(5.393)}$$

LA_{NB}= TN load allocated to natural background sources
X= 0.085 mg/L natural background concentration
Y= streamflow in cubic feet per second
5.393 = conversion factor

Agriculture

The load allocation of agricultural sources is calculated as the difference between the allowable daily load (TMDL) and the natural background load:

$$\mathbf{LA_{AG} = TMDL - LA_{NB}}$$

TN load allocations are summarized in **Table 7-44** and depicted graphically in **Figure 7-44**.

Table 7-44. TN load allocation descriptions, Flat Gulch

Source Category	Load Allocation Descriptions	LA Calculation
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.	**LA_{NB} = (X) (Y) (5.393)**
Agricultural Land Use	• domestic animal waste • loss of riparian and wetland vegetation along streambank	**LA_{AG} = TMDL - LA_{NB}**

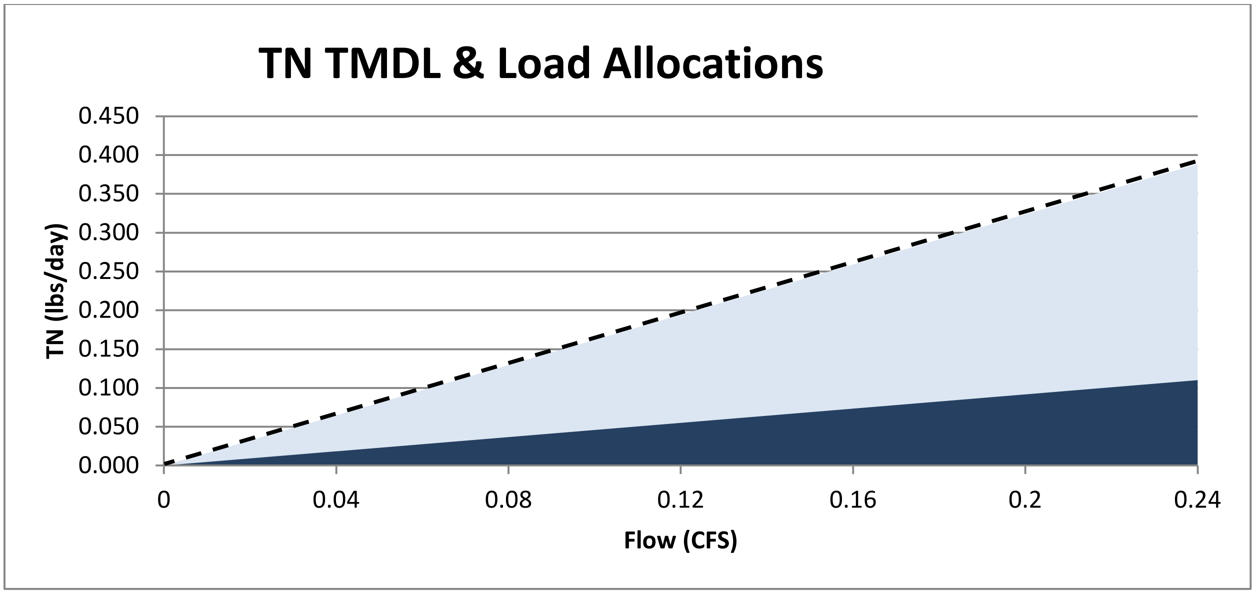

Figure 7-44. TMDL for TN and Load Allocations, Flat Gulch

Table 7-45 provides an example TMDL and example allocations for a typical summer baseflow condition. The TN load allocations and the TN TMDL are a function of streamflow and are developed in accordance with the TMDL and allocation approaches presented above. **Table 7-45** also provides existing loading values for the source categories along with the required percent reductions to satisfy the allocations and TMDL. Estimation of natural background load is explained previously in this section. The existing load is the 80th percentile of instantaneous loads calculated from water quality data used in the assessment process and discussed in **Section 7.4.3**. For each water quality sample that has a corresponding flow measurement, a load is calculated. The 80th percentile of these loads is then used as the existing load.

Table 7-45. Flats Gulch example TN load allocations and TMDL*

Source Category	Existing Load (lbs/day)	Allocation & TMDL (lbs/day)*	Percent Reduction
Natural Background	0.06	0.06	0
Agricultural Land-Use Sources	0.59	0.13	77.9%
	Total = 0.65	**TMDL = 0.19**	**Total = 70.7%**

**based on a median growing season flow of 0.12 cfs*

The TMDL for TN in Flat Gulch is calculated to be 0.19 lbs/day. Existing TN loading to Flat Gulch is estimated at 0.65 lbs/day, requiring a total load reduction of 70.7% in order to meet the TMDL for TN in Flat Gulch. Load allocations and load reductions are specifically designated to agricultural land use which makes up an estimated 90% of the TN load within Flat Gulch. Load reductions should focus on limiting and controlling TN loads from the variety of sources associated with agricultural land use impacts along Flat Gulch.

The source assessment conducted for the Flat Gulch has led DEQ to determine that agricultural sources are the most current and prominent sources of nutrients in the watershed. DEQ maintains that reducing loads from agricultural sources in the Flat Gulch and its tributaries will result in lower TN concentrations throughout the length of Flat Gulch. Reducing loads of this nature will mitigate elevated TN loads. Meeting load allocations may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 8.0**.

7.5.5.3.1 Total Phosphorous (TP) Allocations

The Flat Gulch TMDL for TP comprises the sum of the load allocations to individual source categories. There are no MPDES discharges to the reach requiring wasteload allocations. Relevant TP nonpoint sources include natural background sources and agricultural land use sources. Load allocations are therefore provided for 1) natural background sources and 2) agricultural land-use sources. In the absence of individual WLAs and an explicit MOS, TMDLs for TP in the watershed are equal to the sum of the individual load allocations as follows:

$TMDL = LA_{NB} + LA_{AG}$

LA_{NB} = Load Allocation to natural background sources

LA_{AG+} = Load Allocation to agricultural land-use sources

Natural Background Source

Load allocations for natural background sources are based on a natural background TP concentration of 0.010 mg/L (**see Section 7.5.1.1**) and are calculated as follows:

$LA_{NB} = (X)(Y)(5.393)$

LA_{NB}= TP load allocated to natural background sources

X= 0.010 mg/L natural background concentration

Y= streamflow in cubic feet per second

5.393 = conversion factor

Agriculture

The load allocation of agricultural sources is calculated as the difference between the allowable daily load (TMDL) and the natural background load:

$LA_{AG} = TMDL - LA_{NB}$

TP load allocations are summarized in **Table 7-46** and depicted graphically in **Figure 7-45**.

Table 7-46. TP load allocation descriptions, Flat Gulch

Source Category	Load Allocation Descriptions	LA Calculation
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.	**$LA_{NB} = (X)(Y)(5.393)$**
Agricultural Land Use	• domestic animal waste • loss of riparian and wetland vegetation along streambanks	**$LA_{AG} = TMDL - LA_{NB}$**

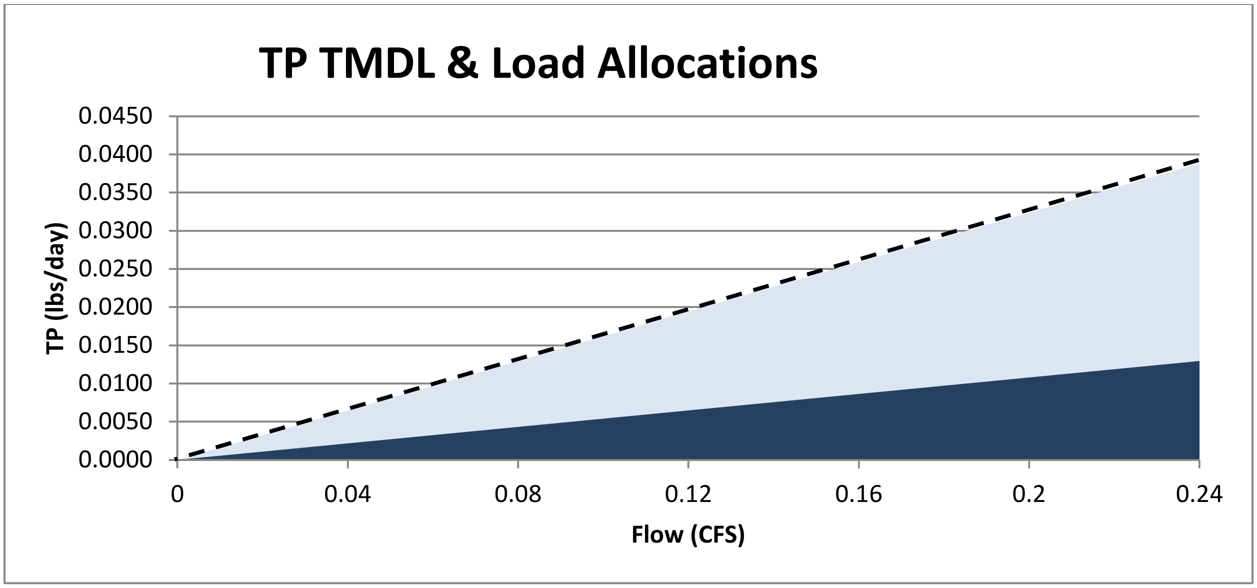

Figure 7-45. TMDL for TP and Load Allocations, Flat Gulch

Table 7-47 provides an example TMDL and example allocations for a typical summer baseflow condition. The TP load allocations and the TP TMDL are a function of streamflow and are developed in accordance with the TMDL and allocation approaches presented above. **Table 7-47** also provides existing loading values for the source categories along with the required percent reductions to satisfy the allocations and TMDL. Estimation of natural background load is explained previously in this section. The existing load is the 80th percentile of instantaneous loads calculated from water quality data used in the assessment process and discussed in **Section 7.4.3**. For each water quality sample that has a corresponding flow measurement, a load is calculated. The 80th percentile of these loads is then used as the existing load.

Table 7-47. Flat Gulch example TP load allocations and TMDL*

Source Category	Existing Load (lbs/day)	Allocation & TMDL (lbs/day)*	Percent Reduction
Natural Background	0.006	0.006	0%
Agricultural Land-Use Sources	0.31	0.013	95.8%
	Total = 0.316	**TMDL =0.019**	**Total = 94.0%**

**based on a median growing season flow of 0.12 cfs*

The TMDL for TP in Flat Gulch is calculated to be 0.019 lbs/day. Existing TP loading to Flat Gulch is estimated at 0.32 lbs/day, requiring a total load reduction of 94.0% in order to meet the TMDL for TP. Load allocations and load reductions are specifically designated to agricultural land use which makes up an estimated 98% of the TP load within Flat Gulch. Load reductions should focus on limiting and controlling TP loads from the variety of sources associated with agricultural land use, primarily grazing impacts along Flat Gulch.

The source assessment conducted for the Flat Gulch has led DEQ to determine that agricultural sources are the most current and prominent sources of nutrients in the watershed. DEQ maintains that reducing loads from agricultural sources in the Flat Gulch and its tributaries will result in lower TP concentrations throughout the length of Flat Gulch. Reducing loads of this nature will mitigate elevated TP loads. Meeting load allocations may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 8.0**.

7.6 Seasonality, Margin of Safety, and Adaptive Management

In developing TMDLs, DEQ must consider the seasonal variability, or seasonality, on water quality impairment conditions, TMDLs, and load allocations. DEQ must also incorporate a margin of safety to account for uncertainties between pollutant sources and the quality of the receiving waterbody, and to ensure (to the degree practicable) that the TMDL components and requirements sufficiently protect water quality and beneficial uses. This section describes seasonality, margin of safety, and adaptive management in developing TMDLs for nutrients in the Rock TPA.

7.6.1 Seasonality

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

- Water quality targets and subsequent allocations apply to the summer growing season (July 1–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 summer to coincide with applicable nutrient targets.
- Nutrient data and sources were evaluated based on an understanding of the sources and seasonal effects on the presence or absences of nutrients.

7.6.2 Margin of Safety

A margin of safety (MOS) is a required component of TMDL development. MOS accounts for the uncertainty about the pollutant loads and the quality of the receiving water; it's intended to protect beneficial uses in the face of this uncertainty. 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, 1999). This plan addresses MOS implicitly in a variety of ways:

- Nutrient target values (0.100 mg/L NO_3+NO_2, 0.30 mg/L TN, and 0.030 mg/L TN) were used to calculate allowable nutrient TMDLs. Allowable exceedances of nutrient targets (see **Section 7.4.3**) were not incorporated into the calculation of allowable loads, thereby adding an MOS to established nutrient allocations.
- The 50th percentile value of summer natural background concentrations was used to establish a natural background concentration for load allocations. This acceptable approach provides an MOS for human-caused nutrient loads during most conditions.
- Seasonality and variability were considered in nutrient loading.
- An adaptive management approach was used to evaluate target attainment and allow for refinement of load allocation, assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development.

7.6.3 Adaptive Management

Uncertainties in the accuracy of field data, target development, source assessments, loading calculations, and other considerations are inherent when assessing and evaluating environmental variables for TMDL development. While uncertainties are a fact of TMDL development, mitigating uncertainties through adaptive management is a key component of ongoing TMDL implementation and evaluation. Uncertainties, assumptions, and considerations are applied throughout this document and point to the need to refine analysis, conduct further monitoring, and address unknowns in order to develop a better understanding of nutrient impairment conditions and the processes that affect impairment.

Adaptive management assumes that TMDL targets, allocations, and the analyses supporting them are not static but are processes subject to adjustment as new information and relationships are understood. For instance, numeric nutrient targets provided in **Table 7-2** are based on the best information and analyses available at the time and represent water quality concentrations believed to limit algal growth below nuisance levels within the Rock TPA. As numeric criteria for nutrients are developed and progress, water quality targets for nutrient may be adjusted.

Uncertainties associated with the assumptions and considerations may be mitigated, and loading estimates refined, to more accurately portray watershed conditions. Further monitoring and evaluation of water quality and source loading conditions should be conducted. Adaptive management land use activities, nutrient management and control should also be implemented and tracked. Changes in land use or management may change nutrient dynamics and may trigger a need for additional monitoring. The extent of monitoring should be consistent with the extent of potential impacts, and can vary from basic BMP assessments to a complete measure of target parameters above and below the project area before the project and after completion of the project. Cumulative impacts from multiple projects must also be a consideration as nutrient sources are ubiquitous in the Rock TPA. This approach will help track the recovery of the system and the impacts, or lack of impacts, from ongoing management activities in the watershed.

Uncertainties in assessments and assumptions should not paralyze, but should point to the need to be flexible in our understanding of complex systems, and to adjust our thinking and analysis in response to this need. Implementation and monitoring recommendations presented in **Section 8.0** provide a basic framework for reducing uncertainty and furthering understanding of these issues.

8.0 Metals TMDL Components

This section focuses on impairment of water quality caused by metals pollution. It describes: 1) the mechanisms by which metals impair beneficial uses, 2) the specific stream segments of concern, 3) the presently available data pertaining to metals impairment in the watershed, 4) the various contributing sources of metals based on recent data and studies, and 5) the metals TMDLs and allocations.

8.1 Effects of Elevated Metals on Beneficial Uses

Elevated metals concentrations in the Rock Creek TPA are partially related to metal mining and exploration which in some cases can cause rapid and extensive exposure of waste rock, metal ores and alluvial sediments to weathering and accelerated erosion. Where mining operations expose metal sulfide minerals to oxygen (O_2) and water (H_2O), chemical reactions produce sulfuric acid and metal oxide precipitates. An example of a common metal sulfide mineral is the iron sulfide pyrite (FeS_2). Others include the lead sulfide galena (PbS), and the copper sulfide chalcocite (Cu_2S).

The following equation describes pyrite oxidation:

$$FeS_2 + 7/2\ O_2 + H_2O \rightarrow Fe^{+2} + 2\ SO4^{2-} + 2\ H^{+}$$

Oxidizing bacteria, such as *Thiobacillus ferrooxidans*, accelerate sulfide oxidation and commonly occur in surface water and groundwater. Sulfuric acid (H_2SO_4) lowers soil and water pH and increases the dissolved concentrations of iron and other metals (e.g. copper, lead, and arsenic) to levels toxic to aquatic life. Metal oxide precipitates often cause turbidity in surface water and coat stream substrates with fine sediment that degrades aquatic habitat.

The acid generation and metal contamination caused by mining-related metal sulfide oxidation are commonly referred to as “acid rock drainage” or ARD. **Figure 8-1** shows the effects of ARD-related iron oxide precipitation on water quality in the discharge from an abandoned mine in western Montana.

Figure 8-1. The iron oxide precipitation effects of acid rock drainage (ARD)

Natural landscape erosion and, in some instances, human land uses other than mining such as timber harvesting and livestock grazing can disturb and expose surface soil to accelerated erosion and can contribute sediment-bound metals loads to surface waters. The specific metal pollutants that can exceed water quality standards as a result of accelerated soil erosion depends upon the chemical composition of the materials from which surface soil or other unconsolidated sediments have been developed. Aluminum and iron are common constituents of minerals soils and exceedances of water quality standards for these metals would be expected in areas where waters are affected by accelerated erosion. Where soils are developed from more mineralized parent materials, sediment-bound metals loads may include other parameters such as arsenic, copper, cadmium, and lead.

Waterbodies with metals concentrations exceeding the aquatic life and/or human health standards can impair several beneficial uses of surface water including aquatic life support, drinking water, and agriculture. Elevated metals concentrations can have toxic, carcinogenic, or bioconcentrating effects on aquatic organisms. Humans and wildlife can suffer acute and chronic health problems from consuming metal contaminated drinking water or fish tissue. Because elevated metals can be toxic to plants and animals, metal contamination may damage irrigation or livestock water supplies.

8.2 Stream Segments of Concern

Table 8-1 lists the 7 waterbody segments in the Rock Creek TPA that have been identified as being impaired for metals pollution. Eureka Gulch, Quartz Gulch, Sluice Gulch, and West Fork Rock Creek are included on the 2012 Montana 303(d) List of metal-impaired waters. Basin Gulch, Flat Gulch, and Scotchman Gulch are not included on the 2012 303(d) List. However they are included in **Table 8-1** because a review of recent water quality data that indicates beneficial uses for these streams are impaired by elevated metal concentrations. All 3 are first order tributary streams in the Rock Creek TPA with evidence of past placer mining. Metals-related listings include aluminum, arsenic, copper, iron, lead, and mercury.

Table 8-1. Waterbody segments in the Rock Creek TPA identified as being impaired for metals

Waterbody ID	Stream Segment
MT76E002_080	BASIN GULCH, Headwaters to mouth (Eureka Gulch)
MT76E002_090	EUREKA GULCH, Basin Gulch-Quartz Gulch confluence to mouth (un-named ditch)
MT76E002_120	FLAT GULCH, Headwaters to mouth (Rock Creek)
MT76E002_070	QUARTZ GULCH, Headwaters to mouth (Eureka Gulch)
MT76E002_100	SCOTCHMAN GULCH, Headwaters to mouth (Upper Willow Creek)
MT76E002_110	SLUICE GULCH, Headwaters to mouth (Rock Creek)
MT76E002_030	WEST FORK ROCK CREEK, Headwaters to the mouth (Rock Creek)

8.3 Information Sources and Assessment Methods

DEQ used the following information sources for describing water quality and metals loading conditions in the planning area:

- The monitoring and assessment database compiled by DEQ for the Rock Creek TPA
- United States Geological Survey (USGS), National Water Information System (NWIS) database of surface water chemistry and discharge
- United States Environmental Protection Agency (EPA) STORET database of surface water chemistry and stream discharge
- State agency databases and GIS layers of inventoried mining properties and mining and milling disturbances
- DEQ discharge permit program files for active mines and mine-related facilities
- Federal and state government agency geographical information system (GIS) data for geology, topography, land cover, and land-use layers
- United States Department of Agriculture, Forest Service Watershed Assessments
- 2011 National Agricultural Imagery Program (NAIP) Aerial photos
- DEQ historical narratives of mining and milling activities

DEQ's monitoring and assessment record (Montana Department of Environmental Quality, 2012c) is the principal basis for stream impairment listings. Most of the metals impairments are based on water column chemistry data collected by DEQ or its contractors during 2004 and from 2009 through 2012. Sediment chemistry data, collected by DEQ monitoring and assessment field crews from 2009 through 2012, is available from samples collected under both high- and low-flow conditions from streams or their tributaries with metals impairment causes. DEQ assessment data was supplemented by STORET and NWIS data collected between 2001 and 2011.

DEQ's Office of Information Technology (OIT) has compiled a host of GIS layer files representing the approximate locations of potential metals loading sources inventoried by various state and federal natural resource agencies. These include inventoried abandoned mines, mills, and ore processing sites, and priority abandoned mines. In addition, OIT maintains a GIS directory of physical and cultural land features that include topography, hydrography, land cover categories, transportation infrastructure, and land ownership, These layers, combined with interpretation of 2011 NAIP aerial imagery, are used to help identify significant sources of metals loading from mining and other sources.

DEQ's Remediation Division has compiled historical narratives of metal mine developments describing the timing, nature, and production levels of mining and milling properties in Montana's mining districts. The narratives are used to describe the level of disturbance and likely pollutant sources at specific properties.

Based on the review of water quality data, geographic information, and project reports and narratives, potential sources of metals loading in the Rock Creek TPA include:

- natural background sources from mineralized bedrock surface erosion
- abandoned mine adit discharges or precipitation seepage through mine wastes
- discharges from mining facilities operating under an Small Miners Exclusion Statement (SMES) from DEQ.
- sediment-bound metals entering surface water from human-caused surface erosion

8.3.1 Natural Background Loading

Natural background loading is assumed to be a result of local geology, with minimal influence from human-caused sources. Metal loading to surface water is strongly influenced by geology and streamflow rate. Bedrock composition commonly affects sediment mineralogy and surface water concentrations of many elements, including metals. Higher suspended sediment concentrations usually increase the water column solids concentration of metals and other constituents during seasonal high flows.
2.1.6
The sampling and analysis plans developed for stream assessments in the Rock Creek TPA from 2009 through 2011 identified three sampling sites remote from mining and other human-caused sources. The three sites occur in the upper reaches of West Fork Rock Creek (C02ROCWF01) and in the Scotchman Gulch (C02SCTMG04, C02SCTMG01) tributary of Upper Willow Creek. A fourth site, similarly remote from human-caused sources, was established in the Miners Gulch tributary of Upper Willow Creek during 2010 (C02MNRSG01). The local bedrock geology at all four sites consists of granitic batholith cells that have intruded folded and faulted Belt Series sediments (see **Section 2.1.6**). **Table 8-2** contains measured high and low-flow values and median values for metal pollutant parameters in samples from the four sites representing natural background conditions. Where measured concentrations are less than analytical method detection limit, one half of the detection limit is used to calculate loading from background sources.

The median values in the shaded rows in **Table 8-2** are used to calculate the load allocations to natural background sources of metals loading in the Rock Creek TPA.

Table 8-2. Measured and median metal concentrations for sites representing natural background conditions in the Rock Creek TPA.

Flow	Station ID	Hardness (mg/L)	Al (µg/L)	As (µg/L)	Cd (µg/L)	Cu (µg/L)	Fe (µg/L)	Pb (µg/L)	Hg (µg/L)	Zn (µg/L)
High	C02ROCWF01	7	70	<3	<0.08	<1	100	< 0.5	<0.005	<10
	C02SCTMG04	25	140	<3	<0.08	<1	310	< 0.5	--	<10
High-flow Medians		16	105	1.5	0.04	0.5	205	0.25	0.0025	5
Low	C02ROCWF01	11	--	<3	<0.08	<1	70	< 0.5	--	<10
	C02ROCWF01	12	<30	<3	<0.08	<1	60	< 0.5	<0.005	<10
	C02ROCWF01	12	<30	<3	<0.08	<1	60	< 0.5	<0.005	<10
	C02MNRSG01	16	50	1	<0.08	<1	--	<0.5	--	<10
	C02MNRSG01	18	40	<1	<0.08	<1	--	<0.5	--	< 5
	C02MNRSG01	18	50	<1	<0.08	<1	--	<0.5	--	<5
	C02SCTMG01	32	30	1	<0.08	<1	150	<0.5	--	<5
	C02SCTMG01	24	130	1	<0.08	<1	--	<0.5	--	<1
Low-flow Medians		17	40	1	0.04	0.5	60	0.25	0.0025	3.75

The data set contains 10 sampling results for most metal parameters. The high-flow data consists of water chemistry for the West Fork Rock Creek and upper Scotchman Gulch collected on June 1, 2010. The remaining 8 low flow samples were collected during low flows in 2009 and 2010. Complete water column chemistry results for the selected natural background sites are contained in **Appendix L**.

Metal concentrations in samples from natural background sites are either less than the method detection limits or within the applicable standards for all metal parameters except dissolved aluminum. The most restrictive aluminum criterion is the chronic aquatic life support value of 87 µg/L. The criterion was exceeded twice in Scotchman Gulch. Once in July, 2010, and once in June, 2012. Despite the aluminum exceedances, median aluminum concentrations values across all nine samples remain less than the aquatic life criterion. The locations of the proposed background sites are highlighted in **Figure 8-2**.

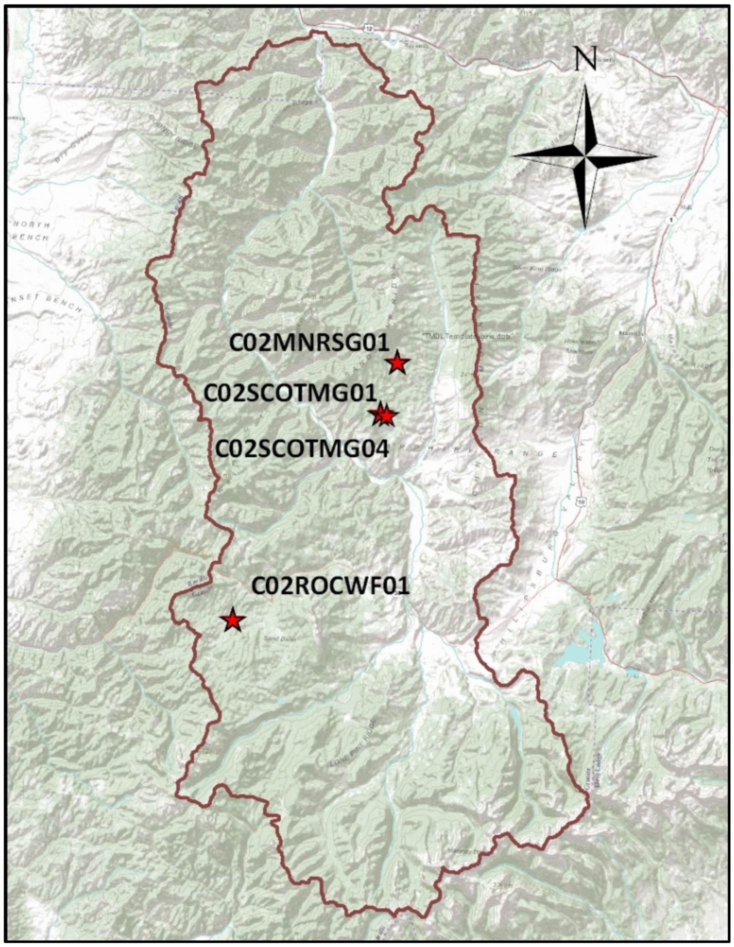

Figure 8-2. Water quality sampling sites representing natural background conditions in the Rock Creek TPA.

The sites occur in headwater reaches that are generally upstream of mining sources. The data suggest that natural background concentrations of aluminum in surface waters draining watersheds with a granitic bedrock may occasionally exceed numeric water quality standards for aluminum during high and low flows. Additional surface water monitoring is recommended to better define natural background levels of aluminum loading.

When possible, background loading is accounted for separately from human-caused sources. However, the effects of past metal mining are localized within the planning area and load allocations to natural background sources cannot always be expressed separately from human-caused sources. Regardless of the allocation scheme, the underlying assumption is that, natural background sources alone would not exceed the target metals concentrations in the water column, or the PELs in sediment. If future monitoring disproves this assumption, metals loading analyses may need revision per the adaptive management strategy described in **Section 8.9**

8.3.2 Loading from Mining Sources

Mining in the Rock Creek TPA began with the discovery of placer gold and later sapphire deposits in a number of upper Rock Creek tributaries beginning in the early 1860s and lasting as late as the 1940s (Montana Department of Environmental Quality, 2013). Placer mining still exists in the Rock TPA in limited amounts. Placer mining for sapphires is focused in several ephemeral drainages in lower West Fork Rock Creek. Placer mining of Gold deposits is taking place in the Eureka Gulch tributary of Rock Creek under three Small Mine Exclusions Statement (SMESs) issued by DEQ (SMES #s 46-126, 46-134, and 46-139). Information on these operations is on file with DEQ's Environmental Management Bureau, describes placer mining disturbances for recovery of gold, sapphires, and garnets. Alluvial deposits in Basin and Cornish gulches have been excavated by track hoe and gravity separated using a portable trommel. Information on file describes disturbances of less than 5 acres at each site. A license (#00709) was issued by DEQ on November, 30, 2009, for gold, sapphire, and garnet exploration in Basin Gulch. Exploration activities included surface trench excavation in the drainage bottom alluvium. An inspection of the exploration work by DEQ staff on September 21, 2011, reported that the excavated area had been re-graded. A portion of the reclamation bond is being withheld by DEQ pending required reseeding and weed control in the disturbed area.

DEQ and the Montana Bureau of Mines and Geology databases for abandoned and inactive mines identify 21 abandoned mine sites within the drainage areas of streams that are either listed in the 2012 Water Quality Integrated Report (Montana Department of Environmental Quality, 2012c) for metals impairment causes, or streams for which recent data indicate elevated metals concentrations. About 130 inactive mine properties are within the Rock Creek TPA boundary. However, many of these occur in the upper Ross Fork, Middle Fork, and East Fork tributaries that are either not assessed or not currently listed as being impaired by metal causes. Other concentrations of inactive mine sites occur in the Stony Creek, Williams Creek, Brewster Creek, and Welcome Creek tributaries of Rock Creek that drain the northwestern sector of the planning area. None of these streams are listed as being impaired by metals causes.

DEQ's Mine Waste Cleanup Bureau classified seven inactive mine sites in the Rock Creek TPA as "priority" mines. Priority mines, are a source of high public concern because of severe environmental degradation caused by heavy metal and mineral processing contamination of surface water and groundwater or contain mine opening hazards that pose a potential public safety issue (Pioneer Technical Services, Inc., 1995). The priority abandoned mines among the seven streams with metals impairment causes include the Silver King and Lori No. 13 properties in the Sluice Creek watershed. The potential of these two properties as metals sources to Sluice Gulch are described in **Appendix M**, **Section M 2.5.1**.

Environmental data describing individual loading contributions from abandoned mines is typically insufficient to guide allocations. Where data is adequate, wastewater discharges from abandoned mines are assigned wasteload allocations (WLA). Contributions from other abandoned mine sources are more commonly included in composite WLAs for mining sources associated with a specific property or drainage area. These allocation approaches assume that reductions in metals loading can be accomplished by treating the discharges and remediating or removing solid waste sources at abandoned mines.

8.3.3 Loading from Permitted Sources

The Integrated Compliance Information System (ICIS) is an EPA database for reporting and tracking federal environmental enforcement cases and tracking the compliance records of National Pollutant Discharge Elimination System (NPDES) permitted wastewater dischargers. Registered users of the ICIS database can retrieve information on permitted sources. A download and review of NPDES permitted facilities for Granite and Missoula Counties did identify one active permitted facility in the Rock Creek

TPA. General permit (#MTR104756) for excavation work was issued to "Scott Tucker - Elkhorn Ranch". The permit expired on 12/31/2012 but was continued on 1/1/2013.This general permit is for discharge of stormwater runoff into an unnamed wetland adjacent to Rock Creek. Discharge associated with this permit does not enter any of the streams under TMDL development in this document.

Allocations to any future permitted point sources having reasonable potential to affect surface water quality for metals would be provided a Wasteload Allocation (WLA). The wasteload allocation under a specific discharge flow is calculated using the following formula:

$$\mathbf{WLA_{NPDES} = (X)\ (Y)\ (k)}$$

WLA= Wasteload Allocation to NPDES permitted discharges
X= lowest applicable metals water quality target in ug/L for a specific instream hardness value
Y= discharge flow in gallons per day
k = conversion factor

Although the example WLA can guide permit development, the allocations should not be strictly applied in discharge permits when recent source-specific data is available that better describes mixing capacity, hardness, and metals concentrations in the receiving waters.

8.4 Water Quality Targets and Supplemental Indicators

Montana's established criteria for numeric water quality are adopted as the water quality targets for metal pollutants in this document. These values are published in Circular DEQ-7 (Montana Department of Environmental Quality, 2012a). Circular DEQ-7 contains acute aquatic life and chronic aquatic life criteria (designed to protect aquatic life uses). It also contains the human health criteria which are designed to protect drinking water uses. TMDLs are calculated using the most stringent target value to ensure protection of all designated beneficial uses.

DEQ has established an assessment method for determining water quality impairment caused by elevated metals concentrations (Montana Department of Environmental Quality, Water Quality Planning Bureau, Montioring and Assessment Section, 2012). The method includes guidelines for making use-support decisions based on water column metals data. Numeric metals criteria established to protect aquatic life are different from those established to protect human health. In general, an exceedance rate of 10 % or less of the chronic aquatic life criteria represents compliance with the numeric criteria and support for aquatic life. The 10 % guideline is not applied for datasets containing a result that is more than twice the acute aquatic life criteria. A single exceedance of this magnitude warrants a conclusion of aquatic life impairment. No exceedances are allowed when assessing compliance with human health criteria. Thus, the drinking water use for a waterbody can be impaired while full support remains for aquatic life uses. Compliance with *chronic* aquatic life criteria is based on an average metals concentration during a 96 hour period. The 1-hour average concentration in surface water may not exceed the a*cute* aquatic life water quality criteria more than once in any 3- year period. The presence of human-caused loading sources is critical to making impairment conclusions.

The metals assessment method recommends that impairment decisions be based on a minimum of 8 samples collected from within the same assessment reach. An impairment decision may be based on fewer samples, but caution should be taken against false conclusions that uses are supported. In general, data from the last 10 years is considered when making attainment decisions for aquatic life and drinking water uses. Older data may be useful for developing a historical reference or for loading analysis when more recent dataset is unavailable. Although samples can be taken any time of the year, 33 % of the dataset should be from samples collected during high-flow conditions, with the remaining samples collected during base-flow. At a minimum, a metals sampling suite should include analysis for total recoverable metals and dissolved aluminum. Although not required for making use-attainment decisions, dissolved concentrations for metals other than aluminum and sediment metal concentrations may be useful for identifying sources.

To summarize, the metals assessment method specifies that the maximum allowable exceedance rate for the chronic aquatic life criteria is 10 % of samples collected using a sound monitoring design that includes representative and independent samples under both high and low flow conditions. No human health exceedances or exceedances greater than twice the acute aquatic life criteria are allowed. Where the numeric criteria apply to protecting of aquatic life and human health, the most restrictive value is adopted as the water quality target. Some of the aquatic life criteria for metals are dependent on water hardness and adjust with changes in hardness. The presence of human-caused sources is required to conclude impairment.

8.4.1 Water Quality Targets: Water Column Metals Concentration

Water column metals concentration targets are the acute aquatic life (AAL), chronic aquatic life (CAL) and human health (HH) criteria. The criteria are dissolved concentrations of aluminum, and total recoverable concentrations of all other metal parameters (Montana Department of Environmental Quality, 2012a). The acute and chronic aquatic life criteria for cadmium, copper, lead, silver, and zinc increase with increasing hardness. **Table B2-5**, in **Appendix B** contains the aquatic life and human health criteria for these metals at hardness values of 25 and 100 mg/L. **Table B2-5** also contains the aquatic life and human health criteria for those metals not affected by water hardness, including aluminum, arsenic, mercury, and iron.

The human health criteria given in Circular DEQ-7 for iron (300 µg/L) and manganese (50 µg/L) are based on secondary maximum contaminant levels (MCL) established by EPA to prevent unwanted tastes, odors, or staining. These values provide a guide for determining interference with the specified uses after conventional water treatment. DEQ assumes that the concentrations of iron and manganese present in Rock Creek waterbodies, after conventional treatment, would not consistently exceed the MCLs. Therefore, the chronic aquatic life criterion of 1,000 µg/L is the water quality target for iron. Since there are no aquatic life criteria for manganese and no manganese impairment causes in the Rock Creek TPA, manganese targets are not developed in this document.

8.4.2 Supplemental Indicators

A supplemental indicator is an environmental variable linked closely to water quality, but the linkage is less certain compared with that of targets. Supplemental indicators are helpful for making TMDL decisions in cases where target departures are minimal or calculated from small or aging data sets. Although, supplemental indicators can help evaluate beneficial-use support, they are used as supporting evidence rather than direct measures of impairment. The number and magnitude of supplemental indicator exceedances are considered together with those for numeric target criteria when evaluating use support. In most cases, a combination of target departure analysis, meaningful qualitative observations, and sound professional judgment is applied in each assessment of TMDL development needs.

Sediment chemistry data are used here as supplemental indicators of water quality problems. In addition to directly affecting life that interact with stream sediments, elevated sediment values can be an indicator of elevated metals concentrations during runoff conditions. Results are available for 42 sample sites throughout the planning area. The general prohibitions in Montana's water quality standards (ARM 17.30.637) apply to additions of pollutants in sediment at harmful or toxic concentrations. The National Oceanic and Atmospheric Administration (NOAA) has developed Screening Quick Reference Tables that contain metals concentration guidelines for freshwater and marine sediments (Buchman, 2008). The screening criteria, developed from a variety of toxicity studies, are expressed as Probable Effects Levels (PELs) in **Table 8-3**.

Table 8-3. Screening criteria for sediment metals concentrations used as supplemental indicators.

Metal Parameter	PEL (µg/g dry weight)
Arsenic	17
Cadmium	3.53
Copper	197
Lead	91.3
Mercury	0.486
Zinc	315

PELs represent the concentration above which toxic effects are expected to occur frequently. PELs are used here as a screening tool to identify potential impacts to aquatic life from sediment-bound metals concentrations.

8.4.3 Targets, Supplemental Indicators, and the Need for TMDLs

The following discussion describes how a number of decision factors, together with targets, are used to determine whether current water quality conditions require TMDL development. The metals targets and supplemental indicators are summarized in **Table 8-4**.

Table 8-4. Targets and Supplemental Indicators for the Rock Creek TPA

Target Parameter	Criterion
Water Column Metal Pollutant Concentration	Montana Water Quality Standards, Circular DEQ 7 (Montana Department of Environmental Quality, 2012a)
Supplemental Indicators	**Criterion**
NOAA Quick Reference Table for Inorganics in Freshwater Sediment	Probable Effects Limits (PELs) (Buchman, 2008)

The need to develop metals TMDLs is based on the assumption that naturally occurring metals concentrations in surface water are less than the most restrictive numeric criterion under both high- and low-flow conditions. Where available background data suggests that targets may be exceeded under naturally occurring conditions, additional monitoring may be needed to better distinguish between natural background and human-caused loading. Adaptive management can be applied to newly available monitoring data to refine an initial, broadly allocated TMDL.

TMDL development decisions are guided by the following factors relating to loading sources, data quality, and pollutant listing status:

- the clear presence of human-caused metal loading sources

- the number and age of available metals data and analysis results obtained for each stream segment
- the rate and magnitude of target and supplemental indicator exceedances
- whether the pollutant in question is a 2012 impairment cause, or is a newly discovered cause.

The current method of assessing metals impairment for surface waters (Montana Department of Environmental Quality, Water Quality Planning Bureau, Montioring and Assessment Section, 2012) recommends a minimum of eight recent analytical results. Recent data are those obtained for samples collected within the past 10 years. Current pollutant impairment causes are those that appear in the Water Quality Integrated Report for 2012 (Montana Department of Environmental Quality, 2012c). New pollutant impairment causes are those that are absent from the 2012 Integrated Report (Montana Department of Environmental Quality, 2012c), but are identified after review of recent data from an adequate dataset. New pollutant causes will appear in the Water Quality Integrated Report for 2014.

The following scenarios apply to current pollutant causes for streams with known human-caused sources. Each scenario describes how the rate and magnitude of target exceedances are interpreted to determine the need for metals TMDLs:

1. Greater than 10 % of recent analytical results exceed CAL concentration targets.
2. The 10 % target exceedance threshold is not exceeded in a dataset with fewer than 8 recent results.
3. At least one analytical result in a recent dataset is greater than twice the AAL target.
4. At least one analytical result in a recent dataset exceeds the HH target.
5. Although targets are not exceeded, water column metals concentrations are elevated under both high and low flows and sediment metals concentrations greatly exceed PELs.

Despite the presence of human-caused sources, metals TMDLs are not developed for currently listed streams if targets and supplemental indicators are met by an adequate and recent dataset. Metals TMDLs are developed for streams without current metals impairment causes when known human-caused sources are present and compliance thresholds for aquatic life and human health targets are exceeded in a recent and adequately sized dataset.

Additional monitoring may be recommended in lieu of TMDL development for unlisted streams if target exceedances occur in small datasets. Additional monitoring may also be recommended in lieu of TMDLs for unlisted streams if background conditions appear to exceed water quality targets and a clear link cannot be made to known human-caused sources.

8.5 Existing Condition and Comparison with Water Quality Targets

The decision factor analysis and TMDL conclusions are summarized below for each stream segment in **Tables 8-5 - 8-11**. The water quality and sediment data on which TMDL decisions are based are compiled by stream segment in **Appendix L**. The recent water quality record for each pollutant impaired stream segment in the planning area is compared with the metal targets and supplemental indicators listed above in **Table 8-4**. The results of the comparison are stated in terms of the TMDL development decision factors described in **Section 8.4.3.** Data for currently listed metals impairment causes are evaluated first, followed by a review of the data for other metal parameters with significant target departures. The stream-by-stream review of metals loading sources and comparison of water quality data with targets and supplemental indicators is contained in **Appendix M**.

Table 8-5. Metals decision factors and TMDL conclusions for Basin Gulch.

Pollutant Parameter	CAL Exceedance Rate > 10%	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded(*)	2012 Listing Status	TMDL Conclusion
Aluminum	N	N	NA	Y	NA	Unlisted	No TMDL
Arsenic	N	N	Y	Y	NA	Unlisted	TMDL
Cadmium	N	N	N	Y	NA	Unlisted	No TMDL
Copper	N	N	N	Y	NA	Unlisted	No TMDL
Iron	N	NA	NA	Y	NA	Unlisted	No TMDL
Lead	N	N	N	Y	NA	Unlisted	No TMDL
Mercury	N	N	N	Y	NA	Unlisted	No TMDL
Silver	NA	N	N	Y	NA	Unlisted	No TMDL
Zinc	N	N	N	Y	NA	Unlisted	No TMDL

*Sediment chemistry data are not available for basin Gulch

Table 8-6. Metals decision factors and TMDL conclusions for Quartz Gulch.

Pollutant Parameter	CAL Exceedance Rate > 10%	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded	2012 Listing Status	TMDL Conclusion
Aluminum	Y	N	NA	Y	NA	Unlisted	TMDL
Arsenic	N	N	N	Y	Y	Unlisted	No TMDL
Cadmium	N	N	N	Y	N	Unlisted	No TMDL
Copper	N	N	N	Y	N	Unlisted	No TMDL
Iron	N	NA	NA	Y	NA	Unlisted	No TMDL
Lead	Y	N	N	Y	N	Unlisted	TMDL
Mercury	N	N	N	Y	Y	Listed	No TMDL
Silver	NA	N	N	Y	NA	Unlisted	No TMDL
Zinc	N	N	N	Y	Y	Unlisted	No TMDL

Table 8-7. Metals decision factors and TMDL conclusions for Eureka Gulch.*

Pollutant Parameter	CAL Exceedance Rate > 10%	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded**	2012 Listing Status	TMDL Conclusion
Aluminum	N	N	NA	Y	NA	Unlisted	No TMDL
Arsenic	N	N	Y	Y	NA	Listed	TMDL
Cadmium	N	N	N	Y	NA	Unlisted	No TMDL
Copper	N	N	N	Y	NA	Unlisted	No TMDL
Iron	N	NA	NA	Y	NA	Unlisted	No TMDL
Lead	N	N	N	Y	NA	Unlisted	No TMDL
Mercury***	NA	NA	NA	Y	NA	Listed	TMDL
Silver	NA	N	N	Y	NA	Unlisted	No TMDL
Zinc	N	N	N	Y	NA	Unlisted	No TMDL

* The recent water quality dataset for Eureka Gulch consists of a single record for a sample collected at site C02EURKG10 (on July 29th, 2004). **Sediment chemistry data are not available for Eureka Gulch.
***Data show 2 exceedance from 1997. Data older than 10 years is not used in TMDL development

Table 8-8. Metals decision factors and TMDL conclusions for West Fork Rock Creek.

Pollutant Parameter	CAL Exceedance Rate > 10%	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded	2012 Listing Status	TMDL Conclusion
Aluminum	Y	N	NA	Y	NA	Unlisted	TMDL
Arsenic	N	N	N	Y	N	Unlisted	No TMDL
Cadmium	N	N	N	Y	N	Unlisted	No TMDL
Copper	N	N	N	Y	N	Unlisted	No TMDL
Iron	N	NA	NA	Y	NA	Unlisted	No TMDL
Lead	N	N	N	Y	N	Unlisted	No TMDL
Mercury	N	N	N	Y	N	Listed	No TMDL
Silver	NA	N	N	Y	NA	Unlisted	No TMDL
Zinc	N	N	N	Y	N	Unlisted	No TMDL

Table 8-9. Metals decision factors and TMDL conclusions for Sluice Gulch.

Pollutant Parameter	CAL Exceedance Rate > 10%	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded	2012 Listing Status	TMDL Conclusion
Aluminum	N	N	NA	Y	NA	Unlisted	No TMDL
Arsenic	N	N	Y	Y	Y	Listed	TMDL
Cadmium	N	N	N	Y	N	Unlisted	No TMDL
Copper	Y	N	N	Y	N	Unlisted	TMDL
Iron	N	NA	NA	Y	NA	Unlisted	No TMDL
Lead	N	N	N	Y	N	Unlisted	No TMDL
Mercury	N	N	N	Y	N	Unlisted	No TMDL
Silver	NA	N	N	Y	NA	Unlisted	No TMDL
Zinc	N	N	N	Y	N	Unlisted	No TMDL

Table 8-10. Metals decision factors and TMDL conclusions for Flat Gulch.

Pollutant Parameter	CAL Exceedance Rate > 10%	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded	2012 Listing Status	TMDL Conclusion
Aluminum	Y	N	NA	Y	NA	Unlisted	TMDL
Arsenic	N	N	N	Y	N	Unlisted	No TMDL
Cadmium	N	N	N	Y	N	Unlisted	No TMDL
Copper	N	N	N	Y	N	Unlisted	No TMDL
Iron	Y	NA	NA	Y	NA	Unlisted	TMDL
Lead	N	N	N	Y	N	Unlisted	No TMDL
Mercury*	NA	NA	NA	Y	NA	Unlisted	No TMDL
Silver	NA	N	N	Y	NA	Unlisted	No TMDL
Zinc	N	N	N	Y	N	Unlisted	No TMDL

* No Mercury data was collected in Flat Gulch as part of assessment efforts

Table 8-11. Metals decision factors and TMDL conclusions for Scotchman Gulch.

Pollutant Parameter	CAL Exceedance Rate > 10%	Results Twice the AAL Criterion	Human Health Criterion exceeded	Human-Caused Sources Present	Sediment PELs Exceeded	2012 Listing Status	TMDL Conclusion
Aluminum	Y	N	NA	Y	NA	Unlisted	TMDL
Arsenic	N	N	N	Y	N	Unlisted	No TMDL
Cadmium	N	N	N	Y	N	Unlisted	No TMDL
Copper	N	N	N	Y	N	Unlisted	No TMDL
Iron	N	NA	NA	Y	NA	Unlisted	No TMDL
Lead	N	N	N	Y	N	Unlisted	No TMDL
Mercury	N	N	N	Y	N	Unlisted	No TMDL
Silver	NA	N	N	Y	NA	Unlisted	No TMDL
Zinc	N	N	N	Y	N	Unlisted	No TMDL

* No Mercury data was collected in Scotchman Gulch as part of assessment efforts

8.5.1 TMDL Development Summary

Seven stream segments in the Rock Creek TPA require development of 11 TMDLs for metals (**Table 8-12**). The metals of concern are aluminum, arsenic, copper, iron, lead, and mercury.

Table 8-12. Metal pollutants requiring TMDLs for streams in the Rock Creek TPA.

Waterbody Segment ID	Waterbody Segment	Metals Listings in the 2012 Integrated Report	Verified Target Exceedances and TMDL/s Developed
MT76E002_080	Basin Gulch	None	Arsenic
MT76E002_090	Eureka Gulch	Arsenic, Mercury	Arsenic, Mercury
MT76E002_120	Flat Gulch	None	Aluminum, Iron
MT76E002_070	Quartz Gulch	Mercury	Aluminum, Lead
MT76E002_100	Scotchman Gulch	None	Aluminum
MT76E002_110	Sluice Gulch	Arsenic	Arsenic, Copper
MT76E002_030	West Fork Rock Creek	Mercury	Aluminum

The recent data support three of the metal pollutant causes reported on the 2012 303(d) List:

1. Arsenic in Eureka Gulch
2. Mercury in Eureka Gulch, and
3. Arsenic in Sluice Gulch

The data also support TMDLs for 8 new pollutant-waterbody combinations and removal from the 303(d) list of 2 other metal impairment causes. All metals listings in Basin Gulch, Flat Gulch, and Scotchman Gulch are new listings. The recent data for Quartz Gulch and West Fork Rock Creek do not support the 2012 mercury listings for these streams.

8.6 TMDLs

TMDLs for metals represent the maximum amount (lbs/day) of each metal that a stream can receive without exceeding water quality standards. A stream's capacity to assimilate metal pollutants is a function of the diluting effect of stream discharge and, in some cases, water hardness. Increasing water hardness reduces the toxicity of several metals (cadmium, copper, lead, silver, and zinc) and so is a factor in determining numeric water quality criteria. Because stream discharge and water hardness vary seasonally, the TMDLs must be applied seasonally to protect beneficial uses over a range of flow and hardness conditions. All TMDLs must contain a margin of safety (MOS) to ensure beneficial-use support in light of the uncertainty in deriving load estimates. All metals TMDLs developed for the Rock TPA contain an implicit margin of safety described in **Section 8.8**. Metals TMDLs are calculated using the following equation:

TMDL = (X) (Y) (k)

Where:
TMDL = Total Maximum Daily Load in lbs/day
X = lowest applicable metals target concentration (µg/L) adjusted for hardness
Y = streamflow in cubic feet per second (cfs)
k = unit conversion factor of 0.0054

All metals TMDLs are calculated using the most restrictive target value to ensure that the TMDLs protect all designated beneficial uses. The most restrictive target is commonly the chronic aquatic life criterion. Exceptions are arsenic and mercury, where the human health criteria are the most restrictive (**Appendix B, Table B 2-5**). Circular DEQ-7 (Montana Department of Environmental Quality, 2012a) specifies that compliance with the chronic aquatic life criteria is based on an average water quality metals concentration occurring over a 96 hour (4-day) period (**Section 8.4**). Calculating an allowable daily load from the chronic criteria that are based on a 4-day exposure duration provides an implicit margin of safety in the TMDL.

Although the TMDL is often derived from the chronic standards, acute aquatic life standards are also established as water quality targets, and are applied as an instantaneous instream pollutant concentration that is not to be exceeded (when the measured concentration is twice the acute standard). The TMDL will ultimately be defined as the total allowable loading using a time period consistent with the application of the most appropriate numeric water quality criterion. Remediation required to eliminate pollutant loading that exceeds the chronic standards will often mitigate more extreme short-duration exceedances of acute criteria.

8.6.1 TMDLs for Non-Hardness Dependent Metals

The toxicity of several metal elements is independent of water hardness. The TMDLs for these substances can be illustrated graphically using the TMDL equation in **Section 8.6**, with the most restrictive water quality criterion substituted for the value of “X,” and stream discharge (cfs) substituted for the value of “Y.” **Figure 8-3** shows the graphs of the TMDLs for aluminum, arsenic, iron, and mercury based on the most restrictive water quality criterion for each parameter over a common range of stream discharge for the Rock TPA.

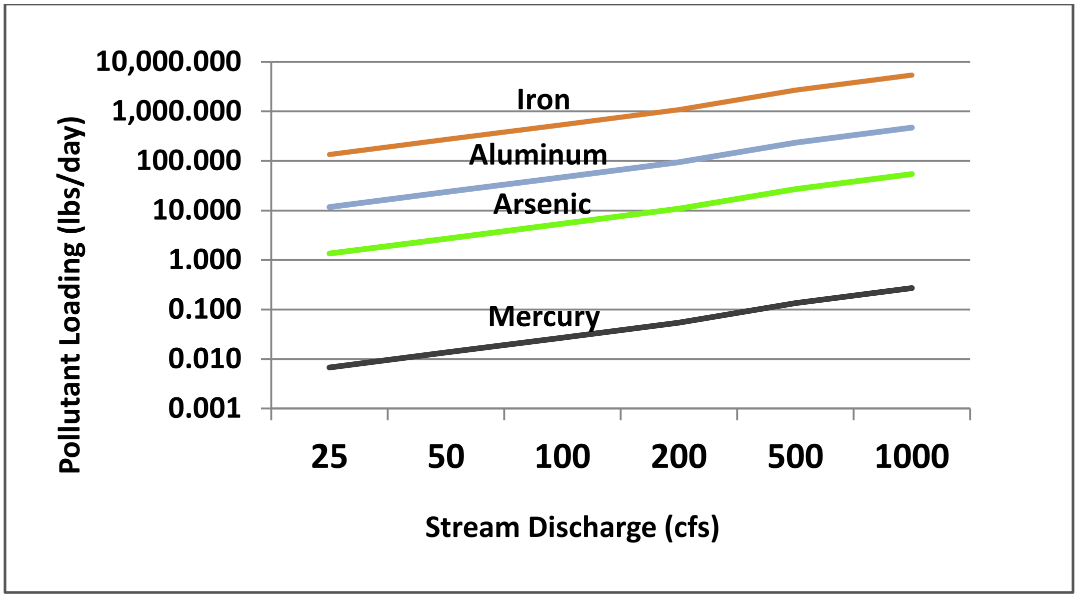

Figure 8-3. Graphs of TMDLs (lbs/day) for iron, aluminum, arsenic, and mercury with increasing stream discharge.

The **Figure 8-3** graph is based on the chronic criteria for iron (1,000 µg/L) and aluminum (87 µg/L) and the human health criteria for arsenic (10 µg/L,) and mercury (0.05 µg/L). The TMDL graph **Figure 8-3** applies to all aluminum, arsenic, iron, and mercury TMDLs in this document.

8.6.2 Example Metals TMDLs for Listed Streams

Table 8-13 gives seasonal discharge rates, hardness values, target values, example TMDLs, and load reduction needed for the seven waterbody segments in the Rock Creek TPA requiring metals TMDLs. The examples are calculated based on high- and low-flow sampling events. High flows are those occurring during the second calendar quarter (April –June); low flows are those during the remaining three quarters. Flows are medians of field measurements taken during high- and low-flow periods from 2010 through 2012. Where flow data is limited, individual high-and low-flow measurements are used. As no flow data exist for Sluice Gulch, the median of measured flows above and below the 50th percentile are used to represent high and low flows. Hardness values are calculated as the means of the field measurements classified by flow condition and stream segment.

The selection of monitoring stations is guided by the availability of flow and hardness data and the existence of significant upstream sources. **Table 8-13.** Existing loads are calculated using the largest target exceedance (i.e., highest observed concentration) multiplied by the most restrictive water quality target and a unit conversion factor. The calculated example TMDLs represent the maximum load (lbs/day) of each metal that each waterbody can receive without exceeding the most restrictive (lowest) applicable water quality standards for the specified flow and hardness. The current loads, percent reductions, and TMDL components contained in this document should not be considered rigid numbers but rather are reasonable approximations portraying the inherent loading variability. Raw data is included in **Appendix L**.

Table 8-13. Example metals TMDLs for waterbodies in the Rock Creek TPA

Stream Segment (Segment ID)	Station	Discharge (cfs)		Hardness (mg/L)		Metal	Target Concentration (µg/L)		TMDL (lbs/day)		Existing Load (lbs/day)	
		High flow	Low flow	High flow	Low flow		High flow	Low flow	High flow	Low flow	High Flow	Low Flow
Basin Gulch (MT76E002_080)	C02BASNG10	0.4	0.1	NA		Arsenic	10	10	0.0216	0.0054	0.0324	0.0081
Eureka Gulch (MT76E002_090)	C02EURKG10	0.67	0.3	NA		Arsenic	10	10	0.0361	0.0162	0.0578	0.0259
						Mercury	0.05	0.05	0.0002	0.0001	0.0018	0.00081
Flat Gulch (MT76E002_120)	C02FLATG04	0.07	0.03	NA		Aluminum	87	87	0.0329	0.0141	0.0188	0.0210
						Iron	1,000	1,000	0.3776	0.1618	0.0641	0.2217
Quartz Gulch (MT76E002_070)	C02QRTZG01	0.37	0.06	NA		Aluminum	87	87	0.1737	0.0282	0.9182	0.0049
				26	57	Lead	0.57	1.56	0.0011	0.0005	0.0012	0.0001
Scotchman Gulch (MT76E002_100)	C02SCTMG03	0.52	0.53	NA		Aluminum	87	87	0.2441	0.2487	0.5966	0.5092
Sluice Gulch (MT76E002_110)	C02SLUCG01	1.4	1.2	NA		Arsenic	10	10	0.0755	0.0647	0.0906	0.0712
				143	148	Copper	12.66	13.04	0.0956	0.0844	0.0302	0.0032
West Fork Rock Creek (MT76E002_030)	C02ROCWF05	940	33	NA		Aluminum	87	87	441	15	456	2.7

8.7 Loading Summaries and Allocations

The following sections provide a loading summary and source allocation for each pollutant-waterbody combination with a metal TMDL. It is helpful to review the loading sections on each segment with the corresponding target departure discussion in **Appendix M**. Loading summaries are based on the sample data contained in **Appendix L**. The descriptions of metals loading to Rock Creek tributaries begins with the Basin and Quartz Gulch tributaries to Eureka Gulch, followed by the adjacent West Fork of Rock Creek, then downstream to Flat Gulch, Sluice Gulch and concluding with the Upper Willow Creek tributary of Scotchman Gulch.

The purpose of the loading summaries is to identify contributing sources, and discuss seasonal pollutant fluctuations and pathways. Loads are expressed in units of pounds per day. While units of pounds per day are appropriate for expressing TMDLs, the most appropriate means of measuring compliance with metals TMDLs is a direct measurement of the contaminant concentration in surface water samples.

As discussed in **Section 4.0**, a TMDL is the sum of all the load allocations (LAs), wasteload allocations (WLAs), and an MOS. LAs are allowable pollutant loads assigned to nonpoint sources and may include the cumulative pollutant load from naturally occurring sources plus allowable human caused sources. When possible, LAs to naturally occurring sources are provided separately. WLAs are allowable pollutant loads that are assigned to permitted and non-permitted point sources. Mining-related waste sources (e.g. adit discharges, tailings accumulations, and waste rock deposits) are non-permitted point sources subject to WLAs. TMDLs are expressed by the following general equation:

TMDL = LA + WLA + MOS

The prevailing human-caused sources of metals loading in the Rock Creek TPA are inactive mines, and sediment-bound sources from road, streambank, and hillslope erosion. Where adequate data are available to evaluate loading from individual sources, these sources will be given separate WLAs. Where data from discrete sources is unavailable, loading contributions from inactive mines, streambank sources or roadways may be grouped into composite WLAs. The adaptive management process discussed in **Section 8.9** is recommended where more detail is needed for future refinement and adjustment of composite WLAs to mining and other sources.

TMDLs must incorporate an MOS. All metals TMDLs in this document apply an implicit MOS by adopting a variety of conservative assumptions in calculating TMDLs and estimating pollutant loads. These assumptions are described in more detail in **Section 8.8**. Therefore, the implicit MOS is applied in the TMDL equations above and not repeated in each of the equations to follow.

The TMDL and allocation tables in the following sections give the TMDLs for each metal pollutant parameter under both high- and low-flow conditions for each stream segment. These TMDL values are brought forward from **Table 8-13**. The **Table 8-13** column following the “TMDL” column gives values for the “Existing Metal Concentration” in units of µg/L. These are the highest values from the water quality monitoring data for each flow condition. The “Existing Loads” are calculated by multiplying these concentrations times the flow values (also brought forward from **Table 8-13**), times a unit conversion factor. For example, **Table 8-14** for Basin Gulch gives a value of 0.0324 lbs/day for existing flow arsenic loading. The high flow in Basin Creek of 0.4 cfs (**Table 8-13**) is multiplied by the highest arsenic concentration measured in Basin Creek during high flows (15 µg/L). The product of flow multiplied by concentration is, in turn, multiplied by the unit conversion factor of 0.0054 to give the existing high flow aluminum load of 0.0324 lbs/day.

Example: Basin Gulch high flow TMDL= 0.4 cfs X 15 µg/L X 0.0054 = 0.0324 lbs/day)

The “Existing Load” column in the allocation tables (eg., **Table 8-14**) is followed by “LA” and “WLA” columns containing the allowable loads from nonpoint sources (i.e. background sources) and the allowable wasteload from human-caused sources. The last column in the allocation tables contains human-caused load reduction percentages needed to meet the TMDLs. The reductions are calculated as the difference between the current and allowable human-caused pollutant loading, expressed as a percentage of the current human-caused load. In cases of high uncertainty in the degree of natural background loading, composite wasteload allocations are proposed that combine natural background and human-caused sources. In these cases, the final column in the allocation tables quantifies the reduction in the total pollutant load needed to meet the TMDL.

Example: Basin Gulch High Flow Arsenic % Reduction

1.) Total Existing Load – Natural Background (LA) = Existing human-caused load (WLA)
0.0324 lbs/day – 0.0032 lbs/day = 0.0292 lbs/day (Existing WLA)

2.) ((Existing WLA – TMDL WLA)/Existing WLA)* 100 = % Reduction from Human-caused Sources
((0.0292 – 0.0184)/0.0292)* 100 = 37% Reduction from Human-caused Sources

8.7.1 Basin Gulch (MT76E002_080)

Loading Summary

Metals target exceedances in Basin Gulch are associated with an inactive underground mine and breached tailings impoundment related to the former Blue Bell silver mine. The drainage bottom alluvium has been placer mined. Re-grading formed a series of valley bottom check dams impounding surface water. Aerial imagery shows additional surface disturbances in the upper drainage that resemble exploration trenches, drill pads, and roadways. Natural background loading is represented by the median water analysis results contained in **Table 8-2**.

TMDLs and Allocations

The metals TMDLs and allocations for high- and low-flow conditions in Basin Gulch are summarized below and in **Table 8-14**. The arsenic allocations include load allocations to natural background concentrations (**$LA_{BG\ NB}$**) and a wasteload allocation to mining sources of arsenic (**$WLA_{BG\ MS}$**). Natural background loading is calculated using one half of the method detection level (1.5 µg/L) for high-flow conditions and 1 µg/L for low-flow conditions. The Basin Gulch arsenic TMDL is summarized by the following equation:

$$\mathbf{TMDL_{BG} = LA_{BG\ NB} + WLA_{BG\ MS}}$$

The wasteload allocation to mining sources is obtained by subtracting the calculated background load from the TMDL. The allocation scheme assumes that natural background loading rates do not exceed water quality standards. The allocations also assume that further applying best management practices (BMPs) to mining sources will reduce loading so that TMDLs and water quality targets are met.

Table 8-14. Example metal TMDLs and load- and wasteload allocation examples for Basin Gulch at site C02BASNG10.

Metal	Flow Conditions	TMDL (lbs/day)	Existing Metal Concentration (µg/L)	Existing Load (lbs/day)	LA_{NB} (lbs/day)	WLA_{MS} (lbs/day)	Needed Reduction (%)
Arsenic	High flow	0.0216	15	0.0324	0.0032	0.0184	37
	Low flow	0.0054	15	0.0081	0.0005	0.0049	36

The similarity between high-flow and low-flow water column concentrations of arsenic indicates a consistent year-round source of this pollutant. There are no sediment chemistry data available for Basin Gulch as a supplemental indicator of metals impairment. Such data would be helpful in learning whether sediment-bound arsenic is consistently contributing to the water quality problem in Basin Gulch.

8.7.2 Eureka Gulch (MT76E002_090)

Loading Summary

Eureka Gulch extends from the confluence of Basin and Quartz gulches to the Rock Creek floodplain where flow is intercepted by a flood irrigation lateral. The Eureka Gulch data record consists of a single water column sample collected on July 29, 2004, from site C02EURKG10. An arsenic result of 16 µg/L was detected in the sample. The mercury impairment determination in Eureka Gulch stems from samples collected from mine disturbances during 1996 and 1997. The results range from 0.2 to 0.5 µg/L.

TMDLs and Allocations

Example TMDLs and allocations for Eureka Gulch are contained in **Table 8-15**. The allocations for arsenic and mercury under both flow conditions include load allocations to natural background concentrations (**LA** $_{EG\ NB}$) and a wasteload allocation to mining sources (**WLA** $_{EG\ MS}$). Natural background loading to Eureka Gulch is represented by water analysis results from the sites listed in **Table 8-2**. This allocation scheme is reflected in the following TMDL equation:

$$\mathbf{TMDL_{EG} = LA_{EG\ NB} + WLA_{EG\ MS}}$$

Table 8-15. Example metals TMDLs and load- and wasteload allocation examples for Eureka Gulch at site C02EURKG10.

Metal	Flow Conditions	TMDL (lbs/day)	Existing Metal Concentration (µg/L)	Existing Load (lbs/day)	LA_{NB} (lbs/day)	WLA_{MS} (lbs/day)	Needed Reduction (%)
Arsenic	High flow	0.0361	16	0.0578	0.0054	0.0307	41
	Low flow	0.0162	16	0.0259	0.0016	0.0146	40
Mercury	High flow	0.0002	0.5	0.0018	0.000009	0.00019	89
	Low flow	0.0001	0.5	0.00081	0.000004	0.00002	88

Where background sample analysis results are less than MDLs, one half of the maximum detection limit (MDL) is the assumed background concentration. The wasteload allocation to mining sources is obtained by subtracting the calculated background load from the TMDL. The allocation scheme assumes that natural background loading rates do not exceed water quality standards and that further application of BMPs to Eureka Gulch mining sources will reduce loading so that TMDLs and water quality standards are met.

The limited dataset does not contain results from high-flow sampling. Low flow sample results were used to estimate high-flows and obtain high-flow allocations for Eureka Gulch. Streambed sediment data are not available for Eureka Gulch.

8.7.3 Quartz Gulch (MT76E002_070)

Loading Summary

Quartz Gulch combines with Basin Gulch to form the Eureka Gulch tributary to Rock Creek. Aluminum and lead target exceedances in Quartz Gulch occur only during high flows, indicating a sediment-bound source of loading. The stream has been extensively placer mined. Channel stabilization after reclamation varies from stable in the upper drainage to no distinguishable channel near the mouth.

TMDLs and Allocations

Example TMDLs and allocations for Quartz Gulch are specified in **Table 8-16**. Two allocation schemes are developed for Quartz Gulch because of uncertainty in the amount of natural background aluminum loading introduced by elevated high-flow aluminum concentrations in samples from background sites. For high-flow aluminum, the TMDL is a composite wasteload allocation to natural background and mining sources. The composite allocation for high-flow aluminum is expressed by the following equation:

$$\mathbf{TMDL_{QG} = WLA_{(QG\ NB\ +\ QG\ MS)}}$$

Using a composite allocation, the sum of allowable aluminum loading from natural background, plus mining sources, is equal to the aluminum TMDL of 0.1737 lbs/day under high-flow conditions. The TMDL equation for high-flow aluminum is inserted into **Table 8-16**.

The allocations for low-flow aluminum loading and lead loading under both flow conditions include load allocations to natural background concentrations (**LA** $_{QG\ NB}$) and wasteload allocations to mining sources of these metals (**WLA** $_{QG\ MS}$). Natural background loading is calculated using the metal concentrations in **Table 8-2**. This allocation scheme is reflected in the following TMDL equation:

$$\mathbf{TMDL_{QG} = LA_{QG\ NB} + WLA_{QG\ MS}}$$

Table 8-16. Example metal TMDLs and wasteload allocation for Quartz Gulch at site C02QRTZG01.

Metal	Flow Conditions	TMDL (lbs/day)	Existing Metal Concentration (µg/L)	Existing Load (lbs/day)	LA_{NB} (lbs/day)	WLA_{MS} (lbs/day)	Needed Reduction (%)
Aluminum	High flow	0.1737	460	0.918	TMDL = 0.1737 lbs/day		81
	Low flow	0.0282	15	0.005	0.013	0.0152	0
Lead	High flow	0.0011	0.60	0.0012	0.0005	0.0006	14
	Low flow	0.0005	0.25	0.0001	0.0001	0.0004	0

Where background sample analysis results are less than MDLs, one half of the MDL is the assumed background concentration. The wasteload allocation to mining sources is obtained by subtracting the calculated background load from the TMDL. The allocation scheme assumes that natural background loading rates do not exceed water quality standards and that further application of BMPs to mining sources in Quartz Gulch will reduce high-flow loading so that TMDLs and water quality standards are met. Additional high-flow aluminum monitoring at background sites is recommended to increase the sample size and improve our understanding of background aluminum loading in the planning area.

Sediment metals concentration data are available for one sample collected at site C02QRTZG01 in September of 2011. The arsenic concentration in the Quartz Gulch sample is 62 times the recommended PEL value. Sediment concentrations of mercury and Zinc are also elevated, but not causing water column exceedances. From the current dataset it appears that neither aluminum nor lead require load reductions during low flow, since targets are exceeded only during high flow. While elevated streambed sediment concentrations of arsenic may indicate a potential problem. None of the eight water column samples exceeded targets, thus an arsenic TMDL is not established at this time. Further arsenic sediment and water quality monitoring is recommended to better characterize arsenic in this basin.

8.7.4 West Fork Rock Creek (MT76E002_030)

Loading Summary

Metals sources in the West Fork Rock Creek consist of inactive abandoned placer mine properties in the upper portion of the drainage and quarried placer deposits in the Anaconda and Sapphire gulch drainages farther downstream. Two lode mine developments for gold recovery in the Maukey Gulch tributary of the lower West Fork consist of hillslope disturbances, access roads, and local timber harvest areas. The mercury impairment listing for West Fork Rock Creek stems from water quality data collected prior to 2000. Recent low level mercury monitoring does not confirm continuing mercury impairment.

The West Fork Rock Creek water quality dataset includes 18 records from 7 monitoring sites (**Appendix M, Figure M-1**). All sites were established by DEQ monitoring and assessment efforts. Water samples were collected during high- and low-flow periods in 2009 and 2010. Water quality records are lacking for streams in the Ross Fork tributary of the West Fork and additional assessment work is required to characterize loading from this large tributary drainage. Natural background loading is represented by the median values in **Table 8-2**.

TMDLs and Allocations

Example aluminum TMDLs and allocations for West Fork Rock Creek are contained in **Table 8-17**. The allocation scheme developed for West Fork Rock Creek is a composite allocation to natural background (NB) and mining-related sources (MS) of aluminum. Use of a composite allocation reflects the uncertainty in the background aluminum concentrations measured during high flows. The composite allocation for high-flow aluminum is expressed by the following equation:

$$\mathbf{TMDL_{WFRC} = WLA_{(WFRC\ NB\ +\ WFRC\ MS)}}$$

The composite allocation scheme states that the sum of allowable high-flow aluminum loading from natural background, plus mining sources, is equal to the TMDL of 441 lb/day under high-flow conditions. The TMDL equation for high-flow aluminum is inserted into **Table 8-17**.

The allocation for low-flow aluminum includes a load allocation to natural background concentrations ($\mathbf{LA_{WFRC\ NB}}$) and a wasteload allocation to mining sources ($\mathbf{WLA_{WFRC\ MS}}$). Natural background loading to West Fork Rock Creek is represented by water analysis results from the sites listed in **Table 8-2**. This allocation scheme is reflected in the following TMDL equation:

$$\mathbf{TMDL_{WFRC} = LA_{WFRC\ NB} + WLA_{WFRC\ MS}}$$

Table 8-17. Example TMDLs and wasteload allocation for West Fork Rock Creek at site C02ROCWF05

Metal	Flow Conditions	TMDL (lbs/day)	Existing Metal Concentration (µg/L)	Existing Load (lbs/day)	LA_{NB} (lbs/day)	WLA_{MS} (lbs/day)	Needed Reduction (%)
Aluminum	High flow	441	90	456	TMDLWFRC = 441 lbs/day		3
	Low flow	15	15	2.7	7.1	7.9	0

Where background sample analysis results are less than MDLs, one half of the MDL is the assumed background concentration. The wasteload allocation to mining sources is obtained by subtracting the calculated background load from the TMDL. The allocation scheme assumes that natural background loading rates do not exceed water quality standards and that application of BMPs to West Fork mining sources will reduce loading so that TMDLs and water quality standards are met. The current dataset indicates that a small (3%) high-flow reduction is needed to meet the TMDL and no reduction is needed under low-flow conditions.

The sediment metals analysis record consists of 8 samples; two samples each for sites C02ROCWF01, C02ROCWF02, C02ROCWF03, and C02ROCWF04. The sediment chemistry data do not indicate a pervasive sediment-bound source of metals loading to West Fork Rock Creek.

8.7.5 Flat Gulch (MT76E002_120)

Loading Summary

There are no abandoned mines described in the Flat Gulch drainage in either the MBMG or DEQ abandoned mine databases. The aluminum impairment to Flat Gulch appears not to be directly related to mining activity but rather to aluminum-bearing minerals in local soils and streambed sediment. Natural landscape erosion and, in some instances, human land uses other than mining such as timber harvesting and livestock grazing can disturb and expose surface soil to accelerated erosion and can contribute sediment-bound metals loads to surface waters. Aluminum and iron are common constituents of minerals soils and exceedances of water quality standards for these metals would be expected in areas where waters are affected by accelerated erosion.

Flat Gulch also has a sediment impairment cause and the impairments are likely related. Sediment sources include streambank trampling by domestic livestock and timber harvesting and the associated road network in the upper portions of the drainage. Timber harvest, livestock grazing are potential sediment sources in the lower assessment reach. While no evidence of load mining was found, placer mining did occur in the low assessment reach and could be a additional source of sediment. A potential source of aluminum may be a unidentified mine adit or shaft within Flat Gulch.

Another potential source of aluminum may include metals contributions from groundwater that recharges Flat Gulch. Aluminum is present in soils and minerals and is generally present in ground and surface water at low level. Acidic conditions can dissolve aluminum in soils and geologic features and transport it to waterbodies in the dissolved state.

Flat Gulch was not listed in the 2012 303(d) List as being impaired for any metals parameter, however monitoring and assessment data has revealed that Flat Gulch is impaired for aluminum, and iron. Both iron and aluminum exceed the chronic aquatic life criteria, and therefore require TMDL development. The Flat Gulch water quality dataset includes 13 records from 4 monitoring sites (**Appendix M, Figure M-4** and **Table M-12**). All sites were established by DEQ monitoring and assessment efforts. Water samples were collected during high- and low-flow periods in 2004, 2009-2011.

TMDLs and Allocations

Example TMDLs and allocations for Flat Gulch are contained in **Table 8-18**. The allocation scheme developed for high flow aluminum in Flat Gulch is a composite load allocation to natural background (NB) and sediment sources (SS) of aluminum. Use of a composite allocation reflects the uncertainty in the background aluminum concentrations measured during high flows. The composite allocation for aluminum is expressed by the following equation

$$\mathbf{TMDL_{FG} = LA_{(FG\ NB\ +\ FG\ SS)}}$$

The allocations for low-flow aluminum and iron loading under both flow conditions include load allocations to natural background concentrations ($\mathbf{LA}_{FG\ NB}$) and load allocations to unidentified human sources of these metals ($\mathbf{LA}_{FG\ UH}$). Natural background loading represented by water analysis results from the sites listed in **Table 8-2**. This allocation scheme is reflected in the following TMDL equation:

$$\mathbf{TMDL_{FG} = LA_{(FG\ NB)} + LA_{(FG\ UH)}}$$

Table 8-18. Example TMDLs and wasteload allocation for Flat Gulch at site C02FLAT02

Metal	Flow Conditions	TMDL (lbs/day)	Existing Metal Concentration (µg/L)	Existing Load (lbs/day)	LA_{NB} (lbs/day)	LA_{UH} (lbs/day)	Needed Reduction (%)
Aluminum	High flow	0.0329	50	0.0188	TMDLFG = 0.0329 lbs/day		0
	Low flow	0.0141	130	0.0210	0.0064	0.0076	47
Iron	High flow	0.3776	170	0.0641	0.0775	0.3002	0
	Low flow	0.1618	1370	0.2217	0.0097	0.1553	27

The load allocation to unidentified human influenced sources is obtained by subtracting the calculated background load from the TMDL. The allocation scheme assumes that natural background loading rates do not exceed water quality standards and that application of BMPs to Flat Gulch unidentified human influenced sources will reduce loading so that TMDLs and water quality standards are met. The current dataset indicates that a 47% low-flow reduction is needed to meet the TMDL for Aluminum, and no reduction is needed under high-flow conditions. The current dataset also indicates that a 27% low-flow reduction is needed to meet the TMDL for Iron, and no reduction is needed under high-flow conditions.

The sediment metals analysis record consists of 3 samples; one samples each for sites C02FLAT01, C02FLAT02 and CO2FLAT10. All sediment samples contained less than the corresponding recommended PEL value. The sediment chemistry data do not indicate a pervasive sediment-bound source of metals loading to Flat Gulch.

8.7.6 Scotchman Gulch (MT76E002_100)

Loading Summary

Metals sources in Scotchman Gulch tend to be associated with local sources of sediment. The predominant sediment sources include past mining operations, livestock grazing and silvicultural practices. Past mining sources include two placer operations that are currently inactive. Livestock sediment sources include streambank trampling by domestic livestock. Silvicultural sources of sediment stem from timber harvesting and the associated road network in the upper portions of the drainage. Past placer mining and livestock grazing are the potential sediment sources in the upper reaches of the drainage. Some timber harvesting has occurred in the lower reaches of the forested portion of the drainage.

Scotchman Gulch was not listed in the 2012 303(d) List as being impaired for any metals parameter, however monitoring and assessment data has revealed that Scotchman Gulch is impaired for aluminum. Aluminum exceeds the chronic aquatic life criteria, and therefore requires the development of a TMDL. The Scotchman Gulch water quality dataset includes 13 records from 5 monitoring sites (**Appendix M, Figure M-5** and **Table M-15**). Scotchman Gulch exceeded the chronic aquatic life criteria four times. This provides an exceedance rate of 31% which is above the 10% threshold, requiring TMDL development. All sites were established by DEQ monitoring and assessment efforts. Water samples were collected during high- and low-flow periods in 2004, and 2009 through 2011.

TMDLs and Allocations

Example TMDLs and allocations for Scotchman Gulch are contained in **Table 8-19**. The allocation scheme developed for high flow aluminum in Scotchman Gulch is a composite allocation to natural background (NB), mining sources (MS) and sediment sources (SS) of aluminum. Use of a composite allocation reflects the uncertainty in the background aluminum concentrations measured during high flows. The composite allocation for high-flow aluminum is expressed by the following equation

$$\mathbf{TMDL_{SG} = WLA_{(SG\ NB\ +\ SG\ MS\ \&\ SS)}}$$

The composite allocation scheme states that the sum of allowable high-flow aluminum loading from natural background, plus sediment sources, is equal to the TMDL of 0.2441 lb/day under high-flow conditions. The TMDL equation for high-flow aluminum is inserted into **Table 8-19**.

The allocations for low-flow aluminum include load allocations to natural background concentrations (**LA** $_{SG\ NB}$) and a wasteload allocation to sediment sources (**WLA** $_{SG\ SS}$). Natural background loading is represented by water analysis results from the sites listed in **Table 8-2**.This allocation scheme is reflected in the following TMDL equation:

$$\mathbf{TMDL_{SG} = LA_{SG\ NB} + WLA_{SG\ SS}}$$

Table 8-19. Example TMDLs and wasteload allocation for Scotchman Gulch at site C02FLAT20

Metal	Flow Conditions	TMDL (lbs/day)	Existing Metal Concentration (µg/L)	Existing Load (lbs/day)	LA_{NB} (lbs/day)	$WLA_{MS\ \&\ SS}$ (lbs/day)	Needed Reduction (%)
Aluminum	High flow	0.2441	140	0.5966	**TMDL = 0.2441 lbs/day**		59
	Low flow	0.2487	160	0.5092	0.1273	0.1213	68

The wasteload allocation to mining and sediment sources is obtained by subtracting the calculated background load from the TMDL. The allocation scheme assumes that natural background loading rates do not exceed water quality standards and that application of BMPs to Scotchman Gulch sediment sources will reduce loading so that TMDLs and water quality standards are met. The current dataset for aluminum indicates that a 59% high-flow reduction and a 68% low-flow reduction is needed to meet the TMDL.

The sediment metals analysis record consists of 8 samples; two samples each for sites C02SCTMG01, C02SCTMG10, C02SCTMG02 and C02SCTMG03. All sediment samples contained less than the corresponding recommended PEL value. The sediment chemistry data do not indicate a pervasive sediment-bound source of metals loading to Scotchman Gulch.

8.7.7 Sluice Gulch (MT76E002_110)

Loading Summary

Metals sources in Sluice Gulch tend to be associated with abandoned mines and past mining activities. The predominant source of metals pollution includes two abandoned mining operations. Past mining operations include two abandoned gold and silver lode mines, the Silver king and Lori No. 13 mines. The Silver King is a former gold and silver lode mine occupying about 18 acres on the south flank of Sluice Gulch where the drainage enters the Upper Willow Creek valley. The Lori No. 13 mine disturbs about 9 acres on the north side of the gulch and is about 800 feet from Sluice Gulch surface water. Both the Silver King and Lori No. 13 are ranked as priority mine sites that have potential human health and safety hazards.

Sluice Gulch was listed in the 2012 303(d) List as being impaired for arsenic. The Sluice Gulch water quality dataset includes 8 records from 5 monitoring sites (**Appendix M, Figure M-3** and **Table M-9**). All 8 results for arsenic exceeded the human health criterion of 10 µg/L. Monitoring and assessment data has revealed that Sluice Gulch is impaired for copper as well. One in 8 results for copper exceeded the chronic aquatic life criterion. This provides an exceedance rate of 12.5% which is above the 10% threshold, requiring TMDL development. All sites were established by DEQ monitoring and assessment efforts. Water samples were collected during high- and low-flow periods in 2004, 2010 and 2011.

TMDLs and Allocations

Example TMDLs and allocations for Sluice Gulch are contained in **Table 8-20**. The allocations for arsenic and copper under both flow conditions include load allocations to natural background concentrations (**$LA_{SLG\ NB}$**) and a wasteload allocation to mining sources (**$WLA_{SLG\ MS}$**). Natural background loading to Sluice Gulch is represented by water analysis results from the sites listed in **Table 8-2**. This allocation scheme is reflected in the following TMDL equation:

$$\mathbf{TMDL = LA_{SLG\ NB} + WLA_{SLG\ MS}}$$

Table 8-20. Example TMDLs and wasteload allocation for Sluice Gulch at site C02SLUG01

Metal	Flow Conditions	TMDL (lbs/day)	Existing Metal Concentration (µg/L)	Existing Load (lbs/day)	LA_{NB} (lbs/day)	WLA_{MS} (lbs/day)	Needed Reduction (%)
Arsenic	High flow	0.0755	12	0.0906	0.0113	0.0642	17
	Low flow	0.0647	11	0.0712	0.0065	0.0582	9
Copper	High flow	0.0956	4	0.0302	0.0038	0.0918	0
	Low flow	0.0844	0.5	0.0032	0.0032	0.0812	0

The wasteload allocation to mining sources is obtained by subtracting the calculated background load from the TMDL. The allocation scheme assumes that natural background loading rates do not exceed water quality standards and that application of BMPs to Sluice Gulch mining related sources will reduce loading so that TMDLs and water quality standards are met. The current dataset for arsenic indicates that a 17% high-flow reduction and 9% low-flow reduction is needed to meet the TMDL. Even though **Table 8-20** shows copper currently meeting the TMDL with an overall reduction of 0% for both flow conditions, Sluice Gulch does require a reduction in copper loading at times not represented by **Table 8-20**. This is because the example TMDL presented in **Table 8-20** is calculated based on the highest flow and corresponding pollutant concentration. By following this selection criterion, it leads to the copper aquatic life exceedance contained in the dataset to not be represented in the example TMDL.

The sediment metals analysis record consists of 4 samples; one samples each for sites C02SLUCG01, C02SLUCG10, C02SLUCG02 and C02SLUCG03. Sediment chemistry samples from 3 of 4 sites exceeded the PEL values for arsenic in fresh water stream sediment. The magnitude of arsenic exceedance increases downstream. Measured copper sediment metals concentrations were below the PEL. The sediment chemistry data do not indicate a pervasive sediment-bound source of copper loading to Sluice Gulch.

8.8 Seasonality and Margin of Safety

All TMDL documents must consider seasonal variability on water quality impairment conditions, maximum allowable pollutant loads in a stream (TMDLs), and load allocations. TMDL development must also incorporate a margin of safety into the load allocation process to account for uncertainties in pollutant sources and other watershed conditions, and ensure (to the degree practicable) that the TMDL components and requirements are sufficiently protective of water quality and beneficial uses. This section describes the considerations of seasonality and a margin of safety in the Rock Creek TPA metal TMDL development process.

8.8.1 Seasonality

Seasonality addresses the need to ensure year round designated use support. Seasonality was considered for assessing loading conditions and for developing water quality targets, TMDLs, and allocation schemes. For metals TMDLs, seasonality is important because metals loading pathways and water hardness change from high to low flow conditions. During high flows, loading associated with overland flow and erosion of metals-contaminated soils and mine wastes tend to be the major cause of elevated metals concentrations. During low flow, groundwater transport and/or adit discharges tend to be the major source of elevated metals concentrations. Hardness tends to be lower during higher flow conditions, which leads to lower water quality standards for hardness-dependent metals during the runoff season. Seasonality is addressed in this document as follows:

- Metals concentrations and loading conditions are evaluated for both high flow and low flow conditions.
- Metals TMDLs incorporate streamflow as part of the TMDL equation.
- Metals targets apply year round, with monitoring criteria for target attainment developed to address seasonal water quality extremes associated with loading and hardness variations.
- Targets, TMDLs and load reduction needs are developed for high and low flow conditions.

8.8.2 Margin of Safety

The margin of safety is to ensure that TMDLs and allocations are sufficient to sustain conditions that will support beneficial uses. All metals TMDLs incorporate an implicit MOS in several ways. The implicit margin of safety is applied by using conservative assumptions throughout the TMDL development process and is addressed by the following:

- Target attainment, refinement of load allocations, and, in some cases, impairment validations and TMDL-development decisions are all based on an adaptive management approach that relies on future monitoring and assessment for updating planning and implementation efforts.

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

8.9 Uncertainty and Adaptive Management

The environmental studies required for TMDL development include inherent uncertainties for example: accuracy of field and laboratory data, of source assessments, and of loading calculations. An adaptive management approach that revisits, confirms, or updates loading assumptions is vital to maintaining stakeholder confidence and participation in water quality improvement. Adaptive management uses updated monitoring results to refine loading analysis, to further customize monitoring strategies and to develop a better understanding of impairment conditions and the processes that affect impairment. Adaptive management recognizes the dynamic nature of pollutant loading and water quality response to remediation.

Data quality concerns are managed and mitigated by DEQ’s data quality objective (DQO) process. The use of DQOs ensures that decisions are based on data of known (and acceptable) quality. The DQO process develops criteria for data performance and acceptance that:

- Clarify study intent
- Define the appropriate type of data
- Establish minimum requirements for the quality and quantity of data necessary to meet the goals of a study

Adaptive management also allows for continual feedback on the progress of restoration and the status of beneficial uses. With it we can refine targets as necessary to protect the resource or re-evaluate whether targets are achievable. Such additional monitoring and resulting refinements to loading can improve achieving and measuring success.

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

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

The Abandoned Mines Section of DEQ's Remediation Division will lead abandoned mine restoration projects funded by provisions of the Surface Mine Reclamation and Control Act of 1977. DEQ's Federal Superfund Bureau (also in the Remediation Division) will provide technical and management assistance to EPA for remedial investigations and cleanup actions at national priorities list mine sites in federal-lead status.

Monitoring and restoration conducted by other parties (USFS, BLM, the Montana Department of Natural Resources and Conservation's Trust Lands Management Division, The Nature Conservancy) should be incorporated into the target attainment and review process as well. Cooperation among agency land managers in the adaptive management process for metals TMDLs will help identify further cleanup and load reduction needs, evaluate monitoring results, and identify water quality trends. There are a number of approaches for cleanup of mining operations or other sources of metals contamination in the State of Montana. Several are mentioned above others (along with associated funding options) are discussed in depth in **Appendix N**.

DEQ acknowledges that construction or maintenance activities related to restoration, construction/maintenance, and future development may result in short term increase in surface water metals concentrations. For any activities that occur within the stream or floodplain, all appropriate permits should be obtained prior to work. Federal and State permits necessary to conduct work within a stream or stream corridor are intended to protect the resource and reduce or eliminate, pollutant loading or degradation from the permitted activity. The permit requirements typically have mechanisms that allow for some short term impacts to the resource, as long as all appropriate measures are taken to reduce impact to the least amount possible.

9.0 OTHER IDENTIFIED ISSUES OR CONCERNS

9.1 NON-POLLUTANT LISTINGS

Water quality issues are not limited simply to those streams where TMDLs are developed. In some cases, streams have not yet been reviewed through the assessment process and do not appear on the 303(d) list. In other cases, streams in the Rock Creek 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 "alteration in streamside or littoral vegetation covers" that could be linked to a pollutant. These habitat related non-pollutant causes are often associated with sediment issues, may be associated with nutrient or temperature issues, or may be having a deleterious effect on a beneficial use without a clearly defined quantitative measurement or direct linkage to a pollutant to describe that impact. Nevertheless, the issues associated with these streams are still important to consider when improving water quality conditions in individual streams, and the Rock Creek watershed as a whole. In some cases, pollutant and *non-pollutant* causes are listed for a waterbody, and the management strategies as incorporated through the TMDL development for the pollutant, inherently address some or all of the non-pollutant listings. **Table 9-1** presents only the *non-pollutant* listings in the Rock Creek TPA. Streams for which no TMDLs have been developed are presented in bold italics.

Table 9-1. Waterbody Segments in the Rock Creek TPA with Non-pollutant (Pollution) Listings on the 2012 303(d) List

Waterbody ID	Stream Segment	2012 Probable Causes of Impairment
MT76E002_080	***BASIN GULCH,*** *headwaters to mouth (Eureka Gulch)*	Alteration in streamside or littoral vegetative covers
MT76E002_050	***BREWSTER CREEK****, East Fork to mouth (Rock Creek)*	Fish Passage Barrier
		Low Flow Alterations
MT76E002_020	EAST FORK ROCK CREEK, East Fork Reservoir to mouth (Middle Fork Rock Creek)	Alteration in streamside or littoral vegetative covers
		Low Flow Alterations
		Chlorophyll-*a*
MT76E002_090	EUREKA GULCH, confluence of Quartz Gulch and Basin Gulch to mouth (Un-Named Ditch)	Alteration in streamside or littoral vegetative covers
MT76E002_070	QUARTZ GULCH, headwaters to mouth (Eureka Gulch)	Alteration in streamside or littoral vegetative covers
MT76E002_110	SLUICE GULCH, headwaters to mouth (Rock Creek)	Alteration in streamside or littoral vegetative covers
MT76E002_060	SOUTH FORK ANTELOPE CREEK, headwaters to mouth (Antelope Creek), T6N R15W S22	Alteration in streamside or littoral vegetative covers
MT76E002_040	***UPPER WILLOW CREEK****, headwaters to mouth (Rock Creek)*	Alteration in streamside or littoral vegetative covers
		Low Flow Alterations
		Physical Substrate

9.2 NON-POLLUTANT CAUSES OF IMPAIRMENT DETERMINATION

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.

Fish Passage Barrier

Impairment caused by fish passage barriers is most often related to channel obstacles such as impoundments or perched culverts at road crossings. The impairments are addressed by modification or removal of the barriers or operational changes to allow migration of fish and other aquatic life. Any fish barrier removal must be done in coordination with state and federal fishery representatives since fish passage barriers can beneficially isolate native fish populations, protecting them from non-native invasive species.

In the Rock Creek watershed toxic barriers due to mine discharge may create another form of fish barrier. Toxic barriers may isolate native fish species from non-native fish species, interrupt spawning or seasonal migrations, restrict access to preferred habitats and food resources, increase the chance of predation and disease and reduce genetic flow between populations through population fragmentation Future projects to address toxic stream conditions should incorporate necessary barrier construction or other methods to maintain appropriate fish movement. For example, mine reclamation work could be conducted in a manner to improve distribution of native fish species while maintaining isolated fisheries upstream of the toxic reach of stream.

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.

Other Flow Regime Alterations

Other flow regime alterations may refer to scenarios where land or water management has led to flows that would not be typical under naturally occurring flow conditions. This could be related to irrigation practices, or dam release operations, or even groundwater use that has subsequently altered stream recharge.

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.

Chlorophyll-*a*/Excess Algal Growth

These 2 terms are interchangeable as they identify an impairment of a beneficial use to primary contact recreation from algal growth in the stream channel. Excess algal growth refers to the often visual identification of impairment from phytoplankton/algal growth while chlorophyll-*a* is a direct measure of plant productivity. The most abundant form of chlorophyll within photosynthetic organisms, chlorophyll-*a* is used as a surrogate measure of net primary production in a stream. It is used as a measurement of the population and distribution of microscopic living plant matter (phytoplankton or algae) in a stream reach. Chlorophyll monitoring is a way to track algal growth. In surface waters high chlorophyll concentrations are often correlated with high nutrient concentrations such as nitrogen and phosphorus which can cause algal blooms. When an algal bloom dies off at the end of its life cycle or due to a change in environmental conditions, the resulting decomposition depletes dissolved oxygen (DO) levels in the water column. A loss of DO can lead to fish kills. High nutrient concentrations can be indicative of fertilizer/manure runoff, impacts from silvicultural practices, an impacts from disturbed ground surface associated with mining. Chlorophyll-*a* can therefore be used as an indirect measure of nutrient levels. For both descriptors, chlorophyll-*a* and excess algal growth indicate an oversupply of nutrients to the system.

9.3 Monitoring and BMPs for Non-Pollutant Affected Streams

Two forms of habitat alteration (alteration in streamside or littoral vegetation covers and physical substrate habitat alterations) can be linked to the sediment TMDL development, where there is overlap between the two. It is likely that meeting the sediment targets will also equate to addressing the habitat impairment conditions in each of these streams. For the streams with no developed TMDL, meeting the sediment targets applied to streams of similar size will likely equate to addressing the habitat impairment condition for each stream.

Streams listed for *non-pollutants* as opposed to a pollutant should not be overlooked when developing watershed management plans. Attempts should be made to collect sediment, nutrient, and temperature information where data is minimal and the linkage between probable cause, non-pollutant listing, and effects to the beneficial uses are not well defined. Watershed management planning should also include strategies to help increase streamflows, particularly during summer low flow periods for those streams with low flow alteration impairment causes. The monitoring and restoration strategies that follow in **Sections 10.0** and **11.0** are presented to address both pollutant and non-pollutant issues for streams in the Rock Creek TPA with TMDLs in this document, and they are equally applicable to streams listed for the above non-pollutant categories.

10.0 Water Quality Improvement Plan

10.1 Summary of Restoration Strategy

This section describes an overall strategy and specific on-the-ground measures designed to restore beneficial water uses and attain water quality standards in Rock Creek TMDL project area streams. The strategy includes general measures for reducing loading from each significant identified pollutant source.

This section should assist stakeholders in developing a more detailed adaptive Watershed Restoration Plan (WRP) in the future. The locally-developed WRP will likely provide more detailed information about restoration goals and spatial considerations within the watershed. The WRP may also encompass broader goals than the focused water quality restoration strategy outlined in this document. The intent of the WRP is to serve as a locally organized “road map” for watershed activities, sequences of projects, prioritizing types of projects, and funding sources towards achieving local watershed goals, including water quality improvements. Within this plan, the local stakeholders would identify and prioritize streams, tasks, resources, and schedules for applying Best Management Practices (BMPs). As restoration experiences and results are assessed through watershed monitoring, this strategy could be adapted and revised by stakeholders based on new information and ongoing improvements.

10.2 Role of DEQ, Other Agencies, and Stakeholders

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

Because most nonpoint source reductions rely on voluntary measures, it is important that local landowners, watershed organizations, and resource managers work collaboratively with local and state agencies to achieve water quality restoration to meet TMDL targets and load reductions. Specific stakeholders and agencies that will likely be vital to restoration efforts for streams discussed in this document include the Granite Conservation District, USFS, USFWS, NRCS, DNRC, FWP, EPA, and DEQ. Other organizations and non-profits that may provide assistance through technical expertise, funding, educational outreach, or other means include the Clark Fork Coalition, Rock Creek Protective Association, Montana Trout Unlimited, Montana Water Trust, Montana Water Center, University of Montana Watershed Health Clinic, Montana Bureau of Mines and Geology, Montana Aquatic Resources Services (MARS), and MSU Extension Water Quality Program.

10.3 Water Quality Restoration Objectives

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

- Provide general technical guidance for full recovery of aquatic life beneficial uses to all impaired streams within the Rock Creek TPA by improving pollutant and non-pollutant related water quality conditions. This technical guidance is provided by the TMDL components in the document which include:
    - water quality targets,

- o pollutant source assessments, and
- o a broad restoration and TMDL implementation strategy to meet TMDL allocations

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

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

Water quality goals for the various pollutants are detailed in **Sections 5, 6, 7, and 8.** These goals include water quality and habitat targets as a measure for long-term effectiveness monitoring. These targets specify satisfactory conditions to ensure protection and/or recovery of beneficial uses of waterbodies in the Rock Creek TPA. It is presumed that the meeting of all water quality and habitat targets will signal the achievement of water quality goals for a given stream. **Section 11** identifies a general monitoring strategy and recommendations to track post-implementation water quality conditions and measure restoration successes.

10.4 Overview of Management Recommendations

TMDLs were completed for ten waterbody segments for sediment, one waterbody segment for temperature, five waterbody segments for nutrients, and seven waterbody segments for metals. Other streams in the watershed may be in need of restoration or pollutant reduction, but insufficient information about them precludes TMDL formation at this time. The following sub-sections describe some generalized recommendations for implementing projects to achieve the TMDL. Details specific to each stream, and therefore which of the following strategies may be most appropriate, are found within **Section 5, 6, 7** and **8**.

10.4.1 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 Rock Creek 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 best management practices, 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 Rock Creek TPA. In particular, the Granite 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 Rock Creek watershed.

10.4.2 Temperature Restoration Approach

The goal of the temperature restoration approach is to reduce water temperatures where possible to be consistent with naturally occurring conditions. The most significant mechanisms for reducing water temperature are increasing shade and increasing flow. Secondarily, recovery of overwidened stream channels to a more natural morphology may also aid in reducing temperatures.

Increase in shade can be accomplished through the restoration and protection of shade-providing vegetation within the riparian corridor. This type of vegetation can also have the added benefit of serving as a stabilizing component to streambanks to reduce bank erosion, slow lateral river migration, and buffer pollutants from upland sources from entering the stream. In some cases, this can be achieved by limiting the frequency and duration of livestock access to the riparian corridor, or through other grazing related BMPs such as installing water gaps or off-site watering. Other areas may require planting, active bank restoration, and protection from browse to establish vegetation.

Increasing instream summer flows can be achieved through a thorough investigation of water use practices and water conveyance infrastructure, and a willingness and ability of local water users to keep more water instream. This TMDL document cannot, nor is it intended to, prescribe limitations on individual water rights owners and users. However, it is understood that increased summer instream flows could improve summer water temperatures, and in addition improve quality and connectivity among instream features used by aquatic life. Local water users should work collectively and with local, state, and federal resource management professionals to review water use options and available assistance programs.

Recovery of stream channel morphology in most cases will occur slowly over time and follow the improvement of riparian condition, stabilization of streambanks, and reduction in overall sediment load. For smaller streams, there may be discrete locations or portions of reaches that demand a more rapid intervention through physical restoration, but size, scale, and cost of restoration in most cases are limiting factors to applying a constructed remedy.

The above approaches give only the broadest description of activities to help reduce water temperatures. The temperature assessment described in **Section 6.0** looked at possible scenarios based on limited information at the watershed scale. Those scenarios showed that improvements in stream temperatures can be made through increased shade and flow, but site-specific analysis and detailed review of current land management and water use practices was not included in the assessment. Therefore, it is not suggested that every operator and water user in the basin need to change their practices in order to reduce stream temperatures; there may be some who currently manage their land and water use consistent with all reasonable land, soil, and water conservation practices, and there may be others for whom changing their practices at this stage is not a viable option due to economic or other constraints. Nevertheless, it is strongly encouraged that continued investigations be conducted by resource managers and land owners to identify all potential areas of improvement and develop projects and practices to reduce stream temperatures in East Fork Rock Creek.

10.4.3 Nutrients Restoration Approach

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 , cropland and historically impacted areas (mining).

Cropland filter strip extension, vegetative restoration, and long-term filter area maintenance are vital BMPs for achieving nutrient TMDLs in predominantly agricultural watersheds. Grazing systems with the explicit goal of increased vegetative post-grazing ground cover are needed to address the same nutrient loading from rangelands. Grazing prescriptions that enhance the filtering capacity of riparian filter areas offer a second tier of controls on the sediment content of upland runoff. Grazing and pasture management adjustments should consider:

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

In addition to the agricultural related BMPs, a reduction of sediment delivery from roads and eroding streambanks is another component of the nutrient reduction restoration plan. Additional sediment related BMPs are presented in **Section 10.5.**

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

Potential nutrient loading sources associated with historical mining practices include discharging mine adits and mine waste materials on-site and in-channel. The goal of the nutrient restoration strategy is to limit the input of nutrients to stream channels from abandoned mine sites and other mining related sources. For most of the mining-related sources, additional analysis and identification will likely be required to identify site-specific delivery pathways and to develop mitigation plans.

Goals and objectives for future restoration work include the following:

- Prevent contaminants or nutrients contaminated solid materials in the waste rock and tailings materials/sediments from migrating into adjacent surface waters to the extent practicable
- Reduce or eliminate concentrated runoff and discharges that generate sediment and/or heavy contamination to adjacent surface waters and groundwater to the extent practicable
- Identify, prioritize, and select response and restoration actions based on a comprehensive source assessment and streamlined risk analysis of areas affected by historical mining.

10.4.4 Metals Restoration Approach

Metal mining is the principal human-caused source of excess metals loading in the planning area. To date, federal and state government agencies have funded and completed reclamation projects associated with past mining. Statutory mechanisms and corresponding government agency programs will continue to have the leading role for future restoration. Restoration of metals sources is typically conducted under state and federal cleanup programs. Rather than a detailed discussion of specific BMPs, general restoration programs and funding sources applicable to mining sources of metals loading are provided in **Section 10.5.6.** Past efforts have produced abandoned mine site inventories with enough descriptive detail to prioritize the properties contributing the largest metals loads. Additional monitoring needed to further describe impairment conditions and loading sources is addressed in the **Section 11.3.1**

10.4.5 Pollution Restoration Approach

Although TMDL development is not required for pollution listings, they are frequently linked to pollutants, and addressing pollution sources is an important component of TMDL implementation. Pollution listings within the Rock Creek TPA are described in **Section 9.0**. Typically, habitat impairments are addressed during implementation of associated pollutant TMDLs. Therefore, if restoration goals within the Rock Creek TPA are not also addressing pollution impairments, additional pollution-related BMP implementation should be considered.

10.5 Restoration Approaches by Source

Generalized management recommendations are outlined below for the major sources of human caused pollutant loads in the Rock Creek TPA: grazing, upland sources, riparian and wetland vegetation removal, irrigation, roads and historical mining practices. Applying BMPs are the core of the pollutant reduction strategy, but are only part of a watershed restoration strategy. Restoration activities may also address other current pollution-causing uses and management practices. In some cases, efforts beyond implementing new BMPs may be required to address key pollutant sources. In these cases, BMPs are usually identified as a first effort and an adaptive management approach will be used to determine if further restoration approaches are necessary to achieve water quality standards. Monitoring is also an important part of the restoration process. Monitoring recommendations are outlined in **Section 11.0**.

10.5.1 Agriculture Sources

Reduction of pollutants from upland agricultural sources can be done by limiting the amount of erodible soil, reducing the rate of runoff, and intercepting eroding soil and runoff before it enters a waterbody. The main BMP recommendations for the Rock Creek watershed are riparian buffers, wetland restoration, and vegetated filter strips, where appropriate. These methods reduce the rate of runoff, promote infiltration of the soil (instead of delivering runoff directly to the stream), and intercept pollutants. Filter strips and buffers are even more effective for reducing upland agricultural related sediment when used in conjunction with BMPs that reduce the availability of erodible soil such as conservation tillage, crop rotation, and stripcropping (although currently there is very little cropping activity that occurs in the Rock Creek watershed). Additional BMP information, design standards and effectiveness, and details on the suggested BMPs can be obtained from your local USDA Agricultural Service Center and in Montana's Nonpoint Source Management Plan (Montana Department of Environmental Quality, 2012d).

An additional benefit of reducing sediment input to the stream is a decrease in sediment-bound nutrients. Reductions in sediment loads may help address some nutrient related problems. Nutrient management considers the amount, source, placement, form, and timing of plant nutrients and soil amendments. Conservation plans should include the following information (NRCS MT 590-1):

- Field maps and soil maps
- Planned crop rotation or sequence
- Results of soil, water, plant, and organic materials sample analysis
- Realistic expected yields
- Sources of all nutrients to be applied
- A detailed nutrient budget

- Nutrient rates, form, timing, and application method to meet crop demands and soil quality concerns
- Location of designated sensitive areas
- Guidelines for operation and maintenance

10.5.1.1 Grazing

Development of riparian grazing management plans should be a goal for any landowner in the watershed who operates livestock and does not currently have such plans. Private land owners may be assisted by state, county, federal, and local conservation groups to establish and implement appropriate grazing management plans. Note that riparian grazing management does not necessary eliminate all grazing in riparian corridors. Nevertheless, in some areas, a more limited management strategy may be necessary for a period of time in order to accelerate re-establishment of a riparian community with the most desirable species composition and structure.

Every livestock grazing operation should have a grazing management plan. The plan should at least include the following elements:

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

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

- Minimizing or preventing livestock grazing in riparian and wetland areas
- Providing off-stream watering facilities or using low-impact water gaps to prevent 'loafing' in wet areas
- Managing riparian pastures separately from upland pastures
- Installing salt licks, feeding stations, and shelter fences to prevent 'loafing' in riparian areas
- Replanting trodden down banks and riparian and wetland areas with native vegetation (this should always be coupled with a reduction in grazing pressure)
- Rotational grazing or intensive pasture management

The following resources may be able to help you prevent pollution and maximize productivity from your grazing operation:

- USDA, Natural Resources Conservation Service. You can find your local USDA Agricultural Service Center listed in your phone directory or on the Internet at www.nrcs.usda.gov
- Montana State University Extension Service www.extn.msu.montana.edu
- DEQ Watershed Protection Section, Nonpoint Source Program www.deq.mt.gov/wqinfo/nonpoint/NonpointSourceProgram

The key strategy of the recommended grazing BMPs is to develop and maintain healthy riparian and wetland vegetation and minimize disturbance of the streambank and channel. The primary recommended BMPs for the Rock Creek watershed are limiting livestock access to streams and stabilizing the stream at access points, providing off-site watering sources when and where appropriate, planting native stabilizing vegetation along streambanks, and establishing and maintaining riparian buffers. Although bank revegetation is a preferred BMP, in some instances bank stabilization may be necessary prior to planting vegetation.

10.5.1.2 Animal Feeding Operations

Animal feeding operations (AFOs) can pose a number of risks to water quality and public health if the animal manure and wastewater they generate contaminates nearby waters. To minimize water quality and public health concerns from AFOs and land applications of animal waste, the USDA and EPA released the Unified National Strategy for AFOs in 1999 (United States Department of Agriculture, Natural Resources Conservation Service, 2005). This strategy encouraged owners of AFOs of any size or number of animals to voluntarily develop and implement site-specific Comprehensive Nutrient Management Plans (CNMPs). A CNMP 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 other options for manure disposal.

An AFO that meets certain specified criteria is referred to as a Concentrated Animal Feeding Operation (CAFO). CAFOs may be required to obtain a Montana Pollution Discharge Elimination System (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. In addition to water quality benefits, these practices may help to 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 percent (United States Department of Agriculture, Natural Resources Conservation Service, 2005). 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. Studies have shown benefits in red meat and milk production of 10 to 20 percent by livestock and dairy animals when good quality drinking water is substituted for contaminated surface water.

Opportunities for financial and technical assistance (including CNMP development) in achieving voluntary AFO and CAFO compliance may be available from conservation districts, NRCS field offices, or the Montana DEQ Watershed Protection Section (among other sources). Further information on CAFO discharge permitting may be obtained from the DEQ website at:
www.deq.mt.gov/wqinfo/mpdes/cafo.mcpx

Montana's Nonpoint Source (NPS) pollution control strategies for addressing AFOs are summarized in the bullets below:

- Work with producers to prevent NPS 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 other 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 and grant opportunities for BMPs that meet their needs. (This is in addition to funds available through NRCS and the Farm Bill).
- Develop early intervention of education & 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 Division, as well as external entities such as DNRC, local watershed groups, conservation districts, and MSU Extension.

10.5.1.3 Flow and Irrigation

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 sediment 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). Restoration targets and implementation strategies recognize the need for specific flow regimes, and may suggest flow-related improvements as a means to achieve full support of beneficial uses. However, 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).

Irrigation management is a critical component of attaining both coldwater fishery conservation and TMDL goals. In the Rock Creek watershed, irrigation management is complicated by a diversion in East Fork Rock Creek for use in the Flint Creek watershed. Management practices for irrigation efficiency in the Rock Creek and Flint Creek watersheds should investigate reducing the amount of stream water diverted during July and August, while still maintaining healthy crops or forage. It may also be desirable to investigate irrigation practices earlier in the year that promote groundwater return during July, August, and September. Understanding irrigation water, groundwater and surface water interactions is an important part of understanding how irrigation practices will affect streamflow during specific seasons.

Some irrigation practices in western Montana are based in flood irrigation methods. Occasionally, head gates and ditches leak, which can decrease the amount of water in diversion flows. The following recommended activities could result in notable water savings.

- Install upgraded head gates for more exact control of diversion flow and to minimize leakage when not in operation.
- Develop more efficient means to supply water to livestock.
- Determine necessary diversion flows and timeframes that would reduce over watering and improve forage quality and production.
- Where appropriate, redesign or reconfigure irrigation systems.
- Upgrade ditches (including possible lining) to increase ditch conveyance efficiency.

Future studies could investigate irrigation water return flow timeframes from specific areas in both the Rock Creek and Flint Creek watersheds. Some water from spring and early summer flood irrigation likely returns as cool groundwater to the streams during the heat of the summer. These critical areas could be identified so that they can be preserved as flood irrigation areas. Other irrigated areas which do not contribute to summer groundwater returns to the river should be identified as areas where year round irrigation efficiencies could be more beneficial than seasonal management practices. Winter baseflow should also be considered during these investigations.

10.5.1.4 Small Acreages

Throughout Montana, the number of small acreage properties is growing rapidly, and many small acreage owners own horses or cattle. Animals grazing in 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 agricultural 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, 2012d) or the MSU extension website at: http://www.msuextension.org/ruralliving/Index.html.

10.5.1.5 Cropland

The primary strategy of the recommended cropland BMPs is to reduce sediment inputs. 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 recommendations for the Rock Creek TPA are vegetated filter strips (VFS) and riparian buffers. Both of these methods reduce the rate of runoff, promote infiltration of the soil (instead of delivering runoff directly to the stream), and intercept sediment. Effectiveness is typically about 70 percent for the filter strips and 50 percent for the buffers (Montana Department of Environmental Quality, 2012d). Filter strips and 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. Filter strips along streams should be composed of natural vegetative communities. Additional BMPs and details on the suggested BMPs can be obtained from NRCS and in Appendix A of Montana's NPS Management Plan (Montana Department of Environmental Quality, 2012d).

10.5.2 Forestry and Timber Harvest

Currently, active timber harvest is not significantly affecting sediment in the Rock Creek TPA. While no nutrient load allocations were allocated directly to timber harvests, a composite nutrient load allocation consisting of agricultural and silvicultural practices were allocated to the South Fork of Antelope Creek. Timber harvesting will likely continue in the future within the Beaverhead-Deer Lodge National Forest, and on private land. Future 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, harvest design, other harvesting activities, slash treatment and site preparation, winter logging, and hazardous substances. While the SMZ Law is intended to guide commercial timber harvesting activities in streamside areas (i.e. within 50 feet of a waterbody), the riparian protection principles behind the law can 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. The 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.

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

10.5.3 Riparian Areas, Wetlands, and Floodplains

Riparian areas, wetlands, and floodplains are critical for wildlife habitat, groundwater recharge, reducing the severity of floods and upland and streambank erosion, and filtering pollutants from runoff. The performance of the above named functions is dependent on the connectivity of riparian areas, wetlands and floodplains to both the stream channel and upland areas. Anthropogenic activities affecting the quality of these transitional habitats or their connectivity can alter their performance and greatly affect the transport of water, sediments, and contaminants (e.g. channelization, increased stream power, bank erosion, and habitat loss or degradation). Therefore, restoring maintaining, and protecting riparian areas, wetlands, and floodplains within the watershed should be a priority of TMDL implementation in the Rock Creek TPA.

Reduction of riparian and wetland vegetative cover by various land management activities is a principal cause of water quality and habitat degradation in watersheds throughout Montana. Although implementation of passive BMPs that allow riparian and wetland vegetation to recover at natural rates is typically the most cost-effective approach, active restoration (i.e. plantings) may be necessary in some instances. The primary advantage of riparian and wetland plantings is that installation can be accomplished with minimum impact to the stream channel, existing vegetation, and private property.

Factors influencing the appropriate riparian and wetland restoration would include severity of degradation, site-potential for various species, and availability of local sources for native transplant materials. In general, riparian and wetland plantings would promote establishment of functioning stands of native species. The following recommended restoration measures would allow for stabilization of the soil, decrease sediment delivery to the stream, and increase absorption of nutrients from overland runoff.

- Harvest and transplant locally available sod mats with an existing dense root mass which provide immediate promotion of bank stability and filtering nutrients and sediments.
- Transplanting mature native shrubs, particularly willows (*Salix* sp.), provides rapid restoration of instream habitat and water quality through overhead cover and stream shading as well as uptake of nutrients.
- Seeding with native graminoids (grasses and sedges) and forbs is a low cost activity at locations where lower bank shear stresses would be unlikely to cause erosion.
- Willow sprigging expedites vegetative recovery, but involves harvest of dormant willow stakes from local sources.
- ***Note***: Before transplanting *Salix* from one location to another it is important to determine the exact species so that we do not propagate the spread of non-native species. There are several non-native willow species that are similar to our native species and commonly present in Montana watersheds.

In addition to the benefits noted above, it should be noted that in some cases wetlands act as areas of shallow subsurface groundwater recharge and/or storage areas. The captured water via wetlands is then generally discharged to the stream later in the season and contributes to the maintenance of base flows and stream temperatures. Restoring ditched or drained wetlands can have a substantial effect on the quantity, temperature, and timing of water returning to a stream, as well as the pollutant filtering capacity that improved riparian and wetlands provide.

10.5.4 Unpaved Roads

The road sediment reductions in this document represent a gross estimation of the sediment load that would remain once road BMPs were applied, assuming no current BMPs are in place. In general, a road with associated BMPs assumes contributing road treads, cutslopes, and fillslopes were reduced to 100 feet (from each side of a crossing). This distance is selected as an example to illustrate the potential for sediment reduction through BMP application and is not a formal goal at every crossing. For example, many roads may easily allow for a smaller contributing length, while others may not be able to meet a 100ft goal. Achieving this reduction in sediment loading from roads may occur through a variety of methods at the discretion of local land managers and restoration specialists. Road BMPs can be found on the Montana DEQ or DNRC websites and within Montana's NPS Management Plan (Montana Department of Environmental Quality, 2012d). Examples include:

- Providing adequate ditch relief up-grade of stream crossings.
- Constructing waterbars, where appropriate, and up-grade of stream crossings.
- Use rolling dips on downhill grades with an embankment on one side to direct flow to the ditch.
- Inslope roads along steep banks with the use of cross slopes and cross culverts.
- Outslope low traffic roads on gently sloping terrain with the use of a cross slope.
- Use ditch turnouts and vegetative filter strips to decrease water velocity and sediment carrying capacity in ditches.
- For maintenance, grade materials to the center of the road and avoid removing the toe of the cutslope.
- Prevent disturbance to vulnerable slopes.
- Use topography to filter sediments; flat, vegetated areas are more effective sediment filters.
- Where possible, limit road access during wet periods when drainage features could be damaged.

10.5.4.1 Culverts

Although there are a lot of factors associated with culvert failure and it is difficult to estimate the true at-risk load, the culvert analysis found that approximately 56% of the culverts pass the discharge of a 25-year storm event. The allocation strategy for culverts is no loading from culverts as a result of being undersized, improperly installed, or inadequately maintained. The culvert assessment included 27 culverts in the watershed, which is a small percentage of the total culverts, and it is recommended that the remaining culverts be assessed so that a priority list may be developed for culvert replacement. As culverts fail, they should be replaced by culverts that pass a 100 year flood on fish bearing streams and at least 25 year events on non fish bearing streams. Some road crossings may not pose a feasible situation for upgrades to these sizes because of road bed configuration; in those circumstances, the largest size culvert feasible should be used. If funding is available, culverts should be prioritized and replaced prior to failure.

Another consideration for culvert upgrades should be fish and aquatic organism passage. In a coarse assessment of fish passage, 96% of assessed culverts were determined to pose a significant passage risk to juvenile fish at all flows; this suggests that a large percentage of culverts in the watershed are barriers to fish passage. Each fish barrier should be assessed individually to determine if it functions as an invasive species and/or native species barrier. These two functions should be weighed against each other to determine if each culvert acting as a fish passage barrier should be mitigated. Montana FWP can aid in determining if a fish passage barrier should be mitigated, and, if so, can aid in culvert design.

10.5.4.2 Traction Sand
Severe winter weather and mountainous roads in the Rock Creek TPA will require the continued use of relatively large quantities of traction sand. Nevertheless, closer evaluation of and adjustments to existing practices should be done to reduce traction sand loading to streams the extent practicable. The necessary BMPs may vary throughout the watershed and particularly between state and private roads but may include the following:

- Utilize a snow blower to directionally place snow and traction sand on cutslopes/fillslopes away from sensitive environments.
- Increase the use of chemical deicers and decrease the use of road sand, as long as doing so does not create a safety hazard or cause undue degradation to vegetation and water quality.
- Improve maintenance records to better estimate the use of road sand and chemicals, as well as to estimate the amount of sand recovered in sensitive areas.
- Continue to fund MDT research projects that will identify the best designs and procedures for minimizing road sand impacts to adjacent bodies of water and incorporate those findings into additional BMPs.
- Street sweeping and sand reclamation.
- Identify areas where the buffer could be improved or structural control measures may be needed.
- Improved maintenance of existing BMPs.
- Increase availability of traction sand BMP training to both permanent and seasonal MDT employees as well as private contractors.

10.5.5 Bank Hardening/Riprap/Revetment/Floodplain Development
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 it is necessary in some instances, it generally redirects channel energy and exacerbates erosion in other places. Bank armoring should be limited to areas with a demonstrated threat to infrastructure. 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. Limit threats to infrastructure by reducing floodplain development through land use planning initiatives.

Bank stabilization using natural channel design techniques can provide both bank stability and habitat potential. The primary recommended structures include natural or “natural-like” structures, such as large woody debris jams. These natural arrays can be constructed to emulate historical debris assemblages that were introduced to the channel by the adjacent cottonwood dominated riparian community types. When used together, woody debris jams and straight log vanes can benefit the stream and fishery by improving bank stability, reducing bank erosion rates, adding protection to fillslopes and/or embankments, reducing near-bank shear stress, and enhancing aquatic habitat and lateral channel margin complexity.

10.5.6 Mining

Mining activities may have impacts that extend beyond increased metal concentrations in the water. Channel alteration, riparian degradation, and runoff and erosion associated with mining can lead to sediment, habitat, nutrient, and temperature impacts as well. The need for further characterization of impairment conditions and loading sources is addressed through the framework monitoring plan in **Section 11.3.1**.

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 Rock Creek watershed include:

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

10.5.6.1 The Surface Mining Control and Reclamation Act (SMCRA)

DEQ's Abandoned Mines Bureau (AMB) is responsible for reclamation of abandoned mines in Montana. The AMB reclamation program is funded through the Surface Mining Control and Reclamation Act of 1977 (SMCRA). SMCRA funding is collected as a per ton fee on coal production that is then distributed to states by the federal Office of Surface Mining Reclamation and Enforcement (OSM). Funding eligibility is based on land ownership and date of mining disturbance. Eligible abandoned coal mine sites have a priority for reclamation construction funding over eligible non-coal sites. Areas within federal Superfund sites and areas where there is a reclamation obligation under state or federal laws are not eligible for expenditures from the abandoned mine reclamation program. **Table 10-1** lists the priority abandoned mines in the Rock Creek TMDL planning area.

Table 10-1. Priority Abandoned Mine Sites in the Rock Creek TMDL Planning Area.

Site Name	Receiving Stream	Disturbance Area (acres)	Current Ranking Score
Alps	Brewster Creek	14	79
Banner Creek Tailings	Middle Fork Rock Creek	7	59
Millers Mine	Middle Fork Rock Creek	13	65
Old Dominion Mine	Middle Fork Rock Creek	14	83
Silver King	Sluice Gulch	18	34
Ant	South Fork Antelope Creek	20	82
Lori 13	Sluice Gulch	10	NA*

*Lori 13 Mine is listed on the Abandoned Hard Rock Mine Priority Sites 1995 Summary Report; however it was considered to not have significant human health or safety issues and was not given a ranking

10.5.6.2 Montana Comprehensive Environmental Cleanup and Responsibility Act (CECRA)

Reclamation of past mining-related disturbances administered by the State of Montana and not addressed under SMCRA, are typically addressed through the DEQ State Superfund program. The Comprehensive Environmental Cleanup and Responsibility Act (CECRA) passed the Montana Legislature in 1989 as a means to require cleanup of hazardous substance releases threatening human health and the environment. The CECRA program maintains a prioritized list of facilities potentially requiring response actions based on the confirmed or threatened release of a hazardous or deleterious substance.

CECRA encourages voluntary cleanup activities under the Voluntary Cleanup and Redevelopment Act (VCRA) that recommended a method of apportioning site liability and created a fund for cleanup of sites where a responsible party has not been identified. Mining-related metals loading sources identified in the future could be added to the CECRA list and addressed through CECRA, with or without the VCRA processes. A site can be added to the CECRA list at DEQ's initiative, or in response to a complete written request made to the department by any person. Currently, there is one active site on the CECRA priority list in the Rock Creek TPA:

The Neal Family Limited Partnership (Silver King Mine); located about a 1/2 mile up gradient of Rock Creek in Sluice Gulch. This site was added to the Comprehensive Environmental Response, Compensation, and Liability Act list based preliminary assessments conducted by the Bureau of Land Management in 1986 found elevated iron in the surface water of Sluice Gulch; slightly elevated copper, iron, manganese and zinc in the adit discharge water; and high arsenic and antimony and somewhat elevated copper, mercury, manganese and lead in tailings and waste rock piles. CECRA's future involvement at the site will depend upon whether or not the site is eligible for cleanup under DSL's reclamation program.

The goal of the metals restoration strategy is to limit the input of metals to streams from priority abandoned mine sites and other significant sources. Additional analysis will likely be required to describe site-specific metals delivery pathways and to develop mitigation plans. The following goals and objectives apply to future restoration of most mining-related sources:

- Prevent soluble metal contaminants or metals contaminated solid materials in waste rock and tailings from migrating into surface waters and groundwater.
- Reduce or eliminate concentrated runoff that entrains and delivers metal-laden sediment to adjacent surface waters.
- Identify, prioritize, and select reclamation and restoration options for mining sources based on a thorough source assessment and streamlined risk analysis.

10.5.6.3 Other Historical Mine Remediation Programs

Appendix N provides a summary of mining remediation programs and approaches that can be or may currently be applied within the Rock Creek watershed. The extent that these programs may be necessary will depend on the level of stakeholder involvement and initiative throughout the watersheds with metals impairment causes.

10.6 Potential Funding Sources

Funding and prioritization of restoration or water quality improvement projects is integral to maintaining restoration activities and monitoring project 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. **Appendix N** of this document outlines funding sources to assist with mining related TMDL implementation.

10.6.1 Section 319 Nonpoint Source Grant Program

Section 319 grant funds are typically used to help identify, prioritize, and implement water quality protection projects with focus on TMDL development and implementation of nonpoint source projects. Individual contracts under the yearly grant typically range from $20,000 to $150,000, with a 40 percent match requirement. 319 projects typically need to be administered through a non-profit or local government such as a conservation district, a watershed planning group, or a county.

10.6.2 Future Fisheries Improvement Program

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

10.6.3 Watershed Planning and Assistance Grants

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

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

10.6.4 Environmental Quality Incentives Program

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

10.6.5 Resource Indemnity Trust/Reclamation and Development Grants Program

The Resource Indemnity Trust/Reclamation and Development Grants Program (RIT/RDG) is an annual program administered by MT DNRC that can provide up to $300,000 to address environmental related 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 typically need to be administered through a non-profit or local government such as a conservation district, a watershed planning group, or a county.

11.0 Monitoring Strategy and Adaptive Management

11.1 Introduction

The monitoring strategies discussed in this section are an important component of watershed restoration, a requirement of TMDL development under Montana's TMDL law, and the foundation of the adaptive management approach. Water quality targets and allocations presented in this document are based on available data at the time of analysis, however the scale of the watershed coupled with constraints on time and resources often result in compromises that must be made that include estimations, extrapolation, and a level of uncertainty. The margin of safety (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 strategy presented in this section provides a starting point for the development of more detailed and specific planning efforts regarding monitoring needs; it does not assign monitoring responsibility. Monitoring recommendations provided are intended to assist local land managers, stakeholder groups, and federal and state agencies in developing appropriate monitoring plans to meet aforementioned goals. Funding for future monitoring is uncertain and can vary with economic and political changes. Prioritizing monitoring activities depends on stakeholder priorities for restoration and funding opportunities.

11.2 Adaptive Management and Uncertainty

An adaptive management approach is recommended to control costs and meet the water quality standards to support all beneficial uses. This approach works in cooperation with the monitoring strategy, and as new information is collected, it allows for adjustments to restoration goals or pollutant targets, TMDLs, and/or allocations, as necessary.

11.3 Future Monitoring Guidance

The objectives for future monitoring in the Rock Creek watershed 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 Rock Creek Watershed 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.

11.3.1 Strengthening Source Assessment

In the Rock Creek TPA, the identification of 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 subwatersheds. Strategies for strengthening source assessments for each of the pollutants may include:

Sediment

- 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 subwatersheds 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 bank erosion conditions and investigation of related contributing factors for each subwatershed of concern through site visits and subwatershed scale BEHI assessments. Additionally, the development of bank erosion retreat rates specific to the Rock Creek 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.

Temperature

- Assessment of irrigation network in East Fork Rock Creek and the Flint Creek watershed to better understand irrigation efficiency and needs for the Flint Creek water users
- Field surveys to better identify riparian area conditions and potential for improvement.
- Additional temperature data logger recordings throughout the East Fork Rock Creek and at major tributary or irrigation return inputs to better discern temperature fluctuations and causes.
- Investigation of groundwater influence on instream temperatures, and relationships between groundwater availability and water use in the valley.
- Assessment of water use in the valley and potential for improvements in water use that would result in increased instream flows.
- Flow measurements at all temperature data locations at the time of data collection.

Nutrients

- A better understanding of nutrient concentrations in groundwater (as well as the sources) and the spatial variability of groundwater with high nutrient concentrations
- A better understanding of the cattle grazing practices and the number of animals grazed in the Rock Creek watershed
- A more detailed understanding of nutrient contributions from historical mining within the watershed
- A review of land management practices specific to sub-watersheds of concern to determine where the greatest potential for improvement can occur for the major land use categories
- Additional sampling in streams with limited data

Metals

The level of detail of the source assessment allows allocations to broad source categories and geographic areas. Additional monitoring may be helpful to better partition pollutant loading at mine sites with multiple sources. The needed refinements may require more seasonally stratified sampling or a more detailed field reconnaissance and follow-up sampling to better locate stream segments representing background loading.

In Flat Gulch, the inability to distinguish background aluminum loading from human-caused aluminum loading led to use of a broad composite allocation. Further sampling would allow better delineation of aluminum sources.

The descriptions of several of the priority abandoned mines are based on information collected during early 1990s site inventories. Additional site reconnaissance and monitoring of discrete sources is needed to better understand sources of metals loading and develop remediation strategies. The following bulleted items describe source assessment information that could improve our understanding of loading at a number of priority mine sites.

- A more detailed characterization of groundwater quality from the Old Dominion and Banner Tailings Mines as well as an assessment of groundwater interactions with surface water in the Middle Fork of Rock Creek.
- A more detailed surface water monitoring regime directed at defining sources of metals pollution from all priority mine sites.
- A more detailed mapping of source locations and past surface water monitoring sites at the Ant and Lori 13 Mines, along with more recent water quality analyses, would help clarify the loading situation these sites in the South Fork of Antelope Creek.

Additional water quality sampling in streams with minimal data such as West Fork Rock Creek, Eureka, Gulch and Scotchman Gulch would yield a better understanding of the specific metals affecting these streams (see discussion in **Section 11.3.2**).

11.3.2 Increase Available Data

While the Rock Creek watershed 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.

Sediment

For sediment investigation in the Rock Creek TPA, each of the streams of interest were stratified into unique reaches based on physical characteristics and anthropogenic influence. A total of 22 sites were sampled throughout the watershed, however this equates to only a small percentage of the total number of stratified reaches, and even less on a stream by stream basis. 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.

Temperature

Temperature investigation for East Fork Rock Creek included 7 data loggers that were deployed throughout the stream and at a key tributary input. Increasing the number of data logger locations and the number of years of data, and collecting associated flow data, would improve our understanding of instream temperature changes in the river, and better identify influencing factors on those changes.

Nutrients
Water quality sampling locations for nutrients were distributed spatially along each assessment unit 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 Rock Creek watershed 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.

Metals
Additional monitoring may be helpful to better partition pollutant loading at mine sites with multiple sources, such as those having discrete adit discharges versus more diffuse runoff from sulfide waste accumulations. The needed refinements may require more seasonally stratified sampling or a more detailed field reconnaissance and follow-up sampling to better locate stream segments representing background loading. **Table 11-1** lists the waterbodies, pollutants, and flow conditions where additional data is needed.

Table 11-1. Waterbodies, metal pollutants, and flow conditions for which additional data is needed

Stream Segment	Pollutant/s	Flow Condition
WEST FORK ROCK CREEK	Mercury	High and Low
EUREAKA GULCH	Aluminum	High and Low
	Arsenic	High and Low
	Cadmium	High and Low
	Copper	High and Low
	Iron	High and Low
	Lead	High and Low
	Silver	High and Low
	Zinc	High and Low
	Mercury	High and Low
SCOTCHMAN GULCH	Mercury	High and Low

For the pollutant-waterbody combinations in **Table 11-1**, follow up monitoring should focus on defining the contribution from discrete sources within abandoned mine sites. As this information becomes available, TMDL allocation schemes may be modified to include load allocations to background sources, as opposed to the current composite WLAs.

11.3.3 Consistent Data Collection and Methodologies
Data has been collected throughout the Rock Creek watershed 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.

The Montana Department of Environmental Quality (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.

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 Rock Creek watershed 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.

Temperature

Consistency in temperature data collection is not as significant for what is collected as much as how and where it is collected. Data loggers should be deployed at the same locations through the years to accurately represent the site specific conditions over time, and recorded temperatures should at a minimum represent the hottest part of the summer when aquatic life is most sensitive to warmer temperatures. Data loggers should be deployed in the same manner at each location and during each sampling event, and follow a consistent process for calibration and installation. Any modeling that is used should refer to previous modeling efforts (such as the QUAL2K analysis used in this document) for consistency in model development to ensure comparability. In addition, flow measurements should also be conducted using consistent locations and method.

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 11-2**). In addition, stream discharge should be measured at time of sampling.

Table 11-2. 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 HDPE	≤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			

Metals

As a result of water and sediment data collected during TMDL development, TMDLs were developed for several metals that were not on the 2012 303(d) List, and TMDLs were not developed for some listed metals because recent data did not exceed water quality targets and/or anthropogenic sources were not identified. Based on the data evaluations within this document (**Section 11.3.2**), several metals have been identified and recommended for future monitoring.

Metals monitoring should include analysis of a suite of total recoverable metals (e.g. As, Cu, Cd, Pb, Zn), sediment samples, hardness, pH, discharge and TSS for all pollutant-waterbody combinations. **Table 11-3** identifies the current DEQ metals sampling methodologies and reporting limits for the standard metals suite (water and sediment).

Table 11-3. DEQ Metals Monitoring Parameter Requirements

Parameter	Preferred Method	Alternate Method	Req. Report Limit ug/L	Holding Time Days	Bottle	Preservative
Water Sample - Common Ions and Physical Parameters						
Total Hardness as $CaCO_3$	A2340 B (Calc)		1000			
Total Suspended Solids	A2540D		4000	7	1000 ml HDPE/500 mlHDPE	≤6oC
Water Sample - Dissolved Metals (0.45 um filtered)						
Aluminum	EPA 200.7	EPA 200.8	9	180	250 ml HDPE	Filt 0.45 um, HNO_3
Water Sample - Total Recoverable Metals						
Total Recoverable Metals Digestion	EPA 200.2	APHA3030F (b)	N/A	180	500 ml HDPE/ 250 ml HDPE	HNO_3
Arsenic	EPA 200.8		1			
Cadmium	EPA 200.8		0.03			
Calcium	EPA 200.7		1000			
Chromium	EPA 200.8	EPA 200.7	1			
Copper	EPA 200.8	EPA 200.7	1			
Iron	EPA 200.7		20			
Lead	EPA 200.8		0.3			
Magnesium	EPA 200.7		1000			
Potassium	EPA 200.7		1000			
Selenium	EPA 200.8		1			

Table 11-3. DEQ Metals Monitoring Parameter Requirements

Parameter	Preferred Method	Alternate Method	Req. Report Limit ug/L	Holding Time Days	Bottle	Preservative
Silver	EPA 200.8	EPA 200.7/200.9	0.2			
Sodium	EPA 200.7		1000			
Zinc	EPA 200.7	EPA 200.8	8			
Antimony	EPA 200.8		0.5			
Barium	EPA 200.7	EPA 200.8	3			
Beryllium	EPA 200.7	EPA 200.8	0.8			
Boron	EPA 200.7	EPA 200.8	10			
Manganese	EPA 200.7	EPA 200.8	5			
Nickel	EPA 200.7	EPA 200.8	2			
Thallium	EPA 200.8		0.2			
Uranium, Natural	EPA 200.8		0.2			
Parameter	**Preferred Method**	**Alternate Method**	**Req. Report Limit mg/kg (dry weight)**	**Holding Time Days**	**Bottle**	**Preservative**
Sediment Sample - Total Recoverable Metals						
Total Recoverable Metals Digestion	EPA 200.2		N/A	180	2000 ml HDPE Widemouth	
Arsenic	EPA 200.8	EPA 200.9	1			
Cadmium	EPA 200.8	EPA 200.9	0.2			
Chromium	EPA 200.8	EPA 200.7	9			
Copper	EPA 200.8	EPA 200.7	15			
Iron	EPA 200.7	EPA 200.7	10			
Lead	EPA 200.8	EPA 200.9	5			
Zinc	EPA 200.7	EPA 200.7	20			
Sediment Sample - Total Metals						
Mercury	EPA 7471B		0.05	28	2000 ml HDPE Widemouth	

11.3.4 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.

11.3.5 Watershed Wide Analyses

Recommendations for monitoring in the Rock Creek watershed 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.

12.0 Stakeholder and Public Participation

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

12.1 Participants and Roles

Throughout completion of the Rock Creek TPA TMDLs, DEQ worked to keep stakeholders 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 Rock TPA and their roles is contained below.

Montana Department of Environmental Quality
Montana state law (MCA 75-5-703) directs DEQ to develop all necessary TMDLs. DEQ has provided resources toward completion of these TMDLs in terms of staff, funding, internal planning, data collection, technical assessments, document development, and stakeholder communication and coordination. DEQ has worked with other state and federal agencies to gather data and conduct technical assessments. DEQ has also partnered with watershed organizations to collect data and coordinate local outreach activities for this project.

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

Conservation Districts
The majority of the Rock Creek TPA falls within Granite County (a small portion of Missoula Conservation District falls within the TPA but does not have any streams with TMDLs). DEQ provided the Granite Conservation District with consultation opportunity during development of TMDLs. This included opportunities to provide comment during the various stages of TMDL development, and an opportunity for participation in the advisory group discussed below.

TMDL Advisory Group
The Rock Creek TMDL Advisory Group consisted of selected resource professionals who possess a familiarity with water quality issues and processes in the Rock Creek 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 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 e-mail and draft documents were made available through DEQ's wiki for TMDL projects (http://montanatmdlflathead.pbworks.com). Opportunities for review and comment were provided for participants at varying stages of TMDL development, including opportunity for review of the draft TMDL document prior to the public comment period.

12.2 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.

This public review period was initiated on July 26th, 2013 and ended on August 23rd, 2013. At the public meeting on August 6th in Philipsburg, MT, DEQ provided an overview of the TMDLs for the Rock Creek TMDL Planning Area, made copies of the document available to the public, and solicited public input and comment on the plan. The announcement for that meeting was distributed among the Watershed Advisory group and advertised in the following newspapers: The Missoulian and the Philipsburg Mail. This section includes DEQ's response to all public comments received during the public comment period.

One letter from the Montana Department of Natural Resources and Conservation was submitted to the DEQ during the public comment period. The comment letter is provided below. The response prepared by DEQ follows the comment. The original comment letter is held on file at the DEQ and may be viewed upon request.

Montana Department of Natural Resources and Conservation
Comment #1
Montana DNRC shares the same concerns that forest management 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. One reference in the draft TMDL that is perplexing is that the TMDL recommends that timber harvest should not increase peak water yield be more than 10 percent of historic conditions and that natural disturbance, such as fire, increases water yield, the increase should be accounted for as part of timber harvest management. I would like additional detail on the basis for the 10% threshold specific to this area. I also don't understand what a 10% increase over historic conditions includes, especially when one considers the range of natural variability in forested conditions. The Rock Creek area has had periodic and extensive fire a Water Yield increase of 10% increase over fully forested conditions is not being very representative of the range of natural conditions that we would expect to occur in the basin.

Response to Comment #1
Thank you for reviewing the document and providing comment. The DEQ agrees that it is difficult to set a numeric threshold to this area because of natural variability. The final paragraph in **Section 10.5.2** appropriately describes the general recommendation, and therefore the entire paragraph regarding the 10% threshold recommendation was deleted.

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