Central Clark Fork Tributaries TMDLs and Water Quality Improvement Plan

June 2014

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Document Number COL-TMDL-01a

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Suggested citation: Montana DEQ. 2014. Draft Central Clark Fork Tributaries TMDLs and Water Quality Improvement Plan. Helena, MT: Montana Dept. of Environmental Quality.

Acknowledgements

This section will be completed prior to EPA submittal.

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Acronym List

This section will be completed prior to EPA submittal.

DOCUMENT SUMMARY

This document presents a total maximum daily load (TMDL) and framework water quality improvement plan for 13 impaired streams in the Central Clark Fork Tributaries TMDL Project Area, including Dry Creek, Flat Creek, Trout Creek, Nemote Creek, West Fork Petty Creek, Petty Creek, Stony Creek, Grant Creek, Cramer Creek, Tenmile Creek, Deep Creek, Mulkey Creek, and Rattler Gulch (see **Figure 2-1** found in **Section 2.0**).

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

The project area follows the mainstem of the Clark Fork River from the mouth of Flint Creek to the mouth of the Flathead River. The area includes the watersheds of smaller streams draining directly to the Clark Fork River. The project area encompasses approximately 2,021 square miles (1,293,440 acres) in western Montana. The project area includes portions of Granite, Missoula, Mineral, and Sanders counties (although no project streams are located in Sanders County). Three TMDL Planning Areas (TPAs) are found within the Central Clark Fork Tributaries project area, and they are the Clark Fork-Drummond TPA, Middle Clark Fork Tributaries TPA, and the Ninemile TPA.

DEQ determined that 13 waterbodies do not meet the applicable water quality standards. The scope of the TMDLs in this document addresses problems with sediment, nutrients, temperature, and turbidity (see **Table DS-1**). This document addresses pollutant and non-pollutant causes of impairment. Future TMDL projects may require additional TMDLs for these TPAs.

Sediment

Sediment was identified as impairing aquatic life in nine of the waterbodies identified in this document, which includes: Flat Creek, West Fork Petty Creek, Petty Creek, Grant Creek, Cramer Creek, Tenmile Creek, Deep Creek, Mulkey Creek, and Rattler Gulch. TMDLs will be written for each of these waterbodies. Sediment is affecting designated uses in these streams by altering aquatic insect communities, reducing fish spawning success, and increasing turbidity. Water quality improvement goals for sediment were established on the basis of fine sediment levels in trout spawning areas and aquatic insect habitat, stream morphology and available in-stream habitat as it related to the effects of sediment, and the stability of streambanks. DEQ believes that once these water quality goals are met, all beneficial uses currently affected by sediment will be restored.

Sediment loads are quantified for natural background conditions and for the following sources: streambank erosion, upland erosion, unpaved roads, and permitted point sources. To meet the TMDLs, permit conditions must be followed for the point sources and nonpoint sources must implement all reasonable land, soil, and water conservation practices. The Central Clark Fork Tributaries sediment TMDLs indicate that reductions in sediment loads ranging from 15% - 57% 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 maintaining unpaved roads and improving upland land cover and expanding riparian buffer areas by using land, soil, and water conservation practices that improve stream channel conditions and associated riparian vegetation.

Nutrients

Nutrients were identified as impairing aquatic life and primary contact recreation in eight of the waterbodies identified in this document. Total nitrogen (TN) total phosphorous (TP), are causing impairment on Dry Creek, Nemote Creek, West Fork Petty Creek, Stony Creek, Grant Creek, Tenmile Creek, and Rattler Gulch. TMDLs will be written for each of these waterbody pollutant combinations. Grant Creek and Deep Creek are also impaired by and nitrate/nitrite (NO_3+NO_2); this impairment cause will be addressed by the TN TMDL for Grant Creek and a NO_3+NO_2 for Deep Creek.

Timber harvest, livestock grazing, mining, septic systems, and agriculture are potential sources of nutrients impairment. TMDL examples based on monitoring data show that measured TN loads require reductions of 43.9% -49.1% to meet the TMDL, measured NO_3+NO_2 loads require reductions of up to 40%, and measured TP loads require reductions 10.7% - 83.1%. BMPs for timber harvest, livestock grazing, mining, septic systems, and agriculture are recommended in this document to limit inputs from those sources and ensure that all water quality targets for nutrients are met. Appropriate BMPs are described in further detail in **Sections 10 and 11**.

Temperature

Temperature was identified as impairing aquatic life on Nemote Creek, Petty Creek, and Grant Creek, and TMDLs will be developed for each stream. Historic removal of riparian vegetation, which is important for regulating stream temperature by providing shade, is the primary cause of impairment. Water quality improvement goals focus on improving riparian shade, however, maintaining stable stream channel morphology and in-stream flow conditions during the hottest months of the summer are also important for meeting the TMDL. DEQ believes that once these water quality goals are met, all water uses currently affected by temperature will be restored given all reasonable land, soil, and water conservation practices.

Nemote Creek, Petty Creek, and Grant Creek exceed naturally occurring maximum daily water temperatures by 6% - 20%. The example TMDLs for Nemote Creek, Petty Creek, and Grant Creek, provided in **Section 7.7** show necessary percent reduction of 19%, 6%, and 20%, respectively. General strategies for achieving the in-stream water temperature reduction goals are also presented in this plan and include BMPs for managing riparian areas and increasing water use efficiency.

Turbidity

Turbidity was identified as impairing aquatic life in Trout Creek, and a turbidity TMDL will be written for that waterbody. The DEQ assessment file links the turbidity listing to wet weather discharges from non-point source and silviculture activities, which were identified in a 1990 assessment of the stream. The source of the turbidity was identified in photo documentation from October 1990 as leachate from sawmill log storage areas near the mouth, which were affecting color and turbidity in Trout Creek. There was a large log-processing facility near the mouth of Trout Creek (Clark Fork River).

Since 1990, sawmill operations have converted to production of posts and poles, wood pellets, and bark mulch at facilities on the site of the old dimension lumber mill on private lands. Significant evidence of historic and active placer mining in the Trout Creek drainage was noted in the 1990 and 2012 assessment work, which are additional potential sources for increased turbidity. By implementing the appropriate mining and stormwater BMPs, DEQ believes that all beneficial uses currently impaired by turbidity will be fully restored.

Water Quality Improvement Measures

Implementation of most water quality improvement measures described in this document 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.

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

Although most water quality improvement measures are based on voluntary measures, federal law specifies permit requirements developed to protect narrative water quality criterion, a numeric water quality criterion, or both, to be consistent with the assumptions and requirements of wasteload allocations (WLAs) on streams were TMDLs have been developed and approved by EPA.

Table DS-1. List of Impaired Waterbodies and their Impaired Uses in the Central Clark Fork Tributaries TMDL Project Area with Completed Sediment, Nutrient, Temperature, and Turbidity TMDLs Contained in this Document

Waterbody & Location Description	TMDL Prepared	TMDL Pollutant Category	Impaired Use(s)
Dry Creek, headwaters to mouth (Clark Fork River)	Nitrogen (Total)	Nutrients	Aquatic Life, Primary Contact Recreation
Flat Creek, headwaters to mouth (Clark Fork River)	Sedimentation/Siltation	Sediment	Aquatic Life, Primary Contact Recreation
Trout Creek, headwaters to mouth (Clark Fork River)	Turbidity	Sediment	Aquatic Life
Nemote Creek, headwaters to mouth (Clark Fork River)	Nitrogen (Total)	Nutrients	Aquatic Life, Primary Contact Recreation
	Phosphorus (Total)	Nutrients	Aquatic Life, Primary Contact Recreation
	Temperature, water	Temperature	Aquatic Life
West Fork Petty Creek, headwaters to mouth (Petty Creek)	Phosphorus (Total)	Nutrients	Aquatic Life, Primary Contact Recreation
	Sedimentation/Siltation	Sediment	Aquatic Life
Petty Creek, headwaters to mouth (Clark Fork River)	Sedimentation/Siltation	Sediment	Aquatic Life
	Temperature, water	Temperature	Aquatic Life

Table DS-1. List of Impaired Waterbodies and their Impaired Uses in the Central Clark Fork Tributaries TMDL Project Area with Completed Sediment, Nutrient, Temperature, and Turbidity TMDLs Contained in this Document

Waterbody & Location Description	TMDL Prepared	TMDL Pollutant Category	Impaired Use(s)
Stony Creek, headwaters to mouth (Ninemile Creek)	Phosphorus (Total)	Nutrients	Aquatic Life, Primary Contact Recreation
Grant Creek, headwaters to mouth (Clark Fork River)	Nitrate/Nitrite (Nitrite + Nitrate as N)	Nutrients	Aquatic Life, Primary Contact Recreation
	Nitrogen (Total)	Nutrients	Aquatic Life, Primary Contact Recreation
	Sedimentation/Siltation	Sediment	Aquatic Life
	Temperature, water	Temperature	Aquatic Life
Cramer Creek, headwaters to mouth (Clark Fork River)	Sedimentation/Siltation	Sediment	Aquatic Life
Tenmile Creek, headwaters to mouth (Bear Creek)	Phosphorus (Total)	Nutrients	Aquatic Life, Primary Contact Recreation
	Sedimentation/Siltation	Sediment	Aquatic Life
Deep Creek, headwaters to mouth (Bear Creek)	Nitrate/Nitrite (Nitrite + Nitrate as N)	Nutrients	Aquatic Life
	Sedimentation/Siltation	Sediment	Aquatic Life
Mulkey Creek, headwaters to mouth (Clark Fork River)	Sedimentation/Siltation	Sediment	Aquatic Life, Primary Contact Recreation
Rattler Gulch, headwaters to mouth (Clark Fork River)	Phosphorus (Total)	Nutrients	Aquatic Life
	Sedimentation/Siltation	Sediment	Aquatic Life

*Impaired uses given in this table are based on updated assessment results and may not match the "2014 Water Quality Integrated Report."

1.0 PROJECT OVERVIEW

This document presents an analysis of water quality information and establishes 23 total maximum daily loads (TMDLs) for sediment, nutrients, temperature, and turbidity problems in the Central Clark Fork Tributaries TMDL Project Area. This document also presents a general framework for resolving these problems. **Figure 2-1**, found in **Section 2.1**, shows a map of waterbodies in the Central Clark Fork Tributaries TMDL Project Area with sediment, nutrients, temperature, and turbidity pollutant listings.

1.1 WHY WE WRITE TMDLS

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

Montana's water quality designated use classification system includes the following:
- fish and aquatic life
- wildlife
- recreation
- agriculture
- industry
- drinking water

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

Montana's biennial IR identifies all the state's impaired waterbody segments. The 303(d) list portion of the IR includes all of those waterbody segments impaired by a pollutant, which require a TMDL, whereas TMDLs are not required for non-pollutant causes of impairments. **Table A-1** in **Appendix A** identifies all impaired waters for the Central Clark Fork Tributaries TMDL Project Area from Montana's 2014 303(d) List, and includes non-pollutant impairment causes included in Montana's "2014 Water Quality Integrated Report"(Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2014). **Table A-1** provides the current status of each impairment cause, identifying whether it has been addressed by TMDL development.

Both Montana state law (Section 75-5-701 of the Montana Water Quality Act) and section 303(d) of the federal CWA require the development of 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 (see **Sections 10 and 11** of this document).

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 "2014 Water Quality Integrated Report" (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2014) that are addressed in this document (also see **Figure 2-1** in **Section 2.1**). Each pollutant impairment falls within a TMDL pollutant category (e.g., sediment, nutrients, temperature, or turbidity) and this document is organized by those categories.

TMDLs are completed for each waterbody – pollutant combination, and this document contains 23 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**. **Section 9** also provides some basic water quality solutions to address those non-pollutant causes not specifically addressed by TMDLs in this document.

Although DEQ recognizes that there are other pollutant listings for the Central Clark Fork Tributaries project area without completed TMDLs (**Table A-1** in **Appendix A**), this document only addresses those identified in **Table 1-1**. This is because DEQ sometimes develops TMDLs in a watershed at varying phases, with a focus on one or a couple of specific pollutant types. Metals TMDLs were previously completed for this project area in 2013 (Montana Department of Environmental Quality, 2013). **Table A-1** in **Appendix A** includes impairment causes with completed TMDLs, as well as non-pollutant impairment causes that were addressed by those TMDLs.

Table 1-1. Water Quality Impairment Causes for the [TPA or Project Area Name] Addressed within this Document

Waterbody & Location Description [1]	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status [2]
Dry Creek, headwaters to mouth (Clark Fork River)	MT76M002_170	Alteration in stream-side or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by a TN TMDL in this document
		Nitrogen (Total)	Nutrients	TN TMDL contained in this document
		Low flow alterations	Not Applicable; Non-Pollutant	Partially addressed in Section 9 of this document
Flat Creek, headwaters to mouth (Clark Fork River)	MT76M002_180	Physical substrate habitat alterations	Not Applicable; Non-Pollutant	Addressed by a sediment TMDL in this document
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document
Trout Creek, headwaters to mouth (Clark Fork River)	MT76M002_050	Alteration in stream-side or littoral vegetative covers	Not Applicable; Non-Pollutant	Partially addressed in Section 9 of this document
		Physical substrate habitat alterations	Not Applicable; Non-Pollutant	Partially addressed in Section 9 of this document
		Turbidity	Sediment	Turbidity TMDL contained in this document
Nemote Creek, headwaters to mouth (Clark Fork River)	MT76M002_160	Chlorophyll-*a*	Not Applicable; Non-Pollutant	Addressed by TN & TP TMDLs contained in this document

Table 1-1. Water Quality Impairment Causes for the [TPA or Project Area Name] Addressed within this Document

Waterbody & Location Description [1]	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status [2]
		Low Flow Alterations	Not Applicable; Non-Pollutant	Partially addressed in Section 9 of this document
		Nitrogen (Total)	Nutrients	TN TMDL contained in this document
		Phosphorus (Total)	Nutrients	TP TMDL contained in this document
		Temperature, water	Temperature	Temperature TMDL contained in this document
West Fork Petty Creek, headwaters to mouth (Petty Creek)	MT76M002_100	Chlorophyll-*a*	Not Applicable; Non-Pollutant	Addressed by a TP TMDL contained in this document
		Phosphorus (Total)	Nutrients	TP TMDL contained in this document
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document
Petty Creek, headwaters to mouth (Clark Fork River)	MT76M002_090	Alteration in stream-side or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by a sediment TMDL in this document
		Low flow alterations	Not Applicable; Non-Pollutant	Partially addressed in Section 9 of this document
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document

Table 1-1. Water Quality Impairment Causes for the [TPA or Project Area Name] Addressed within this Document

Waterbody & Location Description [1]	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status [2]
		Temperature, water	Temperature	Temperature TMDL contained in this document
Stony Creek, headwaters to mouth (Ninemile Creek)	MT76M004_020	Phosphorus (Total)	Nutrients	TP TMDL contained in this document
Grant Creek, headwaters to mouth (Clark Fork River)	MT76M002_130	Alteration in stream-side or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by a sediment TMDL in this document
		Excess Algal Growth	Not Applicable; Non-Pollutant	Addressed by a TN TMDL in this document
		Low flow alterations	Not Applicable; Non-Pollutant	Partially addressed in Section 9 of this document
		Nitrate/Nitrite (Nitrite + Nitrate as N)	Nutrients	Addressed by a TN TMDL in this document
		Nitrogen (Total)	Nutrients	TN TMDL contained in this document
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document
		Temperature, water	Temperature	Temperature TMDL contained in this document
Cramer Creek, headwaters to mouth (Clark Fork River)	MT76E004_020	Cause Unknown	Not Applicable; Non-Pollutant	*Addressed by a sediment TMDL in this document

Table 1-1. Water Quality Impairment Causes for the [TPA or Project Area Name] Addressed within this Document

Waterbody & Location Description [1]	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status [2]
		Physical substrate habitat alterations	Not Applicable; Non-Pollutant	Addressed by a sediment TMDL in this document
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document
Tenmile Creek, headwaters to mouth (Bear Creek)	MT76E004_030	Alteration in stream-side or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by a sediment TMDL in this document
		Phosphorus (Total)	Nutrients	TP TMDL contained in this document
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document
Deep Creek, headwaters to mouth (Bear Creek)	MT76E004_070	Chlorophyll-*a*	Not Applicable; Non-Pollutant	Addressed by a NO_2+NO_3 TMDL contained in this document
		Low Flow Alterations	Not Applicable; Non-Pollutant	Partially addressed in Section 9 of this document
		Nitrate/Nitrite (Nitrite + Nitrate as N)	Nutrients	NO_2+NO_3 TMDL contained in this document
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document
Mulkey Creek, headwaters to mouth (Clark Fork River)	MT76E004_050	Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document

Table 1-1. Water Quality Impairment Causes for the [TPA or Project Area Name] Addressed within this Document

Waterbody & Location Description [1]	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status [2]
Rattler Gulch, headwaters to mouth (Clark Fork River)	MT76E004_060	Alteration in stream-side or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by a sediment TMDL in this document
		Chlorophyll-*a*	Not Applicable; Non-Pollutant	Addressed by a TP TMDL contained in this document
		Low Flow Alterations	Not Applicable; Non-Pollutant	Partially addressed in Section 9 of this document
		Phosphorus (Total)	Nutrients	TP TMDL contained in this document
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document

1. All waterbody segments within Montana's Water Quality Integrated Report are indexed to the National Hydrography Dataset (NHD)
2. TN = Total Nitrogen, TP = Total Phosphorus, NO_2+NO_3 = Nitrite + Nitrate

1.3 What This Document Contains

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 nutrients, temperature, and turbidity. The TMDL components are summarized within the main body of the document. Additional technical details are contained in the appendices and attachments. In addition to this introductory section, this document includes:

Section 2.0 Central Clark Fork Tributaries Project Area Description:
Describes the physical characteristics and social profile of the project area.

Section 3.0 Montana Water Quality Standards
Discusses the water quality standards that apply to the Central Clark Fork Tributaries project area.

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

Sections 5.0 – 8.0 Sediment, Nutrient, Temperature, and Turbidity TMDL Components (sequentially):
Each section includes (a) a discussion of the affected waterbodies and the pollutant's effect on designated beneficial uses, (b) the information sources and assessment methods used to evaluate stream health and pollutant source contributions, (c) water quality targets and existing water quality conditions, (d) the quantified pollutant loading from the identified sources, (e) the determined TMDL for each waterbody, (f) the allocations of the allowable pollutant load to the identified sources.

Section 9.0 Non-Pollutant Impairments:
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 Water Quality Improvement Plan:
Discusses water quality restoration objectives and 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 "Central Clark Fork Tributaries TMDLs and Water Quality Improvement Plan".

Section 12.0 Public Participation & Public Comments:
Describes other agencies and stakeholder groups who were involved with the development of this plan and the public participation process used to review the draft document. Addresses comments received during the public review period.

2.0 Project Area Description

This section describes the physical, ecological, and social characteristics of the Central Clark Fork Tributaries TMDL project area ("project area"). These descriptions provide a context for the more detailed pollutant source assessments presented in following chapters.

2.1 Physical Characteristics

The following information describes the physical geography of the project area. This includes location, climate, hydrology, and geology.

2.1.1 Location

The project area follows the mainstem of the Clark Fork River from the mouth of Flint Creek to the mouth of the Flathead River. The area includes the watersheds of smaller streams draining directly to the Clark Fork River. The project area encompasses approximately 2,021 square miles (1,293,440 acres) in western Montana. The project area includes portions of Granite, Missoula, Mineral, and Sanders counties (although no project streams are located in Sanders County). The 13 streams addressed in this document are mapped below in **Figure 2-1**.

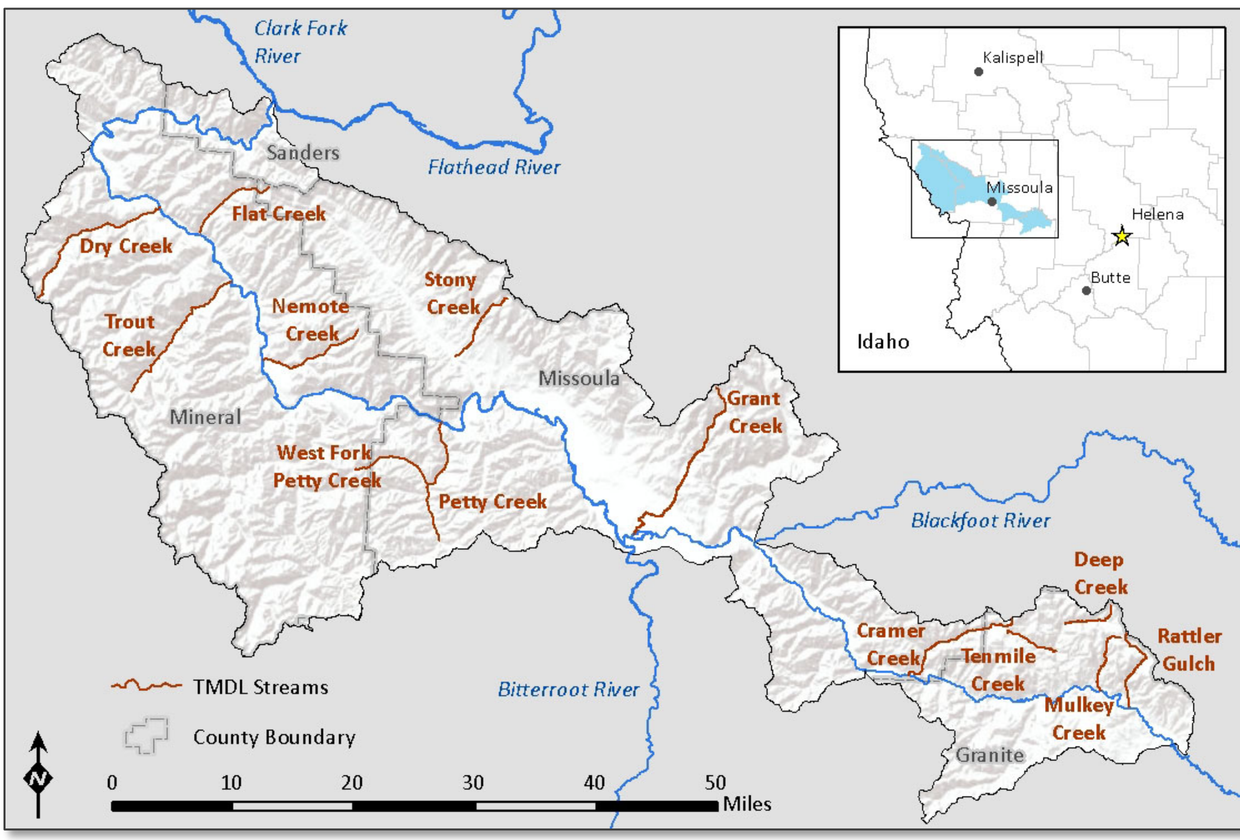

Figure 2-1. Location of project area and project streams

2.1.2 Topography

The topography is mapped below in **Figure 2-2**. Elevation ranges from nearly 9,000 feet in the headwaters of Grant Creek to 2,480 feet at the confluence with the Flathead River.

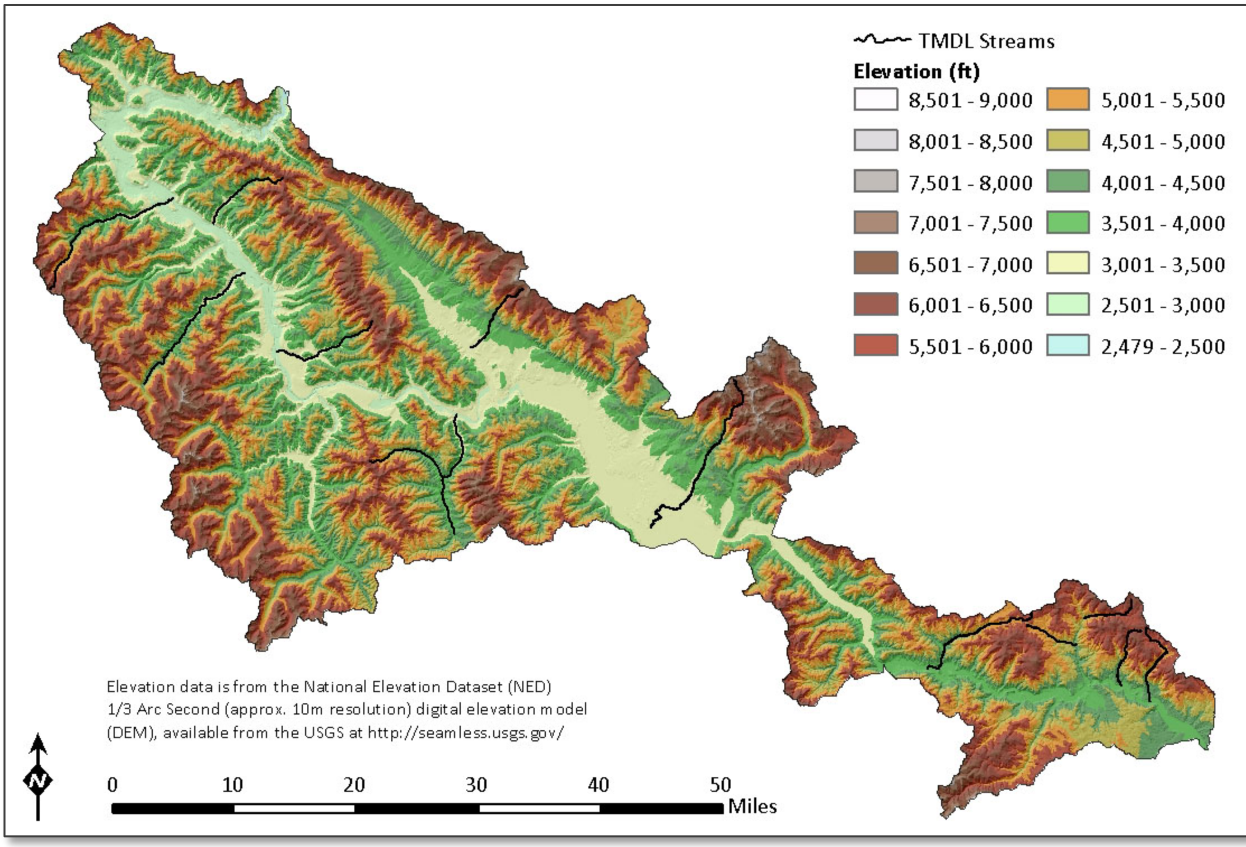

Figure 2-2. Topography

2.1.3 Climate

The project area spans a wide section of western Montana, and there is a measurable gradient in climate along its length. This is well illustrated by considering average precipitation and temperature. Average precipitation along the Clark Fork River corridor ranges from just over 12 inches per year in the Drummond Valley to just under 17 inches per year at Superior, according to climate summaries provided by the Western Regional Climate Center (http://www.wrcc.dri.edu/summary/Climsmnidwmt.html). May and June are consistently the wettest months of the year and winter precipitation is dominated by snowfall. Average annual precipitation is mapped below in **Figure 2-3**. Precipitation is highest in the mountains south of the Clark Fork River, along the Idaho border.

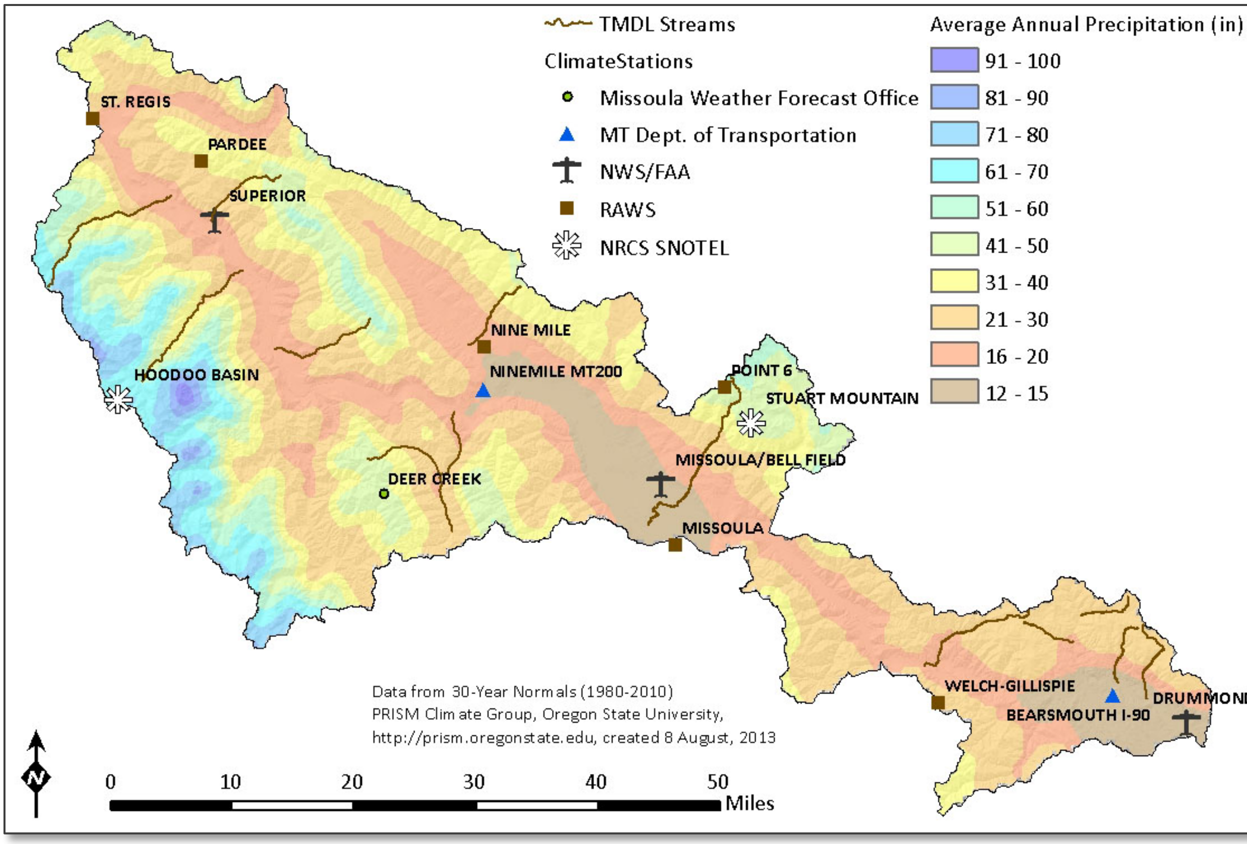

Figure 2-3. Average annual precipitation

The climate tends to be more moderate downstream of Missoula. This is evident in a map of average annual temperatures (**Figure 2-4**). The climatic end members are the Drummond Valley, a mid elevation intermontane basin typified by cold winters and mild summers, to the Plains Valley (just downstream of the project area), a lower elevation intermontane basin typical of the Northern Rockies with warm summers and cool, humid winters (Kendy and Tresch, 1996 1328).

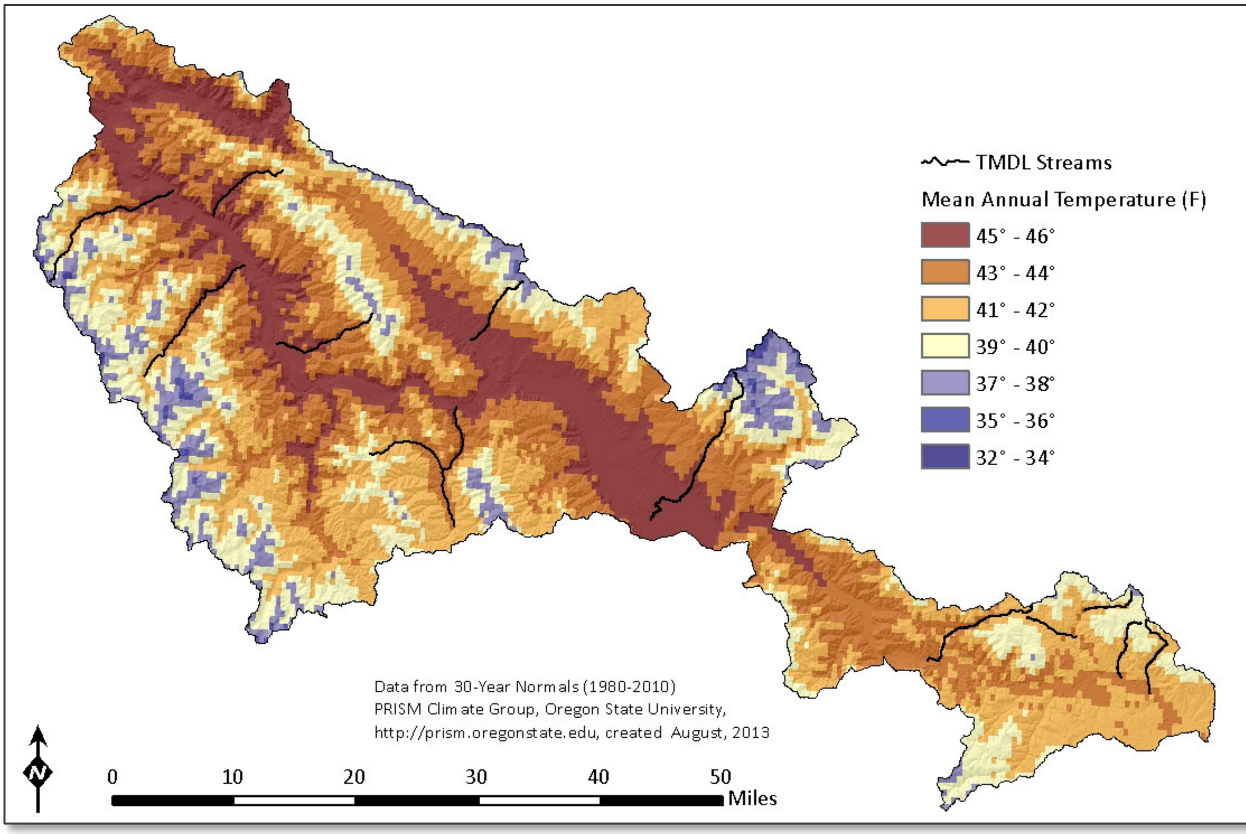

Figure 2-4. Average annual temperatures

2.1.4 Hydrology

The drainage in the project area is characterized by the mainstem of the Clark Fork River and smaller trunk tributaries, mapped below in **Figure 2-5**. The Clark Fork River becomes a 7th order stream at the mouth of Rock Creek. The trunk tributaries tend to be 3rd and 4th order streams, although Fish Creek is a 5th order stream. The watersheds of major tributaries (Flint Creek, Rock Creek, Blackfoot River, and Bitterroot River) that join this part of the Clark Fork River are the subjects of separate documents and not included in this project area.

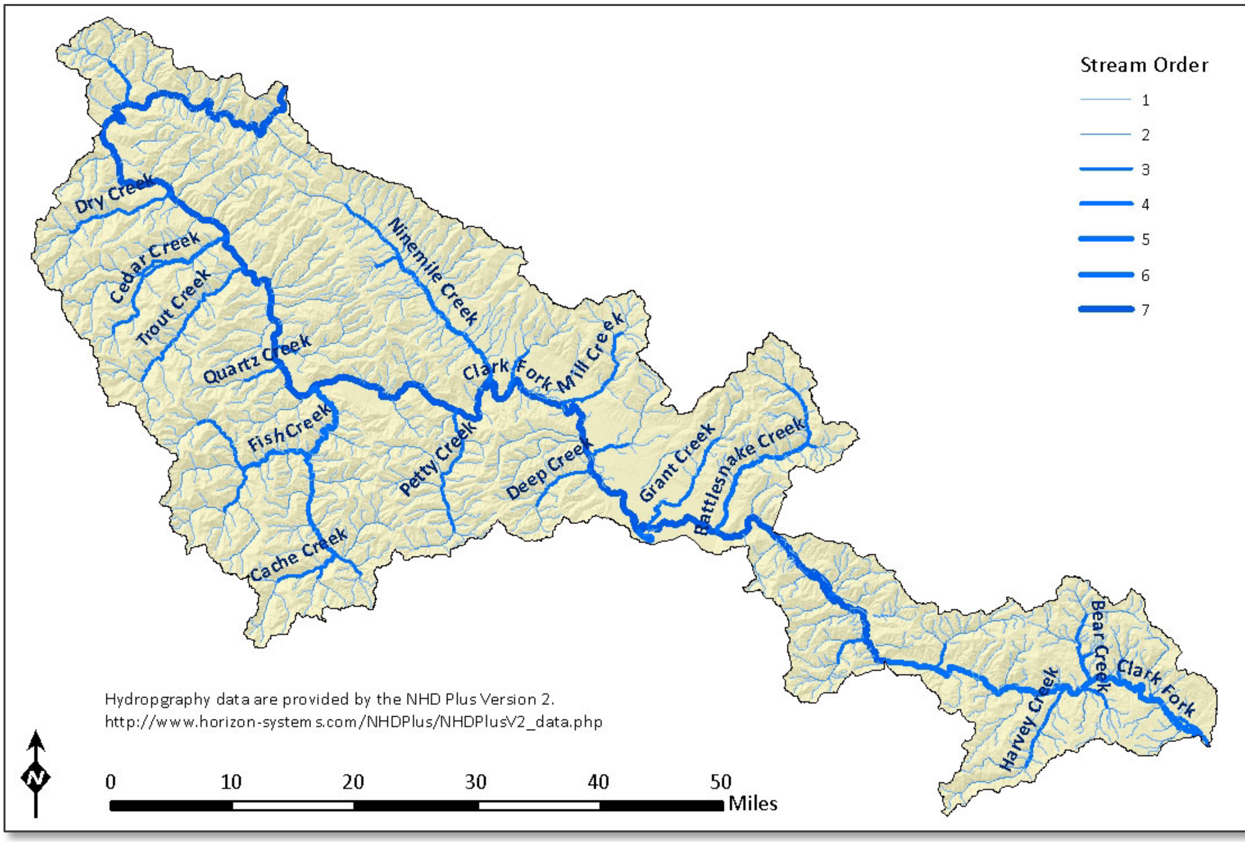

Figure 2-5. Hydrography

The majority of the tributary streams are not monitored by USGS gaging stations, including the streams that are the subject of this TMDL document. Their streamflow generally follows a hydrograph typical for the region, highest in May and June. These are the months with the greatest amount of precipitation and snowmelt runoff. Streamflow begins to decline in late June or early July, reaching minimum flow levels in September when many streams go dry. Streamflow begins to rebound in October and November when fall storms supplement the base-flow levels.

2.1.5 Geology and Soils

The project area is large and the geology is varied. Bedrock is dominated by Precambrian Belt Series metasedimentary rocks, although and Paleozoic and Mesozoic sedimentary rocks are found in the eastern part of the project area, in the southern Garnet Mountains. Additionally, a small area south of the Clark Fork River opposite Frenchtown and Huson is mapped with Cambrian sedimentary rocks. Volcanic rocks are mapped in the northern John Long and southern Garnet mountains, as are isolated igneous intrusive rocks. The northern end of the Idaho Batholith extends north into the headwaters of South Fork Fish Creek. The project area geology is mapped below in **Figure 2-6**.

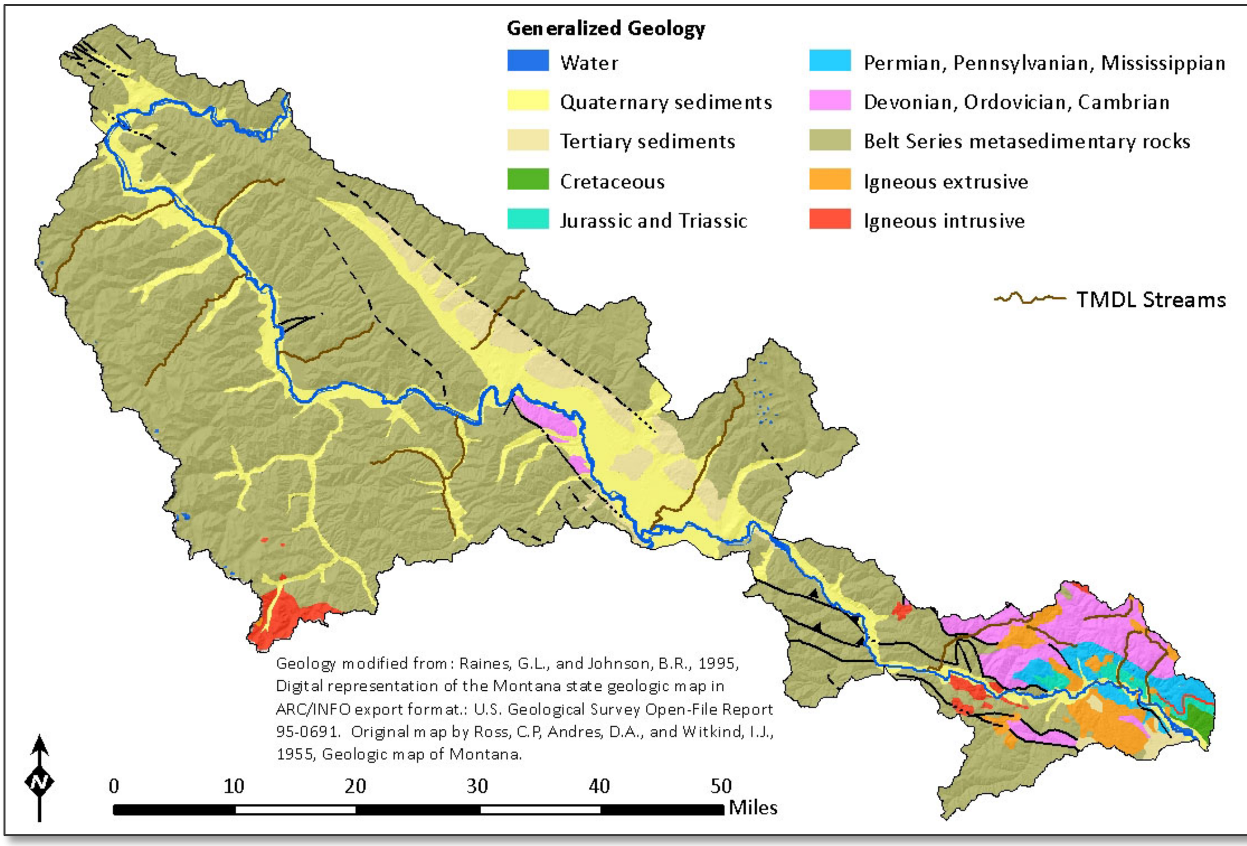

Figure 2-6. Generalized Geology

The USGS Water Resources Division (Schwartz and Alexander, 1995 **5292**) created a dataset of hydrology-relevant soil attributes, based on the USDA Natural Resources Conservation Service (NRCS) STATSGO soil database. The STATSGO data are intended for small-scale (watershed or larger) mapping, and is too general to be used at scales larger than 1:250,000. It is important to realize, therefore, that each soil unit in the STATSGO data may include up to 21 soil components. Soil analysis at a larger scale should use NRCS SSURGO data.

Soil erodibility is based on the Universal Soil Loss Equation (USLE) K-factor (Wischmeier & Smith 1978 **5386**). K-factor values range from 0 to 1, with a greater value corresponding to greater potential for erosion. Susceptibility to erosion is mapped below in **Figure 2-7**, 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. Despite the steep and rugged topography, the majority of the project area is mapped with soils rated as having low and moderate-low erodibility. Soils mapped with moderate-high erodibility are largely localized to the Clark Fork River canyon, Ninemile and Missoula valleys, and the northern end of the John Long Mountains. No values greater than 0.34 are mapped in the project area.

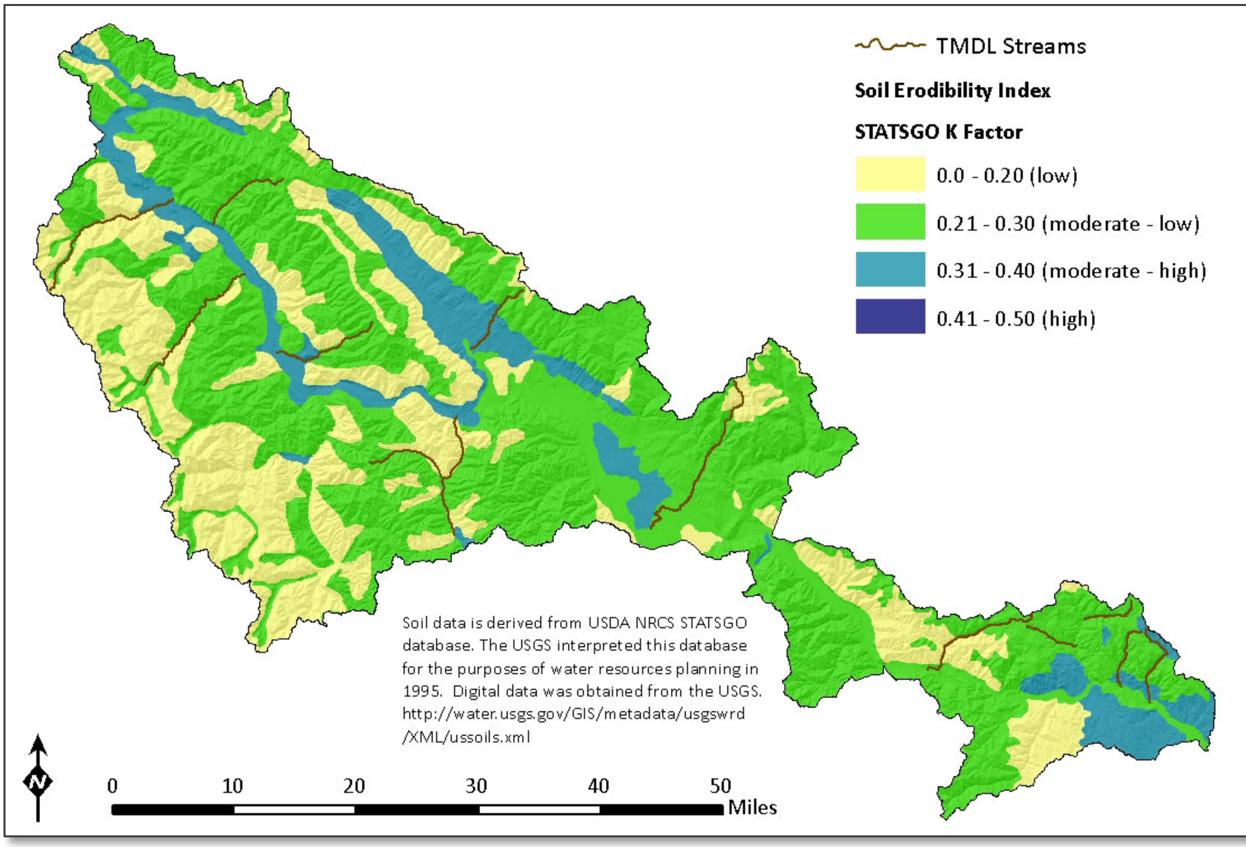

Figure 2-7. Soil erodibility

2.2 Ecological Profile

This section describes the ecology of the project area, including the ecoregions mapped within it, land cover, fire history, and fish species of concern.

2.2.1 Ecoregions

The project area includes portions of both the Middle Rockies and Northern Rockies Level III Ecoregions. The Missoula and Ninemile valleys are the western limit of the Middle Rockies Level III Ecoregion, and west of that, the project area lies within the Northern Rockies Level III Ecoregion. (Woods, et al., 2002 **5764**) The Level IV Ecoregions are mapped below in **Figure 2-8**. More detailed information about the ecoregions is available on the Internet at: http://www.epa.gov/wed/pages/ecoregions/mt_eco.htm.

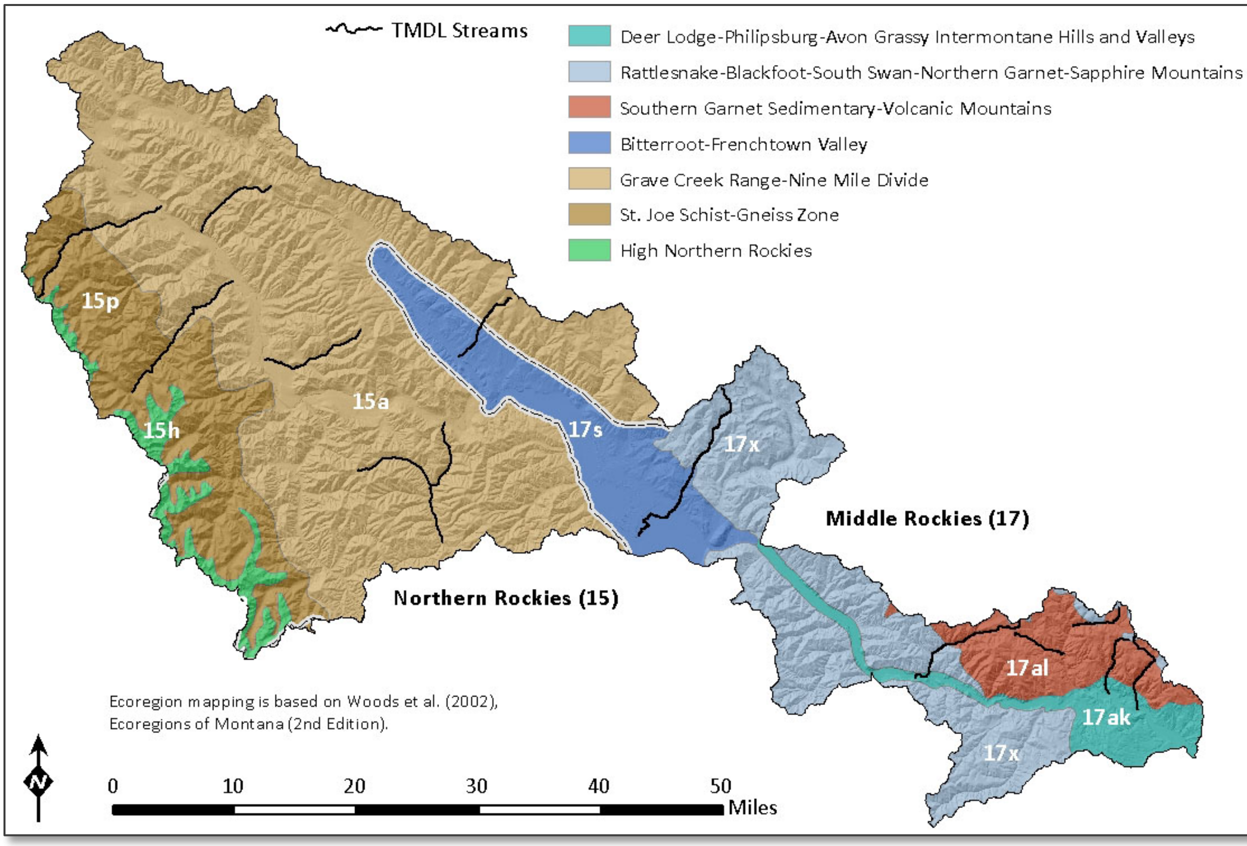

Figure 2-8. Level III and Level IV ecoregions

2.2.2 Land Cover

Land cover is mapped below in **Figure 2-9**, based on the USGS National Land Cover Dataset or NLCD (REF). As apparent in this figure, the project area is dominated by evergreen forest in the uplands, and herbaceous and shrub/scrub cover in the lowlands. Hay/pasture and cultivated crops are localized around the Missoula and Ninemile valleys, as are most of the developed areas.

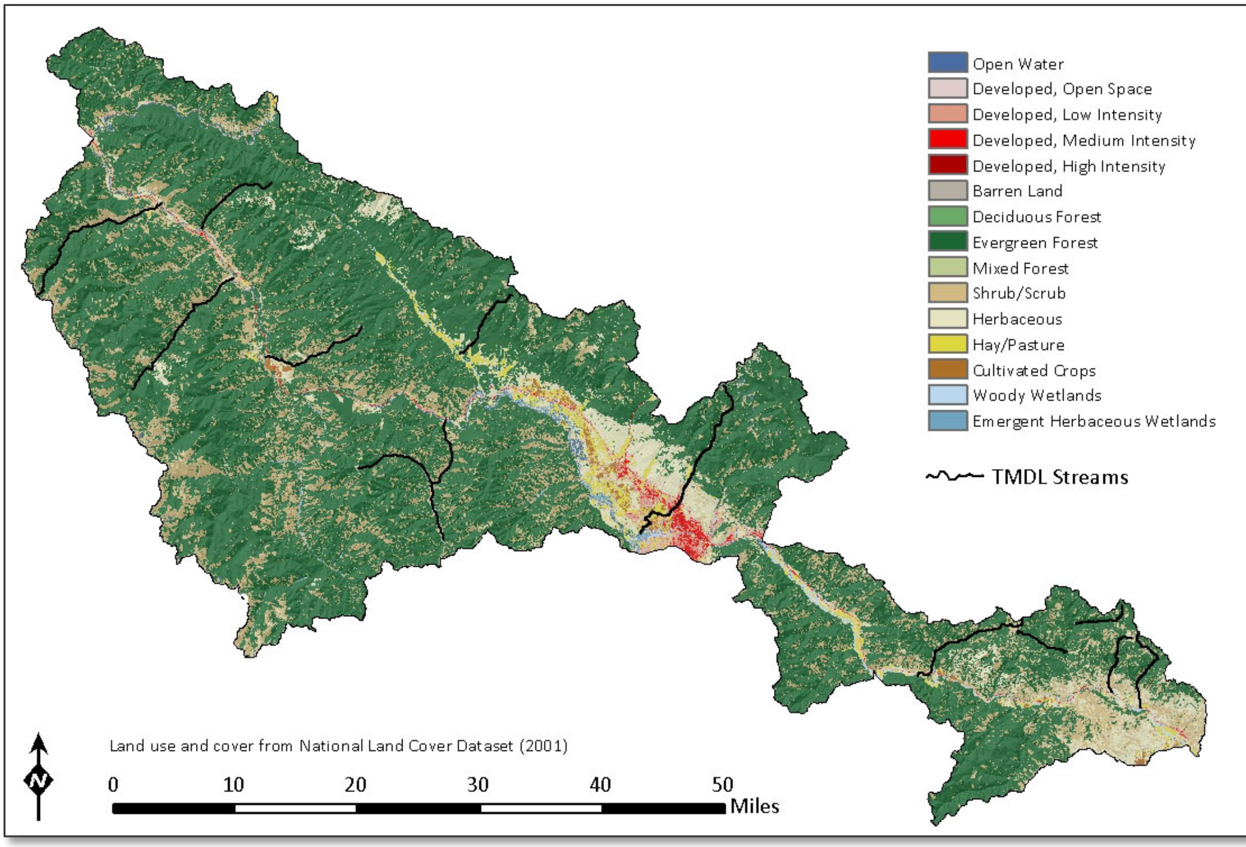

Figure 2-9. Land cover

2.2.3 Fire History

Recent fire history (1985-2013) is mapped below in **Figure 2-10**. Large regions of the project area burned within the last 10 years. Cramer Creek, Trout Creek, West Fork Petty Creek, and Flat Creek are the streams most directly affected by burned areas.

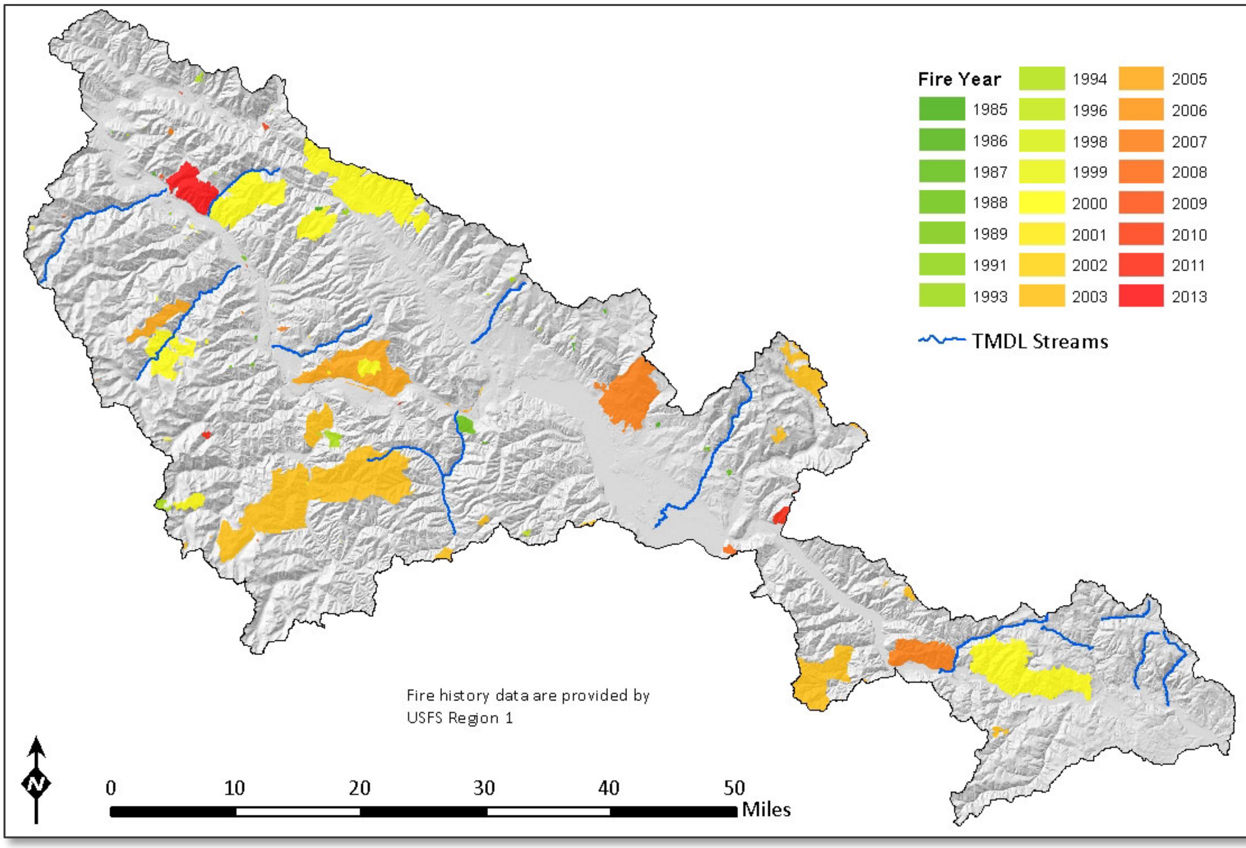

Figure 2-10. Fire history (1985-2013)

2.2.4 Fish distribution

The project area provides habitat for both bull trout, which is considered a threatened species by the US Fish and Wildlife Service, and for westslope cutthroat trout, a Montana Species of Concern. The mapped distribution of both these species is shown below in **Figure 2-11**, based on data provided by Montana Fish, Wildlife, and Parks (MFISH).

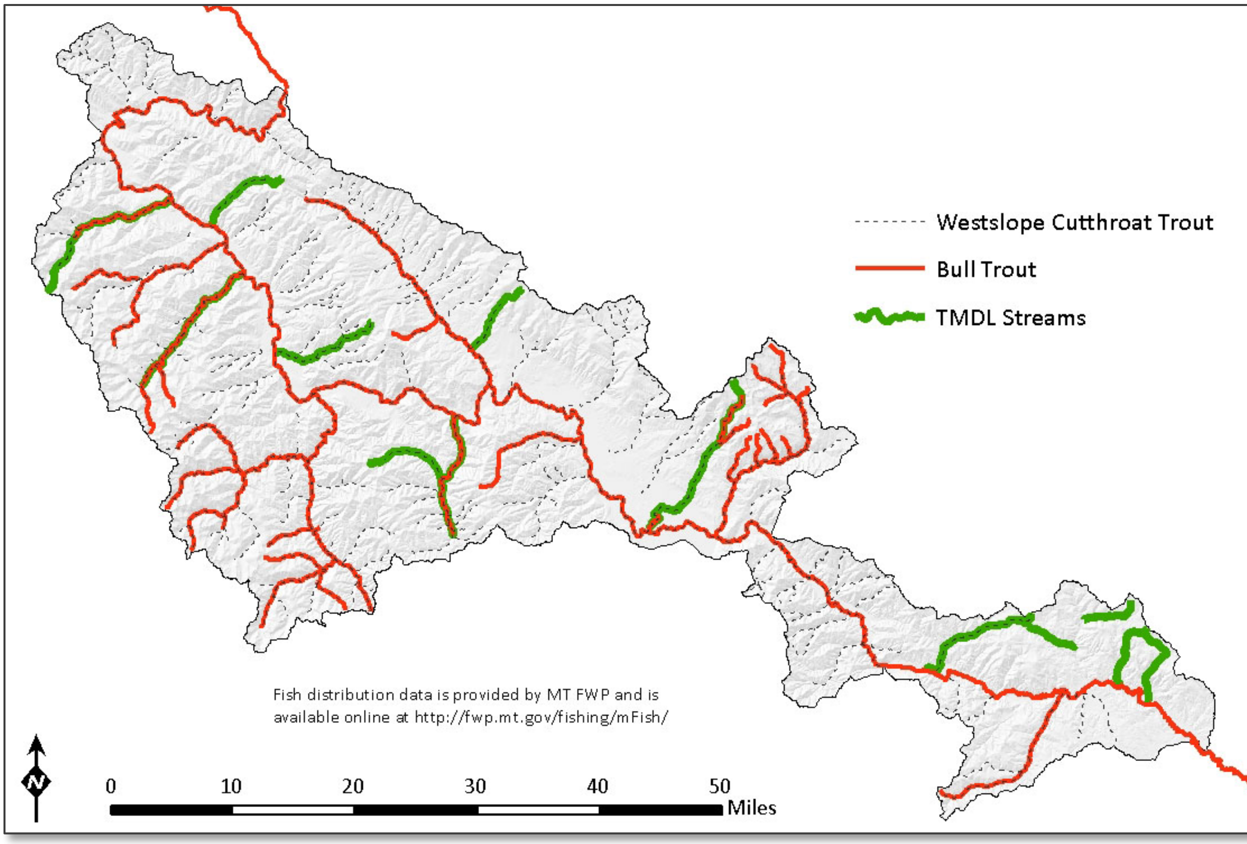

Figure 2-11. Westslope Cutthroat Trout and Bull Trout distribution

2.3 Social Profile

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

2.3.1 Population Density

There are no census geometries that exactly correspond to the project area, but DEQ estimates the population at approximately 76,800 people based on 2010 census GIS files. Missoula is the major population center, although a sizable area of Missoula is in the Bitterroot watershed and therefore outside of this project area. The project area also includes the towns of Drummond, Alberton and Superior, in addition to a number of unincorporated communities (e.g. Clinton, Frenchtown, Tarkio). Large areas of USFS land are uninhabited, although there are isolated inholdings. Population density is mapped below in **Figure 2-12**.

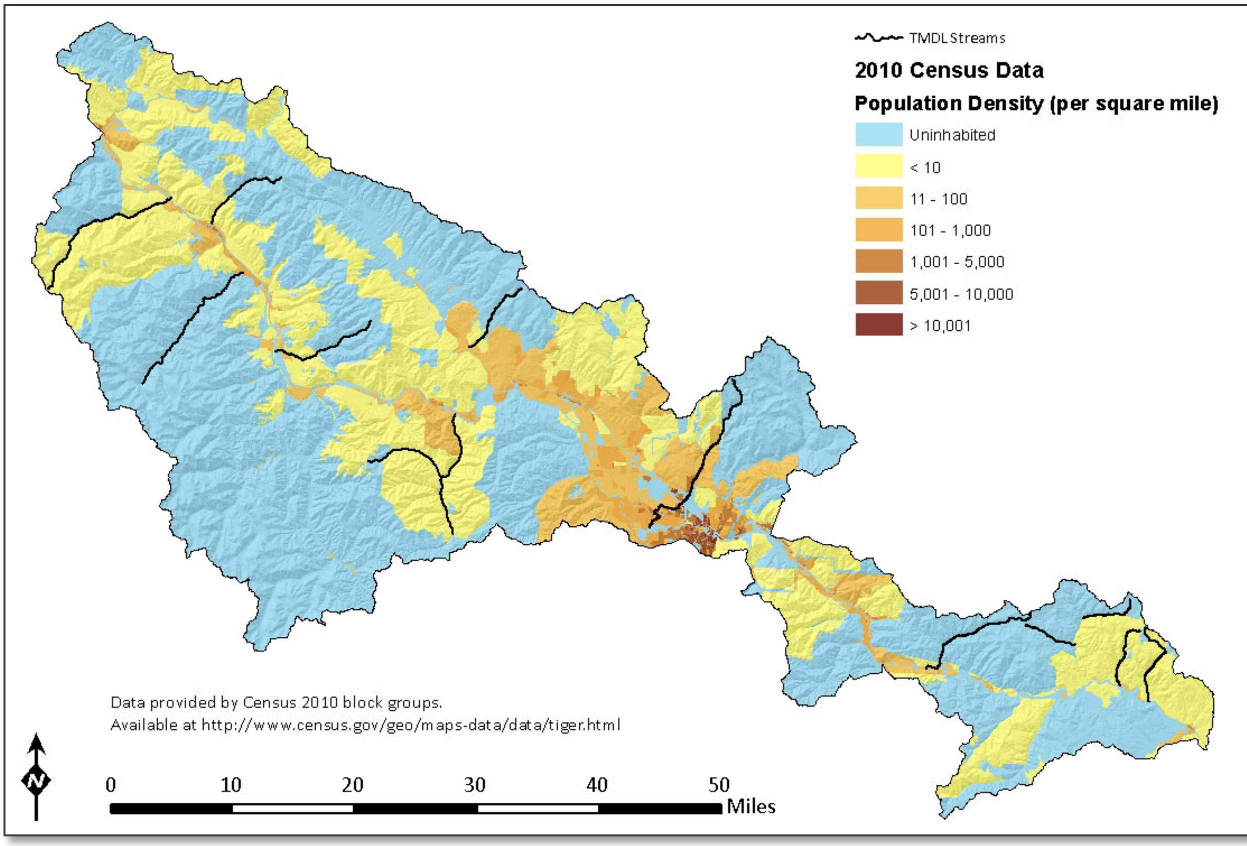

Figure 2-12. Population density

2.3.2 Land Management

Federal lands managed by the US Forest Service (USFS) dominate the project area, and are found mostly in the upland areas. The US Bureau of Land Management (BLM) oversees a large area of the Garnet Range, some of which is included in the project area. Private lands dominate the river corridor and valley bottoms. Plum Creek Timber properties were widespread in this project area, but much of the Plum Creek Timber land was included within the Montana Legacy Project. Under this project, The Nature Conservancy and the Trust for Public Land purchased over 310,000 acres of Plum Creek Timber properties with the goal of transferring them to a mix of public and private conservation management. Lands transferred to the USFS are mostly concentrated around the mouth of the Blackfoot River, Petty Creek, and in the headwaters of Lolo Creek (to the south and outside the project area). Much of the Fish Creek watershed was purchased by Montana Fish, Wildlife, and Parks. Land management is mapped below in **Figure 2-13**. In the eastern part of the project area, much of the land around Cramer Creek is currently owned by The Nature Conservancy, and transfers related to the Montana Legacy Project are in progress.

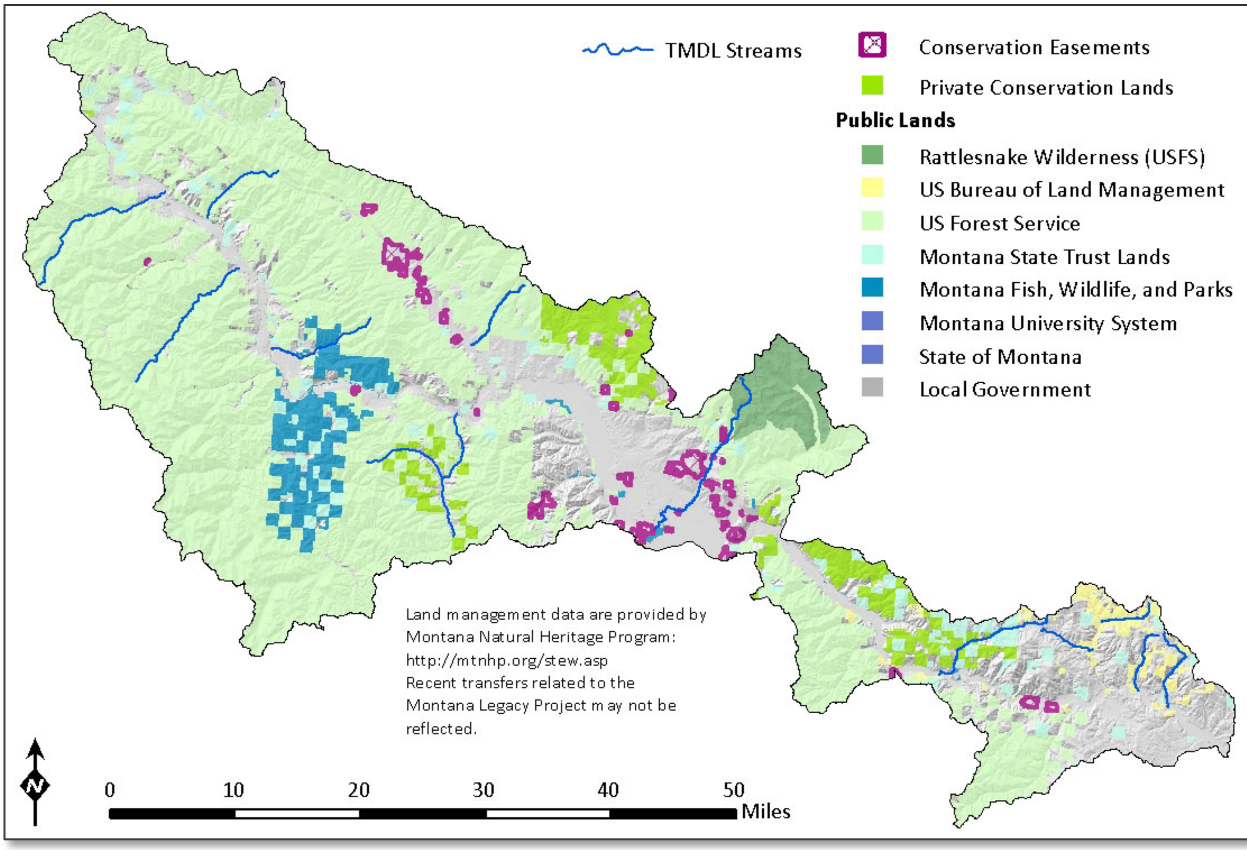

Figure 2-13. Land management

2.3.3 Agricultural Land Use

Montana Department of Revenue (DOR) assesses agricultural land for taxation. The resulting dataset is known as the Final Land Unit (FLU) classification. The agricultural uses were determined by DOR GIS specialists, and confirmed by maps sent to private landholders for verification. The FLU data are available at: ftp://ftp.geoinfo.msl.mt.gov/Data/Spatial/NonMSDI/Geodatabases/revenue_flu.zip. Agricultural uses as determined in the FLU are mapped below in **Figure 2-14**. Also included in this map are BLM and USFS grazing allotments.

As evident in the land cover map above (**Figure 2-9**), forest dominates the project area. Although it is not reflected in the DOR classifications, grazing is common on forested public lands, particularly the BLM lands in the eastern side of the project area.

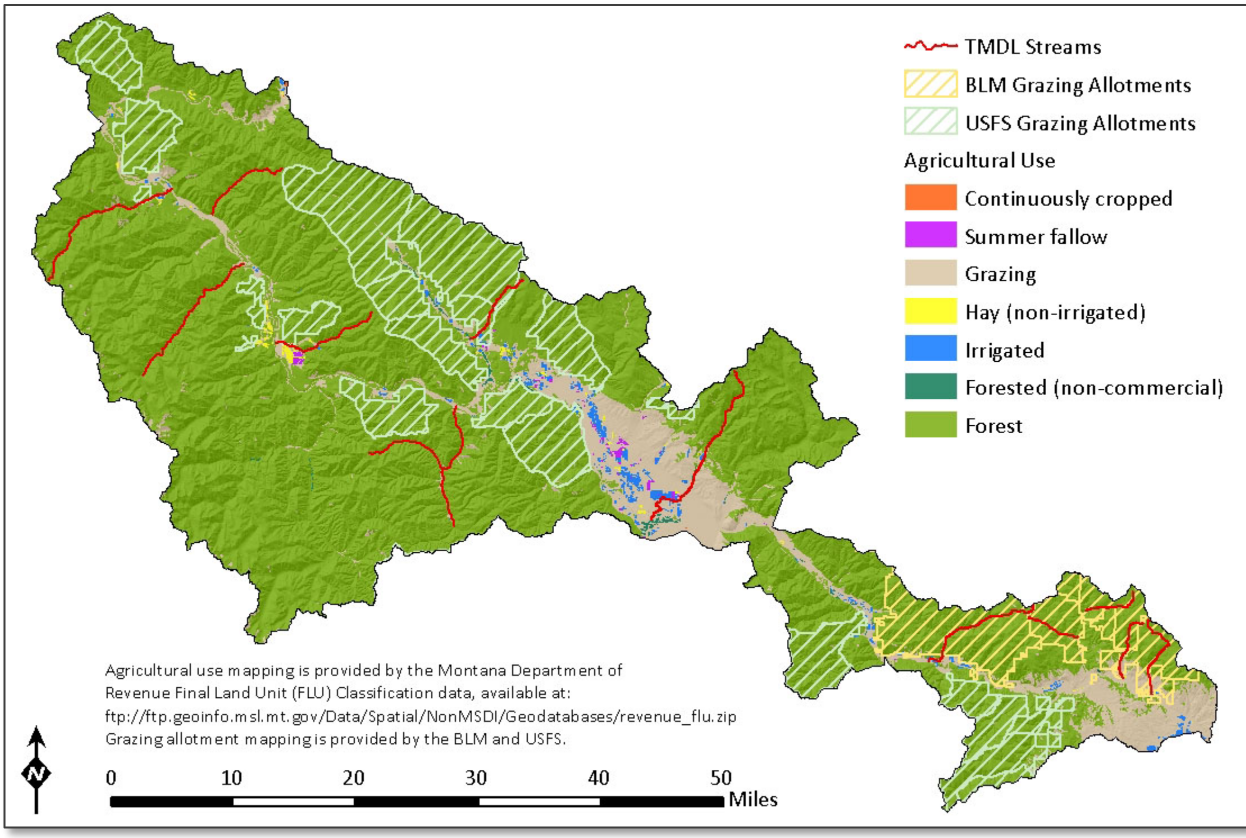

Figure 2-14. Agricultural use and grazing allotments

2.3.5 Road Networks

There are extensive road networks both in the valley bottoms and in the timbered uplands. Many roads were constructed for timber harvesting, and may have been decommissioned. The project area is too large to analyze the road network at this scale, and the network of unpaved roads is discussed in more detail in the sediment source assessments (**Section X.X.X**). However, **Figure 2-15** below provides a general idea of where the upland road networks are most extensive.

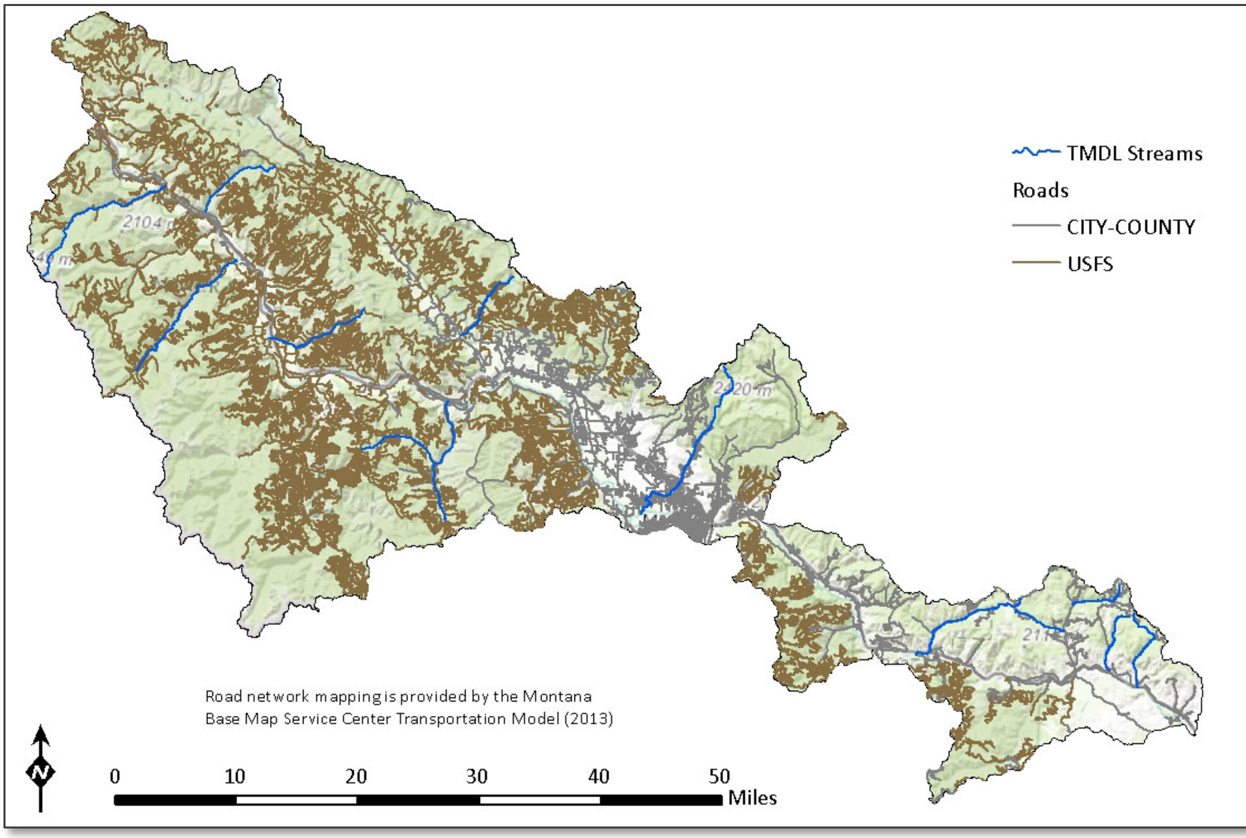

Figure 2-15. Road networks

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 STREAM CLASSIFICATIONS AND DESIGNATED BENEFICIAL USES

Waterbodies are classified based on their designated uses. All Montana waters are classified for multiple uses. All streams and lakes within the Central Clark Fork Tributaries TMDL planning area are classified as B-1. Waters classified as B-1 are to be maintained suitable for drinking, culinary, and food processing purposes after conventional treatment; bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply. 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 water quality assessment methods are designed to evaluate the most sensitive uses for each pollutant group addressed within this document, thus ensuring protection of all designated uses (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2011b). For streams in Western Montana, the most sensitive use assessed for sediment and turbidity is aquatic life; for temperature is aquatic life; and for nutrients is aquatic life and primary contact recreation. DEQ determined that 12 waterbody segments in the Central Clark Fork Tributaries project area do not meet the sediment, nutrient, temperature, and turbidity water quality standards (**Table 3-1**).

Table 3-1: Impaired Waterbodies and their Impaired Designated Uses in the Central Clark Fork Tributaries TMDL Project Area

Waterbody & Location Description	Waterbody ID	Impairment Cause *	Impaired Use(s)
Dry Creek, headwaters to mouth (Clark Fork River)	MT76M002_170	Nitrogen (Total)	Aquatic Life, Primary Contact Recreation
Flat Creek, headwaters to mouth (Clark Fork River)	MT76M002_180	Sedimentation/Siltation	Aquatic Life, Primary Contact Recreation
Trout Creek, headwaters to mouth (Clark Fork River)	MT76M002_050	Turbidity	Aquatic Life
Nemote Creek, headwaters to mouth (Clark Fork River)	MT76M002_160	Nitrogen (Total)	Aquatic Life, Primary Contact Recreation
		Phosphorus (Total)	Aquatic Life, Primary Contact Recreation
		Temperature, water	Aquatic Life
West Fork Petty Creek, headwaters to mouth (Petty Creek)	MT76M002_100	Phosphorus (Total)	Aquatic Life, Primary Contact Recreation
		Sedimentation/Siltation	Aquatic Life
Petty Creek, headwaters to mouth (Clark Fork River)	MT76M002_090	Sedimentation/Siltation	Aquatic Life
		Temperature, water	Aquatic Life
Stony Creek, headwaters to mouth (Ninemile Creek)	MT76M004_020	Phosphorus (Total)	Aquatic Life, Primary Contact Recreation
Grant Creek, headwaters to mouth (Clark Fork River)	MT76M002_130	Nitrate/Nitrite (Nitrite + Nitrate as N)	Aquatic Life, Primary Contact Recreation
		Nitrogen (Total)	Aquatic Life, Primary Contact Recreation
		Sedimentation/Siltation	Aquatic Life
		Temperature, water	Aquatic Life
Cramer Creek, headwaters to mouth (Clark Fork River)	MT76E004_020	Sedimentation/Siltation	Aquatic Life
Tenmile Creek, headwaters to mouth (Bear Creek)	MT76E004_030	Phosphorus (Total)	Aquatic Life, Primary Contact Recreation
		Sedimentation/Siltation	Aquatic Life

Table 3-1: Impaired Waterbodies and their Impaired Designated Uses in the Central Clark Fork Tributaries TMDL Project Area

Waterbody & Location Description	Waterbody ID	Impairment Cause *	Impaired Use(s)
Deep Creek, headwaters to mouth (Bear Creek)	MT76E004_070	Nitrate/Nitrite (Nitrite + Nitrate as N)	Aquatic Life
		Sedimentation/Siltation	Aquatic Life
Mulkey Creek, headwaters to mouth (Clark Fork River)	MT76E004_050	Sedimentation/Siltation	Aquatic Life, Primary Contact Recreation
Rattler Gulch, headwaters to mouth (Clark Fork River)	MT76E004_060	Phosphorus (Total)	Aquatic Life
		Sedimentation/Siltation	Aquatic Life

* Only includes those pollutant impairments addressed by TMDLs in this document

3.2 Numeric and Narrative Water Quality Standards

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

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

Narrative standards are developed when there is insufficient information to develop numeric standards and/or the natural variability makes it impractical to develop numeric standards. Narrative standards describe the allowable or desired condition. This condition is often defined as an allowable increase above "naturally occurring." DEQ often uses the naturally occurring condition, called a "reference condition," to help determine whether or not narrative standards are being met (see **Appendix B**).

For the Central Clark Fork Tributaries TMDL project area, a combination of numeric and narrative standards are applicable. The numeric standards apply to nutrients, and narrative standards are applicable for sediment, temperature, and nutrients. The specific numeric and narrative standards 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.

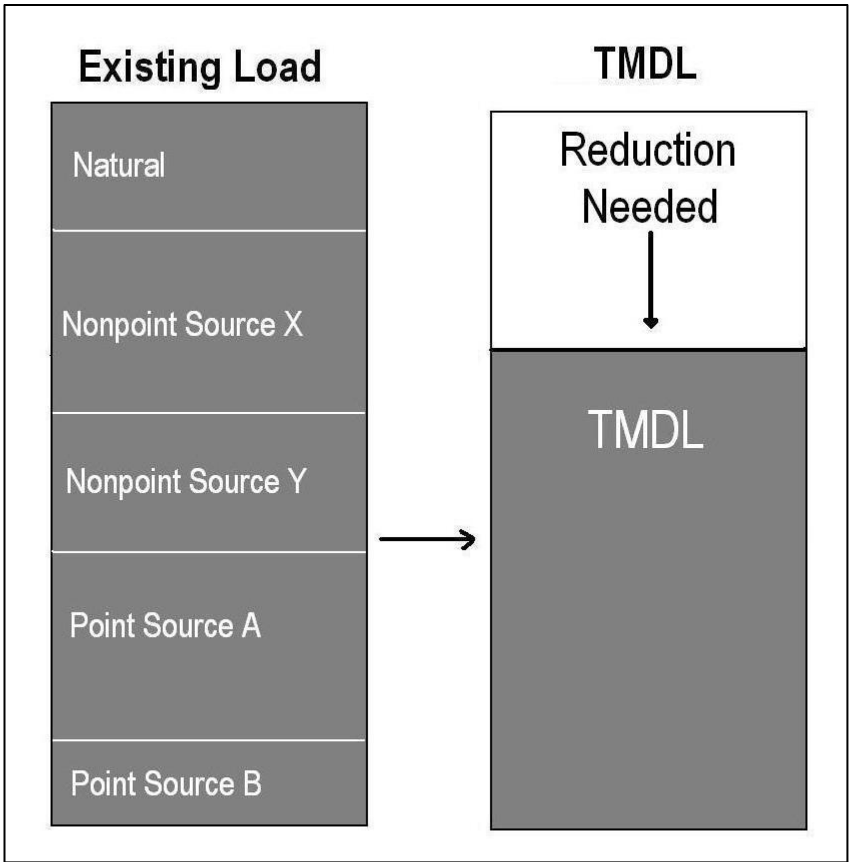

Figure 4-1: Schematic Example of TMDL Development

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 a "TMDL" is specifically defined as a "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. When 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.

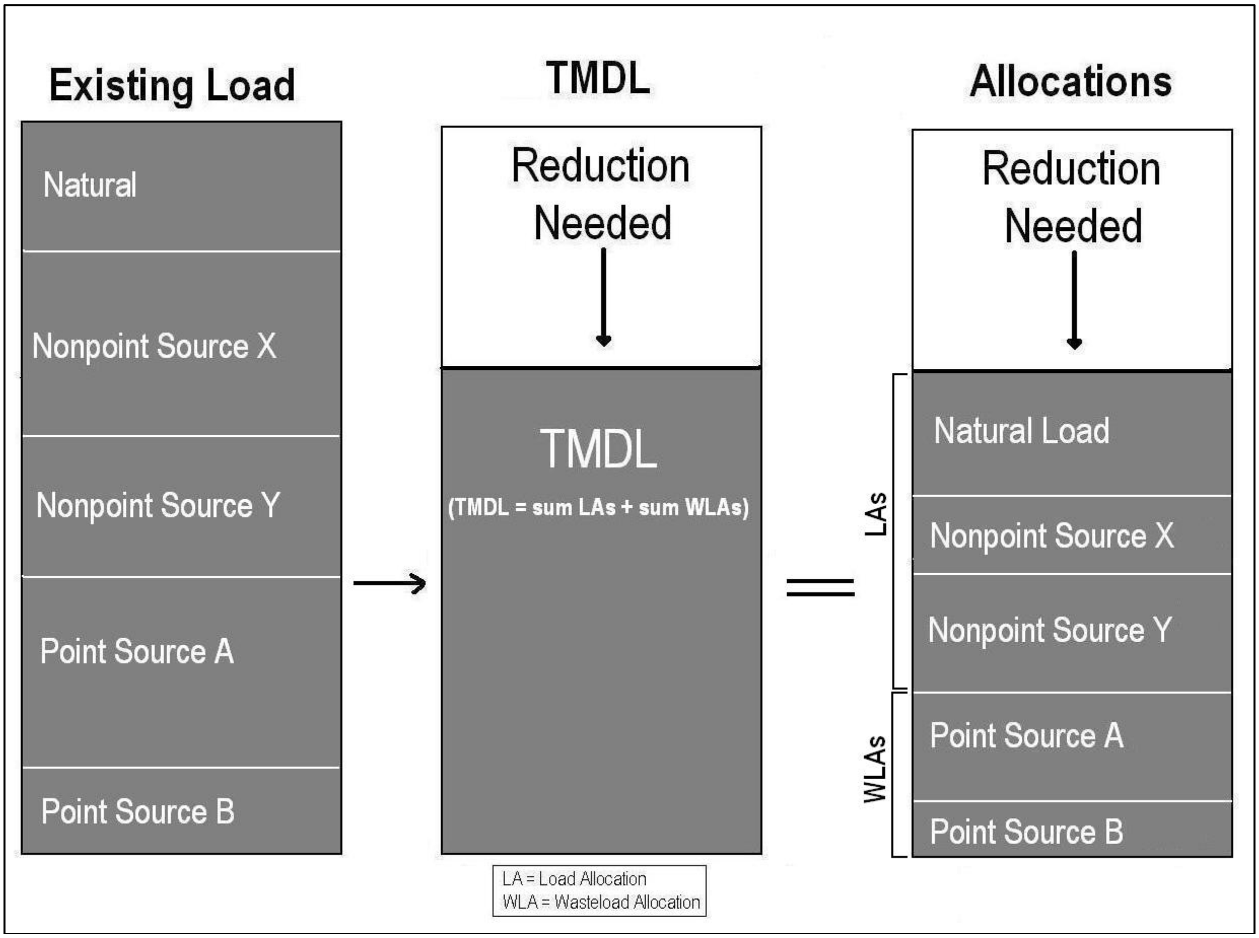

Figure 4.2: Schematic Diagram of a TMDL and its Allocations

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, 1999a) (U.S. Environmental Protection Agency, 1999b). 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.

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

4.5 Implementing TMDL Allocations

The 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** provides a water quality improvement plan that discusses restoration strategies 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 (Nonpoint Source Program) helps to coordinate water quality improvement projects for nonpoint sources of pollution throughout the state and provides resources to stakeholders to assist in nonpoint source BMPs. Montana's Nonpoint Source Management Plan (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 (Section 75-5-703 of the Montana Water Quality Act). TMDLs may be refined as new data become available, land uses change, or as new sources are identified.

5.0 Sediment TMDL Components

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

5.1 Effects of Excess Sediment on Beneficial Uses

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

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

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

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

5.2 Stream Segments of Concern

A total of nine waterbody segments in the Central Clark Fork Basin Tributaries TMDL project area appear on the 2014 Montana 303(d) List for sediment impairments (**Figure 5-1**): Cramer Creek, Deep Creek, Flat Creek, Grant Creek, Mulkey Creek, Petty Creek, Rattler Gulch, Tenmile Creek, and West Fork Petty Creek. Trout Creek is included in **Figure 5-1** as a stream of concern due to an existing turbidity listing on the 2014 303(d) List. As turbidity is often linked to sediment impairment, Trout Creek is included as a sediment stream of concern and is assessed in **Section 5.4.3**.

All but Mulkey Creek and West Fork Petty Creek are also impaired for various forms of habitat alterations (**Table A-1**), which are non-pollutant causes commonly associated with sediment impairment. TMDLs are limited to pollutants, but implementation of land, soil, and water conservation practices to reduce pollutant loading will inherently address some non-pollutant impairments.

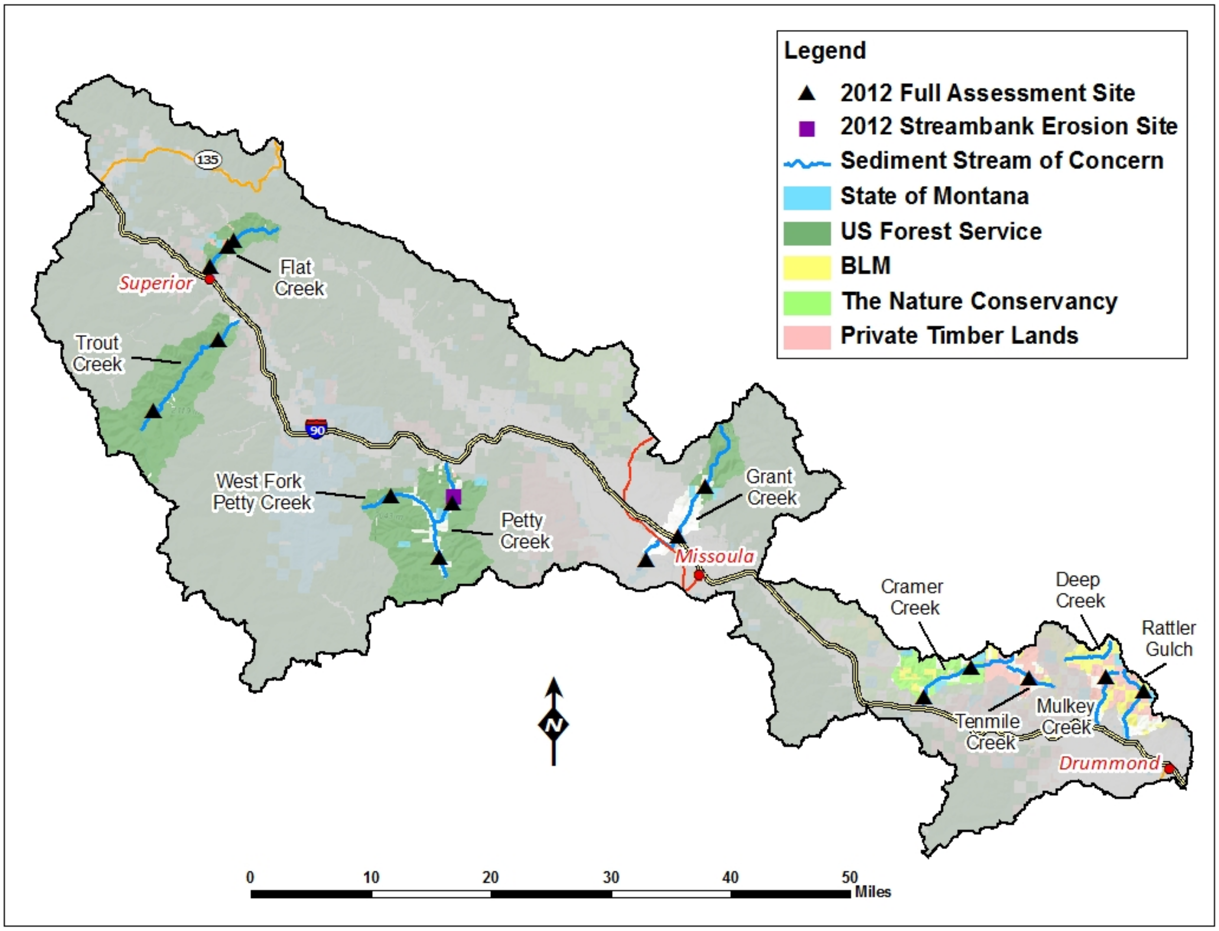

Figure 5-1. Sediment streams of concern and sampling sites in the Central Clark Fork Basin Tributaries TMDL Project Area

5.3 Information Sources and Assessment Methods

For TMDL development, information sources and assessment methods fall within two general categories. The first category, discussed within 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 data compilation was completed and additional monitoring was performed during 2012. The below listed data sources represent the primary information used to characterize water quality and/or develop TMDL targets.

- DEQ Assessment Files
- DEQ 2012 Sediment and Habitat Assessments – Central Clark Fork Basin Tributaries TMDL project area
- Sediment targets from completed TMDL projects
- Relevant Local and Regional Reference Data
- Other Data and Reports

5.3.2 DEQ Assessment Files

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 and/or compiled by DEQ. The files also include information on sediment water quality characterization and potentially significant sources of sediment, as well as information on non-pollutant impairment determinations and associated rationale.

5.3.3 DEQ 2012 Sediment and Habitat Assessments

To aid in TMDL development, field measurements of channel morphology and riparian and instream habitat parameters were collected in August 2012 from 16 reaches (**Figure 5-1**). One additional reach was assessed in 2012 on Petty Creek (denoted as a Streambank Erosion Site in **Figure 5-1**) to determine the severity of bank erosion and identify sources. Reaches were dispersed among the ten segments of concern listed in **Section 5.2**, with between one to three full assessment reaches on all streams. Field assessments were not completed on Deep Creek because permission to access the stream could not be obtained.

Initially, all streams were assessed using 2011 aerial imagery to characterize reaches by four main attributes not linked to human activity: stream order, valley gradient, valley confinement, and ecoregion. These attributes represent main factors influencing stream morphology, which in turn influence sediment transport and deposition.

The next step in the aerial assessment involved identifying near-stream land uses, since land management practices can have a significant influence on stream morphology and sediment characteristics. Streams were stratified into reaches that allow for comparisons among those reaches of the same natural morphological characteristics, while also indicating stream reaches where land management practices may further influence stream morphology. The stream stratification, along with field reconnaissance, allowed DEQ to select the above-referenced monitoring reaches. Although ownership is not part of the reach type category (because of the distribution of private and federal land within the watershed), most reach type categories contain predominantly either private or public lands.

Monitoring reaches on sediment-listed streams were chosen to represent various reach characteristics, land-use categories, and human-caused influences. There was a preference toward sampling those reaches where human influences would most likely lead to impairment conditions, since one step in the TMDL development process is to 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 303(d) listed waterbody with potential sediment 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); therefore, this stream type was the focus of the field effort (**Table 5-1**). Although the TMDL development process necessitates this targeted sampling design, DEQ acknowledges this approach results in less certainty regarding conditions in 1st order streams and higher-gradient reaches, and that conditions within sampled reaches do not necessarily represent conditions throughout the entire stream.

Table 5-1. Stratified Reach Types and Sampling Site Representativeness within the Central Clark Fork Basin Tributaries TMDL Project Area

Level III Ecoregion	Reach Type	Number of Reaches	Number of Monitoring Sites	Monitoring Sites
Middle Rockies	MR-0-3-U	12	3	CRAM07-02, GRNT11-02, GRNT12-03
	MR-10-1-C	3		
	MR-10-1-U	3		
	MR-10-2-C	2		
	MR-2-1-U	2		
	MR-2-2-C	8	2	RATT04-01, TENM03-01
	MR-2-2-U	5		
	MR-2-3-U	5		
	MR-4-1-C	5	1	MULK03-01
	MR-4-1-U	5		
	MR-4-2-C	11	1	CRAM05-01
	MR-4-2-U	3	1	GRNT08-02
	MR-4-3-U	2		
Northern Rockies	NR-0-3-C	3		
	NR-0-3-U	18	4	PETT03-01, PETT07-01, PETT07-02*, TROU12-03
	NR-10-1-C	2		
	NR-10-1-U	1		
	NR-2-2-C	2	1	FLAT09-01
	NR-2-2-U	3		
	NR-2-3-C	2	1	TROU03-01
	NR-2-3-U	4		
	NR-4-1-C	2		
	NR-4-2-C	5	3	FLAT06-01, FLAT06-02, WFPY03-01
	NR-4-3-C	1		

*Streambank Erosion Only Assessment

The field parameters assessed in 2012 included standard measures of stream channel morphology, fine sediment, stream habitat, riparian vegetation, and streambank erosion. Although the sampling areas are frequently referred to as "sites" within this document, to help increase sample sizes and capture variability within assessed streams, they were actually sampling reaches ranging from 500 to 1,500 feet (depending on the channel bankfull width) that were broken into five cells of equal length. Generally, a single cross section measurement, pebble count, and riffle grid toss are performed in each cell, and stream habitat, riparian, and bank erosion measures are performed throughout the reach. Field parameters are briefly described in **Section 5.4**, and summaries of all field data and sampling protocols are contained in the 2012 Sediment and Habitat Assessment report (**Attachment A**).

5.3.4 Relevant Local and Regional Reference Data

Regional reference data were derived from DEQ reference sites within the project area and the PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO). The PIBO reference dataset (http://www.fs.fed.us/biology/fishecology/emp/) includes USFS and BLM sites throughout the Pacific Northwest, but to increase the comparability of the data to conditions in the Central Clark Fork

Basin tributaries project area, only data collected within the Northern Rockies and Middle Rockies ecoregions were evaluated.

5.3.5 Other Data and Reports

Several other documents that provide historical context to sediment sources, describe the sensitivity of watersheds to disturbance, and provide information about current conditions or sources were also used to help evaluate conditions within the stream segments of concern. These documents include:

- Flat Creek/Superior Superfund reports
- Petty Creek Road Improvement project reports
- Grant Creek FEMA Pre-Disaster Mitigation project reports
- TNC Montana Legacy Project reports
- BLM Linton Mine Remediation (Cramer Creek)

5.4 Water Quality Targets

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

In developing targets, natural variation within and among streams must be considered. As discussed in more detail in **Section 3.0** and **Appendix B**, DEQ uses the reference condition to gage natural variability and assess the effects of pollutants with narrative standards, such as sediment. The preferred approach to establishing the reference condition is using reference site data, but modeling, professional judgment, and literature values may also be used. DEQ defines “reference” as the condition of a waterbody capable of supporting its present and future beneficial uses when all reasonable land, soil, and water conservation practices have been applied. In other words, the reference condition reflects a waterbody’s greatest potential for water quality given past and current land use. Although sediment water quality targets typically relate most directly to the aquatic life use, the targets protect 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 from climate, bedrock, soils, hydrology, and other natural physiochemical differences, yet it allows differentiation between natural conditions and widespread or significant alterations of biology, chemistry, or hydrogeomorphology from human activity.

The basis for each water quality target value varies depending on the availability of reference data and sampling method comparability to 2012 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 there is a high degree of confidence in the reference data, and low values are desired (like with fine sediment), the 75th percentile of the reference dataset is typically used.

If reference data are not available, and the sample streams are predominantly degraded, the 25th percentile of the entire sample dataset is typically used as this reflects the low (health/functioning) end of what is expected. However, percentiles may be used differently depending on whether a high or low value is desirable, how much the representativeness and range of data varies, how severe human disturbance is to streams in the watershed, and the size of the dataset.

In general, stream sediment and habitat conditions within the streams evaluated by DEQ in 2012 reflected a minimal to moderate level of human disturbance (i.e., not severely disturbed). For each target, descriptive statistics were generated relative to any available reference data (e.g. PIBO) as well as for the entire sample dataset. The preferred approach for setting target values is to use reference data, where preference is given to the most protective reference dataset.

Additionally, the target value for some parameters may apply to all streams in the Central Clark Fork Tributaries Project Area, whereas others may be stratified by bankfull width, reach type characteristics (e.g., 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 that are achievable. MOS is discussed in additional detail in **Section 5.8.2**.

5.4.1 Sediment targets from completed TMDL projects

The Central Clark Fork Basin Tributaries TMDL project area spans two different Level III ecoregions and is in close proximity to several TPAs where sediment TMDLs have been completed and approved. Given the history of completed TMDLs in the western Montana and the rather diverse nature of the sediment-impaired tributaries in the Central Clark Fork Basin Tributaries TMDL project area, sediment targets developed in adjoining TPAs will be used to assess listed sediment impairments in the Central Clark Fork Basin Tributaries TMDL project area.

There are two Level III ecoregions in the Central Clark Fork Basin Tributaries TMDL project area (**Figure 5-2**). The Middle Rockies Level III ecoregion encompasses six of the sediment-listed tributaries addressed in this document and the Northern Rockies Level III ecoregion includes four sediment-listed tributaries in the TPA. The two ecoregions represent significant differences in climate, annual precipitation, soil characteristics and other environmental parameters. For these reasons, sediment water quality targets cannot be uniformly applied to all impaired streams in the project area.

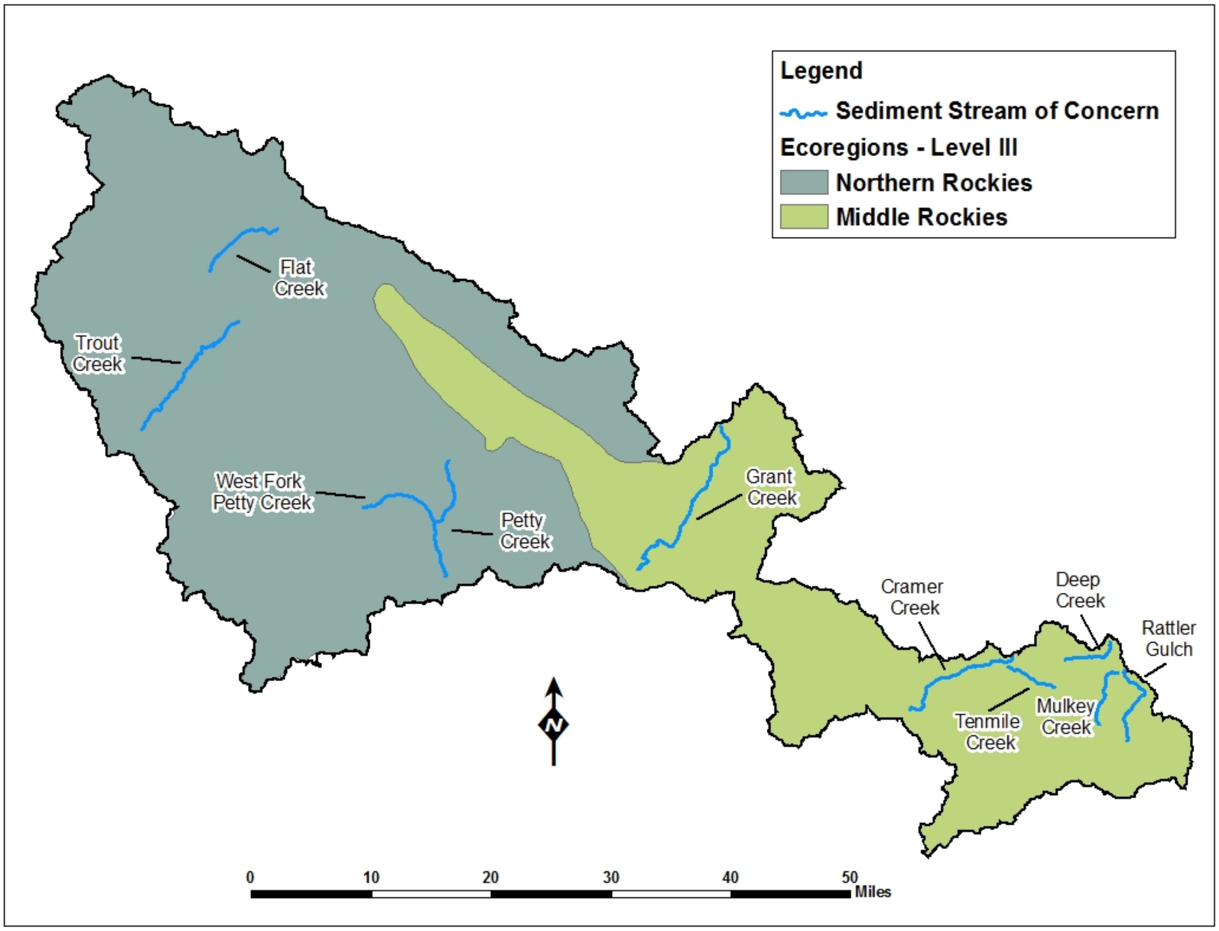

Figure 5-2. Level III ecoregion boundaries in the Central Clark Fork tributaries TPA

Completed sediment TMDL documents with targets applicable to sediment-impaired streams in the Central Clark Fork Basin Tributaries TMDL project area include:

- Upper Clark Fork Tributaries Sediment, Metals and Temperature TMDLs document (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2010)
- Bitterroot Temperature and Tributaries Sediment TMDL document (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2011a)
- Kootenai-Fisher Sediment, Nutrients and Metals TMDL document (**2014 – pending**)

Figure 5-3 includes the TPAs from which sediment water quality targets were taken to compare to sediment listed streams in the Central Clark Fork Basin Tributaries TMDL project area.

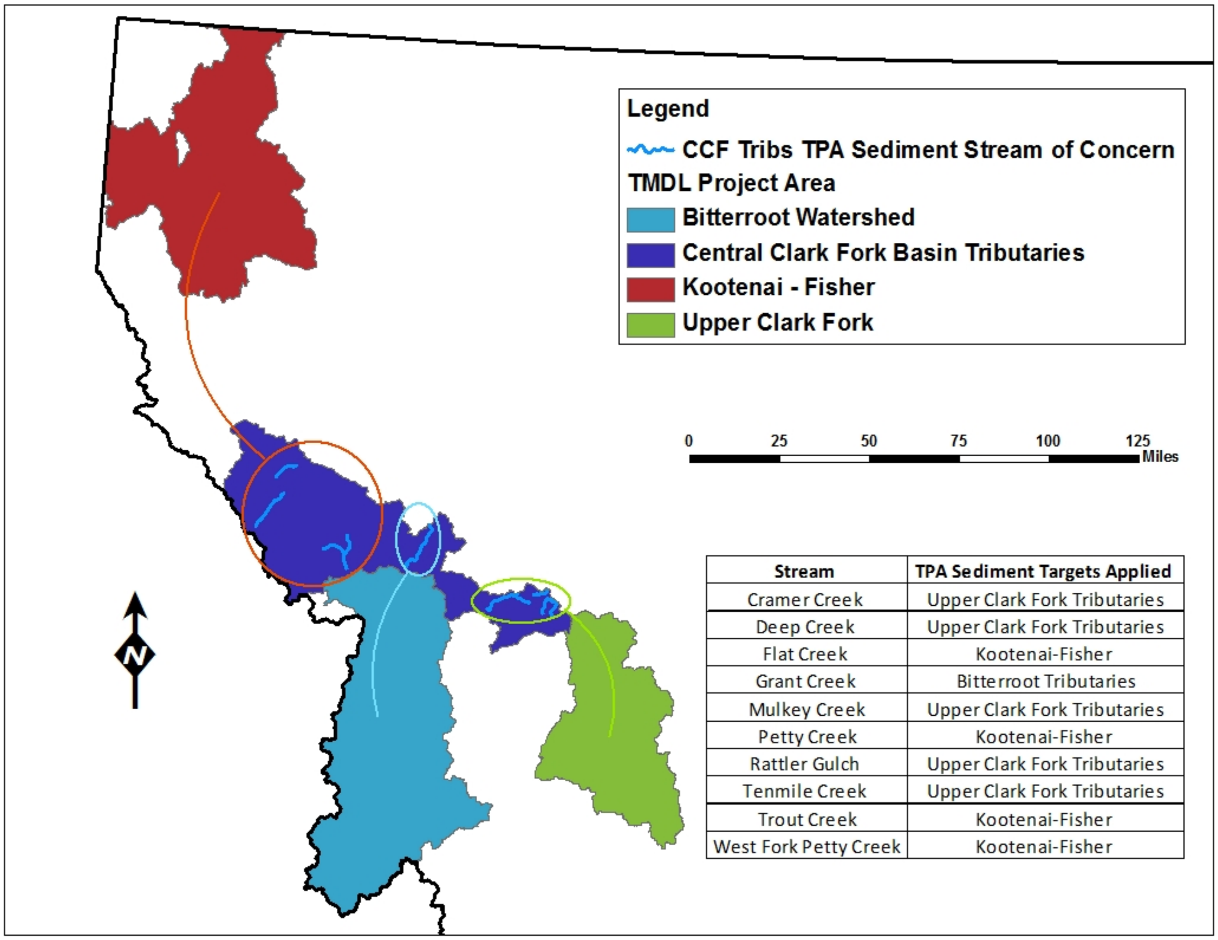

Figure 5-3. Spatial distribution of Central Clark Fork sediment-listed tributaries and use of sediment water quality targets from approved sediment TMDLs

5.4.2 Targets

The sediment water quality targets for the Central Clark Fork Basin Tributaries TMDL project area are summarized in **Table 5-2** and are outlined in the sections that follow. Listed in order of preference, sediment-related targets are based on a combination of reference data from the Northern Rockies and Middle Rockies portions of the PIBO dataset, and sample data from the 2007 DEQ and 2011 EPA field work collected as part of TMDL development activities in the Kootenai-Fisher TMDL project area, Upper Clark Fork TPA, and the Bitterroot TMDL project area.

Consistent with EPA guidance for sediment TMDLs (U.S. Environmental Protection Agency, 1999c), water quality targets for the Central Clark Fork Basin Tributaries TMDL project area 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.

In the three aforementioned project areas with approved sediment TMDLs, sediment targets were not developed for all parameters nor all Rosgen stream types (**Table 5-2**). In some cases, this was the result of limited data and to changes in sediment TMDL approaches through time. Sediment targets from approved TMDL documents will be applied in the same manner for determining if an impaired condition exists in identified Central Clark Fork tributaries.

For specific details on how targets were determined for the parameters listed in **Table 5-2**, please refer to Section 5.0 in the respective approved TMDL documents (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2010; Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2011a) (**K-F is PENDING)**

Table 5-2. Sediment water quality targets used in the Central Clark Fork Tributaries TPA

Parameter Type	Target Description	Kootenai-Fisher	Upper Clark Fork Tributaries	Bitterroot Tributaries (Middle Rockies targets)
Fine Sediment	Percentage of surface fine sediment in riffles via pebble count (reach average)	B & C stream types: 6mm ≤ 15%; 2mm ≤ 8% E stream types: 6mm ≤ 30%; 2mm ≤ 15%	A & B stream types: 6mm ≤ 18%; 2mm ≤ 7% C & E stream types: 6mm ≤ 23%; 2mm ≤ 10%	6mm ≤ 14%; 2mm ≤ 10% E channel - 6mm ≤ 36%; 2mm ≤ 20%
	Percentage of surface fine sediment < 6mm in pool tails and riffles via grid toss (reach average)	B & C stream types: ≤ 9% for pool tails, ≤ 7% for riffles E stream types: ≤ 18% for pool tails, ≤ 14% for riffles	*Not determined*	≤ 6% for pools tails, ≤ 10% for riffles
Channel Form and Stability	Bankfull width/depth ratio (reach median)	B & C stream types with bankfull width < 30ft: ≤ 21	A & B stream types : ≤ 15	Bankfull width ≤ 35' : ≤ 16
		B & C stream types with bankfull width > 30ft: ≤ 32	C & E stream types: ≥ 12 ≤ 22	Bankfull width > 35' : ≤ 29
		E stream types: ≤ 8		E channel : 6-11
	Entrenchment ratio (reach median)	B stream types: > 1.4	A & B stream types: 1.4-2.2	B channel type: > 1.5
		C stream types: > 2.7	C & E stream types: > 2.2	C channel type: > 2.5
		E stream types: > 2.3		E channel type: > 2
Instream Habitat	Residual pool depth (reach average)	< 20' bankfull width : ≥ 0.6 (ft)	A & B stream types : ≥ 0.8 (ft)	< 20' bankfull width : > 0.8 (ft)
		20' - 35' bankfull width : ≥ 1.2 (ft)	C & E stream types: ≥ 1.0 (ft)	20'-35' bankfull width : ≥ 1.1 (ft)
		> 35' bankfull width : ≥ 1.6 (ft)		> 35' bankfull width : ≥ 1.3 (ft)
	Pools/mile	< 20' bankfull width : ≥ 81	A & B stream types: ≥ 15	< 20' bankfull width : ≥ 84
		20' - 35' bankfull width: ≥ 38	C & E stream types: ≥ 12	20'-35' bankfull width : ≥ 49
		> 35' bankfull width : ≥ 25		> 35' bankfull width : ≥ 26
	LWD/mile	< 20' bankfull width : ≥ 359	*Not determined*	< 20' bankfull width : ≥ 573
		20' - 35' bankfull width : ≥ 242		20'-35' bankfull width : ≥ 380
		> 35' bankfull width : ≥ 148		> 35' bankfull width : ≥ 195
Riparian Health	Percent of streambank with understory shrub cover (reach	≥ 58% understory shrub cover	*Not determined*	≥ 57% understory shrub cover

Parameter Type	Target Description	Kootenai-Fisher	Upper Clark Fork Tributaries	Bitterroot Tributaries (Middle Rockies targets)
	average)			
Sediment Source	Significant and controllable sediment sources	Identification of significant and controllable human-caused sediment sources throughout the watershed	Identification of significant and controllable human-caused sediment sources throughout the watershed	Identification of significant and controllable human-caused sediment sources throughout the watershed
Biological Indices	Macroinvertebrate bioassessment metric	O/E ≥ 0.80	O/E ≥ 0.80	O/E ≥ 0.80
	Periphyton Increaser Taxa	Probability of Impairment <51%	NA	NA

5.4.2.1 Fine Sediment

The percent of surface fines <6 mm and <2 mm is a measurement of the fine sediment on the surface of a streambed and is directly linked to the support of the coldwater fish and aquatic life beneficial uses. Increasing concentrations of surficial fine sediment can negatively affect salmonid growth and survival, clog spawning redds, and 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 other measures also include subsurface fine sediment), literature values for harmful fine sediment thresholds are highly variable. Some studies of salmonid and macroinvertebrate survival found an inverse relationship between fine sediment and survival (Suttle et al., 2004) whereas other studies have concluded the most harmful percentage falls within 10% to 40% fine sediment (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 <2 mm is 13% for fish and 10% for macroinvertebrates. Literature values are taken into consideration during fine sediment target development; however, because increasing concentrations of fine sediment are known to harm aquatic life, targets are developed using a conservative statistical approach consistent with **Appendix B** and consistent with Montana’s water quality standard for sediment as described in **Section 3.2.1**.

Pool-tail and riffle fine sediment grid toss targets were not determined in the Upper Clark Fork Tributaries TMDL document.

5.4.2.2 Channel Form and Stability

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

Width/Depth Ratio and Entrenchment Ratio

The width/depth ratio and the entrenchment ratio provide a measure of channel stability as well as an indication of the ability of a stream to transport and naturally sort sediment into a heterogeneous composition of fish habitat features (e.g., riffles, pools, and near-bank zones).

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

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

5.4.2.3 Instream Habitat Measures

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

Residual Pool Depth

Residual pool depth, defined as the difference between the maximum depth and the tail crest depth, is a discharge-independent measure of pool depth and an indicator of the quality of pool habitat. Deep pools are important resting and hiding habitat for fish, and provide refugia during temperature extremes and high flow periods (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 of in channel obstructions (such as large woody debris), and changes of 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.

Although the residual pool depth measure is similar between DEQ's method and the PIBO reference method, the definition of a pool can vary between the methods. Out of both available reference datasets, the core definition of pools for the PIBO protocol is closer to the definition used for the DEQ/EPA sample datasets where pools were defined as depressions in the streambed bounded by a "head crest" at the upstream end and "tail crest" at the downstream end with a maximum depth that is at least 1.5 times the pool tail depth (Kershner et al., 2004).

DEQ further defined pools as large or small depending on the width of the pool in relation to the stream's bankfull width, whereas the PIBO protocol only counts pools greater than half the wetted channel width. In comparison to the PIBO dataset, the DEQ/EPA sample datasets could have a higher pool frequency and more pools with a smaller residual pool depth since the DEQ protocol has no minimum pool width requirement. However, residual pool depths in the sample datasets are not noticeably less than the PIBO depths indicating the slight protocol differences are not an issue and the reference datasets are appropriate to use for setting residual pool depth targets.

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.

Similar to the residual pool depth values, protocol differences did not result in noticeable differences in the pool frequency, indicating the PIBO reference datasets are suitable for setting targets.

Large Woody Debris

Large woody debris (LWD) is a critical component of stream ecosystems, providing habitat complexity, quality pool habitat, cover, and long-term nutrient inputs. LWD also constitutes a primary influence on stream function, including sediment and organic material transport, channel form, bar formation and stabilization, and flow dynamics (Bilby and Ward, 1989). LWD numbers generally are greater in smaller, low order streams. The application of a LWD target will carry very little weight for sediment impairment verification purposes, but may have significant implications as an indicator of a non-pollutant type of impairment.

For DEQ/EPA sampling efforts, wood was counted as LWD if it was greater than 9 feet long or two-thirds of the wetted stream width, and 4 inches in diameter at the small end (Overton et al., 1997). The LWD count for the PIBO reference dataset was compiled using a different definition of LWD than the DEQ/EPA sample datasets. Unlike pool frequency and residual pool depth values, the summary statistics indicate the protocol differences did result in greater numbers in the PIBO dataset (except for bankfull width (BFW) < 20 ft).

LWD targets were not developed in the Upper Clark Fork Tributaries TMDL document per the discretion of the sediment water quality planner at that time.

5.4.2.4 Riparian Health

Riparian Understory Shrub Cover

The constantly evolving dynamic 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 EPA assessments conducted in 2011 and DEQ assessments in 2007, ground cover, understory shrub cover 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 shrub cover is important for stream health, not all reaches have the potential for dense shrub cover and are instead well armored with rock or have the potential for a dense riparian community of a different composition, such as wetland vegetation or mature pine forest.

There are no available understory shrub cover reference data so the targets are based on the sample datasets. Riparian health targets were not developed in the Upper Clark Fork Tributaries TMDL document. While these targets are informative to gage grazing pressure and habitat alteration, they do not conclusively inform a sediment impairment decision.

5.4.2.5 Sediment Supply and Sources

Human/Human Caused Sediment Sources

The presence of human-caused sediment sources does not always result in sediment impairment of a beneficial use. When there are no significant identified human-caused sources of sediment within the watershed of a 303(d) listed steam, no TMDL will be prepared since Montana's narrative criteria for sediment cannot be exceeded in the absence of human causes. There are no specific target values associated with sediment sources, but the overall extent of human sources will be used to supplement any characterization of impairment conditions. This includes evaluation of human induced and natural sediment sources, along with field observations and watershed scale source assessment information obtained using aerial imagery and GIS data layers. Because sediment transport through a system can take years or decades, and because channel form and stability can influence sediment transport and deposition, any evaluation of human-caused sediment impacts must consider both historical sediment loading as well as historical impacts to channel form and stability since the historical impacts still have the potential to contribute toward sediment and/or habitat impairment. Source assessment analysis will be provided by 303(d) listed waterbody in **Section 5.6**.

5.4.2.6 Biological Indices

Macroinvertebrates

Siltation exerts a direct influence on benthic macroinvertebrate assemblages by filling in spaces between gravel and by limiting attachment sites. Macroinvertebrate assemblages respond predictably to siltation with a shift in 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 method 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). The O/E community shift point for all Montana streams is any O/E value < 0.80. Therefore, an O/E score of ≥ 0.80 is established as a sediment target in the Central Clark Fork Tributaries TPA.

Unless noted otherwise, macroinvertebrate samples discussed within this document were collected according to DEQ protocols. USFS PIBO samples were collected in both riffles and pools with a Hess sampler.

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. 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 macroinvertebrate target does not necessarily indicate a waterbody is fully supporting its aquatic life beneficial use and measures that indicate an imbalance in sediment supply and/or transport capacity will also be used for TMDL development determinations.

Periphyton

Periphyton are 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. Measures of the structure of algal associations, such as species diversity and dominance, can be useful indicators of water quality impacts and ecological disturbance.

No periphyton data has been collected by DEQ in the project area. However, future assessments and water quality investigations in the Northern Rockies Level III ecoregion may incorporate periphyton as a measure of water quality conditions.

5.4.3 Existing Conditions and Comparison to Targets

This section includes a comparison of existing data with water quality targets, along with a TMDL development determination for each stream segment of concern in the Central Clark Fork Basin Tributaries TMDL project area (**Section 5.2**). The TMDL development determination is whether or not recent data support the impairment listing and whether a TMDL will or will not be completed, but it is not a formal impairment assessment. All waterbodies reviewed in this section are listed for sediment impairment on the 2014 303(d) List. Although inclusion on the 303(d) list indicates impaired water quality, a comparison of water quality targets with existing data helps define the level of impairment and establishes a benchmark to help evaluate the effectiveness of restoration efforts. Metals TMDLs were previously developed for Flat Creek and Cramer Creek in a 2013 TMDL document (Montana Department of Environmental Quality, 2013).

As noted in **Section 5.4.1**, sediment targets from approved sediment TMDLs in close proximity to the Central Clark Fork Basin Tributaries TMDL project area were used for sediment streams of concern within the Central Clark Fork Basin Tributaries TMDL project area. The table in **Figure 5-3** identified the sediment targets per respective sediment-listed tributary and sediment stream of concern (Trout Creek). Clark Fork tributaries are presented in the following sections in order from downstream (Superior, MT) to upstream (Drummond, MT).

5.4.3.1 Flat Creek (MT76M002_180)

Flat Creek (MT76M002_180) is listed for sedimentation/siltation on the 2014 303(d) List. It was originally listed in 2002 because of extensive mine tailings deposits in the stream channel. Human-caused sediment sources in the Flat Creek watershed are related primarily to abandoned/ inactive mining from the Iron Mountain mine and associated workings near the former town of Pardee in Hall Gulch, and from the site of the mill and concentrator on Flat Creek. The Iron Mountain Mine and Mill (IMM) site is identified on the Montana Priority Abandoned Mines inventory; it was referred to the US EPA and added to the National Priority List (NPL, aka "Superfund") in 2009. The IMM site operated from 1909 to 1930 and again from 1947 to 1953 producing silver, gold, lead, copper, and zinc ores. Mine tailings were disposed of along Flat Creek near the mine site; subsequent high flows then re-deposited mine tailings as far as its confluence with the Clark Fork River using gravity drainage (U.S. Environmental Protection Agency, 2012).

The IMM site has been subdivided into three operable units (OUs). OU 1 consists of waste rock and tailings from the Iron Mountain mill that was used as fill in the town of Superior. The millsite and Flat

Creek downstream of the millsite comprise OU 2. The tributary drainage of Hall Gulch contains additional mines, including the Belle of the Hills mine and the Dillon Millsite, both of which are included in DEQ's inventory of Priority Abandoned Mines (**Figure 32 in Appendix A**). Finally, OU 3 is a waste rock repository in Wood Gulch, a tributary of Flat Creek downstream of Hall Gulch. A thin layer of tailings (up to 12 in deep) in the floodplain have been reported down to RM 1.56 with a large tailings deposit identified between RM 1.5 and 1.75 (MCS Environmental, Inc., 2004). This large deposit is characterized by reddish brown, dense, moist sand up to 3 feet thick (MCS Environmental, Inc., 2004). The history of the Iron Mountain mining district is summarized in DEQ's Abandoned Mine Lands historical narratives (Montana Department of Environmental Quality, 1998) and in a USFS site investigation (MCS Environmental, Inc., 2004). Metals TMDLs were developed for Flat Creek in a 2013 TMDL document (Montana Department of Environmental Quality, 2013).

Several agencies, including DEQ, EPA, and USFS, have studied mining-related metals sources in the Flat Creek watershed (Montana Department of State Lands, 1995; (Hargrave et al., 2003); (MCS Environmental, Inc., 2004); (United States Environmental Protection Agency, 2011). These projects documented metals contamination of soil, groundwater, surface water, and stream sediments. Figure 5-4 shows the spatial extent of historic mining activity and mine wastes in the watershed. DEQ completed additional stream sampling from 2009-2012 to use for an updated assessment and to support subsequent TMDL development (Appendix B).

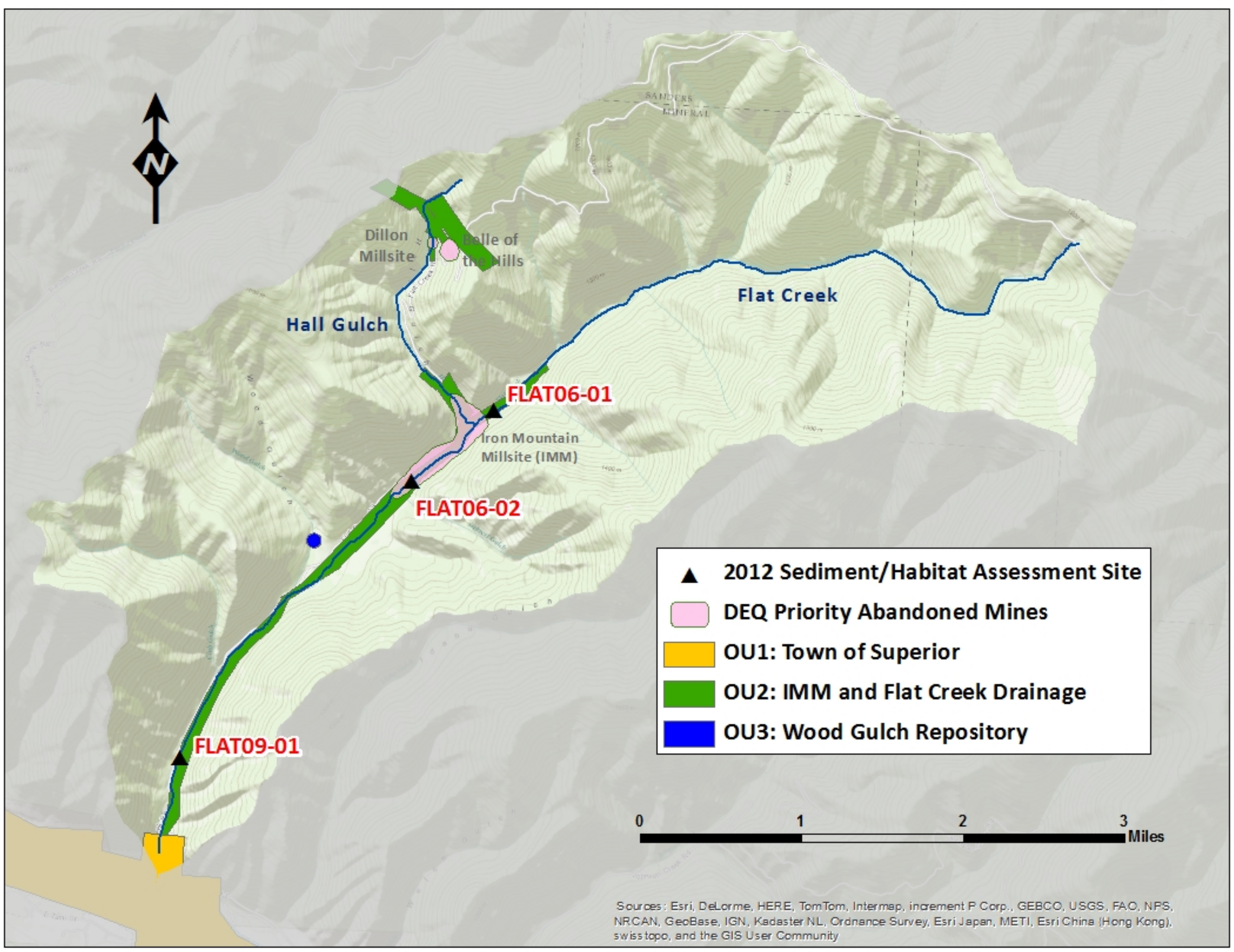

Figure 5-4. 2012 sediment/habitat sampling locations and potential sediment sources in the Flat Creek watershed

Physical Condition and Sediment Sources

Flat Creek was listed for sedimentation/siltation due to significant deposition of mine tailings to the stream channel, which is delineated by OU 2 in **Figure 5-4**. In 2012, DEQ sampled three stream reaches on Flat Creek; one (FLAT06-01) upstream of the IMM site and two (FLAT06-02 and FLAT09-01) downstream of the site.

FLAT06-01 was located upstream of some of the historic mining in the Flat Creek watershed. Signs of historical logging were also observed on the hillslope and in the riparian zone, with large cedar stumps along the channel. An old abandoned road crossed the channel downstream of the monitoring site and ran parallel to the site along river left. Overall, the channel was slightly entrenched, with woody debris formed pools. Appropriate sized spawning gravels were observed. Isolated large eroding streambanks were also observed. Riparian shrubs and young cedar trees lined the stream channel.

FLAT06-02 was located downstream of the IMM and orange colored historic mining tailings lined the channel. Mining tailings were also used to construct the old road bed, which parallels the stream channel. Numerous cans and bottles were observed in the streambanks, suggesting the site was once used as a garbage dump. In this reach, Flat Creek contained a riffle-pool channel with pools formed by woody debris. Some fine sediment was observed surrounding the woody debris. Appropriate sized spawning gravels were observed, along with a few small fish. Moss lined streambanks indicate very slow streambank retreat rates. Riparian vegetation included smaller cedars, alder, and birch.

FLAT09-01 was located upstream of the town of Superior. Superior is located at the mouth of Flat Creek (Clark Fork River). Logging has occurred along the monitoring site with young mixed conifers and shrubs along the channel. The main road was observed approximately 100 feet from the channel. Large tailings piles were observed along the channel margin, with signs of erosion during extreme high water events. Mine tailings were present consistently four feet above the channel suggesting historic aggradation. The stream is comprised primarily of riffles with poorly developed pools at the outsides of meander bends. Small fish were observed. There was less fine sediment in the substrate than at the FLAT06-02 reach upstream.

The Flat Creek channel downstream of IMM may be best described as significantly impacted by mine tailings and road encroachment, but has established some stability since mining activities ceased in 1953.

Comparison with Water Quality Targets

The existing data in comparison with the targets for Flat Creek are summarized in **Table 5-3**. The macroinvertebrate bioassessment data are located in **Table 5-4**. The water quality targets for Flat Creek are those determined for the Kootenai-Fisher TMDL Project Area **(Table 5-2)**. All bolded cells are not meeting the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-3. Existing sediment-related data for Flat Creek relative to targets.
Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat		
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile
FLAT06-01	2012	10.0	B4/F4	B4	12	4	1	**11**	8.5	**1.3**	0.7	95	560
FLAT06-02	2012	10.1	B4/E4	B4	14	4	**9**	**10**	8.8	2.0	0.9	169	729
FLAT09-01	2012	9.9	B4/C4/E4	C4	**21**	**10**	4	8	10.4	2.7	0.7	95	370

Table 5-4. Macroinvertebrate bioassessment data for Flat Creek.
Values that do not meet the target threshold (0.80 for O/E) are in bold.

Station ID	Collection Date	Collection Method	O/E
PIBO_2252	8/7/2007	SURBER	**0.63**

Summary and TMDL Development Determination

DEQ sampled three stream reaches on Flat Creek in 2012. Channel form and instream habitat targets were met at most sites. The sample reach upstream of the IMM site was determined to be slightly entrenched. Sediment water quality targets were exceeded for riffle pebble count (<6 mm and <2 mm) at the most downstream site (FLAT09-01). The target for pool tail fines <6 mm was exceeded at the upper and middle sites on Flat Creek and the riffle grid toss at the site immediately downstream of the IMM also exceeded the target. The nature of the sediment target exceedances suggest that fine sediment in the channel is affecting fish spawning habitat and impairing beneficial uses. The entrenchment ratio targets were slightly below the target of 1.4 at FLAT06-01. As width/depth ratio, and instream habitat (residual pool depth, pool frequency, large woody debris) targets were not exceeded at the sample reaches, this suggests that Flat Creek has achieved a measure of stability since mining operations ceased. Stream banks are aggraded with tailings deposits and remain the largest source of fine sediment to the channel.

A macroinvertebrate sample was collected by a PIBO field crew in 2007 at a site immediately downstream of the FLAT09-01 reach. The sample was less than the target of 0.63 suggesting the macroinvertebrate community is impaired. The number of fine sediment exceedances at FLAT09-01 suggests that fine sediment may be affecting the macroinvertebrate score. However, Flat Creek is impaired by several metals as well as sediment so the macroinvertebrate sample is likely affected by more than sediment.

Based on the mining history and on-going remediation activities concerning the IMM operable units and combined with the fine sediment exceedances, Flat Creek is currently impaired by sedimentation/siltation and a sediment TMDL will be developed.

5.4.3.2 Trout Creek (MT76M002_050)

Trout Creek (MT76M002_050) is listed for turbidity on the 2014 303(d) List. This segment is also listed for alteration in streamside or littoral vegetative covers and physical substrate alterations, which are non-pollutant listings commonly linked to sediment impairment. Trout Creek was first listed for turbidity on the 2002 303(d) list. Turbidity is a measure of water clarity, or the amount of light that can penetrate the water. Although turbidity may be caused by sources other than sediment, it is commonly linked with suspended sediment concentration in the water column. For this reason, sediment/habitat fieldwork was completed on the segment by DEQ in 2012 and Trout Creek is assessed for a sediment impairment.

The DEQ assessment file links the turbidity listing to wet weather discharges from non-point sources and silviculture activities, which were identified in a 1990 assessment of the stream. The source of the turbidity was identified in photo documentation from October 1990 as leachate from sawmill log storage areas near the mouth that was affecting color and turbidity in Trout Creek. Since 1990, sawmill operations located on private lands near the mouth of Trout Creek have been converted to facilities for the production of wood pellets, bark mulch, and natural landscaping materials .

Significant evidence of historic and active placer mining in the Trout Creek drainage was noted in the 1990 and 2012 assessment work. For the entire Trout Creek sub-watershed, 99.8% of the area is administered by the U.S. Forest Service with 1.1% in private ownership. Trout Creek has been identified as being critical to Bull Trout recovery in the lower Clark Fork River drainage (Montana Bull Trout Scientific Group, 1996).

Physical Condition and Sediment Sources

Trout Creek is listed for turbidity, alteration in streamside or littoral vegetative covers, and physical substrate alterations each of which are potentially related to a sediment impairment. DEQ assessed two stream reaches on Trout Creek in 2012.

TROU03-01 was located in the upper Trout Creek watershed upstream of the Verde-Windfall road crossing. Two historic road crossings have been removed near this monitoring site although the main road encroached on the stream channel in places. Extensive logging has occurred throughout the surrounding watershed. This reach of Trout Creek was observed to be a mountain stream with large boulders and boulder formed pools, essentially a step-pool system. Naturally large substrate size limited the spawning potential in the reach. Large woody debris was commonly found along the channel margins during the site visit/reach survey. Streambanks were stable due to the large relative size of the bank material and bed composition. There was a band of alders along the channel margin and mixed conifers in the overstory. The channel margin was lined with alders and mixed conifers dominated the overstory.

TROU12-03 was located in lower Trout Creek along the Lolo National Forest Trout Creek campground. Extensive logging has occurred in the surrounding watershed. Large substrate size was noted to limit the spawning potential. Streambanks were stable due to the large relative size of the bank material and bed composition. The channel margin was lined with alders and mixed conifers dominated the overstory.

Comparison with Water Quality Targets

The existing data in comparison with the targets for Trout Creek are summarized in **Table 5-5**. The macroinvertebrate bioassessment data are located in **Table 5-6**. The water quality targets for Trout Creek are those determined for the Kootenai-Fisher TMDL Project Area **(Table 5-2)**. All bolded cells are not meeting the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-5. Existing sediment-related data for Trout Creek relative to targets.
Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat		
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile
TROU03-01	2012	49.6	C3/B3/F3	B3	9	6	3	4	24.8	1.6	**1.3**	**21**	194
TROU12-03	2012	61.6	B4/C3/B3/F3	B3	7	5	2	1	27.4	1.5	1.7	**14**	**109**
* No pools were observed in the sample reach, therefore, pool tail fines and residual pool depth were not applicable													

Table 5-6. Macroinvertebrate bioassessment data for Trout Creek.
Values that do not meet the target threshold (0.80 for O/E) are in bold.

Station ID	Collection Date	Collection Method	O/E
PIBO_2141	8/8/2007	SURBER	**0.72**

Summary and TMDL Development Determination

Within the two assessed stream reaches on Trout Creek, no sediment targets for riffle pebble count and grid tosses in riffles or pools were exceeded. Likewise, no sediment targets for channel form were exceeded either. At the upstream site (TROU03-01), residual pool depth and pool frequency targets were not met, and at the lower site (TROU12-03) pool frequency and large woody debris targets also failed to meet the targets. However, this is most likely a result of the large substrate size and step-pool system dynamics more so than human-caused effects. Trout Creek is a north-facing, high energy stream with large substrate which is likely not conducive to high pool frequency. Extensive historic logging in the sub-watershed is likely the contributing factor to low large wood debris recruitment in the channel.

The 2007 PIBO macroinvertebrate sample was collected from Trout Creek immediately downstream of a historic placer operation in the channel and ¾ mile upstream of TROU03-01. The sample failed to meet the target threshold of 0.80 for O/E.

The turbidity listing on Trout Creek was linked to stormwater runoff from denuded log yards as part of sawmill operations near the mouth of Trout Creek. Since 1990, sawmill operations have been converted to manufacture of wood pellets, bark mulch and natural landscaping materials. There are large stockpiles of mulch and other wood products on private land and in close proximity to Trout Creek, which were the source of the original listing decision.

The high energy, step-pool system was found to be quite stable with low streambank erosion and no fine sediment accumulations observed. The 2012 DEQ fine sediment data indicate that Total Suspended Solids (TSS) concentrations are not occurring at concentrations that are impairing beneficial uses in the stream. This conclusion is based on the fact that none of the fine sediment targets at the two monitoring sites on Trout Creek were exceeded. Based on the original turbidity listing and the results of the 2012 DEQ assessment on Trout Creek, the stream is not impaired by sediment and a sediment TMDL will not be developed for Trout Creek. The turbidity listing is tied to wet weather discharges of organic solids and leachate from stored wood products on private lands near the mouth with the Clark Fork River. A turbidity TMDL will be developed for Trout Creek (**Section 8**).

5.4.3.3 West Fork Petty Creek (MT76M002_100)

West Fork Petty Creek (MT76M002_090) is listed for sedimentation/siltation on the 2014 303(d) List. It was originally listed in 1990 due to impacts from forest roads (construction and use) and timber harvesting. Currently, the sub-watershed is mostly USFS administered lands with private ownership adjacent to the creek in the lower half of the drainage. The West Fork Petty Creek drainage was part of the Montana Legacy Project where private timberlands were purchased by The Nature Conservancy and transferred to the USFS. In the West Fork Petty Creek sub-watershed, TNC lands were transferred to the Lolo National Forest in March 2010. The land transfer included approximately 9,400 acres or 36% of the West Fork Petty Creek sub-watershed. Included in this transfer was approximately one mile of stream frontage in the upper drainage.

West Fork Petty Creek is also listed for a TP impairment on the 2014 303(d) List (**Section 6.0**).

Physical Condition and Sediment Sources

A DEQ stream assessment on West Fork Petty Creek was completed in 2004. The assessment determined that the upper drainage was in its natural state with well vegetated banks and mature forest canopy. At the lower site, some channel incisement was noted along with some road encroachment on the channel margins. The site was located in a grazed pasture and the riparian area was less robust in this reach than in the upper reach. One site was assessed by DEQ in 2012 in the upper portion of the sub-watershed.

WFPY03-01 was located just upstream of a bridge crossing that was removed in the summer of 2012. Historic logging was noted at the monitoring site, although the conifer forest was regenerating. Extensive logging had occurred throughout the sub-watershed mostly on former private timberlands. In the narrow valley, a road paralleled the stream channel, which was bordered by dense riparian shrubs as was also found in the 2004 assessment. Aggradation was observed where course woody debris is prevalent in the channel. The site generally lacked fine sediment accumulations. Pools were formed by course woody debris and spawning sized gravels were observed.

Comparison with Water Quality Targets

The existing data in comparison with the targets for West Fork Petty Creek are summarized in **Table 5-7**. The macroinvertebrate bioassessment data are located in **Table 5-8**. The water quality targets for West Fork Petty Creek are those determined for the Kootenai-Fisher TMDL Project Area **(Table 5-2)**. All bolded cells are not meeting the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-7. Existing sediment-related data for West Fork Petty Creek relative to targets.
Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat		
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile
WFPT03-01	2012	10.7	E4/C4/B4	B4	15	4	7	6	10.3	4.0	0.9	127	634
* No pools were observed in the sample reach, therefore, pool tail fines and residual pool depth were not applicable													

Table 5-8. Macroinvertebrate bioassessment data for West Fork Petty Creek.
Values that do not meet the target threshold (0.80 for O/E) are in bold.

Station ID	Collection Date	Collection Method	O/E
C04PYWFC01	8/13/2004	KICK	1.05
C04PYWFC02	8/13/2004	KICK	1.17
C04PYWFC02	9/12/2011	MAC-R-500	1.29
C04PYWFC01	9/12/2011	MAC-R-500	1.05

Summary and TMDL Development Determination

On West Fork Petty Creek, there were no exceedances of sediment targets for any of the parameters. In two macroinvertebrate samples collected five miles upstream of the mouth and two samples collected approximately 300 yards upstream of the mouth, O/E scores were greater than the threshold of 0.80.

The original sedimentation/siltation listing was based on forest road construction and timber harvesting on private timberlands in the sub-watershed. In 2010, 9,400 acres of private timberlands in the sub-watershed were transferred to the Lolo National Forest via the TNC Montana Legacy Project. All sediment and macroinvertebrate data suggest that the system is meeting beneficial uses and is not impaired for sedimentation/siltation. However, most of the lower portion of the watershed is under private ownership and DEQ was unable to gain access to this section of West Fork Petty Creek. As the full sediment assessment on the stream could not be completed and the stream is currently listed for a sediment impairment, data were not robust enough to determine that a sediment impairment no longer exists on West Fork Petty Creek. Therefore, a sediment TMDL will be prepared for the waterbody.

5.4.3.4 Petty Creek (MT76M002_090)

Petty Creek (MT76M002_090) is listed for sedimentation/siltation on the 2014 303(d) List. It was originally listed in 1988 based on sediment impacts from agriculture and timber harvesting in the watershed (Bahls, 1988). In addition, this segment is also listed for alteration in stream-side or littoral vegetative covers and low flow alterations, which are non-pollutant listings commonly linked to sediment impairment. The 2006 DEQ assessment report links the sedimentation impairment to agriculture and transportation networks and infrastructure. Comments provided to DEQ by FWP in 1999 linked habitat degradation to overgrazing, loss of riparian vegetation, road encroachment and residential development.

The Petty Creek watershed was part of the Montana Legacy Project where private timberlands were purchased by The Nature Conservancy and transferred to the Lolo National Forest to be administered by the USFS. In the Petty Creek watershed, TNC lands were transferred to the Lolo National Forest in March 2010. The land transfer included approximately 12,300 acres or 23% of the entire Petty Creek watershed including several parcels in close proximity to the stream channel.

It should be noted that FWP lists Petty Creek as being chronically dewatered (dewatering is a significant issue in most years) from 1.6 miles upstream of the mouth to the confluence of Bruce Creek (aka Gus Creek) and Petty Creek. Petty Creek is also listed for a temperature impairment on the 2014 303(d) List (**Section 7.0**).

Physical Condition and Sediment Sources

PETT03-01 was located downstream of the second road crossing of Petty Creek (when heading upstream) in an area with rural residential development, including a small walking bridge crossing the stream. Road construction as part of the Petty Creek Road improvement project was occurring along Petty Creek during the summer of 2012. The stream meandered through an open meadow with pools formed at the outsides of meander bends. Channel substrate was generally considered too large to support spawning except in isolated pockets. Eroding streambanks were also associated with channel meanders. Streambanks were lined with grass and some alder, with sparse cottonwoods and conifers. Petty Creek was dry upstream of this site during temperature monitoring in October 2012, with inputs from Printers Creek and Johns Creek providing all of the stream flow to Petty Creek in this reach.

PETT07-01 was located in a relatively narrow valley lower in the Petty Creek watershed on lands administered by the Lolo National Forest. The Petty Creek Road paralleled this portion of the stream, but was not encroaching on the channel at the monitoring site. This was observed to be a meandering channel with pools formed at the outsides of meander bends. Suitable sized spawning gravels were observed and the larger pools were formed by large woody debris. One large eroding streambank was observed where the stream was cutting into the toe of the hillslope. Erosion at this spot appeared to be due largely to natural processes, though timber harvest throughout the watershed may have altered the hydrology for a period of time. Reed canary grass lined the streambanks along the majority of this monitoring site, along with alders and other deciduous shrubs in the understory and cottonwoods and conifers in the overstory.

PETT07-02 was located downstream of PETT07-01 on USFS administered land. A streambank erosion assessment was conducted at this site to further characterize streambank erosion sediment loads in this reach of Petty Creek where the road periodically encroached upon the stream channel. Extensive erosion was observed due to road encroachment along the river right streambank. Restoration measures in the form of two log vanes were added to this reach, although they were added perpendicular to the flow and were leading to accelerated streambank erosion downstream of the log vanes. Riparian vegetation was similar to PETT07-01 upstream, with alders and other deciduous shrubs in the understory and cottonwoods and conifers in the overstory.

Comparison with Water Quality Targets

The existing data in comparison with the targets for Petty Creek are summarized in **Table 5-9**. The macroinvertebrate bioassessment data are located in **Table 5-10**. The water quality targets for Petty Creek are those determined for the Kootenai-Fisher TMDL Project Area **(Table 5-2)**. All bolded cells are not meeting the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-9. Existing sediment-related data for Petty Creek relative to targets.
Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat		
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile
PETT03-01	2012	20.6	C4/B4	C4	11	3	1	6	15.1	5.0	1.4	74	**137**
PETT07-01	2012	22.1	C4	C4	10	2	**9**	7	16.5	4.7	1.2	53	**53**
PETT07-02	2012	*Only a streambank erosion assessment was completed at this location.*											

Table 5-10. Macroinvertebrate bioassessment data for Petty Creek.
Values that do not meet the target threshold (0.80 for O/E) are in bold.

Station ID	Collection Date	Collection Method	O/E
C04PETYC01	9/7/2011	MAC-R-500	**0.74**
C04PETYC03	9/7/2011	MAC-R-500	1.07
C04PETYC04	9/8/2011	MAC-R-500	1.24

Summary and TMDL Development Determination

At the two sampled reaches in Petty Creek where the full DEQ assessment was completed in 2012, the only sediment target that was exceeded was the riffle fine sediment target at PETT07-01. No other targets were exceeded for fine sediment (riffle pebble count, grid toss) or for channel form. Instream habitat targets were met for residual pool depth and pool frequency. Only the large woody debris target was not met at the sampled reaches. This is more a function of land use/land management and could contribute to a lack of suitable instream habitat in Petty Creek. Three macroinvertebrate samples were collected in Petty Creek in September 2011. Samples collected upstream of the Madison Gulch confluence and downstream of the West Fork Petty Creek confluence were greater than the O/E threshold of 0.80. A sample collected near the mouth with the Clark Fork River within a low impact residential area was less than the 0.80 O/E threshold.

The most significant impact to the Petty Creek watershed in recent years is the Petty Creek Road improvement project, which was completed in late 2013. The Western Land Highway Division of the Federal Highway Administration funded the project at the behest of Missoula County and the Lolo National Forest. As part of this project, road work included paving the Petty Creek Road from the bottom of the drainage up to mile post (MP) 9.8 with a uniform width of 24 feet with one travel lane in each direction and adjacent shoulders. From MP 9.8 to MP 11.7, the road was reconstructed with a gravel surface. As part of construction, the road was moved away from Petty Creek where feasible. Where road movement away from the stream was not possible, riparian vegetation will be planted to promote sediment buffering. Undersized stream crossings, including seven culverts and one bridge structure (Petty Creek Bridge at MP 9.7) were replaced to provide a natural bankfull stream configuration with capacity to transport the 100-year flood event.

As part of the environmental assessment for the project, sediment loading from Petty Creek Road from MP 0 – MP 11.7 pre- and post-project completion were estimated (Appendix 6 of (U.S. Department of Transportation, Federal Highway Administration, Western Federal Lands Highway Division, 2010)). Project engineers estimated pre-construction project area was contributing 433 tons of sediment per year to Petty Creek. Post-project completion, improvements from road paving, culvert and bridge replacement, and road sloping/road re-alignment would reduce the existing sediment load by 94% to 27 tons of sediment per year (U.S. Department of Transportation, Federal Highway Administration, Western Federal Lands Highway Division, 2010).

The Petty Creek Road improvement project outlined above addressed the Petty Creek Road past both 2012 DEQ sampled reaches on Petty Creek. However, most of the middle portion of the watershed is under private ownership and DEQ was unable to gain access to this section of Petty Creek. Aerial imagery suggests that much of the riparian corridor is in poor condition in the middle reaches of Petty Creek. As the full sediment assessment on the stream could not be completed and the stream is currently listed for a sediment impairment, data were not robust enough to determine that a sediment impairment no longer exists. Therefore, a sediment TMDL will be prepared for Petty Creek.

5.4.3.5 Grant Creek (MT76M002_130)

Grant Creek (MT76D002_090) is listed for sedimentation/siltation on the 2014 303(d) List. In addition, this segment is also listed for alteration in stream-side or littoral vegetative covers and low flow alterations, which are non-pollutant listings commonly linked to sediment impairment. The stream was first listed for sedimentation/siltation on the 1996 303(d) List with probable sources given as streambank modifications/destabilization, and site clearance (land development or redevelopment). It was determined to be impairing the beneficial uses of primary contact recreation and aquatic life.

According to the DEQ assessment file, the stream was listed for a variety of observations including residential and commercial development along the channel and irrigation diversions, which eliminated the connection of Grant Creek to the Clark Fork River for most of the year. It should be noted that FWP lists Grant Creek as being chronically dewatered (dewatering is a significant issue in most years) from where the stream crosses Hiawatha Road to the mouth (Clark Fork River).

Grant Creek is also listed for nutrient impairments (**Section 6.0**) and for a temperature impairment (**Section 7.0**) on the 2014 303(d) List.

Since settlement of the Missoula Valley, Grant Creek has been significantly altered in the lower portions of the watershed. The original Grant Creek channel can be roughly located along the band of vegetation that proceeds south and west of International Drive in the 1954 aerial photograph in **Figure 5-5** below. In **Figure 5-5**, the Field-Dougherty Ditch arrow points towards a section of the channel referred to locally as the 'Horseshoe'.

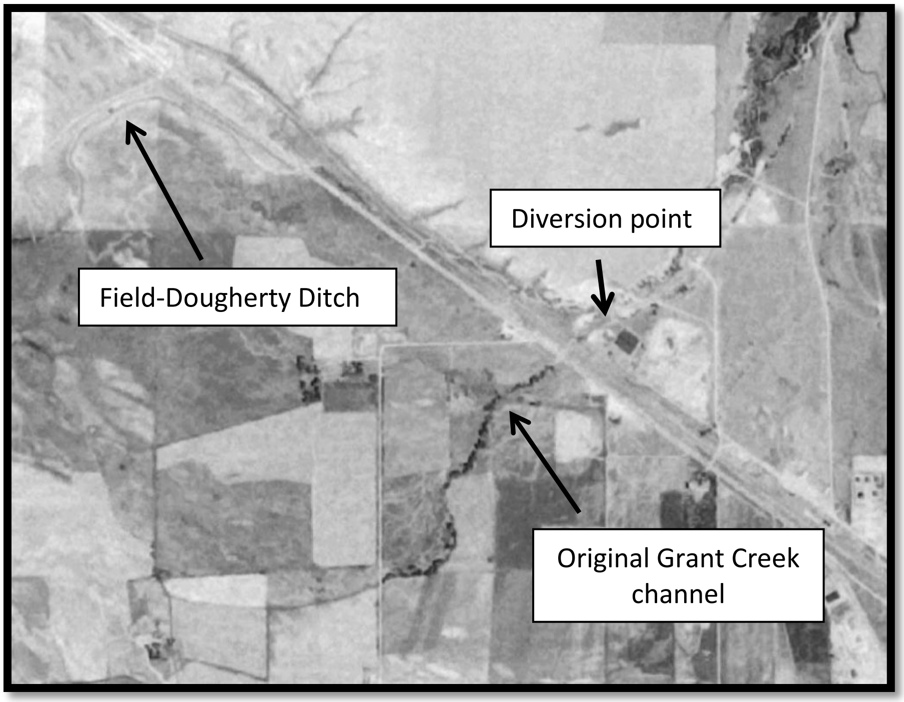

Figure 5-5. 1954 aerial photo of Grant Creek and Field-Dougherty Ditch

In reviewing a sequence of aerial photos taken in 1954, 1961, 1976, 1990, 2000, and 2011 several things become evident. Grant Creek has been altered as an irrigation conduit downstream of International Drive since sometime before 1954 and likely only functions as a natural corridor downstream of Highway 263 (Mullan Road) where it enters the Clark Fork River floodplain (100-yr recurrence interval). Through the 20th century, the areal extent of irrigated acres in the Grant Creek watershed has steadily declined with increases in residential and commercial land development in many parts of the lower drainage and even over top of the original Grant Creek channel. **Figure 5-6** identifies a subdivision built on top of the original channel sometime between 1990 and 2000. Also visible in the photo is the emergence of a riparian corridor along the Field-Dougherty Ditch as it runs westward away from the original Grant Creek channel along with the senescence of riparian vegetation along the original channel.

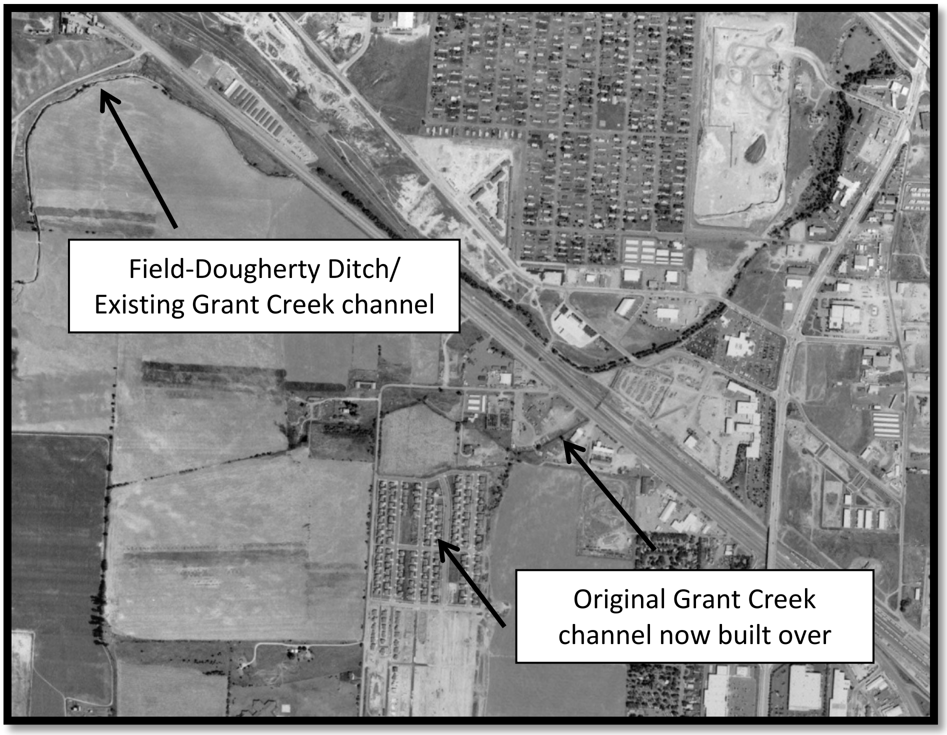

Figure 5-6. 2000 aerial photo of Grant Creek and Field-Dougherty Ditch

Residential land development has only continued to progress along and within the historic Grant Creek channel. In addition, as outlined in the following section, a study completed by Missoula County in 2010 led to changes in the FEMA 100-year floodplain map that now identifies the Field-Dougherty Ditch as the only conduit of Grant Creek flows from the International Road crossing to the Hiawatha Road crossing (Federal Emergency Management Agency, 2011).

Federal Emergency Management Agency (FEMA) Pre-Disaster Mitigation (PDM) grant
In 2005, Missoula County applied for a FEMA PDM grant through the State of Montana to implement cost-effective hazard mitigation on Grant Creek. The catalyst regarding this application was a 10-yr recurrence interval flood event which inundated the Mullan Trail subdivision and damaged 40 homes at a reported cost of $6.2 million in 1997 (Harmon, Dan J. and HDR Engineering, Inc., personal communication 11/24/2010). Sedimentation from channel incisement and erosion was also cited as reducing the hydraulic conveyance of some reaches, which contributed to degradation of the Grant Creek channel in the study reach (Harmon, Dan J. and HDR Engineering, Inc., personal communication 11/24/2010).

The objectives of the FEMA PDM project were to: 1) reduce flooding hazards; 2) improve fish passage; 3) improve fish habitat; and 4) improve recreation opportunities and the aesthetic value of the creek.

Between 2008 and 2010, channel morphology and habitat conditions in the Grant Creek stream channel between West Broadway Street and the Clark Fork River floodplain were addressed by a joint effort involving the US Corps of Engineers, US Fish and Wildlife Service, Montana Fish, Wildlife and Parks, Montana Department of Transportation and Missoula County (6/11/2007; Harmon, Dan J. and HDR Engineering, Inc., personal communication 11/24/2010). The study area included the Grant Creek channel corridor from Schramm Street to the Clark Fork River confluence (**Figure 5-7**). In addition to other stream restoration activities, the project included the elimination of fish passage barriers at several road crossings including West Broadway Street and Mullan Road. The project was closed out in 2010 with completion of updated FEMA flood inundation maps (Harmon, Dan J. and HDR Engineering, Inc., personal communication 11/24/2010).

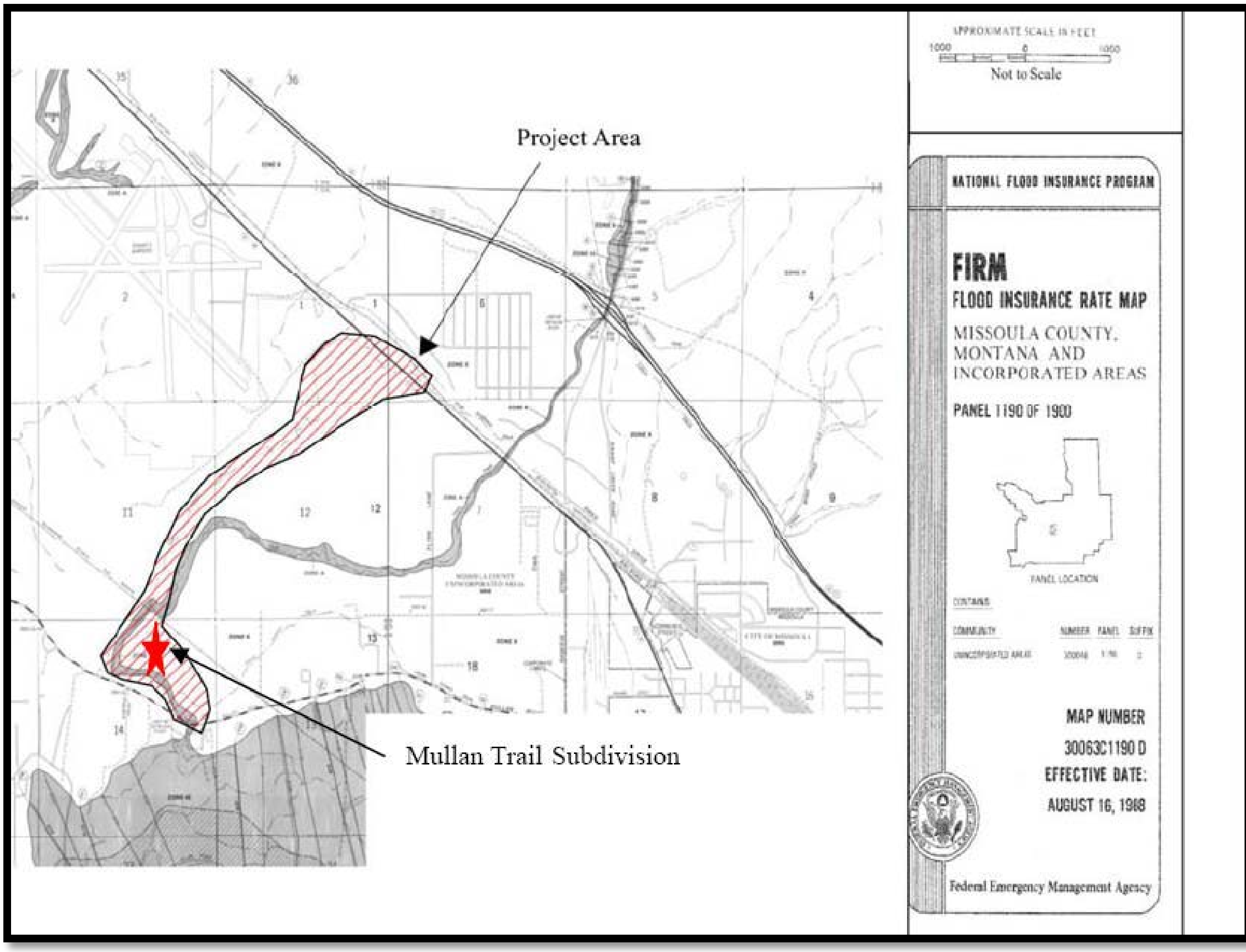

Figure 5-7. FEMA PDM Study area (Harmon, Dan J., personal communication 6/11/2007)

In **Figure 5-7**, the historic Grant Creek channel is identified by the FEMA map as the main conveyance of flows through the watershed. The Mullan Trail subdivision location is also identified. The effective date of the map is August 16, 1988 following flood inundation studies by FEMA in 1978 and 1986. The final task of the Missoula County PMD grant was to submit a Letter of Map Revision (LOMR) to change the 1998 FEMA Flood Insurance Rate Map (FIRM). The updated and current FEMA FIRM for this area has an effective date of December 2011 (Federal Emergency Management Agency, 2011).

For the FEMA flood insurance study, a HEC-RAS model was run using as-built post-construction surveys and various frequency events (2-, 5-, 10-, 50-, and 100-yr events). Updated floodplain boundary maps were produced using GIS capabilities and updated water surface elevations (Harmon, Dan J. and HDR Engineering, Inc., personal communication 11/24/2010). A HEC-RAS model was used to determine flood elevations in Grant Creek and to assess sediment impacts. Given the change in channel slope downstream of West Broadway Street, project engineers anticipated that this reach would experience deposition if there were significant sediment loads being transported to this segment from upstream areas. From the HEC-RAS analysis, the authors determined that "*accumulation of sediment that could decrease channel or culvert/bridge capacity in this reach appears to be unlikely***"** (Harmon, Dan J. and HDR Engineering, Inc., personal communication 11/24/2010).

It was anticipated that certain project elements would stabilize some active erosion locations and mitigate localized sediment issues. Missoula County also intends to schedule and perform sediment maintenance in the 'Horseshoe' segment of the channel on an as-needed basis (Harmon, Dan J. and HDR Engineering, Inc., personal communication 11/24/2010). The county has indicated that sediment transport issues have not been a concern and future problems are not anticipated in Grant Creek.

It is important to note that this modeling effort and associated analyses were performed to quantify floodplain dynamics and hydraulics and not for assessing sediment conditions at baseflow.

Physical Condition and Sediment Sources
In 2012, DEQ completed stream assessments on three reaches in Grant Creek.

GRNT08-02 was located at the upper end of rural residential development along Grant Creek and upstream of the confluence with the East Fork Grant Creek. Channel conditions represented a relatively natural mountain stream. Observed human-caused influences included an irrigation diversion at the upstream end of the reach and vegetation removal. However, dense riparian vegetation lined the majority of the monitoring site with a conifer dominated overstory. Pools formed behind boulders, while large woody debris was relatively sparse. The relatively large substrate limited the spawning potential within this monitoring site. Large substrate in the bank and toe composition may also limit the streambank erosion sediment load. The reach was likely in its natural condition.

GRNT11-02 was located just upstream of where Interstate 90 crosses Grant Creek. This channelized urban stream flowed through a natural area with walking trails along the west side of the channel and a road along the east side of the channel. The channel was noted as being somewhat entrenched with little floodplain access. Pools formed at the outsides of slight meander bends. The relatively large substrate limited the spawning potential within this monitoring site. Many of the streambanks were comprised of exposed cobbles. Large cottonwood trees lined this reach with alder in the understory. The sampled reach was surrounded by urban infrastructure although the reach is currently managed to maintain its natural characteristics.

GRNT12-03 was located in lower Grant Creek immediately upstream of where Mullan Road (Hwy 263) crosses Grant Creek. This reach was part of an extensive FEMA project to alleviate flooding potential/extent in the lower Grant Creek (Harmon, Dan J., personal communication 6/11/2007; Harmon, Dan J. and HDR Engineering, Inc., personal communication 11/24/2010) as discussed in a previous section. DEQ assessors noted that FEMA work re-contoured the channel and put in some natural channel characteristics, including narrowing the channel by adding a bankfull bench with willow plantings. However, the channel still functioned essentially as a ditch lacking meanders, riffles, and pools. The streambed was a mixture of fine sediment and cobbles. The riparian vegetation was comprised of willow plantings and weeds. Additional restoration measures could emphasize re-creating a more natural riffle-pool sequence. Given the nature of this reach, DEQ assessment personnel did not collect instream habitat metrics or pool-tail grid toss measurements.

Comparison with Water Quality Targets

The existing data in comparison with the targets for Grant Creek are summarized in **Table 5-11**. The macroinvertebrate bioassessment data are located in **Table 5-12**. The water quality targets for Grant Creek are those determined for the Bitterroot Tributaries TMDL Project Area **(Table 5-2)**. All bolded cells are not meeting the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-11. Existing sediment-related data for Grant Creek relative to targets.
Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat		
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile
GRNT08-02	2012	25.3	B4	B3	4	1	1	2	**20.5**	2.0	1.1	58	**95**
GRNT11-02	2012	23.9	B4c	C4	12	4	6	**11**	**19.1**	2.7	1.3	**48**	**121**
GRNT12-03[1]	2012	12.9	G5	C4	**77**	**72**	**80**	*NR*	9.2	2.6	*NR*	*NR*	*NR*

[1] No pool or riparian data was collected as the reach was identified as an altered/channelized stream.

Table 5-12. Macroinvertebrate bioassessment data for Grant Creek.
Values that do not meet the target threshold (0.80 for O/E) are in bold.

Station ID	Collection Date	Collection Method	O/E
C04GRNTC01	8/10/2004	KICK	1.11
C04GRNTC02	8/10/2004	KICK	1.08
C04GRNTC03	8/11/2004	KICK	1.28
C04GRNTC04	8/11/2004	JAB	**0.61**
C04GRNTC07	7/25/2011	MAC-R-500	1.15
C04GRNTC01	8/30/2011	MAC-R-500	1.26
C04GRNTC02	8/29/2011	MAC-R-500	1.28
C04GRNTC04	8/29/2011	MAC-R-500	0.92
C04GRNTC04	9/27/2011	MAC-R-500	0.92

Summary and TMDL Development Determination

Several different sediment targets were not met at the 2012 sampled reaches on Grant Creek. At the upper and middle sites, GRNT08-02 and GRNT 11-02, the W/D ratio and large woody debris targets were not met. The data suggest that the stream may be over-widened from its natural condition in these reaches. The lack of large woody debris at the upper and middle sites is not surprising given the relative urban nature of the lower drainage where flood concerns may lead to clearing the stream channel of potential obstructions. At the middle site, GRNT11-02, the target for pool tail fines was exceeded, which suggests that fish spawning habitat may be impaired in this reach by excessive fines. The lower site, GRNT12-03, was the most impacted. A channelized reach mirroring its primary use as a conduit for flood flows, the channel is encroached on both sides by residential development. The creation of an inset floodplain as part of the FEMA project work has given the stream some room to move but it is relatively confined. Percent fines were excessive in observed riffles and in the riffle grid toss measurement. This may be due to the type of substrate, the lack of flushing flows that can move fine sediment in this part of the channel, or recent in-channel construction efforts from 2008-2010.

There were nine macroinvertebrate samples collected from Grant Creek in 2004 and 2011 (**Table 5-12**). Of the nine samples, there was only one macroinvertebrate sample that failed to meet the threshold O/E score of 0.80. This sample was collected at a location 100 yards upstream of the mouth in August, 2004 and was the only sample that used the JAB collection method. It should be noted that the JAB method is no longer used by DEQ as it was determined to provide inconsistent results in its application.

Based on the 2012 sediment and habitat assessment results and the land use history and current state of the channel, Grant Creek is currently impaired by sedimentation/siltation and a sediment TMDL will be developed.

5.4.3.6 Cramer Creek (MT76E004_020)

Cramer Creek (MT76E004_020) is listed for sedimentation/siltation on the 2014 303(d) List. It was originally listed in 1988 due to significant stream channel impacts from mine tailings in the vicinity of the Linton Mine, a DEQ Priority Mine Site. The Linton Mine was a lead zinc mine that operated from 1947-1953; it is located on BLM administered lands in the upstream reaches of Cramer Creek. DEQ assessment files identified additional sediment problems from logging in streamside management zones, grazing in riparian areas, and erosion from roads. In addition, this segment is listed for physical substrate alterations, which is a non-pollutant listing commonly linked to sediment impairment. Metals TMDLs for aluminum and lead were completed for Cramer Creek and included in a previous TMDL document (Montana Department of Environmental Quality, 2013).

The Cramer Creek watershed was part of the Montana Legacy Project, where private timberlands were purchased by The Nature Conservancy. Ultimately, TNC plans to transfer ownership of Cramer Creek properties to the State of Montana DNRC for administration.

Physical Condition and Sediment Sources

The DEQ assessment file states that an assessment performed in 1989 observed that logging practices in the headwaters, upstream of the Linton Mine site, had obscured the stream channel. Evidence of gully and sheet erosion was observed with fine sediment deposition in the stream. Tailings from the Linton Mine and mill site were noted in the stream channel as well. In 2012, DEQ collected sediment and habitat data at two sites on Cramer Creek (**Figure 5-1**). The Linton Mine mill site is located on BLM administered land approximately halfway between the two DEQ 2012 assessment reaches. Impacts from the mine site did spread downstream to private lands. Mine waste had been dumped directly adjacent to Cramer Creek where it washed into the stream and contaminated the creek for several hundred yards downstream. Approximately 130,000 cubic yards of mine waste that contained high levels of arsenic and lead were removed from the site including alongside the stream channel. Removed tailings were used to backfill mine openings and were placed in a mine waste repository several miles from the site. Reclamation work was funded by BLM with Abandoned Mine Land Reclamation funds and was completed in 2004.

CRAM05-01 was located in a narrow valley, upstream of the Linton Mine site. The road was observed to parallel the stream and encroached on the stream channel in places. The reach was heavily grazed with visible pugging and hummocking in the floodplain.

CRAM07-02, the lower site, was located upstream of an area with numerous irrigation withdrawals and more intensive agricultural use. However, evidence of recent riparian restoration work was observed in the reach. Pool tail-outs contained appropriate sized spawning gravels and provided excellent potential for spawning. Fine sediment was noted in the channel in this reach.

Comparison with Water Quality Targets
The existing physical data in comparison with the targets for Cramer Creek are summarized in **Table 5-13**. There are no macroinvertebrate data available for Cramer Creek. The water quality targets for Cramer Creek are those determined for the Upper Clark Fork Tributaries TMDL Project Area **(Table 5-2)**. All bolded cells are not meeting the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-13. Existing sediment-related data for Cramer Creek relative to targets.
Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Channel Form (median)		Instream Habitat	
					% <6mm	% <2mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile
CRAM05-01	2012	8.4	C4	E4	11	4	**11.8**	4.2	**0.8**	95
CRAM07-02	2012	16.8	B4	C4	18	8	14.3	2.3	1.3	69

Summary and TMDL Development Determination
Sediment targets were not met for several channel form and instream habitat targets at the reaches assessed by DEQ in 2012. At CRAM05-01, the median width/depth was less than the target suggesting that the channel is slightly constricted in this reach. The residual pool depth target in the same reach also failed to meet the target, which indicates there might be some pool infilling in this reach. At the lower site, all sediment targets were met. At CRAM05-01, the failed metrics were close to meeting targets. There are no macroinvertebrate data available for the Cramer Creek assessment unit.

DEQ personnel noted that in the most visually impaired section of Cramer Creek was the first 1.75 miles upstream of the mouth with the Clark Fork River. This section of the stream has been channelized and rerouted at several locations to meet irrigation needs and is affected by both the Cramer Creek Road and I-90. Cramer Creek crosses I-90 at three different locations before flowing into the Clark Fork River.

Based on the 2012 DEQ stream reach assessments on Cramer Creek and the existing condition of the lower segment, Cramer Creek is impaired by sediment and a TMDL will be developed for this stream.

5.4.3.7 Tenmile Creek (MT76E004_030)
Tenmile Creek (MT76E004_030) is listed for sedimentation/siltation on the 2014 303(d) List. In addition, this segment is also listed for alteration in streamside or littoral vegetative covers, which is a non-pollutant listing commonly linked to sediment impairment. It was originally listed in 1994 based on a

1991 BLM assessment of the drainage. Only 20% of the drainage is administered by the BLM with the remainder in private ownership.

EPA conducted stream reach assessments at one location on Tenmile Creek in 2004. Assessors noted roads, mines/quarries, and evidence of logging. EPA assessors also observed that Tenmile Creek had a predominantly gravel substrate, but with some fine sediment and embeddedness. A previous assessment by the BLM in 1991 observed that most sections of the stream were impacted by grazing and portions of the stream appeared to have been blown out by past mining and grazing uses. The 1991 assessment also found deep channel incisement of the channel in three distinct locations.

Tenmile Creek is also listed for a TP impairment on the 2014 303(d) List (**Section 6.0**).

Physical Condition and Sediment Sources
DEQ completed a sediment and habitat assessment on Tenmile Creek in 2012.

TENM03-01 was located parallel to a dirt road that connects the Tenmile Creek watershed to the Cramer Creek watershed at the approximate midpoint of the Tenmile Creek assessment unit. Transmission lines also paralleled the channel, with the associated forest clearing. Historic logging occurred throughout the watershed and signs of grazing were observed at the monitoring site. The stream channel was dominated by riffle habitat with infrequent shallow pools. A generally cobble substrate was finer in areas where dense vegetation obscured the channel and course woody debris inputs slowed the water. The streambanks on this small stream were subject to trampling by cattle. Assessors also noted that road encroachment was also leading to streambank erosion. Extremely dense vegetation covered a portion of the monitoring site, while the majority of the site was comprised of a grass-lined channel with sparse shrubs and numerous weeds.

Comparison with Water Quality Targets
The existing data in comparison with the targets for Tenmile Creek are summarized in **Table 5-14**. There are no macroinvertebrate data available for Tenmile Creek. The water quality targets for Tenmile Creek are those determined for the Upper Clark Fork Tributaries TMDL Project Area **(Table 5-2)**. All bolded cells are not meeting the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-14. Existing sediment-related data for Tenmile Creek relative to targets.
Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Channel Form (median)		Instream Habitat	
					% <6mm	% <2mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile
TENM03-01	2012	5.0	E4/F4	E4	**27**	6	**8.2**	4.0	**0.4**	127

Summary and TMDL Development Determination
At the single 2012 DEQ stream assessment reach on Tenmile Creek, several sediment targets were not met. These include the fine sediment fraction in riffles <6 mm in diameter, the width/depth ratio, and

the residual pool depth. The fine sediment and residual pool depth target exceedances suggest that the assessment reach is currently impaired by fine sediment, which is slowly working through the system resulting in pool infilling. The width/depth ratio is less than the target of 12 for an E stream. This suggests that the channel is slightly constricted and narrowed from its natural condition.

The 2004 EPA site visit did collect Wolman Pebble Counts and found that 40% of the substrate were <6mm and 26% were <2 mm in diameter. Pebble counts were conducted at 7 different transects and fractions <2 mm ranged from 6% to 70%. The 2004 assessed stream reach was in the lower sub-watershed at RM 1.0 and sited on BLM administered land. The Tenmile Creek channel at RM 0.35 was noted as dry by the EPA assessment crew (7/16/2004).

Surficial geology maps indicate that significant portions of the Tenmile Creek drainage contain highly erosive volcanic geology, which may exacerbate land use effects on channel sediment dynamics.

Based on the existing land uses and channel condition of Tenmile Creek as reflected in the sediment target discussion, beneficial uses in Tenmile Creek are currently impaired by fine sediment accumulations. A sediment TMDL will be developed for Tenmile Creek.

5.4.3.8 Deep Creek (MT76E004_070)

Deep Creek (MT76E004_070) is listed for sedimentation/siltation on the 2014 303(d) List. It was originally listed in 1996 due to impacts from timber harvesting and mining activities throughout the drainage. In addition, this segment is also listed for low flow alterations, which is a non-pollutant listing commonly linked to sediment impairment. Extensive placer mining is evident in the lower reaches where Deep Creek is diverted from its channel for use in current mining operations. The drainage has a history of mining producing gold, silver, copper, and iron. The 2004 EPA assessment noted that the stream is spring-fed and disappeared subsurface in several sections.

Deep Creek is also listed for a nutrient impairment on the 2014 303(d) List (**Section 6.0**).

Physical Condition and Sediment Sources

No sediment and habitat assessment was performed on Deep Creek. There is a reservoir in the upper portion of the Deep Creek drainage out of which Deep Creek flows, with a portion diverted into a pipe for apparent use in a mining operation. Deep Gulch Road parallels Deep Creek along much of its length. The 2004 EPA assessment noted that there was an adequate buffer between this road and the stream. EPA assessors noted that the stream substrate was largely silt and sand. The channel quickly went dry and lost definition in an area of active mining. Flowing water was again observed downstream of the Gambler Creek confluence. In this reach, the channel resembled a small spring creek flowing through wetland vegetation. The stream then became channelized by the road and proceeded to go dry. Access to the flowing portion of Deep Creek was denied by private landowners. Further downstream, the channel remained encroached upon by Deep Gulch Road and evidence of historic placer mining was observed, including a portion where a small rock wall had been constructed along both sides of the channel. As the valley opens up, there was no flowing water and no defined channel in an area upstream of the Deep Creek confluence with Bear Creek where extensive mine related disturbance has occurred.

Comparison with Water Quality Targets

The existing data in comparison with the targets for Deep Creek are summarized in **Table 5-15**; only macroinvertebrate bioassessment data were available for the assessment unit. The water quality targets for Deep Creek are those determined for the Upper Clark Fork Tributaries TMDL Project Area **(Table 5-2)**. All bolded cells are not meeting the target threshold.

Table 5-15. Macroinvertebrate bioassessment data for Deep Creek.
Values that do not meet the target threshold (0.80 for O/E) are in bold.

Station ID	Collection Date	Collection Method	O/E
C01DEEPC01	7/16/2004	KICK	**0.58**
C01DEEPC01	8/10/2008	MAC-R-500	**0.56**
C02DEEPC01	9/30/2011	MAC-R-500	**0.57**

Summary and TMDL Development Determination
DEQ was unable to gain access permission to flowing sections of Deep Creek in order to conduct a stream assessment in 2012. Based on field notes and site photos taken as part of 2004 and 2012 field work, the channel has been significantly affected by past timber harvesting practices and by historical and current placer mining operations in the channel. The macroinvertebrate data collected at RM 2.0 all failed to meet the O/E threshold of 0.80 indicating impairment.

The 2004 EPA assessment did complete Wolman Pebble Counts on Deep Creek at RM 2.0 and observed that 58% of the stream substrate was less than 6 mm in diameter; 44% less than 2 mm. The D50[1] was 3.2 mm. Site visit notes indicated that the main area of degradation to the stream channel occurred downstream of the sample location on private land near the mouth (Bear Creek) where the most extensive placer mining is currently taking place.

All evidence suggests that significant alterations to the Deep Creek channel from its natural condition have occurred and continue to occur. Deep Creek is impaired by sediment and a sediment TMDL will be developed.

5.4.3.9 Mulkey Creek (MT76E004_050)
Mulkey Creek (MT76E004_050) is listed for sedimentation/siltation on the 2014 303(d) List. First listed on the 303(d) List in 1988, DEQ stream assessment notes from 1991 identify the channel as ephemeral and note significant degradation caused by the road located at the low point in the drainage, which pushed the stream channel to a ditch. Occasionally, the road ditch is the former creek channel. Water bars on the road were found to be diverting sediment into the creek bed in 1991.

Physical Condition and Sediment Sources
In 2012, DEQ completed one sediment and habitat field assessment at a site in the upper drainage on BLM administered land.

MULK03-01 was located in upper Mulkey Creek upstream of an obliterated road crossing. This small stream flowed through a meadow in this reach, though the channel is dry in lower Mulkey Creek. The road along the stream has been re-vegetated and DEQ assessors observed evidence of grazing. The small riffle-dominated channel generally lacked pools. Streambanks were lined with grass and sedge generally limiting sediment contribution.

[1] The sediment size, D50, is defined as the grain diameter at which 50% of the sediment sample is finer than.

Comparison with Water Quality Targets
The existing physical data in comparison with the targets for Mulkey Creek are summarized in **Table 5-16.** There are no macroinvertebrate data available. The water quality targets for Mulkey Creek are those determined for the Upper Clark Fork Tributaries TMDL Project Area **(Table 5-2)**. All bolded cells are not meeting the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-16. Existing sediment-related data for Mulkey Creek relative to targets.
Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Channel Form (median)		Instream Habitat	
					% <6mm	% <2mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile
MULK03-01	2012	8.1	B5/F4/ B4/C4	E4	**37**	**24**	13.9	**2.1**	**0.45**	21

Summary and TMDL Development Determination
Mulkey Creek is ephemeral in the lower reaches and intermittent through much of its drainage. At the assessment site on BLM administered lands in the upper reaches, several sediment targets were not met. These included the riffle pebble counts for fine sediment, the entrenchment ratio and the residual pool depth. The 2012 assessment suggests that a significant amount of fine sediment is moving through the system and is causing pool infilling. The entrenchment ratio was very close to the target (2.2) for this stream and indicates that the channel may be slightly entrenched in the assessed reach. Given the relatively small drainage area and south facing aspect, the channel likely does not frequently carry flushing flows capable of transporting significant sediment loads through the drainage. Road encroachment is the most likely cause of sediment impairment to Mulkey Creek. Surficial geology maps indicate that the headwaters of Mulkey Creek contain highly erosive volcanic geology, which may exacerbate road encroachment and timber harvesting effects on channel sediment dynamics.

Mulkey Creek is impaired by sediment and a sediment TMDL will be developed.

5.4.3.10 Rattler Gulch (MT76E004_060)
Rattler Gulch (MT76E004_060) is listed for sedimentation/siltation on the 2014 303(d) List. This segment is also listed for alteration in streamside or littoral vegetative covers and low flow alterations, which are non-pollutant listings commonly linked to sediment impairment. It was originally listed in 1994 because of a BLM assessment conducted in 1992. The BLM assessment noted that a logging road was constructed in the middle of the streambed. The BLM assessment also noted that the effects of livestock grazing were readily apparent in the drainage, and that, in several sections, seeps and springs provided the only flow in the stream.

EPA conducted stream reach assessments at one location on Rattler Gulch in 2004 on private land at the approximate midpoint of the assessment unit. EPA assessors noted that Rattler Gulch is a small, narrow stream with a substrate dominated by silt, ephemeral in the lower reaches, and likely intermittent in the middle portions of the assessment unit. Bank stability was noted as good.

Rattler Gulch is also listed for a TP impairment on the 2014 303(d) List (**Section 6.0**).

Physical Condition and Sediment Sources
In 2012, DEQ completed one sediment and habitat field assessment at a site in the upper drainage on BLM administered land.

RATT04-01 was located in one of the flowing portions of Rattler Gulch, while the lower reaches are dry and lack a defined stream channel. The logging road, first noted by BLM, has obliterated any signs of a stream channel in the narrow limestone canyon located on the way to the RATT04-01. Active grazing was observed at the monitoring site, with extensive hoof shear along the banks of the small channel. The channel is riffle-dominated and lacked pools or spawning potential. Extensive fine sediment depositions were noted. The channel was lined by grass and lacked woody shrubs.

Comparison with Water Quality Targets
The existing data in comparison with the targets for Rattler Gulch are summarized in **Table 5-17**. The macroinvertebrate bioassessment data are located in **Table 5-18**. The water quality targets for Rattler Gulch are those detemined for the Upper Clark Fork Tributaries TMDL Project Area **(Table 5-2)**. All bolded cells are not meeting the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-17. Existing sediment-related data for Rattler Gulch relative to targets.
Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Channel Form (median)		Instream Habitat	
					% <6mm	% <2mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile
RATT04-01	2012	3.8	E4/E5/ C4	E4	**57**	**40**	**8.5**	5.9	*NA*	**0**

Table 5-18. Macroinvertebrate bioassessment data for Rattler Gulch.
Values that do not meet the target threshold (0.80 for O/E) are in bold.

Station ID	Collection Date	Collection Method	O/E
C02RATTG01	7/16/2004	KICK	**0.54**
C02RATTG01	9/22/2011	MAC-R-500	**0.54**

Summary and TMDL Development Determination
At the assessment site on BLM administered lands in the upper reaches, several sediment targets were not met. These included the riffle pebble counts for fine sediment, the width/depth ratio, and the pool frequency. The 2012 assessment suggests that a significant amount of fine sediment is moving through the system and is causing pool infilling, which may be the reason no pools were identified in the 2012 stream assessment reach. The width/depth ratio was less than the target for this stream and indicates that the channel may be confined in the assessed reach. Given the relatively small drainage area and south facing aspect, the channel likely does not frequently carry flushing flows capable of transporting

significant sediment loads through the drainage. Past timber harvesting practices, active grazing and road encroachment are the most likely causes of sediment impairment to Rattler Gulch.

The 2004 EPA site visit did collect Wolman Pebble Counts and found that 75% of the substrate were <6mm and 69% were <2 mm in diameter. Pebble counts were conducted at 10 different transects and fractions <2 mm ranged from 30% to 90%. The 2004 assessed stream reach was in the middle portion of the sub-watershed approximately ¾ miles downstream of RATT04-01.

Surficial geology maps indicate that the headwaters of Rattler Creek contain highly erosive volcanic geology, which may exacerbate road encroachment and timber harvesting effects on channel sediment dynamics.

Based on the 2004 and 2012 assessment work performed by EPA and DEQ, the stream is impaired by sediment and a sediment TMDL will be developed for Rattler Gulch.

5.5 Sediment TMDL Development Summary

Based on the comparison of existing conditions with water quality targets, 9 sediment TMDLs will be developed in the Central Clark Fork tributaries TPA. **Table 5-19** summarizes the sediment TMDL development determinations and corresponds to the waterbodies of concern identified in **Section 5.2**.

Table 5-19 Summary of Sediment TMDL Development Determinations

Stream Segment	Waterbody #	TMDL Development Determination (Y/N)
FLAT CREEK, headwaters to mouth (Clark Fork River)	MT76M002_180	Y
TROUT CREEK, headwaters to mouth (Clark Fork River)	MT76M002_050	N[1]
WEST FORK PETTY CREEK, headwaters to mouth (Petty Creek)	MT76M002_100	Y
PETTY CREEK, headwaters to mouth (Clark Fork River)	MT76M002_090	Y
GRANT CREEK, headwaters to mouth (Clark Fork River)	MT76M002_130	Y
CRAMER CREEK, headwaters to mouth (Clark Fork River)	MT76E004_020	Y
TENMILE CREEK, headwaters to mouth (Bear Creek)	MT76E004_030	Y
DEEP CREEK, headwaters to mouth (Bear Creek)	MT76E004_070	Y
MULKEY CREEK, headwaters to mouth (Clark Fork River)	MT76E004_050	Y
RATTLER GULCH, headwaters to mouth (Clark Fork River)	MT76E004_060	Y
[1] A turbidity TMDL will be developed for Trout Creek in **Section 8.0**		

5.6 Sediment Source Assessment and Quantification

5.6.1 Eroding Streambank Sediment Assessment

Streambank erosion was assessed in 2012 at the 17 stream assessment reaches discussed in **Section 5.4.3** (**Attachment A**). At each assessment reach, eroding streambanks were classified as either actively or slowly eroding, the susceptibility to erosion was assessed by performing Bank Erosion Hazard Index (BEHI) measurements, and the erosive force was determined by evaluating the Near Bank Stress (Rosgen, 1996b; Rosgen, 2006). BEHI scores were determined at each eroding streambank based on the following parameters: bank height, bankfull height, root depth, root density, bank angle, and surface protection. In addition to BEHI data collection, the source of streambank erosion was evaluated based on observed human-caused disturbances and the surrounding land-use practices based on the following near-stream source categories:

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

Based on the aerial assessment process in which each 303(d) listed waterbody segment is divided into different reaches, streambank erosion data from each 2012 monitoring site were used to extrapolate to the reach scale. Then, the average value for each unique reach category was applied to unmonitored reaches within the corresponding category to estimate loading associated with bank erosion at the listed stream segment and watershed scales.

Streambank erosion was estimated to be predominantly due to natural sources at 7 of the 17 assessed monitoring sites, while streambank erosion was estimated to be predominately due to human-caused sources at 10 monitoring sites. Erosion from predominantly natural sources is defined as reaches where 75% or more of the causes of streambank erosion influence are attributed to natural sources, whereas human influenced reaches attribute streambank erosion to human caused sources for greater than 25% of the reach. The average sediment load per year (24.82 tons/year/1000 feet) for the 10 reaches with erosion predominantly influenced by human sources was then used to represent existing conditions for all reach types throughout the watershed that are predominately influenced by human-caused sources of erosion.

In the Central Clark Fork Basin Tributaries TMDL project area, total streambank erosion sediment loads ranged from 513 tons/year in Mulkey Creek to 1,938 tons/year in Grant Creek (**Attachment A**). On a per mile stream basis, Cramer Creek has the highest sediment load due to streambank erosion per mile of stream, followed by Petty Creek, while Flat Creek has the lowest streambank erosion sediment load per mile of stream. At the stream segment scale, this assessment indicates that transportation, timber harvest, and grazing are the greatest human-caused contributors of sediment loads due to streambank erosion in the Central Clark Fork tributaries TPA (**Figure 5-8**).

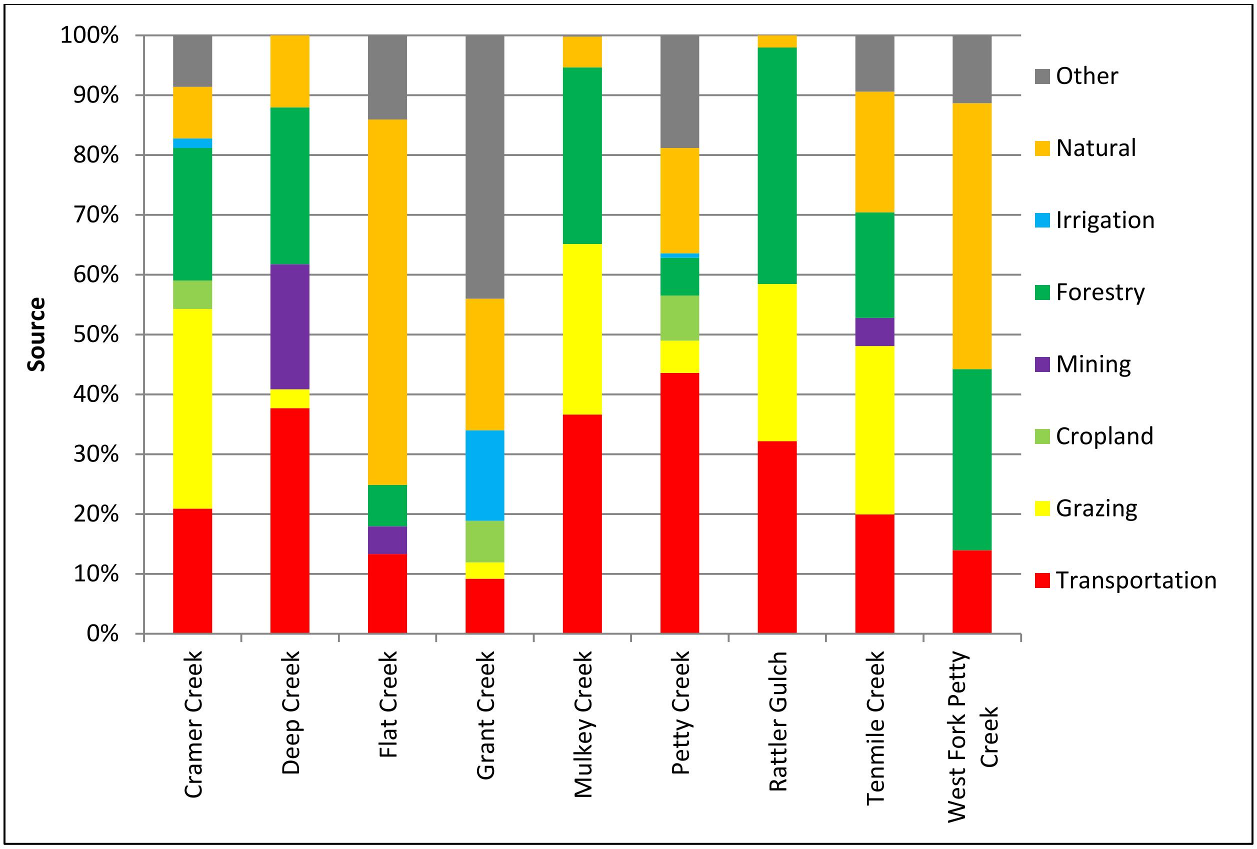

Figure 5-8. Stream Segment and Sub-watershed Streambank Erosion Sources

An average annual sediment load of 336 tons/year was attributed to the 166 assessed eroding streambanks within the 17 monitoring sites. Average annual sediment loads for each monitoring site were normalized to a length of 1,000 feet for the purpose of comparison and extrapolation. In sediment impaired waterbodies in the Central Clark Fork Basin Tributaries TMDL project area, monitoring site sediment loads per 1,000 feet ranged from 7.03 tons/year in MULK03-01 on Mulkey Creek to 39.25 tons/year at CRAM05-01 on Cramer Creek.

The ability to reduce streambank erosion through the application of best management practices (BMPs) was evaluated by comparing the existing conditions sediment load for monitoring sites with predominately human influenced erosion to the sediment load at the seven monitoring sites in which streambank erosion was due to predominately natural sources. The average sediment load per year (12.57 tons/year/1000 feet) for the seven reaches with erosion predominantly influenced by natural sources was used to represent potential bank erosion loading under BMPs for all reach types (**Table 5-20**)

Table 5-20. Sub-watershed Sediment Load Reductions with BMPs

Stream Segment	Existing Sediment Load (Tons/Year)			Reduced Sediment Load through BMPs (Tons/Year)			Potential Reduction in Total Sediment Load (Total Existing-Total Reduced) (Tons/Year)	Percent Reduction in Total Sediment Load
	Total Sub-watershed (Tons/Year)	Human-caused Sub-watershed Load (Tons/Year)	Natural Sub-watershed Load (Tons/Year)	Total Sub-watershed (Tons/Year)	Human-caused Sub-watershed Load (Tons/Year)	Natural Sub-watershed Load (Tons/Year)		
Cramer Creek	1,869.0	1707.3	161.8	905.6	743.8	161.8	963.4	52%
Deep Creek	622.0	546.9	75.1	358.9	283.8	75.1	263.0	42%
Flat Creek	517.7	201.4	316.3	435.2	118.8	316.3	82.5	16%
Grant Creek	1,938.2	1512.2	425.9	1224.5	798.5	425.9	713.7	37%
Mulkey Creek	512.6	486.4	26.2	305.6	279.5	26.2	207.0	40%
Petty Creek (excluding West Fork Petty Creek)	2,213.8	1824.2	389.7	1503.6	1113.9	389.7	710.2	32%
Rattler Gulch	1,060.0	1038.2	21.8	570.7	548.9	21.8	489.3	46%
Tenmile Creek	582.9	465.5	117.4	381.9	264.5	117.4	201.0	34%
West Fork Petty Creek	802.9	445.8	357.1	599.8	242.6	357.1	203.2	25%
TOTAL	**10,119**	**8,228**	**1,891**	**6,286**	**4,394**	**1,891**	**3,833**	**38%**

5.6.1.1 Streambank Assessment Assumptions

The Central Clark Fork Tributaries sediment and habitat assessment assumes reaches with similar reach type characteristics will have similar physical attributes and sediment loads due to streambank erosion. Since only a portion of the streams within the Central Clark Fork Basin Tributaries TMDL project area were assessed in the field, a degree of uncertainty is unavoidable when extrapolating data from assessed reaches to un-assessed reaches. Although the accuracy of the GIS data may influence the length of each reach type, the largest potential sources of inaccuracy within the project are the small sample size per reach type, the near-stream land uses identified based on aerial images, and the retreat rates used for the extrapolation process. These are minimized by careful selection of representative monitoring sites and only using the near-stream land uses for informational purposes within the TMDL document. Since sediment source modeling may underestimate or overestimate sediment inputs due to selection of sediment monitoring sites and the extrapolation methods used, model results should not be taken as an absolutely accurate account of sediment production within each sub-watershed. Instead, the streambank erosion assessment model results should be considered an instrument for estimating existing streambank erosion sediment loads and making general comparisons of streambank erosion sediment loads from various sources.

5.6.2 Quantifying Sediment from Upland Sources

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 Central Clark Fork Basin Tributaries TMDL project area riparian health assessment was used to develop a riparian health score based on the sediment reduction percentage for each individual stream segment sub-watershed (**Attachment B**). 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 2011 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 **Attachment B**

Assessment Summary

Based on the source assessment, upland erosion contributes approximately 6,000 tons per year to the streams in the Central Clark Fork Basin Tributaries TMDL project area that will have a sediment TMDL developed in this document (**Table 5-19**). 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 118 tons/year in the Flat Gulch sub-watershed to 2,442 tons/year in the Petty 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. **Attachment B** contains additional information about sediment loads from upland erosion in the Central Clark Fork tributaries TPA by sub-watershed, 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 sediment/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 5-21 below reports the existing loads and resulting loads after applying the BMP reductions (BMP scenario considers improved riparian buffer zones and grazing and cover management). This information can be used as a basis for setting TMDL load allocations. (See **Attachment B** for more detailed information).

Table 5-21. 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
Cramer Creek	947.5	68%	299.7
Deep Creek	353.9	46%	190.1
Flat Creek	118.2	9%	107.6
Grant Creek	296.0	31%	205.1
Mulkey Creek	560.51	61%	217.1
Petty Creek	2,442.3	34%	1,607.2
Rattler Gulch	624.6	56%	271.7
Tenmile Creek	398.1	67%	133.2
West Fork Petty Creek	258.4	22%	201.7

5.6.3 Road Sediment Assessment

5.6.3.1 Erosion from Unpaved Roads

An assessment of the road network within the Central Clark Fork Basin Tributaries TMDL project area was performed as part of the development of sediment TMDLs for 303(d) listed stream segments with sediment or turbidity as a documented impairment (**Attachment C**). 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 Central Clark Fork Basin Tributaries TMDL project area.

Overall, GIS analysis identified 653.18 miles of road within the Central Clark Fork Tributaries TPA, with all but 48.30 miles (7.4%) being unpaved (**Attachment C**). Of the 719 road crossings identified within the Central Clark Fork Tributaries TPA, 345 were unpaved (gravel or native material) based on attribute information contained in the GIS roads database. An additional 294 crossings were identified with an 'unknown' surface type. Based on attributes of proximal road segments, 256 of the crossings identified as 'unknown' are likely to be unpaved. Therefore, there are an estimated total of 601 unpaved road crossings in the Central Clark Fork Basin Tributaries TMDL project area. Approximately 32% of the crossings are on roads administered by the USFS, with the remainder being a mix of private, state, and county.

Out of the 50 pre-selected sites, 44 crossings were visited in the field in October 2012 and field forms were completed at 18 pre-selected sites where unpaved road crossings of streams were observed. Of the 44 sites visited, 23 lacked defined stream crossings, had become re-vegetated due to road closures, or were inaccessible due to road closures; no measurements were taken at these sites, but notes were made regarding road condition. Measurements were taken and field forms completed at two alternate sites. One additional alternate site was visited, though no data were collected because it lacked a defined channel. Therefore, out of the 47 field assessed sites (i.e., 44 + 3 alternates), field forms were completed at a total of 20 unpaved road crossing sites, and those data were used in the Water Erosion Prediction Project (WEPP) soil erosion model. To account for the contribution of sediment from parallel road segments, field data were collected at four sites identified during field data collection. All four sites were located in the eastern portion of the project area near Drummond.

Sediment loading from unpaved road crossings was estimated using the WEPP:Road soil erosion model version 2012.10.30 (http://forest.moscowfsl.wsu.edu/fswepp/). 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 **Attachment C**.

Assessment Summary

Based on the source assessment, unpaved roads are contributing 7.1 tons of sediment per year to the streams in the Central Clark Fork Basin Tributaries TMDL project area that will have a sediment TMDL developed. Sediment loads are all < 1 ton/year in each sub-watershed with the exception of West Fork Petty Creek (1.6 tons/year) and Petty Creek (3.7 tons/year). 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 5-22** contains annual sediment loads from unpaved road crossings from the watersheds where TMDLs are developed within this document. **Table 5-22** also includes the percent load reduction by watershed based on the contributing road length BMP scenario, which is further defined within **Attachment C**.

Table 5-22. 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
Cramer Creek	0.785	80%	0.161
Deep Creek	0.862	76%	0.207
Flat Creek	0.649	71%	0.187
Grant Creek	0.354	75%	0.089
Mulkey Creek	0.523	80%	0.107
Petty Creek[1]	3.340	71%	0.951
Rattler Gulch	0.201	79%	0.042
Tenmile Creek	0.351	80%	0.071
West Fork Petty Creek	1.635	71%	0.468
[1] Includes the West Fork Petty Creek sub-watershed estimated loads and reductions			

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 barriers to fish passage. 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 17 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 flow capacity and amount of fill material used to bury it. 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 17 culverts. The assessment was based on the methodology defined in **Attachment C**, 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
In the Central Clark Fork Basin Tributaries TMDL project area, 16 of 17 culverts assessed in the field (94%) are capable of passing the two-year flood event and 15 of 17 culverts (88%) are capable of passing a 100-year flood event (see **Attachment C** for more details).

In the Central Clark Fork Basin Tributaries TMDL project area, none of the culverts (*n*=12) assessed at crossings with flowing water had a high probability of allowing fish passage and all 12 culverts were classified as fish passage barriers. The majority of these culverts were located on streams containing fish as evaluated by Montana Fish, Wildlife and Parks, though this was not considered when evaluating a culverts ability to pass fish. In general, too steep of slope led to most of these culverts being classified as fish passage barriers.

5.6.4 Permitted Point Sources
In addition to nonpoint sources, sediment inputs into streams in the Central Clark Fork tributaries TPA come from point sources (i.e., distinct, identifiable sources, such as pipes feeding directly into a waterbody). By law, these point sources must be permitted. As of February 10, 2014, the Central Clark Fork Basin Tributaries TMDL project area had six active Montana Pollutant Discharge Elimination System (MPDES) permitted point sources within sediment-impaired watersheds (**Figure A-22**):

- Missoula MS4 (MTR040007)
- One individual MPDES permit for cooling water discharge
- Two general permits for industrial activity stormwater
- Two general permits for construction activity stormwater

To provide the required wasteload allocation (WLA) for permitted point sources, a source assessment was performed for these point sources. Because of the conditions set within all of the applicable permits, and the nature of sediment loading associated with these permits, the WLAs are not intended to add load limits to the permits; DEQ assumed that the WLAs will be met by adhering to the permit requirements.

5.6.4.1 Missoula MS4 (MTR040007)
Under EPA's Stormwater Phase II Rule, Missoula is regulated as a small MS4 under a DEQ general permit (MTR040000). The Missoula MS4 discharges to several receiving waterbodies including the Bitterroot River, the Clark Fork River, and Grant Creek. DEQ analyzed the City of Missoula's GIS coverage of the stormwater infrastructure, and determined that 2.29 square miles (1,467 acres) of stormwater catchment discharge to Grant Creek. The annual discharge was estimated using the stormwater discharge area of 1,467 acres, average annual precipitation of 14 inches, and an estimated percentage of total annual precipitation draining to surface water of 8% provided by DEQ modeling staff (personal communication, Erik Makus, 2014). This results in an estimated annual discharge of 5,963,550 cubic feet or 168,868,939 liters. Based on the current zoning map for Missoula County, approximately 60% of this discharge is considered to be from suburban/residential areas, with the remaining 40% from commercial areas.

The MS4 permit requires sampling of representative commercial and residential areas for Total Suspended Solids (TSS). Since the MS4 permit requires that the sample locations are representative, and since stormwater management practices have improved since the 1990s, DEQ used the permit sampling data (2007-2013) to estimate the existing TSS loads from the Missoula MS4 to Grant Creek. Based on the sample reporting for the MS4 permit, the average concentration of TSS in stormwater runoff from commercial areas is 167.0 mg/L and from residential area is 60.9 mg/L. Using these concentrations, DEQ estimated that this portion of the MS4 contributes annual loads of 16.6 tons sediment/year to Grant Creek. It is worth noting that the residential sampling point for the Missoula MS4 is in the Grant Creek sub-watershed.

To estimate an average "per-event" load, the annual load estimate is divided by the average number of times the MS4 discharges in a year. DEQ did not identify a threshold magnitude for precipitation events that result in stormwater discharge, and snowmelt complicates estimates by generally lagging behind the precipitation event. DEQ chose 0.25 inches of precipitation as a representative value. Between 1984 and 2013, there was an average of 16.1 precipitation events greater than 0.25 inches. By dividing the estimated annual loads by 16, DEQ estimates that the per-event loads (considered equivalent to daily loads given the short duration of rainfall and runoff events) are 1.04 tons of sediment.

DEQ recognized the extensive channel reconstruction/realignment and floodplain development was completed in the Grant Creek sub-watershed to mitigate future flood events as part of a FEMA PDM grant (2008-2010) (Harmon, Dan J. and HDR Engineering, Inc., personal communication 11/24/2010) (see **Section 5.4.3.5**). As part of this completed project, parts of the Missoula MS4 system in the Grant Creek sub-watershed were expanded/updated to more effectively capture large flood events. It is not known specifically how the FEMA PDM work may affect annual sediment loading from the MS4 to Grant Creek although it would most likely decrease the estimate of 16.6 tons sediment/year. However, for the purposes of this analysis, DEQ will retain the original loading estimate from the stormwater system to Grant Creek.

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

In the general MS4 permit, the median benchmark value for storm water runoff is 125 mg/L TSS. For the Missoula MS4 DMR data, the residential sampling point has a median concentration of 55.8 mg/L (n=12) and the commercial sampling point had a median concentration of 157.4 mg/L (n=12). DMR data suggests that residential areas in the Grant Creek drainage are not exceeding permit requirements. However, commercial areas of the MS4 are discharging >125 mg/L TSS in most events.

Some BMPs are already in place in for the Missoula MS4 in the Grant Creek drainage particularly detention/retention ponds, but monitoring data reflect TSS concentrations greater than the 125 mg/L TSS median concentration benchmark value used in the MS4 general permit in commercial areas. DEQ estimated that commercial areas comprise approximately 40% of the MS4 area in the Grant Creek sub-watershed. Recognizing the improvements to the Grant Creek sub-watershed from the FEMA PDM project and the fact that the median TSS concentration from residential areas were <125 mg/L TSS, the lower limit of reduction efficiencies was used and a 53% reduction was applied to the entire estimated existing load. Using this approach, the WLA is 7.8 tons of sediment per year from the Missoula MS4 to Grant Creek.

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

5.6.4.2 One individual MPDES permit for noncontact cooling water discharge

MPDES MT0029840 is an individual permit for the Econo Lodge in Missoula. During the months of April through October, groundwater is used in the hotel's heat exchange system to regulate temperature in the facility. From the heat exchanger, water is piped directly to Grant Creek on the west side of the parking lot through Outfall 001. This is not a continuous discharge and has a maximum flow rate of 60 gpm (0.13 cfs). The current permit has limits for flow, temperature, and pH but none for TSS.

Given the source of the cooling water and its use at the facility, it may be assumed that TSS loads are negligible. The estimated annual sediment load from Outfall 001 to Grant Creek is 0 lbs TSS/day. A WLA of 0 is provided for the MT0029840 discharge to Grant Creek.

5.6.4.3 Construction Storm Water Permits (MTR100000)

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

For sub-watersheds in the Central Clark Fork tributaries TPA, there are two effective construction storm water permits. The permit files were reviewed to determine the amount of disturbed land associated with each permit. In the Petty Creek sub-watershed, the estimated level of disturbance is 22 acres for one permit (MTR104131). In the Grant Creek sub-watershed, the estimated level of disturbance is 4.5 acres for one permit (MTR104792). The SWPPPs contain BMPs, such as silt fencing, retention basins, fiber rolls, erosion control blankets, and vegetated buffers.

To estimate the potential sediment loading for the construction sites if adequate BMPs are not followed, an upland erosion rate for disturbed ground with less than 15% cover was multiplied by the amount of disturbed acreage associated with each permit (**Table 5-23**). The erosion rate (1.37 tons/acre/year) from a completed upland model for the Little Blackfoot watershed was used for disturbed ground (Montana Department of Environmental Quality, 2012d; Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8, 2011).

It was determined that the 1.37 tons/acre/year was an appropriate estimate of the annual erosion potential for disturbed ground within the Central Clark Fork tributaries TPA. To estimate the reduction in loading associated with following proper BMPs and adhering to permit requirements, a 65% reduction was applied based on studies from EPA and the International Storm Water Best Management Practices

Database (Geosyntec Consultants and Wright Water Engineers, Inc., 2008; U.S. Environmental Protection Agency, 2009). The reduced loads (**Table 5-23**) will be used to set the WLAs for construction stormwater permits. Because following permit conditions meet the intent of the WLA for construction stormwater, any future permits within any watersheds with sediment TMDLs in the Upper Clark Fork basin will meet the TMDL by following all permit conditions, including the SWPPP.

Table 5-23. Sediment Loading and Reductions from Permitted Construction Sites

Watershed	Loading rate based on SWAT (tons/ac/yr)	Annual Disturbed Acres	Estimated Load Without Adequate BMPs (tons/yr)	BMP Sediment Load (tons/yr)	Percent Reduction
Grant Creek	1.37	4.5	6.2	2.2	65%
Petty Creek	1.37	22	30.1	10.5	65%

5.6.4.4 Industrial Storm Water Permit (MTR000095)

In the Central Clark Fork Basin Tributaries TMDL project area, there are two general permits for industrial stormwater. United Parcel Service (UPS) maintains a facility in the Grant Creek sub-watershed near the I-90 interchange (MTR000443). West Company Wilkinson operated an open-cut gravel mining operation as part of the Petty Creek Road improvement project in the Petty Creek watershed (MTR000500). The road improvement project closed out in the fall of 2013.

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

According to **Attachment B** (Monitoring Parameter Benchmark Concentrations) within the general stormwater permit, the benchmark value for TSS is 100 mg/L; this means that the TSS concentration of runoff from the site should not exceed 100 mg/L if permit conditions are followed. Based on the site size (acres), an average annual precipitation rate of 14 inches (from weather station at Missoula Airport) and the benchmark value of 100 mg/L, the maximum allowable annual sediment load for each site is 0.16 tons/ac/yr (**Table 5-24**). The WLA is provided because it is a requirement for permitted point sources but is not intended to add load limits to the permit. DEQ assumed that the WLA will be met by adhering to the permit requirements, including the SWPPP.

Table 5-24. Sediment Loading and Reductions from Permitted Industrial Sites

Watershed	Permit[a]	Loading Rate (tons/ac/yr)	Permitted Area (ac)	BMP Sediment Load (tons/yr)	Percent Reduction
Grant Creek	MTR000443	0.16	4.0	0.6	0%
Petty Creek	MTR000500	0.16	34.49	5.5	0%

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

5.6.5 Source Assessment Summary

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

5.7 TMDL and Allocations

The sediment TMDLs for the Central Clark Fork Basin Tributaries TMDL project area will be based on a percent reduction approach, discussed in **Section 4.0.** This approach will apply to the loading allocated among sources as well as to the TMDL for each waterbody. An implicit MOS will be applied, further discussed in **Section 5.8**.

5.7.1 Application of Percent Reduction and Yearly Load Approaches

Cover et al. (2008) observed a correlation between sediment supply and instream measurements of fine sediment in riffles and pools. DEQ assumed that a decrease in sediment supply, particularly fine sediment, will correspond to a decrease in the percent fine sediment deposition within the streams of interest and result in attaining sediment-related water quality standards. A percent-reduction approach is preferable because there is no numeric standard for sediment to calculate the allowable load and because of the uncertainty associated with the loads derived from the source assessment (which are used to establish the TMDL), particularly when comparing different load categories, such as road crossings to bank erosion. Additionally, the percent-reduction TMDL approach is more applicable for restoration planning and sediment TMDL implementation because this approach helps focus on implementing water quality improvement practices (BMPs) versus focusing on uncertain loading values.

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

5.7.2 Development of Sediment Allocations by Source Categories

The percent-reduction allocations are based on BMP scenarios for each major source type (e.g., streambank erosion, upland erosion, roads, and permitted point sources). These BMP scenarios are discussed in **Section 5.6** and associated appendices/attachments. They reflect reasonable reductions as determined from literature, agency and industry documentation of BMP effectiveness, and field assessments. Sediment loading reductions can be achieved through a combination of BMPs, and the most appropriate BMPs will vary by site. Sediment loading was evaluated at the watershed scale and associated sediment reductions are also applied at the watershed scale based on the fact that many sources deliver sediment to tributaries that then deliver the sediment load to the impaired waterbodies.

It is important to recognize that the first critical step toward meeting the sediment allocations involves applying and/or maintaining the land management practices, or BMPs, that will reduce sediment loading. Once these actions have been completed at a given location, the landowner or land manager will have taken action consistent with the intent of the sediment allocation for that location. For many nonpoint source activities, it can take several years to decades to achieve the full load reduction at the location of concern, even though full BMP implementation is in effect. For example, it may take several years for riparian areas to fully recover after implementing grazing BMPs or allowing re-growth in areas of past riparian harvest. It is also important to apply proper BMPs and other water quality protection practices for all new or changing land management activities to limit any potential increased sediment loading.

Progress toward TMDL and individual allocation achievement can be gaged by adhering to point source permits, implementing BMPs for nonpoint sources, and improving or attaining the water quality targets defined in **Section 5.4**. Any effort to calculate loads and percent reductions for comparison with TMDLs and allocations in this document should be accomplished via the same methodology and/or models used to develop the loads and percent reductions presented within this document.

All TMDLs are watershed TMDLs and incorporate loads from upstream segments/watershed areas. This applies most specifically to the Petty Creek sediment TMDL, which incorporates the West Fork Petty Creek sediment TMDL.

5.7.2.1 Streambank Erosion

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

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

5.7.2.2 Upland Erosion

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

5.7.2.3 Roads

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

5.7.2.4 Permitted Point Sources

All WLAs are expected to be met by adhering to permit conditions.

5.7.3 Allocations and TMDL for Individual Streams

The following subsections present the existing quantified sediment loads, allocations, and TMDL for each waterbody (**Tables 5-25** through **5-35**). Note, sediment loads and percent reductions were rounded and may not exactly match the loads presented. Because TMDLs are presented on a watershed basis, TMDLs include all loading to stream segments upstream of the specific segment for which a TMDL is written.

TMDLs are presented from downstream to upstream in the Central Clark Fork tributaries TPA starting with Flat Creek and working upstream to Rattler Gulch.

5.9.3.1 Flat Creek (MT76M002_180)

Table 5-25. Sediment Source Assessment, Allocations and TMDL for Flat Creek

Sediment Sources		Current Estimated Load (tons/yr)[a]	Total Allowable Load (tons/yr)[a]	Percent reduction
LA	Roads	0.6	0.2	71%
	Streambank Erosion	517.7	435.2	16%
	Upland Sediment Sources	118.2	107.6	9%
Total Sediment Load		636.5	543.0	15%

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

5.9.3.2 West Fork Petty Creek (MT76M002_100)

Table 5-26. Sediment Source Assessment, Allocations and TMDL for West Fork Petty Creek

Sediment Sources		Current Estimated Load (tons/yr)[a]	Total Allowable Load (tons/yr)[a]	Percent reduction
LA	Roads	1.6	0.5	71%
	Streambank Erosion	802.9	599.8	25%
	Upland Sediment Sources	258.4	201.7	22%
Total Sediment Load		1062.9	802.0	25%

[a] Values were rounded to the nearest tenth, differences in loads presented in this table may not

correspond to the identified percent reduction

5.9.3.3 Petty Creek (MT76M002_090)

Load allocations for Petty Creek include estimates for West Fork Petty Creek. The relative percent reductions do not account for improved conditions on Petty Creek Road post-project completion (U.S. Department of Transportation, Federal Highway Administration, Western Federal Lands Highway Division, 2010).

Table 5-27. Sediment Source Assessment, Allocations and TMDL for Petty Creek

Sediment Sources		Current Estimated Load (tons/yr)[a]	Total Allowable Load (tons/yr)[a]	Percent reduction
LA	Roads	3.7	1.0	76%
	Streambank Erosion	3016.7	2103.4	30%
	Upland Sediment Sources	2442.3	1607.2	34%
Point source WLA	Construction Storm Water Permit (MTR100000)	30.1	10.5	65%
	Industrial Storm Water Permit (MTR000095)	5.5	5.5	0%
Total Sediment Load		5498.3	3727.6	32%

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

5.9.3.4 Grant Creek (MT76M002_130)

Table 5-28. Sediment Source Assessment, Allocations and TMDL for Grant Creek

Sediment Sources		Current Estimated Load (tons/yr)[a]	Total Allowable Load (tons/yr)[a]	Percent reduction
LA	Roads	0.4	0.1	75%
	Streambank Erosion	1938.2	1224.5	37%
	Upland Sediment Sources	296	205.1	31%
Point source WLA	Missoula MS4 (MTR040007)	16.6	7.8	53%
	Construction Storm Water Permit (MTR100000)	6.2	2.2	65%
	Industrial Storm Water Permit (MTR000095)	0.6	0.6	0%
Total Sediment Load		2258.6	1440.2	36%

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

5.9.3.5 Cramer Creek (MT76E004_020)

Table 5-29. Sediment Source Assessment, Allocations and TMDL for Cramer Creek

Sediment Sources		Current Estimated Load (tons/yr)[a]	Total Allowable Load (tons/yr)[a]	Percent reduction
LA	Roads	0.8	0.2	80%

	Streambank Erosion	1869	905.6	52%
	Upland Sediment Sources	947.5	299.7	68%
Total Sediment Load		2817.3	1205.5	57%

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

5.9.3.6 Tenmile Creek (MT76E004_030)

Table 5-30. Sediment Source Assessment, Allocations and TMDL for Tenmile Creek

Sediment Sources		**Current Estimated Load (tons/yr)[a]**	**Total Allowable Load (tons/yr)[a]**	**Percent reduction**
LA	Roads	0.4	0.1	80%
	Streambank Erosion	582.9	381.9	34%
	Upland Sediment Sources	398.1	133.2	67%
Total Sediment Load		981.4	515.2	48%

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

5.9.3.7 Deep Creek (MT76E004_070)

Table 5-31. Sediment Source Assessment, Allocations and TMDL for Deep Creek

Sediment Sources		**Current Estimated Load (tons/yr)[a]**	**Total Allowable Load (tons/yr)[a]**	**Percent reduction**
LA	Roads	0.9	0.2	76%
	Streambank Erosion	622	358.9	42%
	Upland Sediment Sources	353.9	190.1	46%
Total Sediment Load		976.8	549.2	44%

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

5.9.3.8 Mulkey Creek (MT76E004_050)

Table 5-32. Sediment Source Assessment, Allocations and TMDL for Mulkey Creek

Sediment Sources		**Current Estimated Load (tons/yr)[a]**	**Total Allowable Load (tons/yr)[a]**	**Percent reduction**
LA	Roads	0.5	0.1	80%
	Streambank Erosion	512.6	305.6	40%
	Upland Sediment Sources	560.51	217.1	61%
Total Sediment Load		1073.6	522.8	51%

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

5.9.3.9 Rattler Gulch (MT76E004_060)

Table 5-33. Sediment Source Assessment, Allocations and TMDL for Rattler Gulch

Sediment Sources		**Current Estimated**	**Total Allowable**	**Percent**

		Load (tons/yr)[a]	Load (tons/yr)[a]	reduction
LA	Roads	0.2	<0.1	79%
	Streambank Erosion	1060	570.7	46%
	Upland Sediment Sources	624.6	271.7	56%
Total Sediment Load		1684.8	842.4	50%

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

5.8 Seasonality and Margin of Safety

Seasonality and MOS are both required elements of TMDL development. This section describes how seasonality and MOS were applied during development of the Central Clark Fork Basin Tributaries TMDL project area 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:

- 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 fall 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 Central Clark Fork Basin Tributaries TMDL project area. 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 effects, no matter how rigorous, will include some level of uncertainty or error. To compensate for this uncertainty and ensure water quality standards are attained, a MOS is required as a component of each TMDL. The MOS may be applied implicitly by using conservative assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading (U.S. Environmental Protection Agency, 1999a). This plan incorporates an implicit MOS in a variety of ways:

- By using multiple targets to assess a broad range of physical and biological parameters known to illustrate the effects of sediment in streams and rivers. These targets serve as indicators of potential impairment from sediment and also help signal recovery, and eventual standards attainment, after TMDL implementation. Conservative assumptions were used during development of these targets; an effort was made to select achievable water quality targets, but in all cases, the most protective statistical approach was used. **Appendix B** contains additional details about statistical approaches used by DEQ.
- This approach addresses some of the uncertainty associated with sampling variability and site representativeness and recognizes that capabilities to reduce sediments exist throughout the watershed.
- Sediment impairment is typically identified based on excess fine sediment but the targets and TMDLs address both coarse and fine sediment delivery.
- By properly incorporating seasonality into target development, source assessments, and TMDL allocations (details provided in **Section 5.8.1**).
- By using an adaptive management approach to evaluate target attainment and allow for refinement of LA, targets, modeling assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development (discussed in **Sections 5.9**, **9.0**, and **10.0**).
- By using naturally occurring sediment loads as described in ARM 17.30.602(17) (see **Appendix B**) to establish the TMDLs and allocations based on reasonably achievable load reductions for each source category. Specifically, each major source category must meet percent reductions to satisfy the TMDL because of the relative loading uncertainties between assessment methodologies.
- By developing TMDLs at the watershed scale to address all potentially significant human-related sources beyond just the impaired waterbody segment scale. This approach should also reduce loading and improve water quality conditions within other tributary waterbodies throughout the watershed.

5.9 Uncertainty and Adaptive Management

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

As noted in **Section 5.9.2**, adaptive management represents an important component of the implicit MOS. This document provides a framework to satisfy the MOS by including sections focused on TMDL implementation, monitoring, and adaptive management (**Sections 9.0** and **10.0**). Furthermore, state law (ARM 75-5-703) requires monitoring to gage progress toward meeting water quality standards and satisfying TMDL requirements. These TMDL implementation monitoring reviews represent an important component of adaptive management in Montana.

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

5.9.1 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 in **Attachment A**. To control sampling variability and improve accuracy, the sampling was done by trained environmental professionals using a standard DEQ procedure developed for creating sediment TMDLs (Montana Department of Environmental Quality, 2011). This procedure defines specific methods for each parameter, including sampling location and frequency, to ensure proper representation and applicability of results. Before any sampling was conducted, a Sampling and Analysis Plan (SAP) was developed to ensure that all activity was consistent with applicable quality control and quality assurance requirements. Site selection was a major component of the SAP and was based on a stratification process described in **Attachment A**. The stratification work ensured that each stream included one or more sample sites representing a location where excess sediment loading or altered stream habitat could affect fish or aquatic life.

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

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 several TPAs from which targets were developed (Bitterroot, Upper Clark Fork, Kootenai-Fisher). These differences were acknowledged within the target development discussion and taken into consideration during target setting. For each target parameter, DEQ stratified the sample results and target data into similar categories, such as stream width or Rosgen stream type, to ensure that the target exceedance evaluations were based on appropriate comparison characteristics.

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

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

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

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

<u>Bank Erosion</u>

The load quantification approach for bank erosion is based on a standard methodology (BEHI) as defined within **Attachment A**. 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. The results were then extrapolated across the sediment impaired watersheds in the Central Clark Fork Basin Tributaries TMDL project area as defined in **Attachment A** 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, thereby 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 Central Clark Fork tributaries TPA. 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 Central Clark Fork tributaries TPA.

Upland Erosion

A professional modeler determined upland erosion loads by applying a standard erosion model as defined in **Attachment B**. As with any model, there is 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 sediment impaired watersheds in the Central Clark Fork tributaries TPA.

Roads

As described in **Attachment C**, the road crossings sediment load was estimated via a standardized simple yearly model developed by the USFS. This model relies on a few basic input parameters that are easily measured in the field, as well as inclusion of precipitation data from local weather stations. A total of 20 unpaved road crossings were evaluated in the field, representing about 6% of the total population of unpaved road crossings in the evaluated watersheds in the Central Clark Fork Basin Tributaries TMDL project area. 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 Nutrient TMDL Components

This section focuses on nutrients (nitrogen and phosphorus forms) as a cause of water quality impairment in the Central Clark Fork Basin Tributaries Total Maximum Daily Load (TMDL) Project area. It describes 1) nutrient impairment of beneficial uses; 2) specific stream segments of concern; 3) available data on nutrient impairment assessment in the watershed, including target development and a comparison of existing water quality condition to targets; 4) quantification of nutrient sources based on recent studies; and 5) identification and justification for nutrient TMDLs and TMDL allocations.

6.1 Effects of Excess Nutrients on Beneficial Uses

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

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

6.2 Stream Segments of Concern

Eight waterbody segments in the Central Clark Fork Basin Tributaries TMDL Project area are identified on the Draft 2014 Montana 303(d) List of Impaired Waters for phosphorus and/or nitrogen impairments. These stream segments of concern are listed in **Table 6-1** and shown in **Figure 6-1**. DEQ used data collected during the past several years to update nutrient assessments on all streams identified in **Table 6-1**. The assessment results are presented in **Section 6.4.3**, and a summary of nutrient impairments and TMDLs prepared for the project area is contained in **Table 6-20**. There are 15 nutrient causes of impairment that are addressed in this section of the document.

Table 6-1. Stream Segments of Concern for Nutrient Pollutant Impairments Based on the Draft 2014 303(d) List of Impaired Waters

Waterbody Segment	Waterbody ID	2014 303(d) Nutrient Impairment Cause(s)
DEEP CREEK, headwaters to mouth (Bear Creek, which is a tributary to Clark Fork River near Bearmouth)	MT76E004_070	Nitrate/Nitrite (Nitrite + Nitrate as N)[1]
DRY CREEK, headwaters to mouth (Clark Fork River)	MT76M002_170	Nitrogen (Total)
GRANT CREEK, headwaters to mouth (Clark Fork River)	MT76M002_130	Nitrogen (Total), Nitrate/Nitrite (Nitrite + Nitrate as N)[1]
NEMOTE CREEK, headwaters to mouth (confluence Clark Fork River)	MT76M002_160	Nitrogen (Total), Phosphorus (Total)
RATTLER GULCH, headwaters to mouth (Clark Fork River), T11N R13W S22	MT76E004_060	Phosphorus (Total)
STONY CREEK, headwaters to mouth (Ninemile Creek)	MT76M004_020	Phosphorus (Total)
TENMILE CREEK, headwaters to mouth (Bear Creek-Clark Fork River)	MT76E004_030	Phosphorus (Total)
WEST FORK PETTY CREEK, headwaters to mouth (Petty Creek)	MT76M002_100	Phosphorus (Total)

[1] Nitrate/Nitrite (Nitrite + Nitrate as N) will be referred to as NO_3+NO_2 throughout this document.

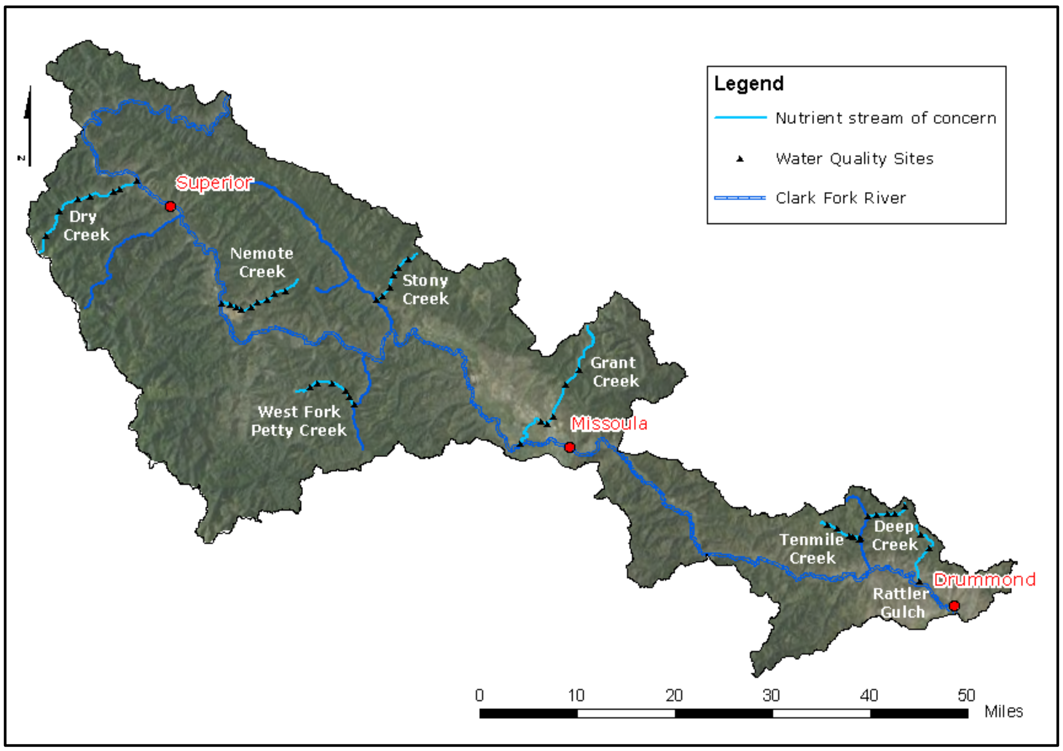

Figure 6-1. Nutrient streams of concern and sampling sites in the Central Clark Fork Basin Tributaries TMDL Project area.

DEQ also collected data and performed updated nutrient assessments for Cedar Creek (MT76M002_020) and Petty Creek (MT76M002_090) to update the 2014 303(d) list. No nutrient impairment causes were identified for Cedar Creek and Petty Creek. Therefore, nutrient TMDLs will not be developed for these 2 streams and discussion of the monitoring data and assessment results are not included in this document. The assessment results for these streams as well as those within **Table 6-1** are contained within the DEQ assessment record files (Montana Department of Environmental Quality CWAIC website) and documented within the 2014 Water Quality Integrated Report (Montana Department of Environmental Quality, 2014).

Half of the nutrient impaired streams in the Central Clark Fork Basin Tributaries TMDL Project area are located in the Middle Rockies ecoregion, and the other half are located in the Northern Rockies ecoregion (**Table 6-2** and **Figure 6-2**). The 2 ecoregions represent significant differences in climate, annual precipitation, soil characteristics and other environmental parameters. Stony Creek spans both the Northern Rockies and Middle Rockies ecoregions. The headwaters and the upper reaches, where most of the stream's flow is believed to originate, are in the Northern Rockies and the lower reaches are in the Middle Rockies. Using this rationale, DEQ applied the Northern Rockies nutrient targets to this waterbody's nutrient assessment as they are most representative of the nutrient conditions expected in this setting.

Table 6-2. Nutrient Impaired Streams in the Central Clark Fork Basin Tributaries TMDL Project Area and the Level III Ecoregions they are Contained Within

Level III Ecoregion	Waterbody Segment
Northern Rockies	DRY CREEK, headwaters to mouth (Clark Fork River)
	NEMOTE CREEK, headwaters to mouth (confluence Clark Fork River)
	WEST FORK PETTY CREEK, headwaters to mouth (Petty Creek)
	STONY CREEK, headwaters to mouth (Ninemile Creek)
Middle Rockies	GRANT CREEK, headwaters to mouth (Clark Fork River)
	TENMILE CREEK, headwaters to mouth (Bear Creek-Clark Fork River)
	DEEP CREEK, headwaters to mouth (Bear Creek, which is a tributary to Clark Fork River near Bearmouth)
	RATTLER GULCH, headwaters to mouth (Clark Fork River), T11N R13W S22

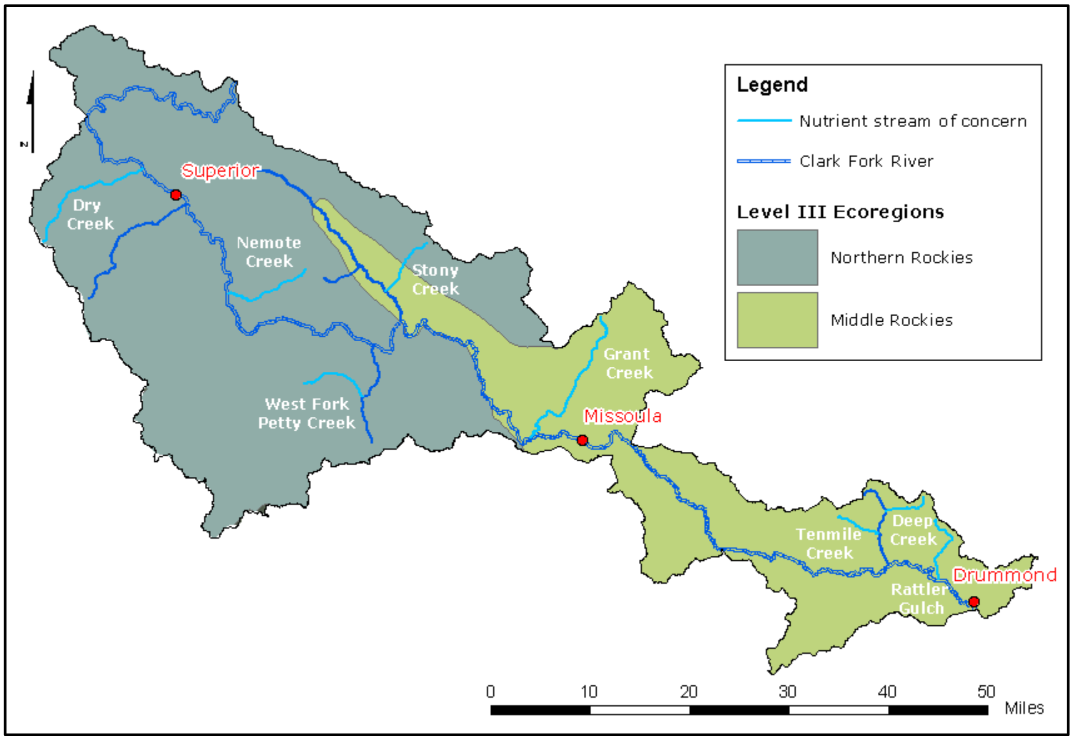

Figure 6-2. Nutrient stream segments of concern and Level III Ecoregions in the Central Clark Fork Basin Tributaries TMDL Project Area.

6.3 Information Sources and Water Quality Assessment Methods

To assess nutrient impairment status and develop TMDLs for streams in the Central Clark Fork Basin Tributaries TMDL Project area, DEQ compiled nutrient data and completed additional monitoring. Primary data sources used to evaluate existing instream nutrient conditions include the following data collected within the specific waterbody segments (i.e., assessment units):

DEQ Water Quality Sampling: In support of water quality assessment and TMDL development, DEQ collected water quality samples from 43 different monitoring site locations in the planning area between 2003 and 2012. Nutrient samples were collected at these sites on Dry Creek, Nemote Creek, West Fork Petty Creek, Stony Creek, Grant Creek, Tenmile Creek, Deep Creek and Rattler Gulch. All samples were collected by DEQ for the purpose of assessment and TMDL development support. In 2009, samples were collected by members of DEQ's Reference Stream Project field crew in support of assessment and TMDL development. During the years indicated below, several monitoring sites were visited each year and sometimes individual sites were visited more than once per year. During these site visits, a number of nutrient samples (*n*) were collected. A majority of this nutrient monitoring occurred between 2009 and 2011.

1) 2003 – 2 sites (*n* = 2)
2) 2004 – 13 sites (*n* = 14)
3) 2007 – 3 sites (*n* = 3)
4) 2009 – 15 sites (*n* = 26)
5) 2010 – 8 sites (*n* = 13)
6) 2011 – 36 sites (*n* = 68)
7) 2012 – 6 sites (*n* = 9)

Generally, samples were collected at monitoring sites along the entire length of streams to provide a comprehensive view of nutrient concentrations (**Figure 6-1**). The locations where samples were collected also allowed for analysis of potential source impacts (e.g., changes in land use, tributary influence). All data used in TMDL development were collected during the growing season for the Middle Rockies and Northern Rockies Level III ecoregions (July 1 – September 30) during which nutrient targets apply.

Benthic algae samples were collected from 2007 through 2011. Each stream segment had at least 3 benthic algae samples collected except for Stony Creek (n = 2). Benthic algae samples were analyzed for chlorophyll-*a* concentration and, where applicable, ash free dry mass (AFDM) (Montana Department of Environmental Quality, 2011a). AFDM is a measurement that captures both living and dead algal biomass and is particularly helpful for quantifying algal growth in streams where some or all of the algae are dead because chlorophyll-*a* measures only living algae. Periphyton (diatom) samples were collected from 2003 through 2011. Each stream located within the Northern Rockies Level III ecoregion (**Figure 6-2**) had at least 2 periphyton samples collected. No validated diatom increaser metrics have been developed for the Middle Rockies Level III ecoregion at this time, therefore, periphyton data are not included for streams within the Middle Rockies ecoregion. At least 2 macroinvertebrate samples were collected from each stream between 2003 and 2011.

Because these sampling events conducted from 2003 through 2012 represent the most recent, and the most exhaustive water quality characterization of nutrients, DEQ used data from these events as the primary source for evaluating water quality targets and assessing nutrient sources. Raw data from these sources are extensive but are not included in this document; however, they are publicly available via EPA's STOrage and RETrieval (STORET) water quality database. Data are also available from DEQ upon request.

DEQ Assessment Records: These electronic and hard-copy files contain information used to make previous and existing nutrient impairment determinations. This includes water chemistry, habitat, and biological data and historical information collected or obtained by DEQ. These reports provide historical context to these waters' water quality status and describe the data analyses upon which impairment determinations were based for the stream segments of concern. DEQ's nutrient water quality assessment method has specific objectives and decision-making criteria for assessing the validity and reliability of data. DEQ uses a Data Quality Assessment (DQA) process to evaluate data for use in assessments and decision making. The DQA considers the technical, representativeness, currency, quality, and the spatial and temporal components of the readily available data. The specific data requirements are detailed in the nutrient assessment method (Suplee and Sada de Suplee, 2011). As documented in the assessment records, only primary data sources that passed DEQ's Data Quality Assessment (DQA) process were used to make impairment determinations.

Secondary data sources were used to describe point and nonpoint sources within the stream segments of concern and to evaluate existing instream nutrient concentrations in the Central Clark Fork Basin Tributaries TMDL Project area. These data sources include:

- Discharge Monitoring Report (DMR) nutrient data collected by MPDES permittees for Missoula's municipal separate storm sewer system (MS4)
- Bureau of Land Management (BLM) and United States Forest Service (USFS) grazing allotment records
- DEQ and Montana Bureau of Mines and Geology (MBMG) abandoned and active mine records

- Geospatial data including land cover and land use, cropland and irrigation, septic systems, fire history, and silviculture activities

6.4 Water Quality Targets

TMDL water quality targets are numeric indicator values used to evaluate whether water quality standards have been met. These are discussed further in **Section 4.0**. This section presents nutrient water quality targets and compares them with recently collected nutrient data in the Central Clark Fork Basin Tributaries TMDL Project area following DEQ's nutrient assessment methodology (Suplee and Sada de Suplee, 2011). To be consistent with DEQ's assessment methodology, and because of improvements in analytical methods, only data from the past 10 years (2003-2012) are included in the review of existing data. Several of the nutrient samples collected before 2005 were analyzed for total Kjeldahl nitrogen (TKN), which DEQ has since replaced with total persulfate nitrogen (TPN), also referred to throughout this document as total nitrogen or TN, as the preferred analytical method for determining total nitrogen. TPN has also replaced TKN as a preferred parameter for evaluating nitrogen impairment. TKN data were excluded in the nutrient assessments for streams in this TMDL Project area as the TKN data quality could not be verified; this exclusion explains the difference in sample size between TN and TP and NO_3+NO_2 exhibited frequently throughout the existing condition summary in **Section 6.4.3**.

6.4.1 Nutrient Water Quality Standards

Montana's water quality standards for nutrients (nitrogen and phosphorous forms) are narrative and are addressed via narrative criteria requiring that state surface waters must be free from substances attributable to municipal, industrial, or agricultural practices or other discharges that produce nuisance conditions; create concentrations or combinations of material toxic or harmful to aquatic life; or create conditions that produce undesirable aquatic life [ARM 17.30.637(1)]. DEQ is currently developing numeric nutrient criteria at levels consistent with the requirements of narrative criteria (Montana Department of Environmental Quality, 2013). These draft numeric criteria are the basis for the nutrient TMDL targets consistent with EPA's TMDL development guidance (U.S. Environmental Protection Agency website http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/strategy/) and federal regulations (40 CFR §131.11(a) & (b)).

6.4.2 Nutrient Target Values

Nutrient water quality targets include nutrient concentrations in surface waters and measures of benthic algae, a form of aquatic life that at elevated concentrations is undesirable, chlorophyll-*a* concentrations and AFDM. The target concentrations for nitrogen and phosphorus are established at levels believed to prevent excess growth and proliferation of algae which can cause harm to aquatic life, fishes, and contact recreation beneficial uses. Since 2002, DEQ has conducted studies in order to develop numeric criteria for nutrients (nitrogen and phosphorus forms). DEQ is developing draft numeric nutrient standards for total nitrogen and total phosphorus based on 1) public surveys defining what level of algae was perceived as "undesirable" (Suplee et al., 2009) and 2) the outcome of nutrient stressor-response studies. These stressor-response studies are to determine nutrient concentrations that will maintain algal growth below undesirable and harmful levels (Suplee et al., 2008a; Suplee and Watson, 2013) and to identify reference values (Suplee et al., 2008b).

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 6-3**. The NO_3+NO_2 target is based on research by Suplee et al. (2008a) and Suplee (2013) and is shown in **Table 6-3**. Nutrient targets developed for the Middle Rockies Level III ecoregion differ from those developed for the Northern Rockies Level III ecoregion and both are shown.

DEQ has determined that the values for TN, TP, and NO_3+NO_2 provide an appropriate numeric translation of the applicable narrative nutrient water quality standards based on existing water quality data in the Central Clark Fork Basin Tributaries TMDL Project area and on the type of typical coldwater wadeable streams addressed by nutrient TMDL development in this document. The target values are based on the most sensitive uses; therefore, the nutrient TMDLs are protective of all designated uses.

Table 6-3. Nutrient Targets for the Central Clark Fork Basin Tributaries TMDL Project Area

Parameter	Target Values per Ecoregion	
	Middle Rockies	Northern Rockies
Total Nitrogen (TN) (mg/L)	≤ 0.300	≤ 0.275
Total Phosphorus (TP) (mg/L)	≤ 0.030	≤ 0.025
Nitrate/Nitrite (NO_3+NO_2) (mg/L)	≤ 0.100	≤ 0.100
Benthic Algal Chlorophyll-*a* (mg/m^2)	≤ 125	
Benthic Algal Ash-Free Dry Mass (g/m^2)	≤ 35	
Periphyton Nutrient Increaser Taxa Probability of Impairment (%)	≤ 51	
Macroinvertebrates Hilsenhoff Biotic Index	≤ 4.0	

Influence of volcanic geology

Analysis of DEQ reference data suggested that there is a subset of DEQ reference sites within the Middle Rockies ecoregion that are influenced by volcanic geology. This volcanic geology promotes higher phosphorus concentrations than what is typically seen in Middle Rockies ecoregion streams as a whole. Volcanic geology constitutes a significant portion of 2 nutrient-impaired stream sub-basins in the Central Clark Fork Basin Tributaries TMDL Project area including Tenmile Creek and Rattler Gulch. As the parent material for soil development in the aforementioned impaired streams, these systems are at potentially higher risk of target exceedance for TP due to sediment deposition/transport of phosphorus-enriched soils. However, data analysis was limited and existing data were not strong enough to support alternative water quality targets to those in **Table 6-3**. Volcanic derived soils are often more highly erodible than other soils with different parent materials in a similar climatic regime. Tenmile Creek and Rattler Gulch have completed sediment TMDLs included in **Section 5.0** of this document.

6.4.3 Existing Conditions and Comparisons to Targets

DEQ evaluated nutrient target attainment by comparing existing water quality conditions with the water quality targets in **Table 6-3**, using the methodology in DEQ's guidance document "Assessment Methodology for Determining Wadeable Stream Impairment Due to Excess Nitrogen and Phosphorus Levels" (Suplee and Sada de Suplee, 2011). These updated nutrient assessment determinations are reflected in the 2014 Water Quality Integrated Report in which nutrient impairments appear on the 303(d) list of impaired waters. Each waterbody segment is evaluated for impairment from total nitrogen, total phosphorus and nitrate plus nitrite using data collected within the past 10 years. In this section, for each waterbody segment, nutrient concentration data and associated parameters are summarized and compared to targets in accordance with the assessment methodology. TMDL development determinations depend on results of this data evaluation and are also presented in this section. As mentioned in **Section 6.2**, Cedar Creek and Petty Creek showed no nutrient impairment, and therefore TMDLs are not being developed for them and assessment information is not included in this document.

DEQ's nutrient assessment methodology uses 2 statistical tests (Exact Binomial Test and One-Sample Student's T-test for the Mean) to evaluate nutrient concentration data for compliance with established target values. Chlorophyll-*a*/ash-free dry mass (AFDM) threshold values are used to evaluate benthic algae data. In general, water quality targets are not attained when (a) nutrient chemistry data have a target exceedance rate of >20% (Exact Binomial Test), (b) the mean of nutrient chemistry results exceed target values (Student T-test), or (c) a single chlorophyll-*a*/AFDM result exceeds benthic algal target concentrations (125 mg chl-a/m^2 or 35 g AFDM/m^2). When applying the T-test, one-half the detection limit is substituted for nutrient chemistry values below detection limits. Where water chemistry and algae data do not provide a clear determination of impairment status, or when other limitations exist, periphyton and/or macroinvertebrate biometrics are considered in further evaluating whether nutrient targets have been achieved, as directed by the nutrient assessment methodology.

Periphyton (diatom) increaser taxa metrics were developed by DEQ as an indicator of nutrient impairment. Following taxonomic identification, nutrient increaser taxa metrics (number of taxa on the increaser taxa list and percent relative abundance of increaser taxa) are calculated. The probability that the sample represents a stream impaired due to nutrients is determined based on increaser taxa metrics. Probabilities greater than 51% indicate nutrient impairment (Montana Department of Environmental Quality, 2011b). In the Central Clark Fork Basin Tributaries TMDL Project area, periphyton metrics are incorporated throughout the nutrient assessment process only for streams located within the Northern Rockies Level III ecoregion. No validated diatom increaser metrics have been developed for the Middle Rockies Level III ecoregion at this time and, therefore, periphyton metrics are not included in nutrient assessments for streams within the Middle Rockies ecoregion. The Hilsenhoff Biotic Index (HBI) is a macroinvertebrate biometric based on tolerance values. A large number of macroinvertebrate taxa have been assigned a numeric value that represents the organism's tolerance to organic pollution (Barbour et al., 1999). HBI is then calculated as a weighted average tolerance value of all individuals in a sample (Suplee and Sada de Suplee, 2011). Higher index values indicate increasing tolerance to pollution.

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

6.4.3.1 Dry Creek (MT76M002_170)

Dry Creek is on the 2014 303(d) list as impaired for TN. Dry Creek is located in the westernmost extent of the Central Clark Fork Basin Tributaries TMDL Project area. The stream originates near the Montana-Idaho border in the Bitterroot Mountain Range and flows northeast approximately 15.9 miles to its confluence with the Clark Fork River approximately 4 miles west of the town of Superior, MT. The Dry Creek watershed has an area of 28,697 acres. Approximately 96% of the watershed is publicly owned (USFS) and the remainder (4%) is privately owned.

Summary nutrient data statistics and assessment method evaluation results for Dry Creek are provided in **Tables 6-4 and 6-5**, respectively. Fourteen TN samples were collected between 2007 and 2011; values ranged from < 0.010 to 0.930 mg/L with 3 samples exceeding the TN target of 0.275 mg/L. Sixteen TP samples were collected between 2004 and 2011; values ranged from < 0.001 to 0.009 mg/L with zero samples exceeding the TP target of 0.025 mg/L. Sixteen NO_3+NO_2 samples were collected between 2004 and 2011; values ranged from < 0.010 to 0.035 mg/L with zero samples exceeding the NO_3+NO_2 target of 0.100 mg/L.

Eight chlorophyll-*a* and 2 AFDM samples were collected from Dry Creek between 2007 and 2011. Chlorophyll-*a* values ranged from 0.94 to 6.04 mg/m², and AFDM values ranged from 3.23 to 3.96 g/m², all of which are below the targets of 125 mg/m² and 35 g/m², respectively. Six periphyton samples were collected from Dry Creek between 2004 and 2011. Probabilities of impairment ranged from 15.25% to 51.43%, with 1 sample exceeding the target of 51%. Four macroinvertebrate samples were collected from Dry Creek between 2004 and 2011. HBI values ranged from 1.91 to 3.05 with zero exceeding the threshold of 4.0.

Both statistical tests failed for TN showing nutrient concentrations in excess of the acceptable exceedance rate and indicating concentrations in excess of the criteria. Both chlorophyll-*a* and AFDM tests pass, although algae sampling timing may have missed the periods of peak growth. The periphyton increaser taxa metric indicates high probability of nutrient impairment. The high TN exceedance rate coupled with periphyton probability of impairment suggesting nutrient impairment supports the decision to maintain the TN impairment listing for Dry Creek. A TMDL will be written for TN.

Table 6-4. Nutrient Data Summary for Dry Creek

Nutrient Parameter	Sample Timeframe	Sample Size	Min*	Max	Median	80th percentile
TN, mg/L	2007-2011	14	< 0.01	0.930	0.060	0.196
TP, mg/L	2004-2011	16	< 0.001	0.009	0.005	0.006
NO_3+NO_2, mg/L	2004-2011	16	< 0.01	0.035	0.010	0.020
Chlorophyll-*a*, mg/m^2	2007-2011	8	0.94	6.04	1.20	3.50
AFDM, g/m^2	2011	2	3.23	3.96	3.60	3.81
Periphyton Prob. of Impairment, %	2004-2011	6	15.25	51.43	29.75	32.77
Macroinvertebrate HBI	2004-2011	4	1.91	3.05	1.99	2.43

*Values preceded by a "<" symbol are detection limits for that parameter. The actual sample value was below the detection limit.

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

Nutrient Parameter	Sample Size	Target Value (mg/L)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a and AFDM Test Results	Peri Test Result	Macro Test Result	TMDL Required ?
TN	14	0.275	3	FAIL	FAIL	PASS	FAIL	PASS	YES
TP	16	0.025	0	PASS	PASS				NO
NO_3+NO_2	16	0.10	0	PASS	PASS				NO

6.4.3.2 Nemote Creek (MT76M002_160)

Nemote Creek is on the 2014 303(d) list as impaired for TN and TP. In addition, this segment is listed for chlorophyll-*a,* a non-pollutant listing commonly linked to nutrient impairment. Nemote Creek is located in the western portion of the Central Clark Fork Basin Tributaries TMDL Project area approximately 15 miles east of Dry Creek. It originates south of the Ninemile Divide in Lolo National Forest and flows 10.4 miles to its confluence with the Clark Fork River approximately 3 miles northeast of the unincorporated community of Tarkio and at Quartz, MT. The Nemote Creek watershed has an area of approximately 22,455 acres. Approximately 83% of the watershed is publicly owned (56% USFS, 26% Montana Fish, Wildlife and Parks, and 1% Montana State Trust Lands) and the remainder (17%) is privately owned.

Summary nutrient data statistics and assessment method evaluation results for Nemote Creek are provided in **Tables 6-6 and 6-7**, respectively. Sixteen TN samples were collected between 2007 and 2011; values ranged from < 0.010 to 0.540 mg/L with 2 samples exceeding the TN target of 0.275 mg/L. Eighteen TP samples were collected between 2004 and 2011; values ranged from 0.015 to 0.059 mg/L with 5 samples exceeding the TP target of 0.025 mg/L. Eighteen NO_3+NO_2 samples were collected between 2004 and 2011; values ranged from < 0.010 to 0.100 mg/L with zero samples exceeding the NO_3+NO_2 target of 0.100 mg/L.

Four chlorophyll-*a* and 2 AFDM samples were collected from Nemote Creek between 2007 and 2011. Chlorophyll-*a* values ranged from 6.20 to 20.00 mg/m², and AFDM values ranged from 2.62 to 21.43 g/m², all of which are below the targets of 125 mg/m² and 35 g/m², respectively. Seven periphyton samples were collected from Nemote Creek between 2004 and 2011. Probabilities of impairment ranged from 24.31% to 62.71%, with 1 sample exceeding the threshold of 51%. Five macroinvertebrate samples were collected from Nemote Creek between 2004 and 2011. HBI values ranged from 2.28 to 6.17 with 4 exceeding the threshold of 4.0.

For TN, the binomial test failed and the T-test passed, showing TN concentrations in excess of the acceptable exceedance rate. For TP, both statistical tests failed. Both chlorophyll-*a* and AFDM tests pass, although sampling timing may have missed the periods of peak algae growth. The periphyton increaser taxa metric indicates high probability of nutrient impairment, and macroinvertebrate HBI scores above the threshold indicate nutrient impairment. This supports the decision to maintain the TN and TP impairment listings for Nemote Creek. The chlorophyll-*a* impairment listing will also be retained and, since chlorophyll-*a* is a non-pollutant cause associated with nutrient impairment, it will be by addressed by the nutrient TMDLs. TMDLs will be written for TN and TP.

Table 6-6. Nutrient Data Summary for Nemote Creek

Nutrient Parameter	Sample Timeframe	Sample Size	Min*	Max	Median	80th percentile
TN, mg/L	2007-2011	16	< 0.01	0.540	0.060	0.210
TP, mg/L	2004-2011	18	0.015	0.059	0.023	0.027
NO_3+NO_2, mg/L	2004-2011	18	< 0.01	0.100	0.020	0.054
Chlorophyll-*a*, mg/m^2	2007-2011	4	6.20	20.00	10.72	16.29
AFDM, g/m^2	2011	2	2.62	21.43	12.03	17.67
Periphyton Prob. of Impairment, %	2004-2011	7	24.31	62.71	28.37	54.77
Macroinvertebrate HBI	2004-2011	5	2.28	6.17	5.04	5.39

*Values preceded by a "<" symbol are detection limits for that parameter. The actual sample value was below the detection limit.

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

Nutrient Parameter	Sample Size	Target Value (mg/L)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a and AFDM Test Results	Peri Test Result	Macro Test Result	TMDL Required ?
TN	16	0.275	2	FAIL	PASS	PASS	FAIL	FAIL	YES
TP	18	0.025	5	FAIL	FAIL				YES
NO_3+NO_2	18	0.1	0	PASS	PASS				NO

6.4.3.3 West Fork Petty Creek (MT76M002_100)

West Fork Petty Creek is on the 2014 303(d) list as impaired for TP. In addition, this segment is listed for chlorophyll-*a,* a non-pollutant listing commonly linked to nutrient impairment. West Fork Petty Creek originates between the Fish Creek and Petty Creek drainages and flows approximately 7.6 miles to its confluence with Petty Creek. Petty Creek is a tributary of the Clark Fork River and joins the river less than 2 miles east of the town of Alberton, MT. West Fork Petty Creek joins with Petty Creek approximately mid-segment. The West Fork Petty Creek watershed is approximately 9,373 acres. Approximately 87% of the watershed is publicly-owned (USFS) and the remainder (13%) is privately owned.

Summary nutrient data statistics and assessment method evaluation results for West Fork Petty Creek are provided in **Tables 6-8 and 6-9**, respectively. Fourteen TN samples were collected between 2007 and 2012; values ranged from < 0.010 to 0.250 mg/L with zero samples exceeding the TN target of 0.275 mg/L. Sixteen TP samples were collected between 2004 and 2012; values ranged from 0.030 to 0.052 mg/L with all 16 samples exceeding the TP target of 0.025 mg/L. Sixteen NO_3+NO_2 samples were collected between 2004 and 2012; values ranged from < 0.010 to 0.080 mg/L with zero samples exceeding the NO_3+NO_2 target of 0.100 mg/L.

Three chlorophyll-*a* and 2 AFDM samples were collected from West Fork Petty Creek between 2007 and 2011. Chlorophyll-*a* values ranged from 6.73 to 9.40 mg/m², and AFDM values ranged from 2.27 to 2.97 g/m², all of which are below the targets of 125 mg/m² and 35 g/m², respectively. Six periphyton samples were collected from West Fork Petty Creek between 2004 and 2011. Probabilities of impairment ranged from 32.20% to 77.33%, with 3 samples exceeding the threshold of 51%. Five macroinvertebrate samples were collected from West Fork Petty Creek between 2004 and 2011. HBI values ranged from 1.01 to 2.62 with zero exceeding the threshold of 4.0.

Both statistical tests failed, showing TP concentrations in excess of the acceptable exceedance rate and indicating concentrations in excess of the criteria. Both chlorophyll-*a* and AFDM tests pass, although algae sampling timing may have missed the periods of peak growth. The periphyton increaser taxa metric indicates high probability of nutrient impairment. Nutrient assessment supports the decision to maintain the TP impairment listing for West Fork Petty Creek. The chlorophyll-*a* impairment listing will also be retained and, since chlorophyll-*a* is a non-pollutant cause associated with nutrient impairment, it will be by addressed by the nutrient TMDL. A TMDL will be written for TP.

Table 6-8. Nutrient Data Summary for West Fork Petty Creek

Nutrient Parameter	Sample Timeframe	Sample Size	Min*	Max	Median	80th percentile
TN, mg/L	2007-2012	14	< 0.01	0.250	0.060	0.100
TP, mg/L	2004-2012	16	0.030	0.052	0.040	0.046
NO_3+NO_2, mg/L	2004-2012	16	< 0.01	0.080	0.020	0.030
Chlorophyll-*a*, mg/m^2	2007-2011	3	6.73	9.40	7.70	8.72
AFDM, g/m^2	2011	2	2.27	2.97	2.62	2.83
Periphyton Prob. of Impairment, %	2004-2011	6	32.20	77.33	57.50	76.67
Macroinvertebrate HBI	2004-2011	5	1.01	2.62	1.86	2.36

*Values preceded by a "<" symbol are detection limits for that parameter. The actual sample value was below the detection limit.

Table 6-9. Assessment Method Evaluation Results for West Fork Petty Creek

Nutrient Parameter	Sample Size	Target Value (mg/L)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a and AFDM Test Results	Peri Test Result	Macro Test Result	TMDL Required ?
TN	14	0.275	0	PASS	PASS				NO
TP	16	0.025	16	FAIL	FAIL	PASS	FAIL	PASS	YES
NO_3+NO_2	16	0.1	0	PASS	PASS				NO

6.4.3.4 Stony Creek (MT76M004_020)

Stony Creek is on the 2014 303(d) list as impaired for TP. Stony Creek is located in the western portion of the Central Clark Fork Basin Tributaries TMDL Project area, originates near the southern border of the Flathead Indian Reservation boundary and flows southwest approximately 7 miles southwest to its confluence with Ninemile Creek. Ninemile Creek is a tributary of the Clark Fork River and joins the river approximately 4 miles west of the unincorporated community of Huson, MT. The Stony Creek confluence is 5 miles above the mouth of Ninemile Creek. The Stony Creek sub-watershed area is approximately 11,700 acres. Approximately 81% of the Stony Creek watershed is publicly owned (78% USFS and 3% Montana State Trust Lands), and the remainder (19%) is privately owned.

Summary nutrient data statistics and assessment method evaluation results for Stony Creek are provided in **Tables 6-10 and 6-11**, respectively. Thirteen TN samples were collected between 2011 and 2012; values ranged from < 0.050 to 0.730 mg/L with 2 samples exceeding the TN target of 0.275 mg/L. Fifteen TP samples were collected between 2003 and 2012; values ranged from < 0.005 to 0.028 mg/L with 2 samples exceeding the TP target of 0.025 mg/L. Fifteen NO_3+NO_2 samples were collected between 2003 and 2012; values ranged from < 0.010 to 0.040 mg/L with zero samples exceeding the NO_3+NO_2 target of 0.100 mg/L.

Two chlorophyll-*a* and 2 AFDM samples were collected from Stony Creek in 2011. Chlorophyll-*a* values ranged from 3.30 to 4.30 mg/m^2, and AFDM values ranged from 1.57 to 4.99 g/m^2, all of which are below the targets of 125 mg/m^2 and 35 g/m^2, respectively. Four periphyton samples were collected from Stony Creek between 2003 and 2011. Probabilities of impairment ranged from 31.72% to 67.45%, with 3 samples exceeding the threshold of 51%. Four macroinvertebrate samples were collected from

Stony Creek between 2003 and 2011. HBI values ranged from 1.98 to 3.37 with zero exceeding the threshold of 4.0.

The binomial test failed and the T-test passed, showing TP concentrations in excess of the acceptable exceedance rate. Both chlorophyll-*a* and AFDM tests pass, although sampling timing may have missed the periods of peak algae growth. Because the water chemistry and algae as primary indicators of nutrient impairment are conflicting, periphyton are included as a secondary indicator. The periphyton increaser taxa metric indicates high probability of nutrient impairment. As such, nutrient assessment supports the decision to maintain the TP impairment listing for Stony Creek. A TMDL will be written for TP.

Table 6-10. Nutrient Data Summary for Stony Creek

Nutrient Parameter	Sample Timeframe	Sample Size	Min*	Max	Median	80th percentile
TN, mg/L	2011-2012	13	< 0.05	0.730	0.050	0.226
TP, mg/L	2003-2012	15	< 0.005	0.028	0.009	0.011
NO_3+NO_2, mg/L	2003-2012	15	< 0.01	0.040	0.010	0.010
Chlorophyll-*a*, mg/m^2	2011	2	3.30	4.30	3.80	4.10
AFDM, g/m^2	2011	2	1.57	4.99	3.28	4.31
Periphyton Prob. of Impairment, %	2003-2011	4	31.72	67.45	59.12	64.06
Macroinvertebrate HBI	2003-2011	4	1.98	3.37	2.90	3.36

*Values preceded by a "<" symbol are detection limits for that parameter. The actual sample value was below the detection limit.

Table 6-11. Assessment Method Evaluation Results for Stony Creek

Nutrient Parameter	Sample Size	Target Value (mg/L)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a and AFDM Test Results	Peri Test Result	Macro Test Result	TMDL Required ?
TN	13	0.275	2	PASS	PASS				NO
TP	15	0.025	2	FAIL	PASS	PASS	FAIL	PASS	YES
NO_3+NO_2	15	0.1	0	PASS	PASS				NO

6.4.3.5 Grant Creek (MT76M002_130)

Grant Creek is on the 2014 303(d) list as impaired for TN and NO_3+NO_2. In addition, this segment is listed for excess algal growth, a non-pollutant listing commonly linked to nutrient impairment. Grant Creek is located directly north of the city of Missoula. It originates in the Rattlesnake National Recreational Area and flows southwest approximately 18.8 miles to its confluence with the Clark Fork River just west of Missoula city limits. The Grant Creek watershed has an area of approximately 19,466 acres. Approximately 55% of the watershed is publicly owned (51% USFS, 3% Missoula County Government, and <1% each city of Missoula Government, Montana State Trust Lands, Montana Department of Transportation, and Montana Fish, Wildlife and Parks) and the remainder (45%) is privately owned.

Summary nutrient data statistics and assessment method evaluation results for Grant Creek are provided in **Tables 6-12 and 6-13**, respectively. Twenty-three TN samples were collected between 2009 and 2011; values ranged from 0.040 to 0.860 mg/L with 9 samples exceeding the TN target of 0.300 mg/L. Twenty-seven TP samples were collected between 2004 and 2011; values ranged from 0.005 to 0.02 mg/L with zero samples exceeding the TP target of 0.030 mg/L. Twenty-seven NO_3+NO_2 samples were collected between 2004 and 2011; values ranged from < 0.010 to 1.14 mg/L with 14 samples exceeding the NO_3+NO_2 target of 0.100 mg/L.

Sixteen chlorophyll-*a* and 5 AFDM samples were collected from Grant Creek in 2011. Chlorophyll-*a* values ranged from 1.30 to 27.54 mg/m², and AFDM values ranged from 2.70 to 13.50 g/m², all of which are below the targets of 125 mg/m² and 35 g/m², respectively. Nine macroinvertebrate samples were collected from Grant Creek between 2004 and 2011. HBI values ranged from 1.85 to 7.15 with 4 exceeding the threshold of 4.0. Periphyton metrics are unavailable for Grant Creek as it is located within the Middle Rockies Level III ecoregion.

Assessment results shown in **Table 6-13** indicate that Grant Creek is impaired for TN, NO_3+NO_2 and chlorophyll-*a*. Both statistical tests are failed for TN and NO_3+NO_2 showing nutrient concentrations in excess of the acceptable exceedance rate and indicating concentrations in excess of the criteria. Both chlorophyll-*a* and AFDM tests pass, although sampling timing may have missed the periods of peak algae growth. Macroinvertebrate HBI scores higher than the acceptable threshold suggest nutrients are the cause, supporting the TN and NO_3+NO_2 impairment listings for Grant Creek. The excess algal growth impairment listing will also be retained and, since excess algal growth is a non-pollutant cause associated with nutrient impairment, it will be by addressed by the nutrient TMDLs. TMDLs will be written for TN and NO_3+NO_2.

The assessment results shown in **Table 6-13** are for the entire Grant Creek assessment unit, from the headwaters to the mouth. It was noted during monitoring and assessment activities that an apparent change in land use occurs around the Interstate-90 crossing, from the upper forested and residential uses to the lower commercial/industrial and agricultural uses. To allow for a more detailed analysis, sufficient data were collected from both the upper and lower reaches of Grant Creek to enable assessment of nutrient conditions independently for each reach. It is important to note that nutrient impairment decisions made for any 1 reach apply to the entire assessment unit as a whole, that is, if 1 reach indicates impairment and the other does not, the entire assessment unit is considered nutrient impaired. For Grant Creek, the TN assessment for the upper reach indicates non-impairment and the lower reach indicates impairment. This suggests sources of TN are likely more abundant in the lower reaches of the stream.

Table 6-12. Nutrient Data Summary for Grant Creek

Nutrient Parameter	Sample Timeframe	Sample Size	Min*	Max	Median	80th percentile
TN, mg/L	2009-2011	23	0.040	0.860	0.300	0.466
TP, mg/L	2004-2009	27	< 0.005	0.020	0.011	0.016
NO_3+NO_2, mg/L	2004-2011	27	< 0.01	1.140	0.220	0.344
Chlorophyll-*a*, mg/m^2	2009-2011	16	1.30	27.54	5.21	9.43
AFDM, g/m^2	2011	5	2.70	13.50	3.27	11.70
Macroinvertebrate HBI	2004-2011	9	1.85	7.15	3.91	5.30

*Values preceded by a "<" symbol are detection limits for that parameter. The actual sample value was below the detection limit.

Table 6-13. Assessment Method Evaluation Results for Grant Creek

Nutrient Parameter	Sample Size	Target Value (mg/L)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a and AFDM Test Results	Macro Test Result	TMDL Required ?
TN	20	0.3	9	FAIL	FAIL	PASS	FAIL	YES
TP	24	0.03	0	PASS	PASS			NO
NO_3+NO_2	24	0.1	14	FAIL	FAIL			YES

6.4.3.6 Tenmile Creek (MT76E004_030)

Tenmile Creek is on the 2014 303(d) list as impaired for TP. Tenmile Creek is located in the eastern extent of the Central Clark Fork Basin Tributaries TMDL Project area about 10 miles west of Rattler Gulch. It originates in the Garnet Mountain Range and flows southeast approximately 4.9 miles to its confluence with Bear Creek. Bear Creek is a tributary of the Clark Fork River and Tenmile Creek joins with Bear Creek approximately mid-segment. The Tenmile Creek watershed has an area of approximately 6,715 acres. Approximately 11% of the watershed is publicly owned (10% BLM and 1% Montana State Trust Lands), and the remainder (89%) is privately owned.

Summary nutrient data statistics and assessment method evaluation results for Tenmile Creek are provided in **Tables 6-14 and 6-15**, respectively. Thirteen TN samples were collected between 2009 and 2011; values ranged from 0.080 to 0.230 mg/L with zero samples exceeding the TN target of 0.300 mg/L. Fourteen TP samples were collected between 2004 and 2011; values ranged from 0.116 to 0.272 mg/L with all samples exceeding the TP target of 0.030 mg/L. Fourteen NO_3+NO_2 samples were collected between 2004 and 2011; values ranged from < 0.010 to 0.130 mg/L with 2 samples exceeding the NO_3+NO_2 target of 0.100 mg/L.

Nine chlorophyll-*a* and 3 AFDM samples were collected from Tenmile Creek between 2009 and 2011. Chlorophyll-*a* values ranged from 1.68 to 41.80 mg/m², and AFDM values ranged from 1.87 to 12.10 g/m², all of which are below the targets of 125 mg/m² and 35 g/m², respectively. Five macroinvertebrate samples were collected from Tenmile Creek between 2004 and 2011. HBI values ranged from 2.50 to 4.0 with zero exceeding the threshold of 4.0. Periphyton metrics are unavailable for Tenmile Creek as it is located within the Middle Rockies Level III ecoregion.

Assessment results shown in **Table 6-15** indicate that Tenmile Creek is impaired for TP. Both statistical tests failed for TP showing nutrient concentrations in excess of the acceptable exceedance rate and indicating concentrations much in excess of the criteria. Both chlorophyll-*a* and AFDM tests pass, although algae sampling timing may have missed the periods of peak growth. Macroinvertebrate HBI scores are below the acceptable threshold. Uncertainty in the nutrient impairment outcome stems from evidence of substantially elevated nutrient concentrations coupled with the lack of biological indicators of nutrient impairment (i.e., benthic algae and macroinvertebrate metrics are within acceptable thresholds). However, the high exceedance rate (100%) and elevated nutrient concentrations support the decision to maintain the TP impairment listing for Tenmile Creek. A TMDL will be written for TP.

Table 6-14. Nutrient Data Summary for Tenmile Creek

Nutrient Parameter	Sample Timeframe	Sample Size	Min*	Max	Median	80th percentile
TN, mg/L	2009-2011	13	0.080	0.230	0.190	0.200
TP, mg/L	2004-2011	14	0.116	0.272	0.186	0.234
NO_3+NO_2, mg/L	2004-2011	14	< 0.01	0.130	0.010	0.058
Chlorophyll-*a*, mg/m^2	2009-2011	9	1.68	41.80	13.80	24.96
AFDM, g/m^2	2011	3	1.87	12.10	6.92	10.03
Macroinvertebrate HBI	2004-2011	5	2.50	4.01	2.58	3.14

*Values preceded by a "<" symbol are detection limits for that parameter. The actual sample value was below the detection limit.

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

Nutrient Parameter	Sample Size	Target Value (mg/L)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a and AFDM Test Results	Macro Test Result	TMDL Required ?
TN	13	0.3	0	PASS	PASS			NO
TP	14	0.03	14	FAIL	FAIL	PASS	PASS	YES
NO_3+NO_2	14	0.1	2	PASS	PASS			NO

6.4.3.7 Deep Creek (MT76E004_070)

Deep Creek is on the 2014 303(d) list as impaired for NO_3+NO_2. In addition, this segment is listed for chlorophyll-*a,* a non-pollutant listing commonly linked to nutrient impairment. Deep Creek is located in the eastern extent of the Central Clark Fork Basin Tributaries TMDL Project area between Tenmile Creek and Garnet ghost town. It originates in the Garnet Mountain Range and flows southeast approximately 5.1 miles to its confluence with Bear Creek. Bear Creek is a tributary of the Clark Fork River and Deep Creek joins with Bear Creek 2 to 3 miles downstream from Bear Creek's headwaters. The Deep Creek sub-watershed has an area of approximately 6,700 acres. Approximately 81% of the Deep Creek watershed is publicly owned (75% BLM and 6% Montana State Trust Lands), and the remainder (19%) is privately owned.

Summary nutrient data statistics and assessment method evaluation results for Deep Creek are provided in **Tables 6-16 and 6-17**, respectively. Fourteen TN samples were collected between 2010 and 2011; values ranged from 0.080 to 0.250 mg/L with zero samples exceeding the TN target of 0.300 mg/L. Sixteen TP samples were collected between 2004 and 2011; values ranged from 0.010 to 0.031 mg/L with 1 sample exceeding the TP target of 0.030 mg/L. Sixteen NO_3+NO_2 samples were collected between 2004 and 2011; values ranged from < 0.010 to 0.20 mg/L with 13 samples exceeding the NO_3+NO_2 target of 0.100 mg/L.

Three chlorophyll-*a* and 2 AFDM samples were collected from Deep Creek in 2011. Chlorophyll-*a* values ranged from 5.00 to 23.73 mg/m^2, and AFDM values ranged from 13.65 to 23.69 g/m^2, all of which are below the targets of 125 mg/m^2 and 35 g/m^2, respectively. Seven macroinvertebrate samples were collected from Deep Creek between 2004 and 2011. HBI values ranged from 2.93 to 4.88 with 2 samples exceeding the threshold of 4.0. Periphyton metrics are unavailable for Deep Creek as it is located within the Middle Rockies Level III ecoregion.

Both statistical tests failed for NO_3+NO_2 showing nutrient concentrations in excess of the acceptable exceedance rate and indicating concentrations in excess of the criteria. Both chlorophyll-*a* and AFDM tests passed, although algae sampling timing may have missed the periods of peak growth. Because the water chemistry and algae as primary indicators of nutrient impairment are conflicting, periphyton are included as a secondary indicator. Macroinvertebrate HBI scores higher than the acceptable threshold suggest nutrients are the cause, supporting the NO_3+NO_2 impairment listing for Deep Creek. The chlorophyll-*a* impairment listing will also be retained and, since chlorophyll-*a* is a non-pollutant cause associated with nutrient impairment, it will be by addressed by the NO_3+NO_2 TMDL. A TMDL will be written for NO_3+NO_2.

Table 6-16. Nutrient Data Summary for Deep Creek

Nutrient Parameter	Sample Timeframe	Sample Size	Min*	Max	Median	80th percentile
TN, mg/L	2010-2011	14	0.080	0.250	0.175	0.204
TP, mg/L	2004-2011	16	0.010	0.031	0.020	0.023
NO_3+NO_2, mg/L	2004-2011	16	< 0.01	0.200	0.155	0.180
Chlorophyll-*a*, mg/m^2	2011	3	5.00	23.73	11.95	19.02
AFDM, g/m^2	2011	2	13.65	23.69	18.67	21.68
Macroinvertebrate HBI	2004-2011	7	2.93	4.88	3.61	4.33

*Values preceded by a "<" symbol are detection limits for that parameter. The actual sample value was below the detection limit.

Table 6-17. Assessment Method Evaluation Results for Deep Creek

Nutrient Parameter	Sample Size	Target Value (mg/L)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a and AFDM Test Results	Macro Test Result	TMDL Required?
TN	14	0.3	0	PASS	PASS	PASS	FAIL	NO
TP	16	0.03	1	PASS	PASS			NO
NO_3+NO_2	16	0.1	13	FAIL	FAIL			YES

6.4.3.8 Rattler Gulch (MT76E004_060)

Rattler Gulch is on the 2014 303(d) list as impaired for TP. This segment is also listed for chlorophyll-*a,* a non-pollutant listing commonly linked to nutrient impairment. Rattler Gulch is located near the eastern extent of the Central Clark Fork Basin Tributaries TMDL Project area. It originates in the Garnet Mountain Range and flows generally south approximately 8 miles to its confluence with the Clark Fork River about 4 miles west of the town of Drummond. The Rattler Gulch watershed has an area of approximately 9,841 acres. Approximately 36% of the watershed is publicly owned (32% BLM and 4% Montana State Trust Lands), and the remainder (64%) is privately owned. Flow is intermittent in the lowermost reaches of the stream and does not reach the Clark Fork River year-round.

Summary nutrient data statistics and assessment method evaluation results for Rattler Gulch are provided in **Tables 6-18** and **6-19**, respectively. Twelve TN samples were collected between 2009 and 2011; values ranged from < 0.050 to 0.490 mg/L with 2 samples exceeding the TN target of 0.300 mg/L. Thirteen TP samples were collected between 2004 and 2011; values ranged from 0.089 to 0.193 mg/L with all 13 samples exceeding the TP target of 0.030 mg/L. Thirteen NO_3+NO_2 samples were collected between 2004 and 2011; values ranged from < 0.010 to 0.070 mg/L with zero samples exceeding the NO_3+NO_2 target of 0.100 mg/L.

Seven chlorophyll-*a* and 3 AFDM samples were collected from Rattler Gulch between 2009 and 2011. Chlorophyll-*a* values ranged from 2.52 to 38.7 mg/m², and AFDM values ranged from 4.84 to 8.69 g/m², all of which are below the targets of 125 mg/m² and 35 g/m², respectively. Four macroinvertebrate samples were collected from Rattler Gulch between 2004 and 2011. HBI values ranged from 3.27 to 6.31 with 3 exceeding the threshold of 4.0. Periphyton metrics are unavailable for Rattler Gulch as it is located within the Middle Rockies Level III ecoregion.

Both statistical tests failed for TP showing nutrient concentrations in excess of the acceptable exceedance rate and indicating concentrations in excess of the criteria. Both chlorophyll-*a* and AFDM tests pass, although algae sampling timing may have missed the periods of peak growth. Macroinvertebrate HBI scores greater than the acceptable threshold suggest nutrients are the cause, supporting the decision to maintain the TP impairment listing for Rattler Gulch. The chlorophyll-*a* impairment listing will also be retained and, since chlorophyll-*a* is a non-pollutant cause associated with nutrient impairment, it will be by addressed by the nutrient TMDL. A TMDL will be written for TP.

Table 6-18. Nutrient Data Summary for Rattler Gulch

Nutrient Parameter	Sample Timeframe	Sample Size	Min*	Max	Median	80th percentile
TN, mg/L	2009-2011	12	< 0.05	0.490	0.160	0.204
TP, mg/L	2004-2011	13	0.089	0.193	0.119	0.175
NO_3+NO_2, mg/L	2004-2011	13	< 0.01	0.070	0.020	0.030
Chlorophyll-*a*, mg/m^2	2009-2011	7	2.52	38.70	18.20	21.44
AFDM, g/m^2	2011	3	4.84	8.69	5.34	7.35
Macroinvertebrate HBI	2004-2011	4	3.27	6.31	4.70	5.66

*Values preceded by a "<" symbol are detection limits for that parameter. The actual sample value was below the detection limit.

Table 6-19. Assessment Method Evaluation Results for Rattler Gulch

Nutrient Parameter	Sample Size	Target Value (mg/L)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a and AFDM Test Results	Macro Test Result	TMDL Required ?
TN	12	0.3	2	PASS	PASS			NO
TP	13	0.03	13	FAIL	FAIL	PASS	FAIL	YES
NO_3+NO_2	13	0.1	0	PASS	PASS			NO

6.4.4 Nutrient TMDL Development Summary

Table 6-20 summarizes the nutrient impairment determinations and the nutrient pollutants for which TMDLs will be prepared for streams in the Central Clark Fork Basin Tributaries TMDL Project area based on DEQ's updated assessments. Per **Table 6-20,** a total of 9 separate nutrient TMDLs will be developed for 8 stream segments. These 9 TMDLs address ten nutrient pollutant impairment causes and 5 chlorophyll-*a* or excess algae (non-pollutant) impairment causes. TMDLs will be developed mostly for TN and TP. A TMDL for NO_3+NO_2 will be developed for Deep Creek. A TMDL will be developed for TN for Grant Creek and this TN TMDL will serve as a surrogate TMDL to address the NO_3+NO_2 listing (**Section 6.6.5**).

Table 6-20. Summary of Nutrient TMDL Development Determinations

Waterbody Segment	Waterbody ID	2014 Nutrient Impairment Causes	TMDLs Prepared
DRY CREEK, headwaters to mouth (Clark Fork River)	MT76M002_170	TN	TN
NEMOTE CREEK, headwaters to mouth (confluence Clark Fork River)	MT76M002_160	TN, TP, Chlorophyll-*a*[1]	TN, TP
WEST FORK PETTY CREEK, headwaters to mouth (Petty Creek)	MT76M002_100	TP, Chlorophyll-*a*[1]	TP
STONY CREEK, headwaters to mouth (Ninemile Creek)	MT76M004_020	TP	TP
GRANT CREEK, headwaters to mouth (Clark Fork River)	MT76M002_130	TN, NO_3+NO_2, Excess Algal Growth[1]	TN[2]
TENMILE CREEK, headwaters to mouth (Bear Creek-Clark Fork River)	MT76E004_030	TP	TP
DEEP CREEK, headwaters to mouth (Bear Creek, which is a tributary to Clark Fork River near Bearmouth)	MT76E004_070	NO_3+NO_2, Chlorophyll-*a*[1]	NO_3+NO_2
RATTLER GULCH, headwaters to mouth (Clark Fork River), T11N R13W S22	MT76E004_060	TP, Chlorophyll-*a*[1]	TP

[1] Non-pollutant; addressed via nutrient TMDLs

[2] NO_3+NO_2 remains a nutrient impairment for Grant Creek; the TN TMDL will address both TN and NO_3+NO_2.

6.5 Source Assessment, TMDL and Allocation Approaches

This section provides the overall approach used for nutrient source assessment, TMDL development, and allocations in the Central Clark Fork Basin Tributaries TMDL Project area. This approach is then applied to each of the 8 stream segments of concern.

6.5.1 Nutrient Source Assessment Approach

Assessment of existing nutrient (i.e., nitrate, nitrogen, and phosphorus) sources is needed to develop load allocations to specific source categories. Water quality sampling data collected from 2003 through 2012 represents the most recent data for determining existing nutrient water quality conditions. These data were collected with the objectives of (1) evaluating attainment of water quality targets and (2) assessing load contributions from nutrient sources within the Central Clark Fork Basin Tributaries TMDL Project area. These data form the primary dataset from which existing water quality conditions were evaluated and from which TN, TP, and NO_3+NO_2 loading estimates are derived. Data used to conduct these analyses are publicly available at: http://www.epa.gov/storet/dw_home.html.

This section characterizes the type, magnitude, and distribution of sources contributing to nutrient loading to impaired streams, provides loading estimates for significant source types, and establishes the approach applied toward establishing the TMDLs for each stream and allocations to specific source categories. Source types include natural and human-caused nonpoint and point sources; these are described in further detail for each stream in **Section 6.6**. Source characterization links nutrient sources, nutrient loading to streams, and water quality response, and supports the formulation of the load allocation (LA) portion of the TMDL. As described in **Section 6.4.2**, TN, TP, and NO_3+NO_2 water quality targets are applicable during the summer growing season (i.e., July 1 to September 30) and, as a result, TMDLs will only apply during this season as well. Consequently, source characterizations are focused mainly on sources and mechanisms that influence nutrient contributions during this period. Total loading estimates are established for the summer growing season time period and are based on observed water quality data and flow conditions measured during this time period.

Source characterization and assessment were conducted by using monitoring data collected from the TMDL Project area from 2003 through 2012. Box plots are used to display nutrient values measured from the impaired streams and determine spatial patterns in nutrient concentrations. In descriptive statistics, box plots are a convenient way of graphically depicting groups of numerical data through their 5 number summaries. Box plots depict the smallest observation (sample minimum), 25th percentile, median, 75th percentile, and the largest observation (sample maximum). Box plots display differences between the data without making any assumptions of the underlying statistical distribution of the data. The spacing between the different parts of the box indicates the degree of dispersion and skewness in data and identifies outliers. For data representation, when sample data were below detection limits the detection limit was used.

Land use in the Central Clark Fork Basin Tributaries TMDL Project area primarily consists of agriculture (livestock grazing and irrigated cropland), silviculture (timber harvest and forest roads), historical mining, and semi-rural or suburban residential areas, along with urban areas in the Missoula Valley. Of the watersheds for which TMDLs will be developed (**Table 6-20**), only Grant Creek receives discharge from a MPDES surface water point source permit (Missoula MS4 Storm Water Discharge Permit). Nutrient sources in most of the listed tributaries consist primarily of (1) natural sources derived from airborne deposition, vegetation, soils, and geologic weathering; and (2) human-caused sources (agriculture, silviculture, mining, and subsurface wastewater treatment and disposal). These sources may include a variety of discrete and diffuse pollutant inputs that have differing pathways to a waterbody.

6.5.1.1 Nonpoint Sources of Nutrients

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

- Agriculture (cropping and pasture/rangeland)
- Silviculture (timber harvest)
- Mining

- Subsurface wastewater disposal and treatment (individual, community septic systems that discharge to groundwater)
- Natural background

Agriculture (cropping and pasture/rangeland)

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

Pastures/Rangeland

Grazing on forest lands and in pastures is common in the Central Clark Fork Basin Tributaries TMDL Project area. Cattle are allowed to roam and are generally not concentrated along the valley bottoms during the growing season when many pasture systems are hayed. Horses may also be allowed to roam and graze though they have been mostly observed on small acreage lots that are fenced. Pastures are managed for hay production during the summer and for grazing during the fall and spring. Hay pastures are thickly vegetated in the summer; less so in the fall through spring. The winter grazing period is typically long (October–May), and trampling and feeding further reduces biomass when it is already low. Commercial fertilizers are used infrequently in the watershed, and naturally applied cattle manure is a more significant source of nutrients. Cattle manure occurs in higher quantities on pasture ground from October through May because of much higher cattle density than that found on range and forested areas.

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

More specifically, livestock grazing on state and federal lands is another potential nutrient source in some nutrient impaired waterbodies in the Central Clark Fork Basin Tributaries TMDL Project area. Grazing allotment data were collected from the BLM and USFS and were compiled per impaired waterbody watershed as total Animal Unit Months (AUM) per drainage (**Table 6-21**). The BLM does not make an annual "count" of the livestock that graze on BLM-managed lands because the actual number of livestock grazing on public lands on any single day varies throughout the year and livestock are often moved from one grazing allotment to another. Instead, the BLM compiles information on the number of AUMs used each year, which takes into account both the number of livestock and the amount of time they spend on public lands (Bureau of Land Management website factsheet).

Total AUMs were determined only for allotments that have some areas draining to an impaired waterbody. These numbers constitute the existing permits for grazing leases on public (federal and state) lands within grazing allotments and represent a maximum number of AUMs possible at any one time. AUMs are reported for public lands within each allotment. However, since allotment boundaries differ from the watershed boundaries, a distinction is made between grazing on public land within the entire allotment and on public land within the allotment that also lies within the sub-watershed boundary. For each sub-watershed, **Table 6-21** shows the total acreage of public lands as well as the approximate acreage of public land that lies within allotment boundaries. Although it may be unlikely that all permitted AUMs for an entire allotment area will be grazed exclusively on public lands within a sub-drainage boundary, it is possible. Therefore, the AUMs shown in **Table 6-21** are the maximum possible that could theoretically be grazing, at any given time, on the sub-drainage public lands that lie within allotment boundaries. No attempts were made to verify actual grazing practices or current stocking densities and this compilation is for coarse source assessment purposes only.

Several grazing allotments in the Central Clark Fork Basin Tributaries TMDL Project area permit grazing only during the summer/early fall period, beginning generally in early- to mid-June and extending to late-September or mid-October. In Rattler Gulch, Tenmile, Deep and Stony Creeks, all public lands within the drainage are within a grazing allotment. In the Dry Creek sub-drainage, there is a very small amount of allotment area relative to the total area of public lands. The Dry Creek and Nemote Creek sub-basins contain far more public land than grazing allotment area. Approximately half of the allotment area within the Dry Creek sub-basin is public land (215 acres). Almost the entire allotment area within the Nemote Creek sub-basin is public land (3,175 acres).

Table 6-21. Summary of Permitted Grazing Allotment Animal Unit Months (AUMs) on Federal and State Lands within Watersheds with Nutrient Impairments

Drainage Basin[1]	Total Permitted AUMs	Total Allotment Area (Acres)	Public Land in Allotment		Allotment Area in Sub-Drainage		Public Lands in Sub-Drainage		Public Lands in Sub-Drainage within Allotment
			Acres	%	Acres	%	Acres	%	Acres
Rattler Gulch	157	14,131	3,798	27%	9,711	69%	3,567	36%	3,567
Tenmile Creek	276	80,622	5,113	6%	6,451	8%	768	11%	768
Deep Creek	258	32,242	11,535	36%	8,617	27%	5,414	81%	5,414
Dry Creek	20	810	810	100%	431	53%	27,422	96%	215
Nemote Creek[2]	0	6,168	6,165	100%	3,175	51%	18,606	83%	3,175
Stony Creek	50	51,565	51,543	100%	13,390	26%	9,439	81%	9,439

[1]Grant Creek and West Fork Petty Creek drainages do not have any allotments and thus no grazing permitted on public lands.
[2]Approximately 51% of the Miller-Micayune grazing allotment lies within the Nemote Creek sub-drainage, and a majority of the allotment area within the Nemote basin is public land; however, as of March 06, 2014, this allotment is vacant with zero permitted AUMs.

<u>Irrigated and Dryland Cropping</u>

Cropping in the sub-drainages of nutrient impaired waterbodies in the Central Clark Fork Basin Tributaries TMDL Project area is relatively minimal. It is predominately irrigated production of alfalfa hay and pasture/hay, with smaller acreages of irrigated and dryland cultivated cropland. Irrigated lands are usually in continuous production and have annual soil disturbance and fertilizer inputs. Dryland cropping may have fallow periods of 16 to 22 months, depending on site characteristics and landowner management. Nutrient pathways include overland runoff, deep percolation, and shallow groundwater flow, which transport nutrients off site.

Silviculture (including timber harvest and forest roads)

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

A coarse assessment of recent timber operations was made based on the Montana Spatial Data Infrastructure (MDSI) geospatial land cover data layer for the watersheds of interest in the Central Clark Fork Basin Tributaries TMDL Project area that have nutrient impaired waterbodies. These data were used to better understand recent operations by scale and location in comparison with available water chemistry data. These are used where appropriate to inform the source assessment.

Mining

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

Subsurface Wastewater Treatment and Disposal (individual septic systems that discharge to groundwater)

Discharge of septic effluent from individual and community septic systems that discharge to groundwater may contribute to nutrient loading in streams depending on a combination of discharge, soils, and distance from the downgradient waterbody. Septic systems, even when operating as designed, can contribute nutrients to surface water through subsurface pathways. These sources are accounted for by using septic density mapping and water quality data to determine if subsurface wastewater treatment and disposal was having an identifiable effect on nutrient loading.

Natural background

Load allocations for natural background sources in all applicable impaired segments are based on median concentration values from reference sites in either the Middle Rockies or the Northern Rockies Level III ecoregions, as applicable, during the July 1 to September 30 growing season. For the Middle Rockies ecoregion, these values are TN = 0.095 mg/L, TP = 0.01 mg/L (Suplee and Watson, 2013), and NO_3+NO_2 = 0.02 mg/L (Suplee et al., 2008a). For the Northern Rockies ecoregion, these values are TN = 0.041 mg/L, TP = 0.006 mg/ L (Suplee and Watson, 2013) and NO_3+NO_2 = 0.009 mg/L (Suplee et al., 2008a). Reference sites were chosen to represent stream conditions where human activities may be present but do not negatively harm stream uses. The effects of natural events such as flooding, fire, and beetle kill may be captured at these sites. Natural background loads are calculated by multiplying the median reference concentration by the measured median growing season streamflow from the available dataset per waterbody.

6.5.1.2 Point Sources of Nutrients

In addition to nonpoint sources, nutrient inputs into streams in the Central Clark Fork Basin Tributaries TMDL Project area point sources (i.e., distinct, identifiable sources, such as pipes feeding directly into a waterbody) were examined. As of March 10, 2014, there are 2 active MPDES permitted point sources that have the potential to discharge nutrient loads to a waterbody listed as nutrient-impaired on the Draft 2014 303(d) list of impaired waters in the Central Clark Fork Basin Tributaries TMDL Project area: the Missoula Small MS4 Storm Water System and the Econo Lodge. Both discharge to Grant Creek.

Econo Lodge (MT0029840)

The Econo Lodge (MT0029840) is authorized to discharge noncontact cooling water from a heat exchanger to Grant Creek. The permitted discharge is limited to an end of pipe outfall located just south of the Interstate-90 crossing, between the Grant Creek Village monitoring site and the Broadway Street road crossing. During the months of April through October, groundwater is used in the hotel's heat exchange system to regulate temperature in the facility. From the heat exchanger, water is piped directly to Grant Creek on the west side of the parking lot through Outfall 001. This is not a continuous discharge and has a maximum flow rate of 60 gpm (0.13 cfs). The current permit has limits for flow, temperature, and pH but none for nutrients.

Given the source of the cooling water and its use at the facility, it may be assumed that TSS loads are negligible. Therefore, since the discharge is noncontact cooling water and Econo Lodge does not have permitted effluent limitations for nutrients, Econo Lodge is considered not to have reasonable potential to be a nutrient source and a Wasteload Allocation (WLA) has not been developed.

Missoula MS4 (MTR040007)

Under EPA's Stormwater Phase II Rule, Missoula is regulated under the general permit for storm water discharge associated with small municipal separate storm water sewer systems (MS4) (MTR04000). The city of Missoula, Missoula County, the University of Montana and Montana Department of Transportation are co-permittees. The Missoula MS4 discharges to several receiving waterbodies including the Bitterroot River, the Clark Fork River, and Grant Creek. The permit states that the MS4 drains an area of approximately 29.7 mi^2 and closely approximates the urban limit boundary (25.3 mi^2). As Grant Creek has nutrient impairment listings on the 2014 303(d) List, a Wasteload Allocation (WLA) for the Missoula MS4 is required. The physical boundary of this point source discharge is identified in **Figure 6-3.**

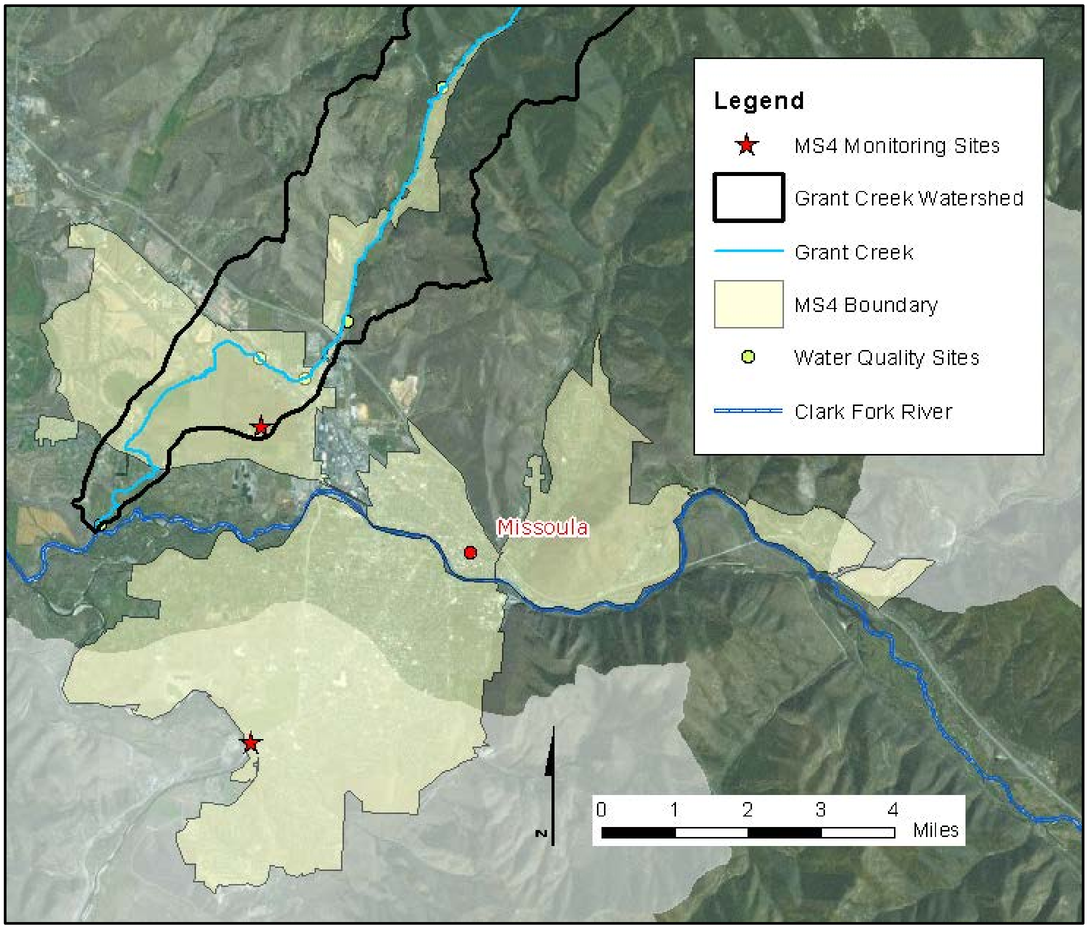

Figure 6-3. Location of the MPDES permitted Missoula small MS4 storm water system including the Grant Creek sub-basin.

The permit does not include effluent limits, but requires the development and implementation of a Storm Water Management Program (SWMP) to minimize nutrient loading to surface waters. The SWMP must include 6 minimum control measures: (1) public education and outreach; (2) public involvement/participation; (3) detection and elimination of illicit discharges; (4) control of stormwater runoff from construction sites; (5) management of post-construction stormwater in new development and redevelopment; and (6) pollution prevention/good housekeeping. Additionally, the permit requires semiannual monitoring at 2 sites within city limits; one representing a residential area and the other representing a commercial/industrial area.

DEQ analyzed the city of Missoula's GIS coverage of the stormwater infrastructure, and determined that 2.29 square miles (1,467 acres) of stormwater catchment discharge to Grant Creek. The annual discharge was estimated using the stormwater discharge area of 1,467 acres, average annual precipitation of 14 inches, and an estimated percentage of total annual precipitation draining to surface water of 8% provided by DEQ modeling staff (personal communication, Erik Makus, 2014). This results in an estimated annual discharge of 5,963,550 cubic feet per year or 168,868,939 liters. Similarly, the annual discharge during the summer growing season when nutrient criteria apply (July 1 – September 30) was estimated using the stormwater discharge area of 2.29 square miles, average annual summer growing season precipitation of 3.1 inches over a 30-yer period (1984 to 2013), and an estimated percentage of total annual precipitation draining to surface water of 8%. This results in an estimated annual summer growing season discharge of 1,322,411 cubic feet per summer or 37,446,506 liters.

Based on the current zoning map for Missoula County, approximately 60% of this discharge is considered to be from suburban/residential areas, with the remaining 40% from commercial areas. The MS4 permit requires semiannual monitoring of TN in stormwater effluent at 1 site representing a residential area and at another site representing a commercial/industrial area. Since the MS4 permit requires that the sample locations are representative, and since stormwater management practices have improved since the 1990s, DEQ used the permit sampling data (2007-2013) to estimate the existing TN load from the Missoula MS4 to Grant Creek. Based on the sample reporting for the MS4 permit, the 80^{th} percentile concentration of TN in stormwater runoff from commercial areas is 5.58 mg/L and from residential area is 4.61 mg/L. Using these concentrations, DEQ estimated that this portion of the MS4 contributes annual summer growing season TN loads of 412.7 lbs/summer to Grant Creek (184.3 lbs/summer commercial and 228.4 lbs/summer residential). It is worth noting that the residential sampling point for the Missoula MS4 is in the Grant Creek sub-watershed. It is also worth noting that this loading will be associated with storm events that will also likely increase the flow within Grant Creek.

DEQ recognized the extensive channel reconstruction/realignment and floodplain development was completed in the Grant Creek sub-watershed to mitigate future flood events as part of a FEMA PDM grant (2008-2010) {Harmon, 2010 6301 /id} (see **Section 5.4.3.5**). As part of this completed project, parts of the Missoula MS4 system in the Grant Creek sub-watershed were expanded/updated to more effectively capture large flood events. It is not known specifically how the FEMA PDM work may affect annual nutrient loading from the MS4 to Grant Creek although it would most likely decrease the estimate of 412.7 lbs TN per summer. However, for the purposes of this analysis, DEQ will retain the original loading estimate from the stormwater system to Grant Creek.

To estimate an average “per-event” load, the annual summer growing season TN load estimate is divided by the average number of times the MS4 discharges in a summer. DEQ did not identify a threshold magnitude for precipitation events that result in stormwater discharge, and snowmelt complicates estimates by generally lagging behind the precipitation event. DEQ chose 0.25 inches of precipitation as a representative value. Between 1984 and 2013, there was an average of 4.1 summer precipitation events greater than 0.25 inches. By dividing the estimated annual summer TN loads by 4, DEQ estimates that the per-event loads (considered equivalent to daily loads given the short duration of rainfall and runoff events) are 103.2 lbs per summer storm event.

Ultimately, when the MS4 is activated, load reductions are based on the successful implementation of a SWMP. Therefore, since the system should not be actively discharging during typical summer low flow conditions, both the existing load and WLA are defined as 0.0 (zero) lbs/day for TN in the example TMDL presented in **Section 6.6.5**. Although nutrient loading only occurs a few times during the summer algal growing season, loading reductions are desirable and are possible via full implementation of stormwater BMPs consistent with the MS4 general permit requirements. These stormwater permit BMPs typically address multiple pollutants and represent an important component of Montana’s efforts to prevent pollution and protect or improve water quality. The degree of possible load reductions is discussed below.

BMP effectiveness values reported from the International Storm Water BMP Database (Geosyntec Consultants and Wright Water Engineers, Inc., 2011) will be used as the basis for the WLA. In this database, studies for nutrient loading reduction efficiencies for a variety of BMP categories were summarized by evaluating the 75th percentile, median, and 25th percentile concentrations of influent and effluent. BMP categories include bioretention, composite/treatment train, bioswales, detention basins, filter strips, manufactured devices, media filters, porous pavement, retention ponds, wetland basins, and wetland channels. Using the median TN concentrations of influent and effluent, the following BMPs significantly reduced TN concentrations in stormwater, with the reduction efficiency shown for each: bioretention (28%), composite (28%) and retention ponds (30%). This range of reduction efficiencies (28% to 30%) for the 3 most effective BMP categories has a median and average reduction of 29%.

In the general MS4 permit, the median benchmark value for stormwater runoff is 2.0 mg/L TN. For the Missoula MS4 DMR data, the commercial sampling point had a median concentration of 2.55 mg/L (*n*=12) and the residential sampling point has a median concentration of 2.40 mg/L (*n*=13). Some BMPs are already in place in for the Missoula MS4 in the Grant Creek drainage, particularly detention/retention ponds. However, data from both residential and commercial sampling greater than the benchmark value suggest implementation of additional BMPs effective at reducing total nitrogen in stormwater is desirable in the Missoula MS4 system. Since benchmarks only address concentration whereas loading is a function of both concentration and flow, any future evaluations of MS4 BMP effectiveness must also take into account the role of BMPs that mitigate the quantity of stormwater reaching Grant Creek.

Recognizing recent improvements to the Grant Creek sub-watershed from the FEMA PDM project, the upper limit of the range of potential reduction efficiencies may overestimate reductions needed to reduce TN concentrations. Likewise, DMR data exceeding the median benchmark for total nitrogen suggest the lower limit of potential reduction efficiencies may underestimate reductions needed. As such, DEQ used the median of potential reduction efficiencies from BMPs that are most likely to reduce TN concentrations in stormwater (29%) to determine the WLA from the Missoula MS4 to Grant Creek.

When applied to the total estimated summer TN load (412.7 lbs/summer), a 29% reduction produces a WLA for TN of 293.0 lbs/summer from the Missoula MS4 to Grant Creek. When applied to the estimated TN load per summer storm event (103.2 lbs/event), a 29% reduction produces a WLA of 73.3 lbs/summer storm event. This “per event” load equates to the daily load expected during the 4 summer storm events, on average, that qualify (0.25 inches) as producing stormwater discharge. It is anticipated that stormwater discharge will not present an issue for compliance with targets and water quality standards since these events will be infrequent (less than 20% of the summer growing season) and randomly spaced throughout that period (July 1 – September 30) (Suplee et al., 2008a).

The WLAs are not intended to add concentration or load limits to the permit. Consistent with EPA guidance and the CWA (U.S. Environmental Protection Agency, 2002), DEQ assumes the WLAs will be met by adhering to the permit requirements and reducing either the nutrient concentrations or the discharge volumes, or both. As identified in the permit, monitoring data should continue to be collected and evaluated to assess BMP performance and help identify whether and where additional BMP implementation may be necessary. In addition to the current representative sampling locations, a storm sewer outfall draining the urban core of Missoula should be added to the sampling locations in order to characterize this source area.

6.5.2 Approach to TMDL Development, Load Allocations, Wasteload Allocations, and Current Loading

6.5.2.1 TMDL Equation

TMDL calculations for TN, TP, and NO_3+NO_2 are based on the following formula:

Equation 1: TMDL = (X) (Y) (5.4)

TMDL= Total Maximum Daily Load in lbs/day
*X = water quality target (***Table 6-3***)*
Y = streamflow in cubic feet per second
5.4 = conversion factor

Note that the TMDL is not static, as flow increases the allowable (TMDL) load increases as shown by the total phosphorus example in **Figure 6-4**.

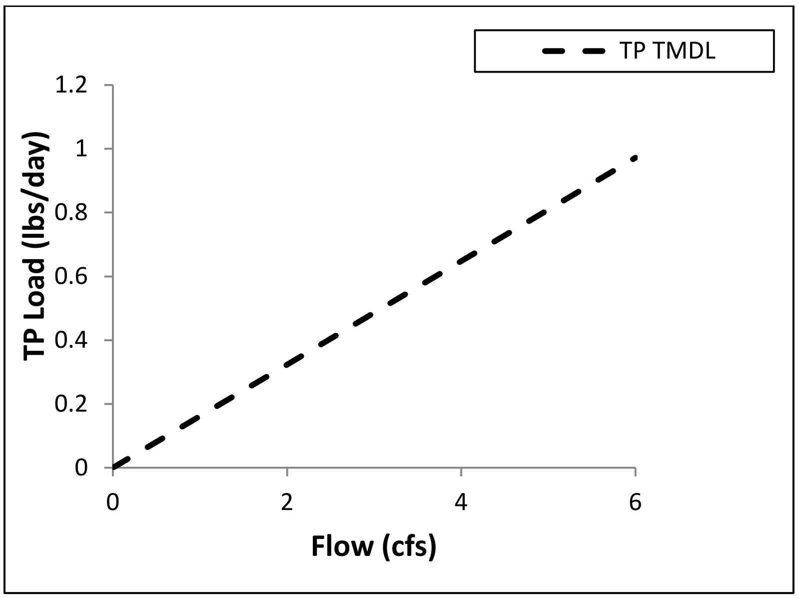

Figure 6-4. Example total maximum daily load for total phosphorus (TP) from 0 to 6 cfs.

Approach to TMDL Allocations

As discussed in **Section 4.0**, the TN, TP and NO_3+NO_2 TMDLs for applicable impaired waterbody AUs consist of the sum of load allocations (LAs) to individual source categories plus wasteload allocations (WLAs) and margin of safety (MOS) (**Tables 6-22** and **6-23**). LAs will be calculated for the following source categories: (1) Natural background, and (2) Human-caused (agriculture, silviculture, mining, and subsurface wastewater treatment and disposal). In the absence of individual wasteload allocations (WLAs) and an explicit margin of safety (MOS), the TMDLs for TN, TP, and NO_3+NO_2 in each waterbody are equal to the sum of the individual loads as follows:

Equation 2: TMDL = LA_{NB} + LA_H

LA_{NB} = Load Allocation to natural background sources

LA_H = Load Allocation to human-caused nonpoint sources (agriculture, silviculture, mining, and subsurface wastewater treatment and disposal sources)

The exception to this approach is Grant Creek, which contains a permitted point source, the Missoula MS4 Storm Water System. **Equation 3** will be used to calculate Grant Creek's TMDL.

Equation 3: $TMDL = LA_{NB} + LA_H + WLA_{MS4}$

LA_{NB} = Load Allocation to natural background sources

LA_H = Load Allocation to human-caused nonpoint sources (agriculture, silviculture, mining, and subsurface wastewater treatment and disposal sources)

WLA_{MS4} = Wasteload Allocation to Missoula's MS4 Storm Water System

Table 6-22. TN and NO_3+NO_2 LA Source Categories and Descriptions for the Central Clark Fork Basin Tributaries TMDL Project Area

Source Category	LA Descriptions
Natural Background	• soils and local geology • natural vegetative decay • wet and dry airborne deposition • wild animal waste • natural biochemical processes that contribute nitrogen to nearby waterbodies
Human-Caused (Agricultural, Silviculture, Mining, Subsurface Wastewater Treatment and Disposal)	• domestic animal waste • fertilizer • loss of riparian and wetland vegetation along streambanks • limited nutrient uptake due to loss of overstory • cyanide breakdown from leaching • runoff from exposed rock containing natural background nitrate • residual chemicals left over from mining practices • human waste

Table 6-23. TP LA Source Categories and Descriptions for the Central Clark Fork Basin Tributaries TMDL Project Area

Source Category	LA Descriptions
Natural Background	• soils and local geology • natural vegetative decay • wet and dry airborne deposition • wild animal waste • natural biochemical processes that contribute phosphorus to nearby waterbodies
Human-Caused (Agricultural, Silviculture, Mining, Subsurface Wastewater Treatment and Disposal)	• domestic animal waste • fertilizer • loss of riparian and wetland vegetation along streambanks • limited nutrient uptake due to loss of overstory • runoff from exposed rock containing natural background phosphorus • human waste

Natural background Allocation

Natural background loading is discussed in **Section 6.5.1.1**. The natural background load is calculated as follows:

Equation 4: LA_{NB} = (X) (Y) (5.4)

LA_{NB} = Load Allocated to natural background sources
X = natural background concentration in mg/L (for streams in the Middle Rockies ecoregion: TN = 0.095 mg/L, TP = 0.01 mg/L or NO_3+NO_2 = 0.02 mg/L; for streams in the Northern Rockies ecoregion: TN = 0.041 mg/L, TP = 0.006 mg/L or NO_3+NO_2 = 0.009 mg/L)
Y = streamflow in cubic feet per second (the streamflow that is associated with the median reduction for measured loads that exceed the TMDL)
5.4 = conversion factor

Allocations for Human-Caused Sources

The LA to human-caused sources is calculated as the difference between the allowable daily load (TMDL) and the natural background load:

Equation 5: LA_H = TMDL – LA_{NB}

LA_H = Load Allocation to agriculture, silviculture, mining, and subsurface wastewater treatment and disposal sources

This same approach can be applied to Grant Creek for normal summer flow conditions since the WLA_{MS4} will equal 0 as discussed above in Section 6.5.1.2.

6.5.2.2 Total Existing Load

To estimate the total existing loading for the purpose of estimating a required load reduction, the following equation will be used:

Equation 6: Total Existing Load = (X) (Y) (5.4)

X = measured concentration in mg/L (the concentration that is associated with the median reduction for measured loads that exceed the TMDL)
Y = streamflow in cfs (the streamflow that is associated with the median reduction for measured loads that exceed the TMDL)
5.4 = conversion factor

6.5.2.3 Reductions

Figures portraying the load reductions necessary to meet the nutrients targets are shown for each waterbody segment requiring TMDL(s) in **Section 6.6**. These reductions were calculated using all nutrient data points that had an associated flow. **Equation 7** was used to calculate all load reductions:

Equation 7: Load Reduction = (Measured Load – TMDL) / Measured Load)*100

*Measured Load = measured nutrient concentration in mg/L*measured flow in cfs*5.4*
*TMDL = target concentration in mg/L*measured flow in cfs*5.4*

Calculated load reduction values greater than zero indicate that the TMDL is being exceeded and reductions are necessary. Calculated load reduction values less than or equal to zero are meeting the TMDL and no reductions are needed to achieve the TMDL.

6.6 Source Assessments, TMDLs, Allocations, and Reductions for Each Stream

6.6.1 Dry Creek

6.6.1.1 Assessment of Water Quality Results

The source assessment for Dry Creek consists of an evaluation of TN concentration data. This is followed by a description of the most significant human caused sources of nutrients in the Dry Creek sub-watershed. **Figure 6.5** presents the approximate locations of data pertinent to the source assessment in the sub-watershed.

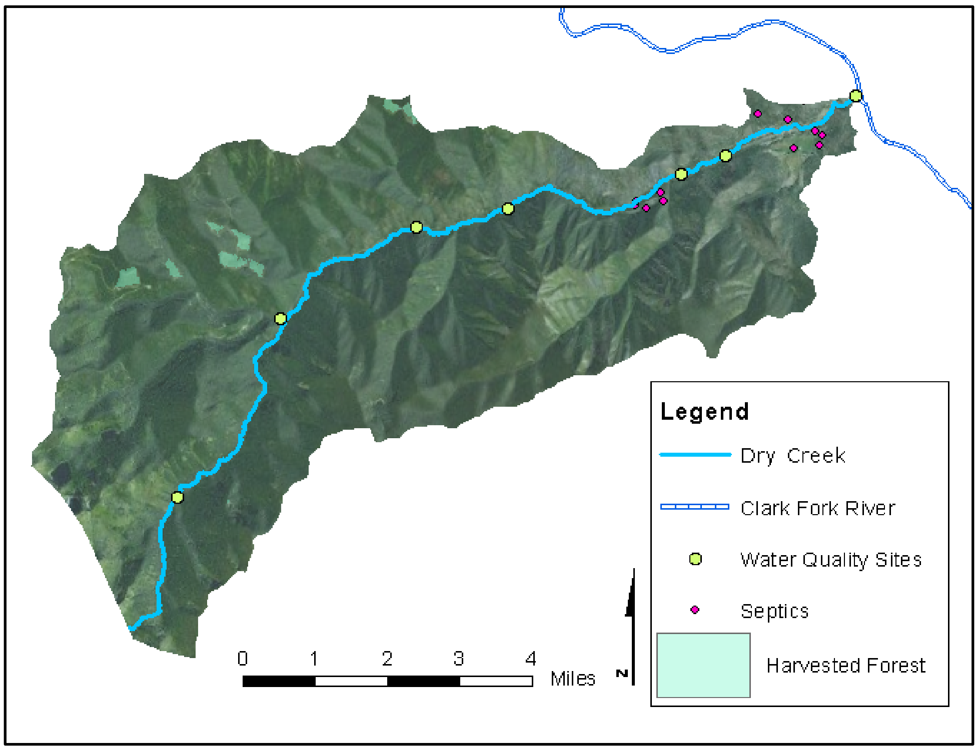

Figure 6-5. Dry Creek sub-watershed with water quality sampling locations.

DEQ collected water quality samples from Dry Creek during the growing season over the time period 2007 to 2011 (**Section 6.4.3.1**, **Table 6-4**). Six monitoring site locations were established during this time. **Figure 6-6** presents summary statistics for TN concentrations at sampling sites in Dry Creek.

Fourteen TN samples were collected at 6 sites and TN concentrations were in excess of the TN target concentration of 0.275 mg/L in 3 samples. The recent dataset for benthic algae did not indicate excess algal growth, although sampling timing may have missed the periods of peak growth. Periphyton samples were collected in 2004, 2006, 2007, and 2011 and 1 of 6 probabilities of impairment were above the target, suggesting nutrient impairment. Macroinvertebrate samples were collected in 2004 and 2011 and all 4 HBI scores were below the target.

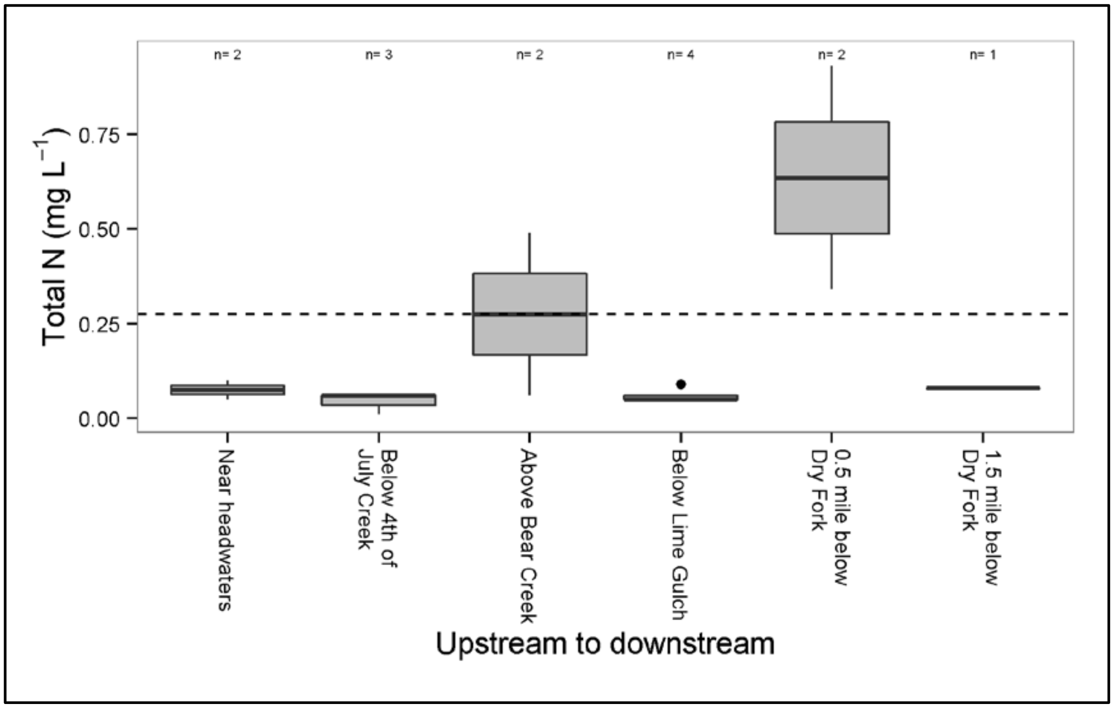

Figure 6-6. TN boxplots for Dry Creek.

The highest concentrations of TN in Dry Creek were observed at 2 sites, above Bear Creek and below Dry Fork of Dry Creek. The upper 2 sites, near the headwaters and below Fourth of July Creek, both had TN concentrations below the target. One sample at the site above Bear Creek had a concentration 1.78 times greater than the target. The site below Lime Gulch had concentrations below the target. Moving further downstream, both TN concentrations measured at the site just below Dry Fork were, on average, 2.31 times greater than the TN target. Finally, the site nearest the mouth included a TN concentration below target. Target exceedance ratios were plotted for Dry Creek nutrient concentrations for which an associated flow value was collected are depicted in these figures. Ratios less than 1.0 indicate sample concentrations below the TN target. Flows ranged from 2.85 cfs to 28.73 cfs throughout the growing season, and were consistently greater in August (average = 21.4 cfs) compared to September (average = 5.6) (**Figure 6-7**). **Figure 6-8** shows the percent reductions for TN loads measured in Dry Creek from 2004-2011. Reductions needed to achieve the TMDL range from 19.12% to 70.43% with a median reduction of 43.88%.

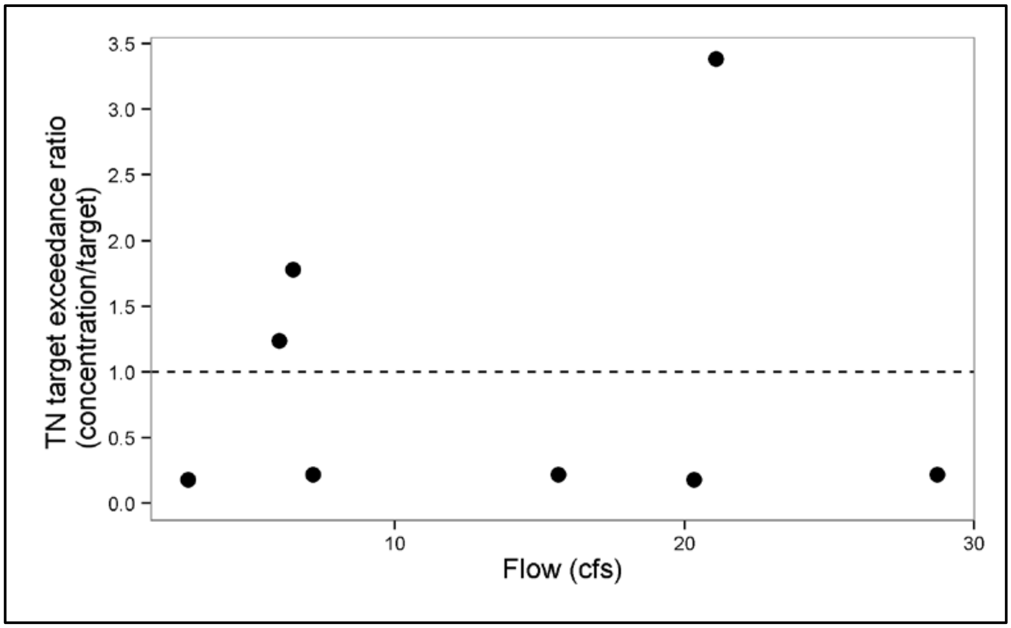

Figure 6-7. TN target exceedance ratio in Dry Creek (2007-2011).

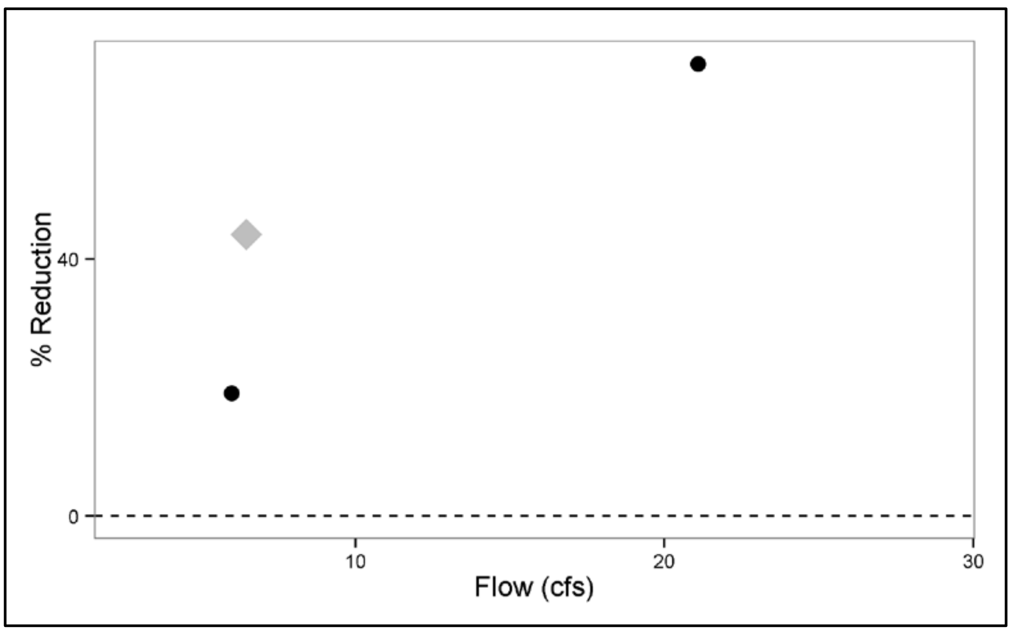

Figure 6-8. Measured TN percent load reductions necessary to achieve the TN TMDL in Dry Creek (2007-2011). The gray diamond represents a median percent reduction value used to calculate existing load and percent reductions in the example TMDL for Dry Creek.

6.6.1.2 Assessment of Loading by Source Categories

Dry Creek appears on the Montana Department of Fish, Wildlife and Parks dewatered streams list as being chronically dewatered on the lowermost reaches from the Dry Fork to the mouth, river mile 0.0 to 3.2. This list identifies streams that support or contribute to important fisheries that are significantly dewatered, referring to a reduction in streamflow below the point where stream habitat is adequate for fish. Chronically dewatered streams describe where dewatering is a significant problem in virtually all years. According to previous DEQ assessment records for Dry Creek, a large irrigation diversion was observed taking a significant amount of water from the channel. It is unclear if the removal of this water causes the channel to become intermittent or if the channel would lose water naturally. Observations of a very large pipe on the hillside above the stream channel between the Dry Fork confluence and the mouth were also noted in previous assessments, although it is unclear is this pipe is used to divert or return water.

The majority of the Dry Creek sub-watershed is forested with shrubland interspersed throughout. Two forest fires have burned in the Dry Creek drainage since 2000: in 2000, the Torino Peak fire (approximately 10 acres), and in 2009, the Ann Arbor fire (approximately 42 acres). Both fires occurred in the upper, northwestern portion of the drainage several thousands of feet from the Dry Creek channel. Since these are relatively small fires that were not in close proximity of the Dry Creek channel, they are not thought to have contributed substantial nutrients.

Agriculture

Agricultural land use in the Dry Creek sub-watershed is minimal, with only small amounts of both grazing and crop production. The Dry Creek sub-watershed is 28,697 acres, and 27,422 acres (96%) of this is public land. The sub-watershed contains a very small amount of allotment area relative to the total area of public lands. There is 1 grazing allotment that overlaps with the Dry Creek sub-watershed. The Bouchard allotment number 00093 is 810 acres, of which 431 acres (53%) is within the Dry Creek sub-watershed. Roughly half of this allotment area within the Dry Creek sub-watershed is public, USFS administered land (approximately 215 acres). The public lands within the grazing allotment boundary have, at most, 20 permitted AUMs. While it may be unlikely that all 20 permitted AUMs for the entire allotment area will be grazed exclusively on public lands within the Dry Creek sub-watershed, this represents the maximum AUMs possible at any given time. No attempts were made to verify actual grazing practices or current stocking densities. Presence of pasture land and moderate livestock use was noted in previous DEQ assessment records based on field observations, verifying that livestock grazing may be a minor contributor to the existing TN load in Dry Creek.

Analysis of aerial imagery and geospatial land cover data reveals the majority of drainage is forested with relatively small parcels of pasture land scattered throughout the drainage, much of which is located in the lower one-third to one-fifth of the channel extent and watershed area. Several relatively small parcels of cultivated cropland and pasture/hay are located just upstream from the mouth of Dry Creek. One small parcel of irrigated cropland is in this area near the mouth, which corresponds to a small area of barley and alfalfa production. As stated at the beginning of this section, an irrigation diversion was observed drawing water from the channel. Like grazing, irrigated cropland may be another minor contributor to the existing TN load in Dry Creek.

Silviculture

Silviculture activities are not a primary land use in the Dry Creek sub-watershed. An analysis of aerial imagery and geospatial land cover data reveals several small parcels of timber harvest in the northwestern portion of the sub-drainage, although these operations are not within close proximity to the stream channel. Contributions of nutrients to Dry Creek from timber harvest are unlikely. Forest Road 342 runs along much of the stream channel and is in relatively close proximity in some places. However, there exists a substantial riparian buffer between the road and the channel in most places and this road is not thought to be a substantial contributor of nutrients.

Mining

According to DEQ records, there are 9 abandoned mines in the Dry Creek drainage, none of which appear on DEQ's Priority Mine Sites List (Pioneer Technical Services, Inc., 1995). One underground past producer gold lode mine is in the Fourth of July Creek drainage; no mines are present above Fourth of July Creek confluence. Three past producer fluorine lode mines (including the Spar Mine) are scattered around mouth of the Bear Creek confluence just below the C04DRYC05 monitoring site. One past producer fluorine lode mine (Lucky Jack/Wilson Gulch) is in the lower reaches of Wilson Gulch that joins with Dry Creek below the Bear Gulch confluence, and the other cluster of abandoned mines is situated near mouth of Dry Fork. The proximity of these mines to the stream channel suggests that mining may be a minor contributor to nutrient loads in Dry Creek.

Subsurface wastewater disposal and treatment

According to DEQ records, there are 12 individual septic systems in the Dry Creek sub-watershed. These are located in 2 clusters. One cluster has 5 individual septics and is situated just above the Dry Fork confluence. The other cluster has 7 septics and is located below the monitoring site 0.5 miles below the Dry Fork confluence and above the mouth. The upper cluster has 2 septics that are approximately 50 to 150 feet from the channel, and the lower cluster has 1 septic system approximately 175 feet from the channel; all others are 500 to 1000 feet from the channel and thought to be outside the main floodplain. There is a discernible increase in TN concentrations at the site below the upper cluster of septic systems, although the Dry Fork also joins between these points. It is possible that septic effluent is a minor contributor to the existing Dry Creek TN daily load.

6.6.1.3 TN TMDL, Allocations, and Current Loading

The TMDL for TN is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the TN TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TN TMDL for Dry Creek uses **Equation 1** with the flow associated with the median concentration of measured TN values that exceed the target reduction from all sites during 2007-2011 sampling (6.47 cfs, as represented by the gray diamond in Figure 6-8):

TMDL = (0.275 mg/L) (6.47 cfs) (5.4) = 9.61 lbs/day

Equation 4 is the basis for the natural background load allocation for TN. To continue with the example at a flow of 6.47 cfs, this allocation is as follows:

LA_{NB} = (0.041 mg/L) (6.47 cfs) (5.4) = 1.43 lbs/day

Using **Equation 5,** the combined human-caused TN allocation at 6.47 cfs can be calculated:

LA_{H} = 9.61 lbs/day – 1.43 lbs/day = 8.18 lbs/day

An example total existing load is calculated as follows using **Equation 6**, the example flow of 6.47 cfs, and the corresponding concentration associated with the median reduction for measured loads that exceed the TMDL for TN in Dry Creek from 2007-2011 (0.490 mg/L):

Total Existing Load = (0.490 mg/L) (6.47 cfs) (5.4) = 17.12 lbs/day

The portion of the existing load attributed to human sources is 15.69 lbs/day, which is determined by subtracting out the 1.43 lbs/day natural background load. This 15.69 lbs/day represents the load measured within the stream after potential nutrient uptake.

Table 6-24 summarizes the example TN TMDL, load allocations, and current loading. **Table 6-24** also contains the percent reduction to human-caused load allocation required to meet the water quality target for TN. The percent reduction to natural background is 0%. At the median concentration of measured TN values that exceed the target (0.490 mg/L) and the growing season flow associated with this median concentration (6.47 cfs), the existing loading in Dry Creek is greater than the TMDL. Under these example conditions a 47.9% reduction of human-caused sources and an overall 43.9% reduction of TN in Dry Creek would result in the TMDL being met. The source assessment of the Dry Creek watershed indicates that livestock grazing in the riparian zone and subsurface wastewater treatment and disposal is the most likely source of TN in Dry Creek; load reductions should focus on limiting and controlling TN loading from these sources. Meeting load allocations for Dry Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 7.0**.

Table 6-24. Dry Creek TN Example TMDL, Load Allocations, Current Loading, and Reductions

Source Category	Allocation & TMDL (lbs/day)[1]	Existing Load (lbs/day)[1]	Percent Reduction
Natural Background	1.43	1.43	0%
Human-caused (primarily agriculture and subsurface wastewater disposal)	8.18	15.69	47.9%
	TMDL = 9.61	**Total = 17.12**	**Total = 43.9%**

[1] Based on a growing season flow of 6.47 cfs.

6.6.2 Nemote Creek

6.6.2.1 Assessment of Water Quality Results

The source assessment for Nemote Creek consists of an evaluation of TN and TP concentrations. This is followed by a description of the most significant human caused sources of nutrients. **Figure 6.9** presents the approximate locations of data pertinent to the source assessment in the sub-watershed.

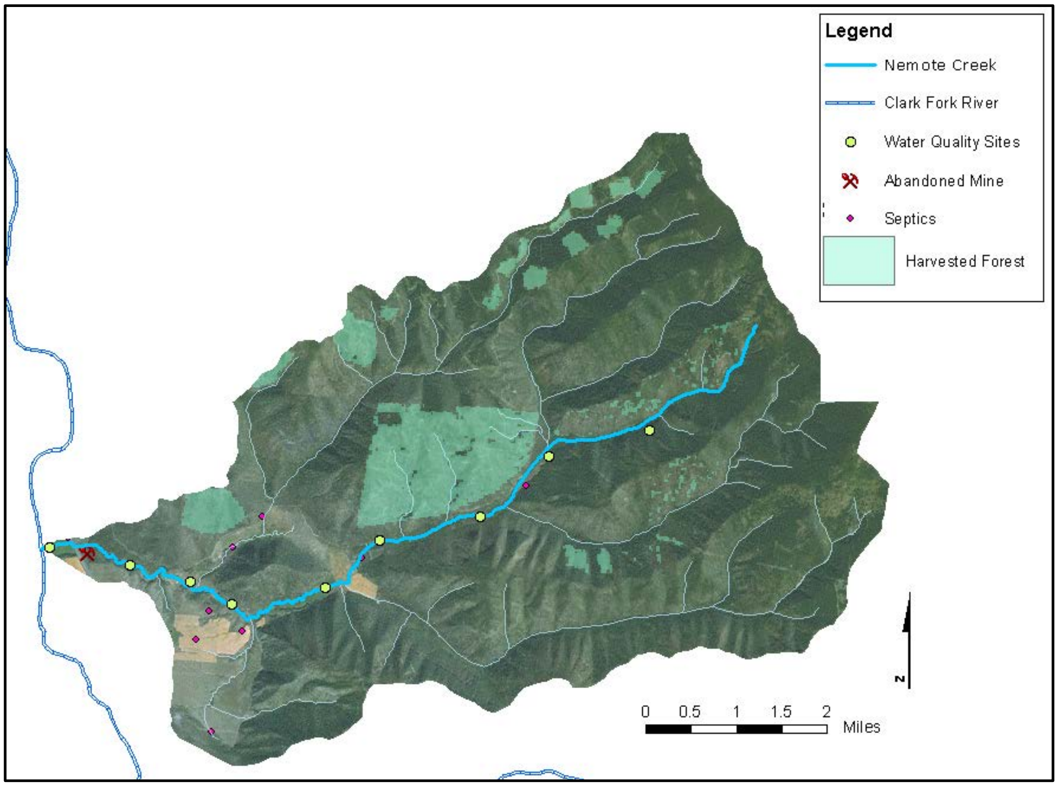

Figure 6-9. Nemote Creek sub-watershed with water quality sampling locations.

Total Nitrogen
DEQ collected water quality samples from Nemote Creek during the growing season over the time period 2004 to 2011; TN data are available only from 2007 to 2011 (**Section 6.4.3.2**, **Table 6-7**). Nine monitoring site locations were established during the sampling period. **Figure 6-10** presents summary statistics for TN concentrations at sampling sites in Nemote Creek.

Sixteen TN samples were collected at 8 sites and TN concentrations were in excess of the TN target concentration of 0.275 mg/L in 2 of the samples. The recent dataset for benthic algae did not indicate excess algal growth, although sampling timing may have missed the periods of peak growth. Nutrient concentrations, in excess of the target, present conditions that may lead to excess algal growth and support the continued chlorophyll-*a* impairment listing. Periphyton samples were collected in 2004, 2006, 2007, and 2011 and 3 of 7 had probabilities of impairment above the threshold, suggesting nutrient impairment. Macroinvertebrate samples were collected in 2004 and 2011 and 4 of 5 HBI scores were above the threshold.

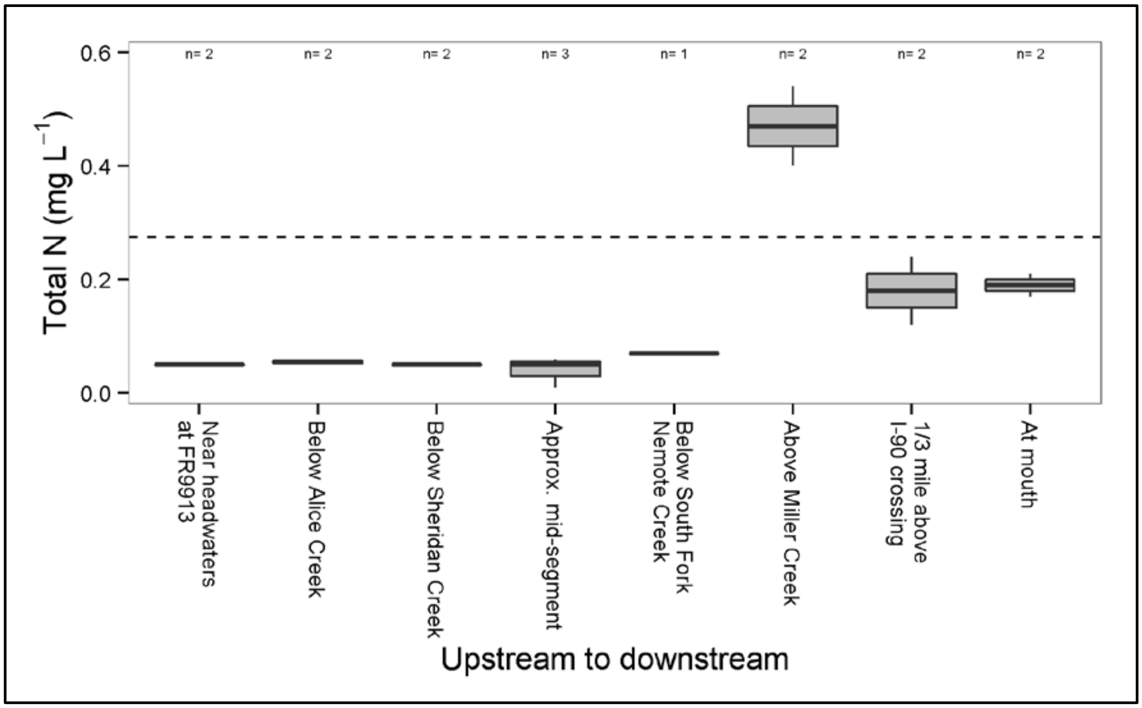

Figure 6-10. TN boxplots for Nemote Creek.

As shown in **Figure 6-10**, the only site on Nemote Creek that exhibited TN concentrations in excess of the TN target was above the Miller Creek confluence in the lower portion of the assessment unit. At this site, TN concentrations were, on average, 1.71 times greater than the TN target of 0.275 mg/L. TN concentrations at the other 7 sites were below the TN target (no exceedances). The uppermost 5 sites reaching from near the headwaters of Nemote Creek to just below the South Fork Nemote Creek confluence have very similar low TN concentrations, ranging from 0.01 to 0.07 mg/L, on average less than one-quarter of the TN target concentration. The lower 2 sites also have similar concentrations, ranging from 0.12 to 0.24 mg/L, on average just over one-half of the TN target concentration.

Target exceedance ratios were plotted for all Nemote Creek TN samples and only nutrient concentrations for which an associated flow value was collected are depicted in these figures. Ratios less than 1.0 indicate sample concentrations below the TN target. Flows ranged from 0.28 cfs to 6.16 cfs throughout the growing season (**Figure 6-11**). **Figure 6-12** shows the percent reductions for TN loads measured in Nemote Creek from 2007-2011. Reductions needed to achieve the TMDL range from 31.25% to 49.07% with a median reduction of 40.16%.

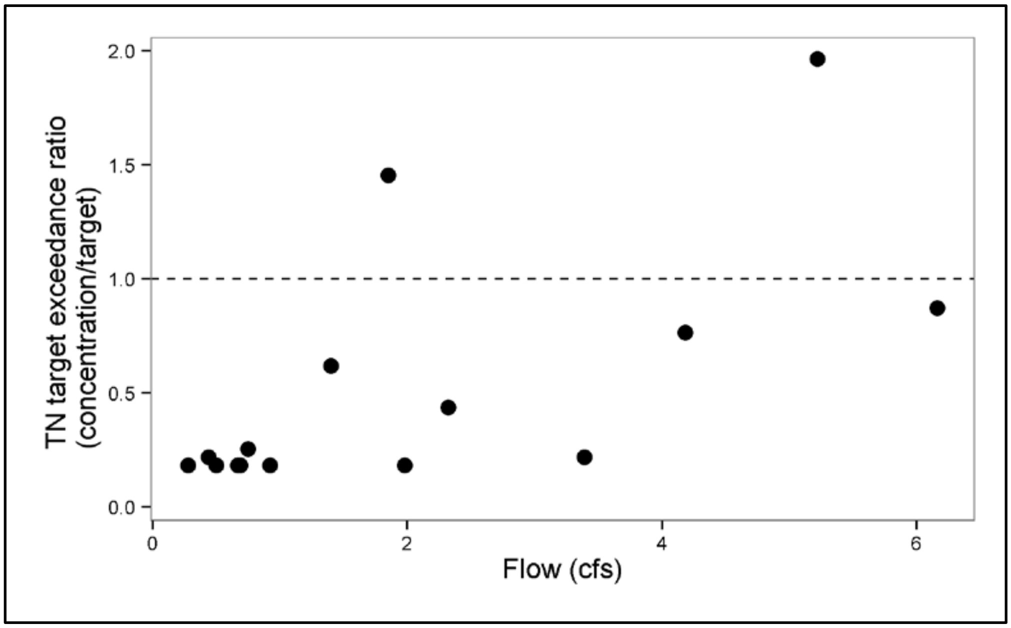

Figure 6-11. TN target exceedance ratio in Nemote Creek (2007-2011).

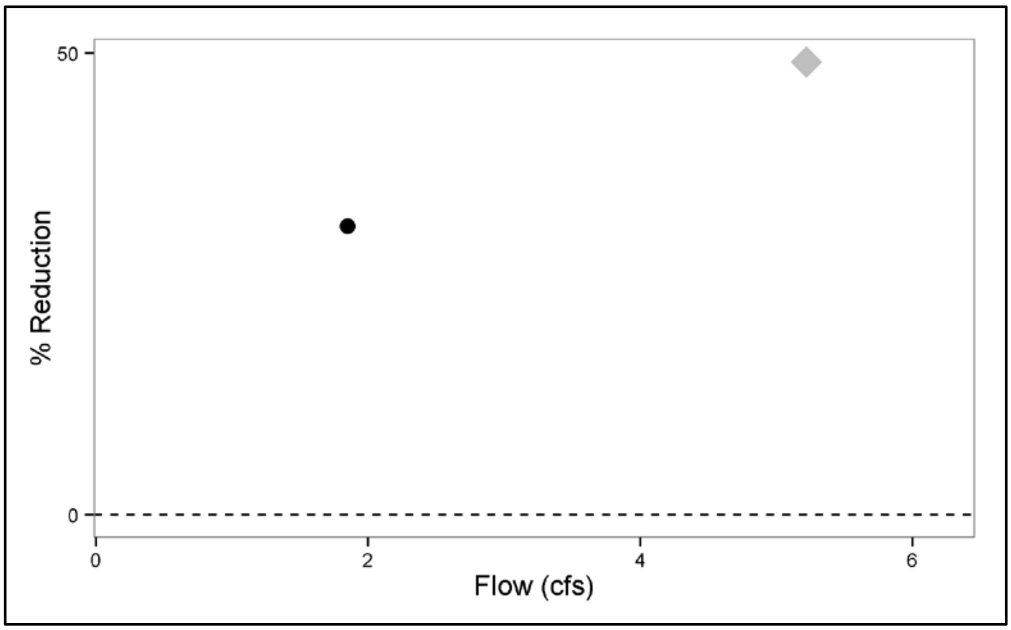

Figure 6-12. Measured TN percent load reductions necessary to achieve the TN TMDL in Nemote Creek (2007-2011). The gray diamond represents a median percent reduction value used to calculate existing load and percent reductions in the example TMDL for Nemote Creek.

Total Phosphorus

DEQ collected water quality samples from Nemote Creek during the growing season over the time period 2004 to 2011 (**Section 6.4.3.2**, **Table 6-7**). Nine monitoring site locations were established during the sampling period. **Figure 6-13** presents summary statistics for TP concentrations at sampling sites in Nemote Creek.

Eighteen TP samples were collected at 8 sites and TP concentrations were in excess of the TP target concentration of 0.025 mg/L in 5 samples.

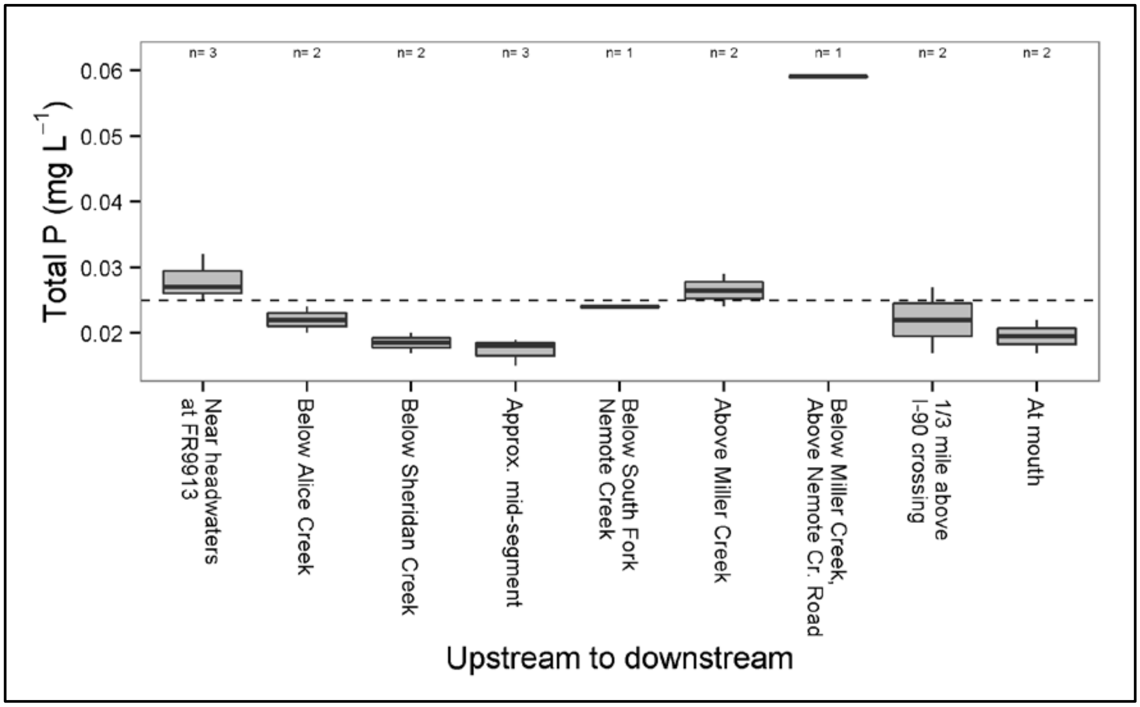

Figure 6-13. TP boxplots for Nemote Creek.

As shown in **Figure 6-13**, 4 of 9 sites on Nemote Creek exhibited TP concentrations in excess of the TP target. The site nearest the headwaters had TP concentrations, on average 1.12 times greater than the TP target with 2 of 3 samples exceeding the target. Moving downstream, concentrations at the next 4 sites, from the Alice Creek confluence to below the South Fork Nemote Creek confluence, were all below the TP target. The remaining TP target exceedances were seen at the next 3 sites. The site below Miller Creek exhibited the greatest TP concentration at 2.36 times greater than the target. Target exceedance ratios were plotted for all Nemote Creek TP samples and only nutrient concentrations for which an associated flow value was collected are depicted in these figures. Ratios less than 1.0 indicate sample concentrations below the TP target. Flows ranged from 0.28 cfs to 6.16 cfs throughout the growing season (**Figure 6-14**). **Figure 6-15** shows the percent reductions for TP loads measured in Nemote Creek from 2004-2011. Reductions needed to achieve the TMDL range from 7.4% to 57.6% with a median reduction of 10.6%.

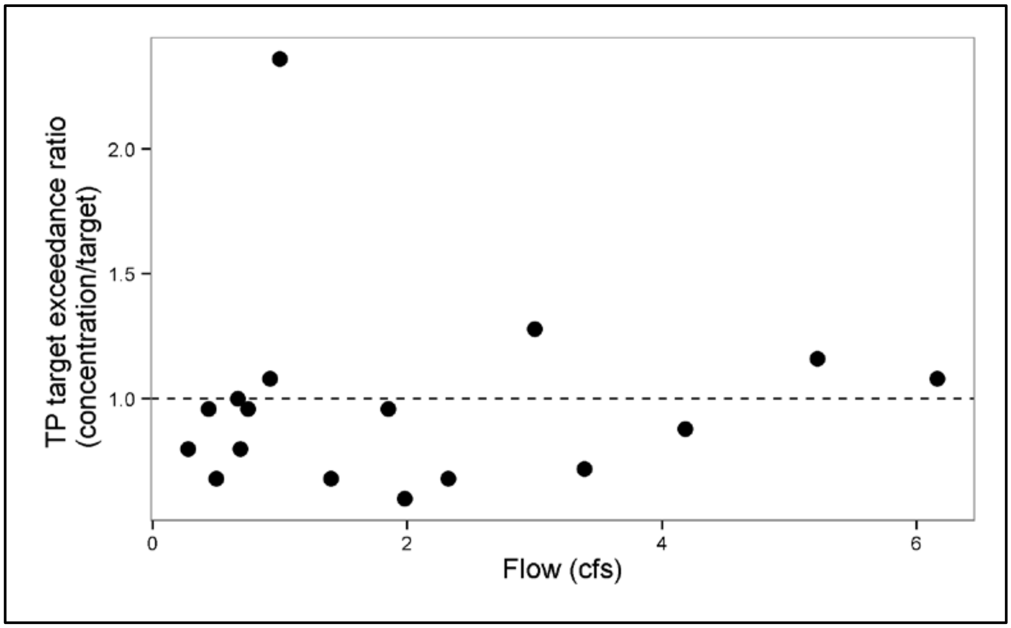

Figure 6-14. TP target exceedance ratio in Nemote Creek (2004-2011).

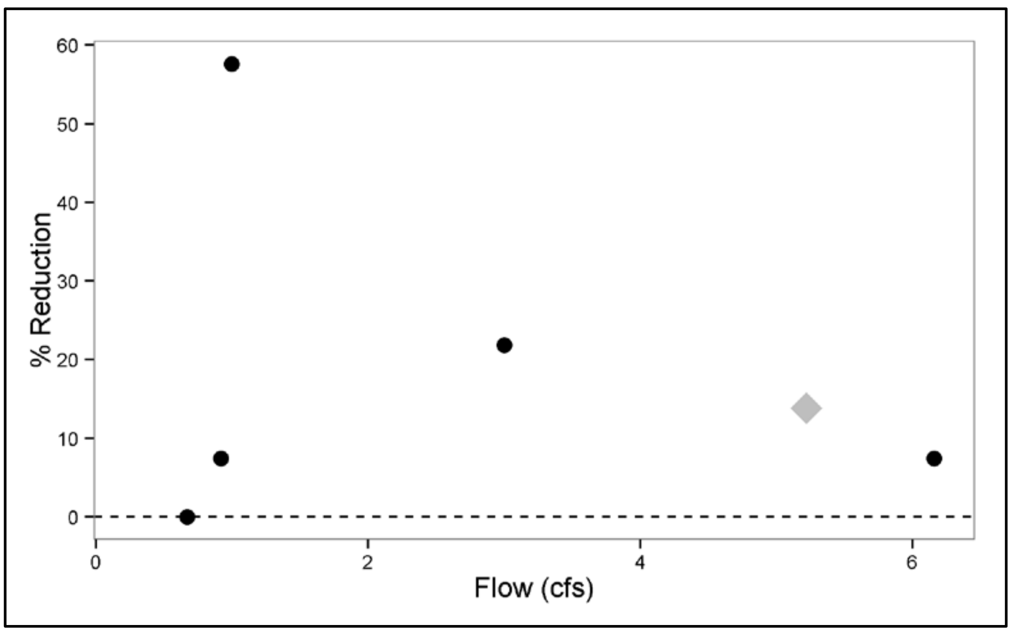

Figure 6-15. Measured TP percent load reductions necessary to achieve the TP TMDL in Nemote Creek (2004-2011). The gray diamond represents a median percent reduction value used to calculate existing load and percent reductions in the example TMDL for Nemote Creek.

6.6.2.2 Assessment of Loading by Source Categories

The upper half of the Nemote Creek sub-watershed is forested with shrubland interspersed, and the valley is fairly narrow and steep. The lower half of the watershed, from near the South Fork Nemote Creek confluence to the mouth, includes ranches and hayfields, and the valley widens. The last quarter-mile of the stream channel is in a steep and narrow canyon prior to entering the Clark Fork River.

Nemote Creek appears on the Montana Department of Fish, Wildlife and Parks dewatered streams list as being chronically dewatered between Sheridan Creek and Miller Creek, and as being periodically dewatered between Miller Creek and the mouth. This list identifies streams that support or contribute to important fisheries that are significantly dewatered, referring to a reduction in streamflow below the point where stream habitat is adequate for fish. Chronically dewatered streams describe where dewatering is a significant problem in virtually all years whereas periodically dewatered streams describe where dewatering is a significant problem only in drought or water-short years.

Two forest fires have burned in the Nemote Creek sub-watershed since 2001. The 2001 Mullan Gulch fire was quite small (approximately 15 acres) and was located in the Miller Creek drainage. The 2005 Tarkio fire was a large fire (approximately 9,477 acres), of which approximately half or one-third of the total burn area was within the Nemote Creek drainage. This fire burned throughout most of the South Fork Nemote Creek drainage.

Agriculture
Agriculture is a primary land use in the Nemote Creek sub-watershed, particularly in the lower half of the stream, with crop production far more prevalent than livestock production. The Nemote Creek sub-watershed contains 3,175 acres (51%) of the Miller-Micayune grazing allotment number 00094. Nearly the entire area of this grazing allotment is public (USFS administered) land. However, according to USFS records, this grazing allotment is vacant with zero permitted AUMs, and the DEQ assessment record for Nemote Creek states that the allotment has been inactive since the 1970s. Several dryland parcels are used for pasture/hay production, particularly downstream along the lower reaches of the stream channel. DEQ's assessment record notes several cattle crossings and trampled banks, which suggest livestock grazing occurs throughout some of the private land in the lower reaches.

Cultivated cropland is also common throughout the lower reaches on private land in the sub-watershed. A majority of the irrigated cropland is situated around the South Fork Nemote Creek confluence. The DEQ assessment record for Nemote Creek describes the stream as having frequent dry sections with subterranean flow, with adequate flow in the upper section but frequently dry throughout the lower reaches. The assessment record also includes local landowners' comments about recent and historic dredging that have altered the hydrologic properties of the stream, allowing water to go subsurface, and several points of diversion on the stream, some of which are substantial (e.g., > 4 cfs). Unirrigated crop production is also common in the vicinity of the Miller Creek confluence. For both TN and TP, several of the highest concentrations of nutrients were experienced around Miller Creek, suggesting agriculture (both crop and livestock production) may be a relatively significant source contributing to the existing Nemote Creek TN and TP loads.

Silviculture
Analysis of aerial imagery and geospatial land cover data indicates silviculture activities are relatively common in parts of the Nemote Creek sub-watershed, and these activities typically occur on public land in the upper half of the watershed. There are several small scattered parcels where timber harvest occurred in the upper 2.5 miles of the stream. Here, there is also a network of logging roads in relatively close proximity to the stream. Runoff from the timber harvest activities and/or sedimentation from road influence may help to explain the elevated phosphorus concentrations exhibited in the dataset for the uppermost monitoring site. The most substantial area of timber harvest is found north of the segment and approximately mid-segment before the creek reaches the wider valley, between the Alice Creek and South Fork Nemote Creek confluences. Water quality data collected in these reaches of the stream do

not indicate a discernible impact on nutrient water quality from these activities. Silviculture activities may be a minor contributor to nutrient loads in Nemote Creek.

Mining

According to DEQ records, there is 1 abandoned mine in the Nemote Creek sub-watershed, the Highbar Placer gold mine. This mine is located above the mouth northeast of the frontage road near the Interstate-90 crossing, and it does not appear on DEQ's Priority Mine Sites List (Pioneer Technical Services, Inc., 1995). The site is having no discernible impacts on nutrient water quality based on water quality at the 2 downstream water quality monitoring sites.

Subsurface wastewater disposal and treatment

According to DEQ records, there are 9 individual septic systems in the Nemote Creek sub-watershed. All potential septic influence is located below the Alice Creek confluence. There is 1 septic system below the Alice Creek confluence and another below the Sheridan Creek confluence, although both are outside the main floodway. The other septic systems along the mainstem are all below the Round Mountain Road crossing. One of these, below the South Fork confluence, appears to be within 100 feet of the channel, and all others are more than 500 feet from the channel. Two individual septics are found in the lower reaches of Miller Creek and appear to be in close proximity (approximately 50 feet) of the stream channel. Septic effluent is considered a minor contributor to the existing Nemote Creek TN and TP daily loads based on instream water quality results.

6.6.2.3 TN TMDL, Allocations, and Current Loading

The TMDL for TN is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the TN TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TN TMDL for Nemote Creek uses **Equation 1** with the flow associated with the median concentration of measured TN values that exceed the target reduction from all sites during 2007-2011 sampling (5.22 cfs, as represented by the gray diamond in Figure 6-12):

TMDL = (0.275 mg/L) (5.22 cfs) (5.4) = 7.75 lbs/day

Equation 4 is the basis for the natural background load allocation for TN. To continue with the example at a flow of 5.22 cfs, this allocation is as follows:

LA_{NB} = (0.041 mg/L) (5.22 cfs) (5.4) = 1.16 lbs/day

Using **Equation 5**, the combined human-caused TN allocation at 5.22 cfs can be calculated:

LA_{H} = 7.75 lbs/day – 1.16 lbs/day = 6.59 lbs/day

An example total existing load is calculated as follows using **Equation 6**, the example flow of 5.22 cfs, and the corresponding concentration associated with the median reduction for measured loads that exceed the TMDL for TN in Nemote Creek from 2007-2011 (0.540 mg/L):

Total Existing Load = (0.540 mg/L) (5.22 cfs) (5.4) = 15.22 lbs/day

The portion of the existing load attributed to human sources is 14.06 lbs/day, which is determined by subtracting out the 1.16 lbs/day natural background load. This 14.07 lbs/day represents the load measured within the stream after potential nutrient uptake.

Table 6-25 summarizes the example TN TMDL, load allocations, and current loading. **Table 6-25** also contains the percent reduction to human-caused load allocation required to meet the water quality target for TN. The percent reduction to natural background is 0%. At the median concentration of measured TN values that exceed the target (0.540 mg/L) and the growing season flow associated with this median concentration (5.22 cfs), the existing loading in Nemote Creek is greater than the TMDL. Under these example conditions a 53.1% reduction of human-caused sources and an overall 49.1% reduction of TN in Nemote Creek would result in the TMDL being met. The source assessment of the Nemote Creek watershed indicates that grazing in the riparian zone and crop production are the most likely sources of TN in Nemote Creek; load reductions should focus on limiting and controlling TN loading from these sources. Meeting load allocations for Nemote Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 7.0**.

This TMDL along with the TMDL for TP serves to address the chlorophyll-*a* impairment for Nemote Creek. By reducing nutrient loads in Nemote Creek, it is expected that the potential for excess algae growth and thus chlorophyll-*a* levels will be reduced. By controlling the input of nutrient sources, it is expected that overall nutrient and thus algae levels will be reduced.

Table 6-25. Nemote Creek TN Example TMDL, Load Allocations, Current Loading, and Reductions

Source Category	Allocation & TMDL (lbs/day)[1]	Existing Load (lbs/day)[1]	Percent Reduction
Natural Background	1.16	1.16	0%
Human-caused (primarily agriculture and silviculture)	6.60	14.06	53.1%
	TMDL = 7.76	**Total = 15.22**	**Total = 49.1%**

[1] Based on a growing season flow of 5.22 cfs.

6.6.2.4 TP TMDL, Allocations, and Current Loading

The TMDL for TP is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the TP TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TP TMDL for Nemote Creek uses **Equation 1** with the flow associated with the median concentration of measured TP values that exceed the target reduction from all sites during 2004-2011 sampling (5.22 cfs , as represented by the gray diamond in Figure 6-15):

TMDL = (0.025 mg/L) (5.22 cfs) (5.4) = 0.70 lbs/day

Equation 4 is the basis for the natural background load allocation for TP. To continue with the example at a flow of 5.22 cfs, this allocation is as follows:

LA_{NB} = (0.006 mg/L) (5.22 cfs) (5.4) = 0.17 lbs/day

Using **Equation 5**, the combined human-caused TP allocation at 5.22 cfs can be calculated:

LA_H = 0.70 lbs/day – 0.17 lbs/day = 0.53 lbs/day

An example total existing load is calculated as follows using **Equation 6**, the example flow of 5.22 cfs and the corresponding concentration associated with the median reduction for measured loads that exceed the TMDL for TP in Nemote Creek from 2004-2011 (0.029 mg/L):

Total Existing Load = (0.029 mg/L) (5.22 cfs) (5.4) = 0.82 lbs/day

The portion of the existing load attributed to human sources is 0.65 lbs/day, which is determined by subtracting out the 0.17 lbs/day natural background load. This 0.65 lbs/day represents the load measured within the stream after potential nutrient uptake.

Table 6-26 summarizes the example TP TMDL, load allocations, and current loading. **Table 6-26** also contains the percent reduction to human-caused load allocation required to meet the water quality target for TP. The percent reduction to natural background is 0%. At the median concentration of measured TP values that exceed the target (0.029 mg/L) and the growing season flow associated with this median concentration (5.22 cfs), the existing loading in Nemote Creek is greater than the TMDL. Under these example conditions a 17.4% reduction of human-caused sources and an overall 13.8% reduction of TP in Nemote Creek would result in the TMDL being met. The source assessment of the Nemote Creek watershed indicates that grazing in the riparian zone, crop production and sedimentation from silviculture activities and forest roads is the most likely source of TP in Nemote Creek; load reductions should focus on limiting and controlling TP loading from these sources. Meeting load allocations for Nemote Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 7.0**.

Table 6-26. Nemote Creek TP Example TMDL, Load Allocations, Current Loading, and Reductions

Source Category	Allocation & TMDL (lbs/day)[1]	Existing Load (lbs/day)[1]	Percent Reduction
Natural Background	0.17	0.17	0%
Human-caused (primarily agriculture and silviculture)	0.53	0.65	17.4%
	TMDL = 0.70	**Total = 0.82**	**Total = 13.8%**

[1] Based on a growing season flow of 5.22 cfs.

6.6.3 West Fork Petty Creek

6.6.3.1 Assessment of Water Quality Results

The source assessment for West Fork Petty Creek consists of an evaluation of TP concentrations. This is followed by a description of the most significant human caused sources of nutrients. **Figure 6-16** presents the approximate locations of data pertinent to the source assessment in the sub-watershed.

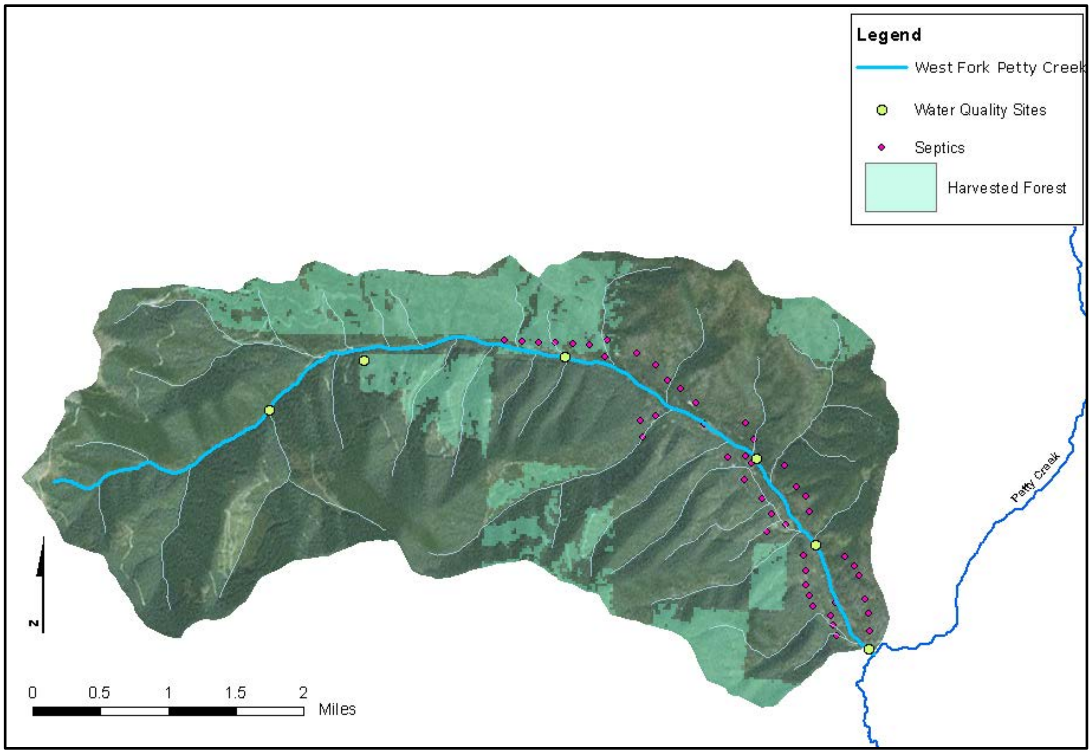

Figure 6-16. West Fork Petty Creek sub-watershed with water quality sampling locations.

DEQ collected water quality samples from West Fork Petty Creek during the growing season over the time period 2004-2012 (**Section 6.4.3.3**, **Table 6-8**). Six monitoring site locations were established during the sampling period. **Figure 6-17** presents summary statistics for TP concentrations at sampling sites in West Fork Petty Creek.

Sixteen TP samples were collected at 6 sites and TP concentrations were in excess of the TP target concentration of 0.025 mg/L in every sample collected. The recent dataset for benthic algae did not indicate excess algal growth, although sampling timing may have missed the periods of peak growth. Nutrient concentrations, in excess of the target, present conditions that may lead to excess algal growth and support the continued chlorophyll-*a* impairment listing. Periphyton samples were collected in 2004, 2007, and 2011 and 3 of 6 probabilities of impairment were above the threshold, suggesting nutrient impairment. Macroinvertebrate samples were collected in 2004 and 2011 and HBI scores from all 5 sites were below the threshold.

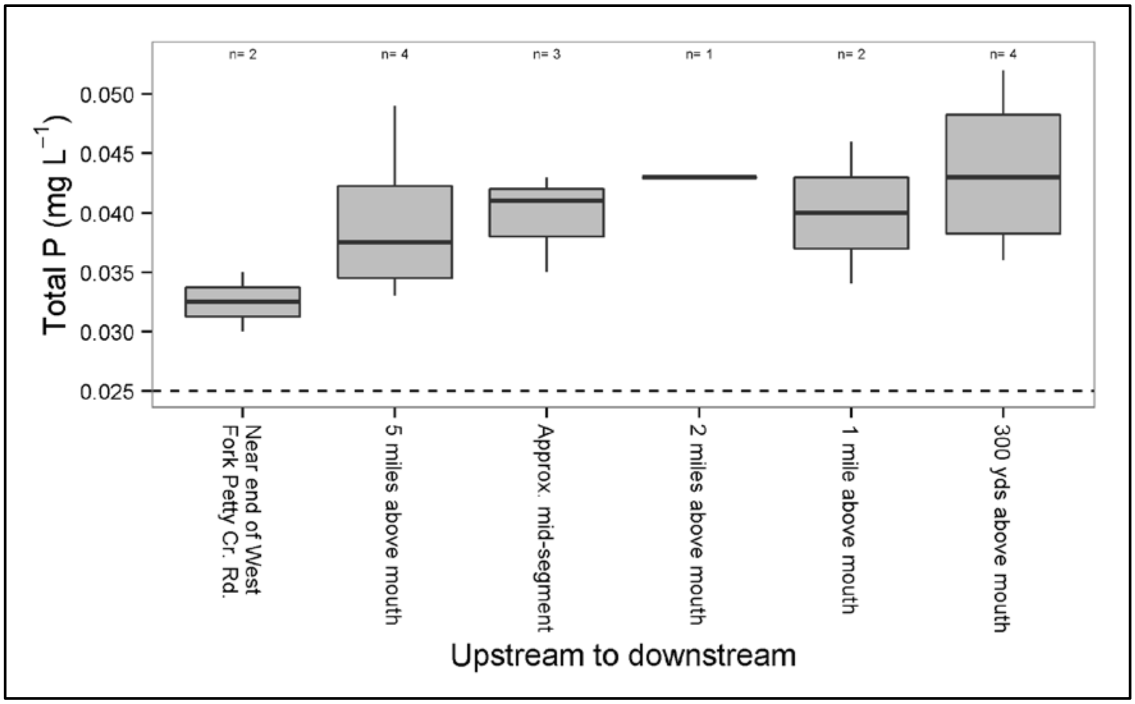

Figure 6-17. TP boxplots for West Fork Petty Creek.

In general, there is an increase in TP concentrations when moving in the downstream direction. The uppermost site near the western end of West Fork Petty Creek Road exhibited the lowest TP concentrations, although TP concentrations were relatively similar at all sites. At all sites, TP concentrations were, on average, 1.6 times greater than the target and ranged from 1.2 to 2.08 times greater than the TP target concentration.

Target exceedance ratios were plotted for all West Fork Petty Creek samples and only nutrient concentrations for which an associated flow value was collected are depicted in these figures. Ratios less than 1.0 indicate sample concentrations below the TP target. Flows ranged from 0.75 cfs to 4.64 cfs throughout the growing season (**Figure 6-18**). **Figure 6-19** shows the percent reductions for TP loads measured in West Fork Petty Creek from 2004-2012. Reductions needed to achieve the TMDL range from 16.7% to 51.9% with a median reduction of 35.9%.

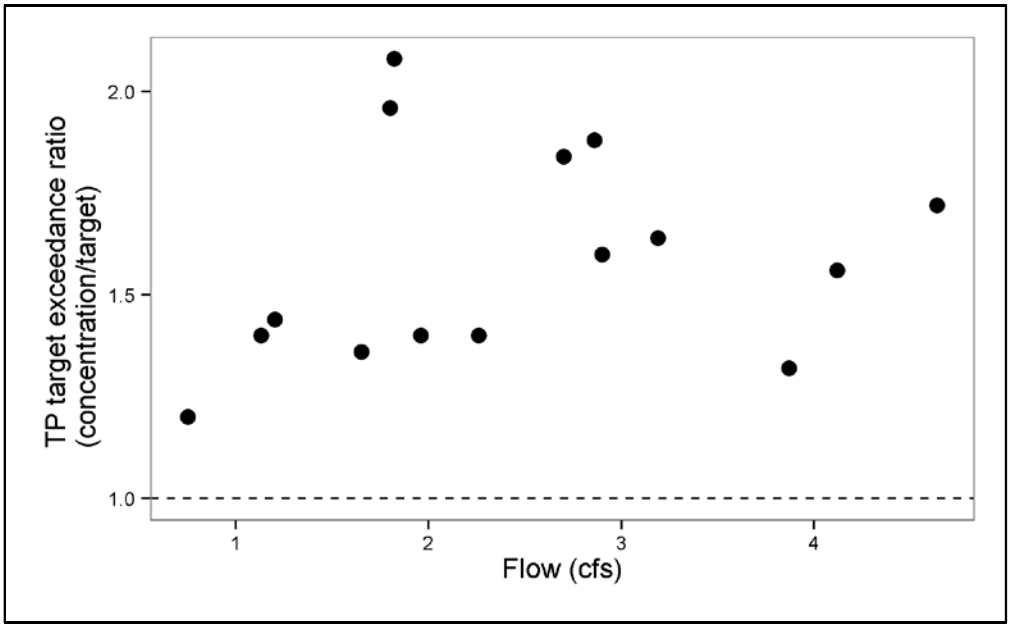

Figure 6-18. TP target exceedance ratio in West Fork Petty Creek (2004-2012).

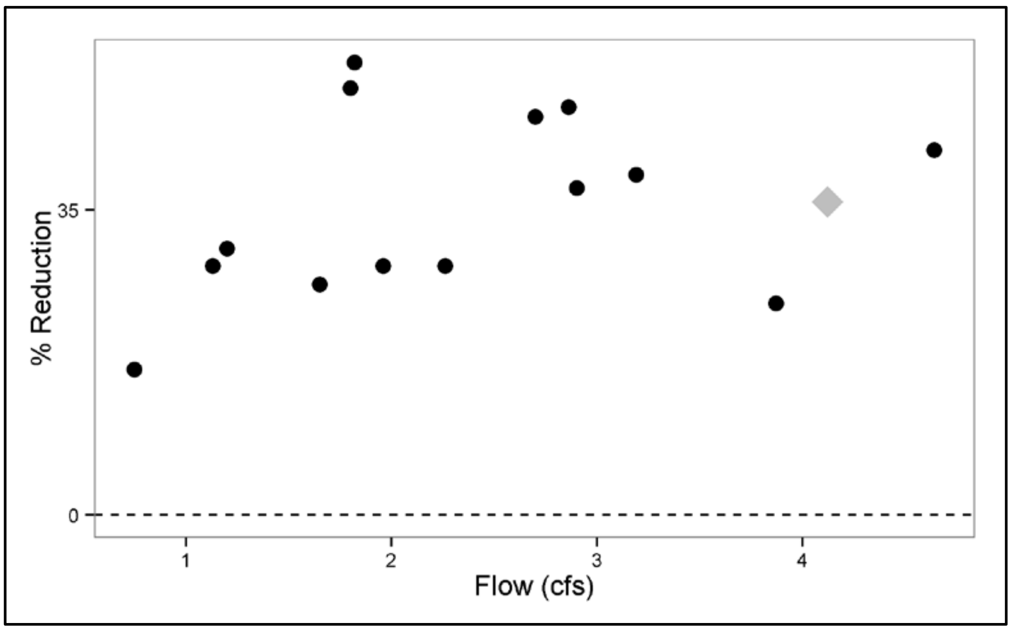

Figure 6-19. Measured TP percent load reductions necessary to achieve the TP TMDL in West Fork Petty Creek (2004-2012). The gray diamond represents a median percent reduction value used to calculate existing load and percent reductions in the example TMDL for West Fork Petty Creek.

6.6.3.2 Assessment of Loading by Source Categories

The upper reaches of West Fork Petty Creek flow through relatively undisturbed forest. The lower reaches appear similar to the upper, although moving in the downstream direction toward the mouth there are an increasing number of private residences.

West Fork Petty Creek does not appear on the Montana Department of Fish, Wildlife and Parks dewatered streams list. This list identifies streams that support or contribute to important fisheries that are significantly dewatered, referring to a reduction in streamflow below the point where stream habitat is adequate for fish. In 2003, approximately one-quarter of the total Thompson Creek fire (33,653 acres) area burned in the West Fork Petty Creek sub-watershed. The western third of the West Fork Petty drainage was within the burn area, with the headwaters and several tributaries affected.

Agriculture
The West Fork Petty Creek sub-watershed is 9,373 acres, of which 8,137 acres (87%) is public land. However, there are no grazing allotments contained within the drainage. Based on field observations and land cover data, livestock grazing is limited to small scattered parcels of pasture in the lower reaches on private land. Minimal, if any, cropland exists. Agriculture is thought to be a minor contributor to existing nutrient loads to West Fork Petty Creek.

Silviculture
Silviculture activities are a primary land use in the West Fork Petty creek sub-watershed. An analysis of aerial imagery and geospatial land cover data reveals that timber harvest is extensive in the drainage, particularly to the north and south of the middle third of the stream segment. The West Fork Petty Creek drainage was part of the Montana Legacy Project where private timberlands were purchased by The Nature Conservancy and transferred to the USFS. In the West Fork Petty Creek sub-watershed, TNC lands were transferred to the Lolo National Forest in March 2010. The land transfer included approximately 9,400 acres or 36% of the West Fork Petty Creek sub-watershed. Included in this transfer was approximately 1 mile of stream frontage in the upper drainage.

The DEQ assessment record indicates that aerial photographs show fairly extensive clear-cuts around the stream. Aerial images also show a multitude of logging roads in the drainage. These images also indicate that a substantial riparian buffer (greater than 100 feet) was retained. Runoff from timber harvest activities and sedimentation from logging roads in close proximity to the stream channel are likely contributing phosphorus to the segment and may help explain the increase in phosphorus concentrations moving in the downstream direction.

Mining
According to DEQ records, there are no abandoned or active mines in the West Fork Petty Creek drainage and mining is not considered a source of nutrients in the drainage.

Subsurface wastewater disposal and treatment
According to DEQ records, there are 48 individual septic systems in the West Fork Petty Creek sub-watershed. These septic systems are all within approximately 1,500 feet of the stream channel and are scattered along the entire lower half of the stream channel on both sides (i.e., north and south). Several of these appear to be within several hundred feet of the stream channel. Given the number, proximity and relatively high density of individual septic systems in the lower West Fork Petty Creek sub-watershed, septic effluent may be contributing to the increasing nutrient concentrations and is considered a moderate to significant contributor to the existing West Fork Petty Creek TP daily loads.

6.6.3.3 TP TMDL, Allocations, and Current Loading
The TMDL for TP is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the TP TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TP TMDL for West Fork Petty Creek uses **Equation 1** with the flow associated with the

median concentration of measured TP values that exceed the target reduction from all sites during 2004-2012 sampling (4.12 cfs, as represented by the gray diamond in Figure 6-19):

TMDL = (0.025 mg/L) (4.12 cfs) (5.4) = 0.56 lbs/day

Equation 4 is the basis for the natural background load allocation for TP. To continue with the example at a flow of 4.12 cfs, this allocation is as follows:

LA_{NB} = (0.006 mg/L) (4.12 cfs) (5.4) = 0.13 lbs/day

Using **Equation 5**, the combined human-caused TP allocation at 4.12 cfs can be calculated:

LA_{H} = 0.56 lbs/day – 0.13 lbs/day = 0.43 lbs/day

An example total existing load is calculated as follows using **Equation 6**, the example flow of 4.12 cfs and the corresponding concentration associated with the median reduction for measured loads that exceed the TMDL for TP in West Fork Petty Creek from 2004-2012 (0.039 mg/L):

Total Existing Load = (0.039 mg/L) (4.12 cfs) (5.4) = 0.87 lbs/day

The portion of the existing load attributed to human sources is 0.74 lbs/day, which is determined by subtracting out the 0.13 lbs/day natural background load. This 0.74 lbs/day represents the load measured within the stream after potential nutrient uptake.

Table 6-27 summarizes the example TP TMDL, load allocations, and current loading. **Table 6-27** also contains the percent reduction to human-caused load allocation required to meet the water quality target for TP. The percent reduction to natural background is 0%. At the median concentration of measured TP values that exceed the target (0.039 mg/L) and the growing season flow associated with this median concentration (4.12 cfs), the existing loading in West Fork Petty Creek is greater than the TMDL. Under these example conditions, a 42.4% reduction of human-caused sources and an overall 35.9% reduction of TP in West Fork Petty Creek would result in the TMDL being met. The source assessment of the West Fork Petty Creek watershed indicates that sedimentation from silviculture activities and subsurface wastewater disposal and treatment are the most likely sources of TP in West Fork Petty Creek; load reductions should focus on limiting and controlling TP loading from these sources. Meeting load allocations for West Fork Petty Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 7.0**.

This TMDL serves to address the chlorophyll-*a* impairment for West Fork Petty Creek. By reducing nutrient loads in West Fork Petty Creek, it is expected that the potential for excess algae growth and thus chlorophyll-*a* levels will be reduced. By controlling the input of nutrient sources, it is expected that overall nutrient and thus algae levels will be reduced.

Table 6-27. West Fork Petty Creek TP Example TMDL, Load Allocations, Current Loading, and Reductions

Source Category	Allocation & TMDL (lbs/day)[1]	Existing Load (lbs/day)[1]	Percent Reduction
Natural Background	0.13	0.13	0%

Human-caused (primarily silviculture and subsurface wastewater disposal)	0.43	0.74	42.4%
	TMDL = 0.56	**Total = 0.87**	**Total = 35.9%**

[1] Based on a growing season flow of 4.12 cfs.

6.6.4 Stony Creek

6.6.4.1 Assessment of Water Quality Results

The source assessment for Stony Creek consists of an evaluation of TP concentrations. This is followed by a description of the most significant human caused sources of nutrients. **Figure 6-20** presents the approximate locations of data pertinent to the source assessment in the sub-watershed.

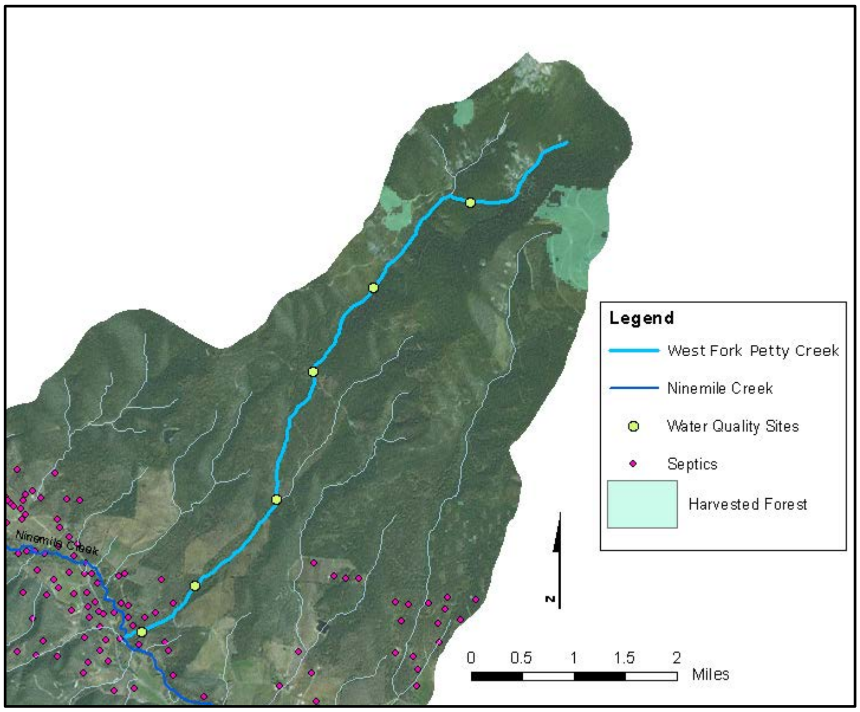

Figure 6-20. Stony Creek sub-watershed with water quality sampling locations.

DEQ collected water quality samples from Stony Creek during the growing season over the time period 2003-2012 (**Section 6.4.3.4**, **Table 6-10**). Six monitoring site locations were established during the sampling period. **Figure 6-21** presents summary statistics for TP concentrations at sampling sites in Stony Creek.

Fifteen TP samples were collected at 6 sites and TP concentrations were in excess of the TP target concentration of 0.025 mg/L in 2 of 15 samples. The recent dataset for benthic algae did not indicate excess algal growth, although sampling timing may have missed the periods of peak growth. Periphyton samples were collected in 2003 and 2011 and 3 of 4 samples had probabilities of impairment above the threshold, suggesting nutrient impairment. Macroinvertebrate samples were collected in 2003 and 2011 and HBI scores from all 4 sites were below the threshold.

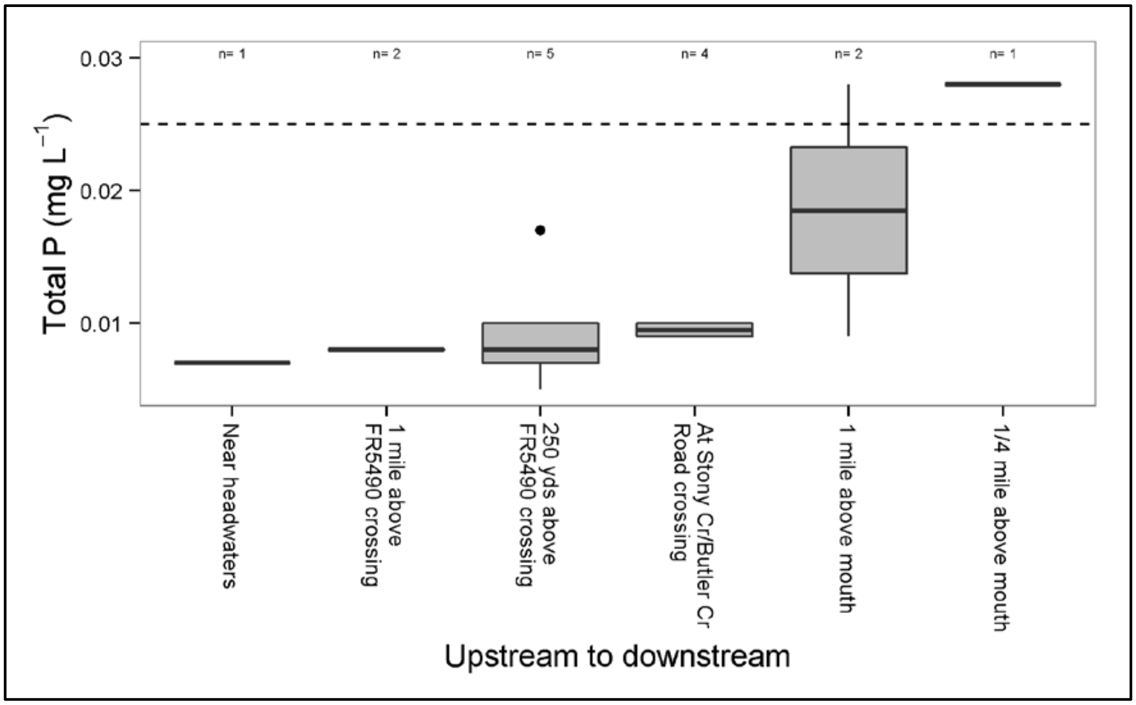

Figure 6-21. TP boxplots for Stony Creek.

In general, there is an increase in TP concentrations when moving in the downstream direction. At the upper 4 sites, from the headwaters to the Stony Creek/Butler Creek Road crossing, all TP concentrations are below the TP target. Concentrations at these 4 sites were, on average, less than half the target concentration of 0.025 mg/L. The site situated 1 mile above the mouth of Stony Creek and the site just above the mouth each had 1 TP concentration that is 1.12 times greater than the target. However, during these 2 sampling events no measureable flow was recorded at either site. Field observations indicate that the site 1 mile above the mouth exhibited no measurable flow and was comprised of standing pools, and the site near the mouth was nearly dry and flow was not recorded. This suggests that only when no or very low flow conditions occur are TP concentrations indicating nutrient impairment.

Target exceedance ratios were plotted for all Stony Creek samples and only nutrient concentrations for which an associated flow value was collected are depicted in these figures. Ratios less than 1.0 indicate sample concentrations below the TP target. Flows ranged from 0 cfs to 8 cfs throughout the growing season (**Figure 6-22**).

To accommodate the calculation of an example loading and reduction scenario during very low flow conditions when elevated nutrient concentrations are most likely to occur, a flow value of 0.25 cfs was substituted where zero flows were observed during the 2 sampling events when exceedances occurred. The flow value 0.25 cfs was chosen as it is believed to represent a reasonable low flow scenario in Stony Creek because: 1) it is a lower value than any other flow measurement recorded during these synoptic sampling events, 2) it produces a TP load close to the 25th percentile of the loads calculated for the entire dataset, and 3) it is a value that has been measured at stream sites that resemble the channel geometry and flow conditions at these lower Stony Creek sites. It is worth noting that percent reduction is based on the ratio of the target concentration and the measured concentration and does not take flow into consideration, therefore choosing a different flow value would not change the percent reduction recommended in **Section 6.6.4.3**.

Figure 6-23 shows the percent reductions for TP loads measured in Stony Creek from 2003-2012. Since the TP concentration (0.028 mg/L) was the same for both samples that exceeded the target, the reduction needed to achieve the TMDL did not vary and is 10.7%.

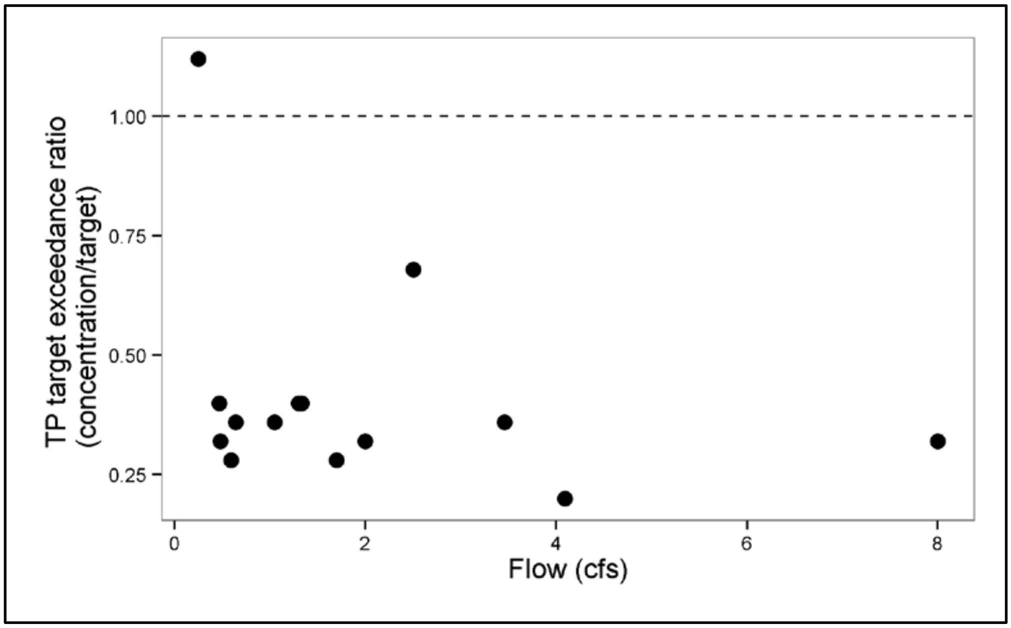

Figure 6-22. TP target exceedance ratio in Stony Creek (2003-2012).

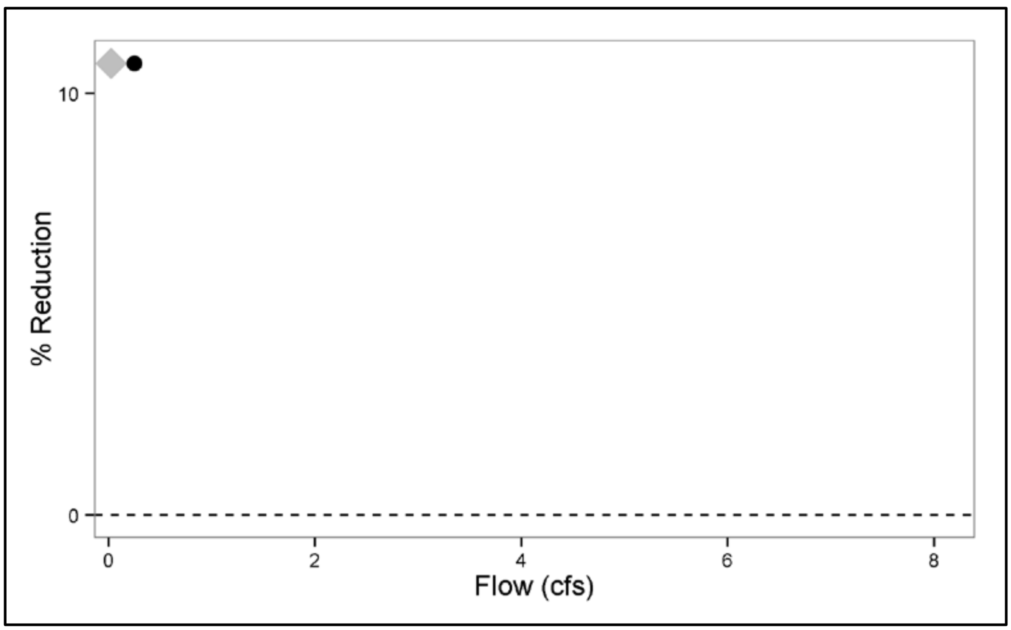

Figure 6-23. Measured TP percent load reductions necessary to achieve the TP TMDL in Stony Creek (2003-2012). The gray diamond represents a median percent reduction value used to calculate existing load and percent reductions in the example TMDL for Stony Creek.

6.6.4.2 Assessment of Loading by Source Categories

The upper reaches of Stony Creek flow through heavily forested land and, there is a gradual increase in the amount of agricultural and residential land use moving downstream to the lower reaches of the stream. Stony Creek does not appear on the Montana Department of Fish, Wildlife and Parks dewatered streams list. This list identifies streams that support or contribute to important fisheries that are significantly dewatered, referring to a reduction in streamflow below the point where stream habitat is adequate for fish.

There have not been any forest fires in the Stony Creek sub-watershed since 1994 when 2 small fires (each 18-19 acres) burned in the northwestern region of the drainage.

Agriculture
A primary land use and potentially significant nutrient source in the Stony Creek sub-watershed is agriculture, with livestock grazing and cropland likely to be contributing to elevated TP concentrations. A majority of the western half of the drainage is encompassed by 2 grazing allotments on USFS administered land. The Ninemile Adm. Pasture allotment number 00136 is 5,439 acres, of which approximately 4,287 acre (79%) is within the Stony Creek sub-watershed. This entire grazing allotment is on public land and there are 38 permitted animal unit months (AUMs). The Josephine-Butler allotment number 00063 is 34,073, of which 2,104 acres (6%) is within the Stony Creek drainage. Of the total allotment area, 34,058 acres are within public land and there are 12 permitted animal unit months (AUMs).

The Stony Creek sub-watershed is approximately 11,700 acres and 9,439 acres (81%) is public land. These public lands are all within the 2 grazing allotment boundaries described above, which have 50 permitted AUMs at most. While it may be unlikely that all 50 permitted AUMs for the entire allotment areas will be grazed exclusively on public lands within the Stony Creek sub-watershed, this represents the maximum AUMs possible at any given time. No attempts were made to verify actual grazing practices or current stocking densities.

Land used for cultivated crops in the vicinity of the stream or tributaries is found in the lower 1.5 miles of the stream. The DEQ assessment record notes that there are 2 substantial irrigation diversions and geospatial land cover data reveals that a network of irrigation ditches exists near and in these croplands.

Silviculture
Silviculture activities are present in the Stony Creek sub-watershed, although timber harvest is not widespread according to an analysis of aerial imagery and geospatial land cover data. There are several parcels of public land that have been harvested in the upper, northernmost extent of the sub-watershed area. Aerial images and assessment record comments suggest these areas have been clear-cut. Aerial images also show a multitude of logging roads in the drainage. Runoff from timber harvest activities and sedimentation from logging roads in close proximity to the stream channel are likely contributing phosphorus to the segment and may help explain the increase in phosphorus concentrations moving in the downstream direction.

Mining
According to DEQ records, there are no abandoned or active mines in the Stony Creek drainage and mining is not considered a source of nutrients in the drainage.

Subsurface wastewater disposal and treatment
According to DEQ records, there are approximately 30 individual septic systems in the Stony Creek sub-watershed. A majority of these are located along Nine Mile Road and White Tail Ridge Road, 1 to 2 miles from the stream channel with no apparent proximity to the mainstem or any tributaries. About 5

of the septic systems are within 1,000 feet of the channel, which are all located around and just above the lowermost monitoring site C04STNYC03; this coincides with the areas where phosphorus concentrations were becoming elevated. Septic effluent is considered a minor contributor to existing Stony Creek TP daily loads.

6.6.4.3 TP TMDL, Allocations, and Current Loading

The TMDL for TP is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the TP TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. As described in **Section 6.6.4.1**, the following example TP TMDL for Stony Creek uses **Equation 1** with the flow value that represents a reasonable low flow scenario associated with the measured TP values that exceed the target reduction from all sites during 2003-2012 sampling (0.25 cfs, as represented by the gray diamond in Figure 6-23):

TMDL = (0.025 mg/L) (0.25 cfs) (5.4) = 0.034 lbs/day

Equation 4 is the basis for the natural background load allocation for TP. To continue with the example at a flow of 0.25 cfs, this allocation is as follows:

LA_{NB} = (0.006 mg/L) (0.25 cfs) (5.4) = 0.008 lbs/day

Using **Equation 5**, the combined human-caused TP allocation at 0.25 cfs can be calculated:

LA_{H} = 0.034 lbs/day – 0.008 lbs/day = 0.026 lbs/day

An example total existing load is calculated as follows using **Equation 6**, the reasonable low flow value of 0.25 cfs and the concentration associated with the measured loads that exceed the TMDL for TP in Stony Creek from 2003-2012 (0.028 mg/L):

Total Existing Load = (0.028 mg/L) (0.25 cfs) (5.4) = 0.038 lbs/day

The portion of the existing load attributed to human sources is 0.030 lbs/day, which is determined by subtracting out the 0.008 lbs/day natural background load. This 0.030 lbs/day represents the load measured within the stream after potential nutrient uptake.

Table 6-28 summarizes the example TP TMDL, load allocations, and current loading. **Table 6-28** also contains the percent reduction to human-caused load allocation required to meet the water quality target for TP. The percent reduction to natural background is 0%. At the concentration of measured TP values that exceed the target (0.028 mg/L) and the growing season low flow condition reasonably associated with this concentration (0.25 cfs), the existing loading in Stony Creek is greater than the TMDL. Under these example conditions a 13.6% reduction of human-caused sources and an overall 10.7% reduction of TP in Stony Creek would result in the TMDL being met. The source assessment of the Stony Creek watershed indicates that sedimentation from silviculture activities and forest roads, livestock grazing and crop production are the most likely sources of TP in Stony Creek; load reductions should focus on limiting and controlling TP loading from these sources. Meeting load allocations for Stony Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 7.0**.

Table 6-28. Stony Creek TP Example TMDL, Load Allocations, Current Loading, and Reductions

Source Category	Allocation & TMDL (lbs/day)[1]	Existing Load (lbs/day)[1]	Percent Reduction
Natural Background	0.008	0.008	0%
Human-caused (primarily silviculture, agriculture and subsurface wastewater disposal)	0.026	0.030	13.6%
	TMDL = 0.034	**Total = 0.038**	**Total = 10.7%**

[1] Based on a growing season flow of 0.25 cfs.

6.6.5 Grant Creek

6.6.5.1 Assessment of Water Quality Results

The source assessment for Grant Creek consists of an evaluation of TN concentrations. This is followed by a description of the most significant human caused sources of nutrients. **Figure 6-24** presents the approximate locations of data collection pertinent to the source assessment in the sub-watershed.

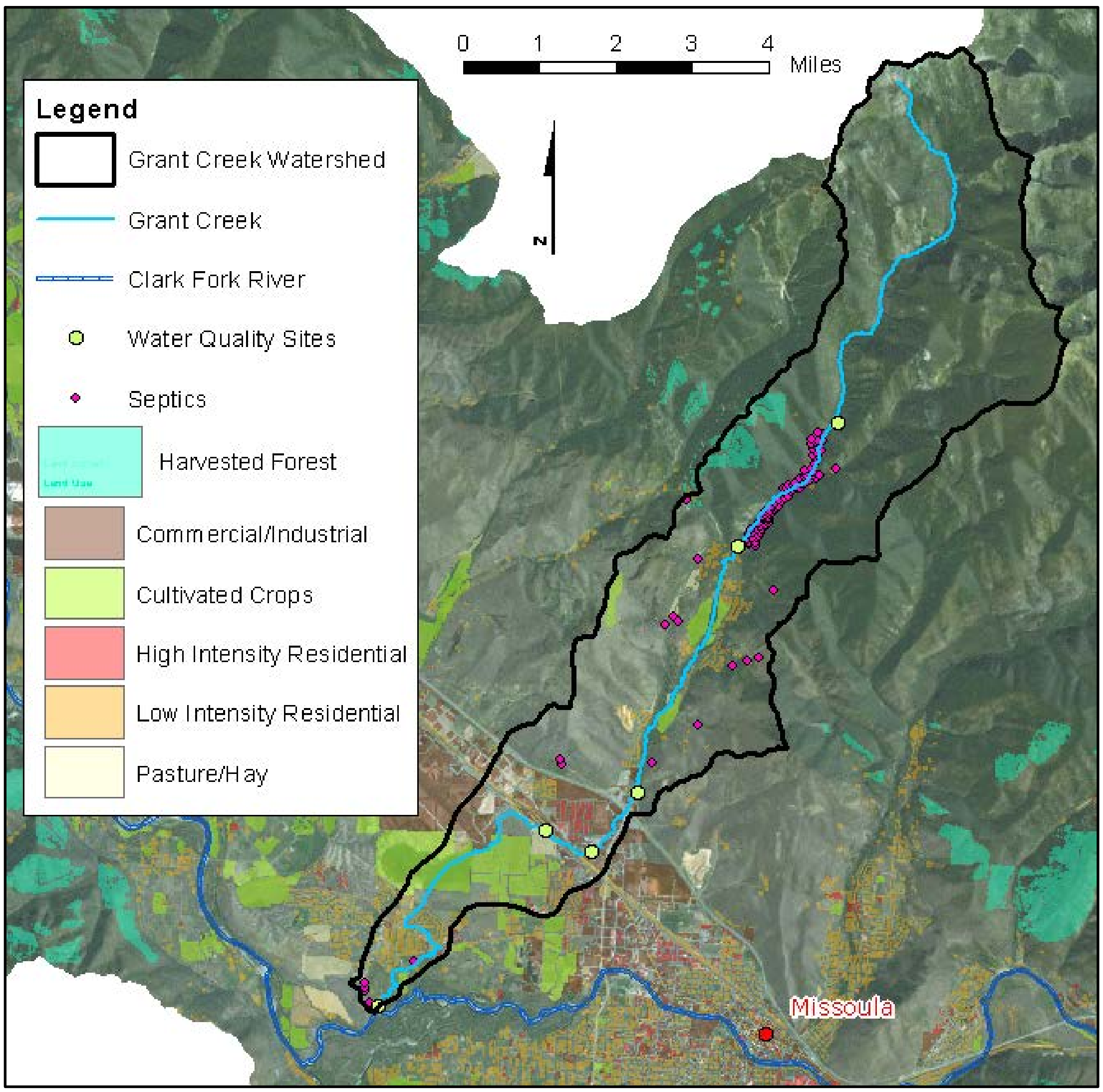

Figure 6-24. Grant Creek sub-watershed with water quality sampling locations.

DEQ collected water quality samples from Grant Creek during the growing season over the time period 2004-2011, and TN samples were collected from 2009-2011 (**Section 6.4.3.5**, **Table 6-12**). Six monitoring locations were established during the sampling period and TN samples were collected at 5 of these sites. **Figure 6-25** presents summary statistics for TN concentrations at sampling sites in Grant Creek.

A total of 20 TN samples were collected at 5 sites and TN concentrations were in excess of the TN target concentration of 0.30 mg/L in 9 samples collected. In general, there is an increase in TN concentrations in the downstream direction. Samples collected in the lower reach of Grant Creek, downstream from the Interstate-90 crossing, are more indicative of nitrogen impairment than those collected in the upper reach upstream from the Interstate. The recent dataset for benthic algae did not indicate excess algal growth, although sampling timing may have missed the periods of peak growth. Nutrient concentrations, in excess of the target, present conditions that may lead to excess algal growth and supports the Excess Algal Growth impairment listing. Macroinvertebrate samples were collected in 2004 and 2011 and HBI scores from 3 sites exceeded the threshold.

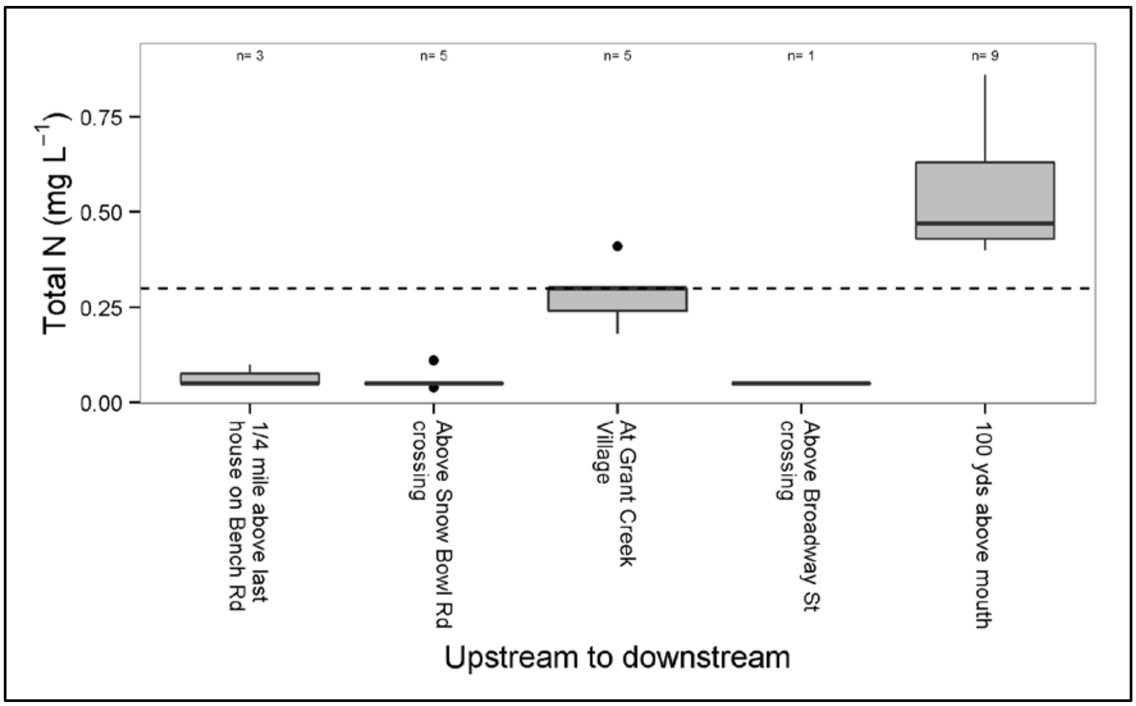

Figure 6-25. TN boxplots for Grant Creek.

The uppermost 2 sites, both above the Snowbowl Road crossing, had TN concentrations below the target concentration of 0.30 mg/L. Four of 5 TN samples at the Grant Creek Village site, above the Interstate-90 crossing, were below the target concentration, although 1 sample was 1.4 times greater than the target. The site above the Broadway Street crossing had TN concentrations below the target. The lowermost site, 100 yards above the mouth, had the highest TN concentrations at, on average, 1.87 times greater than the target concentration of 0.30 mg/L. Target exceedance ratios were plotted for all Grant Creek samples and only TN concentrations for which an associated flow value was collected are depicted in these figures. Ratios less than 1.0 indicate sample concentrations below the TN target. Flows ranged from 2.53 cfs to 19.58 cfs (**Figure 6-26**). **Figure 6-27** shows the percent reductions for TN loads measured in Grant Creek from 2009 to 2011. Reductions needed to achieve the TMDL range from 26.83% to 65.12% with a median reduction of 45.45%.

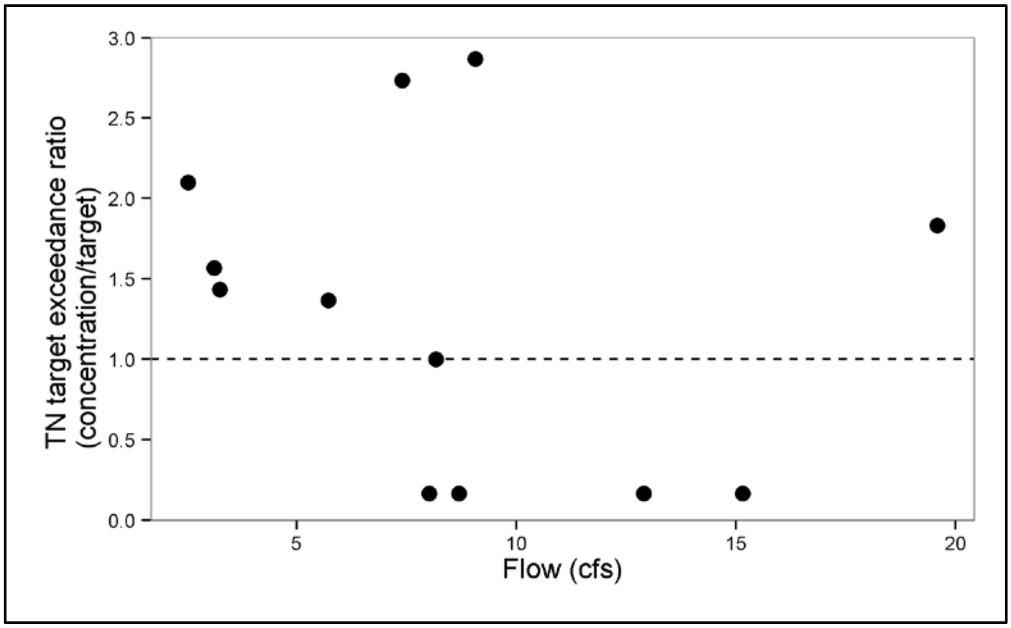

Figure 6-26. TN target exceedance ratio in Grant Creek (2009-2011).

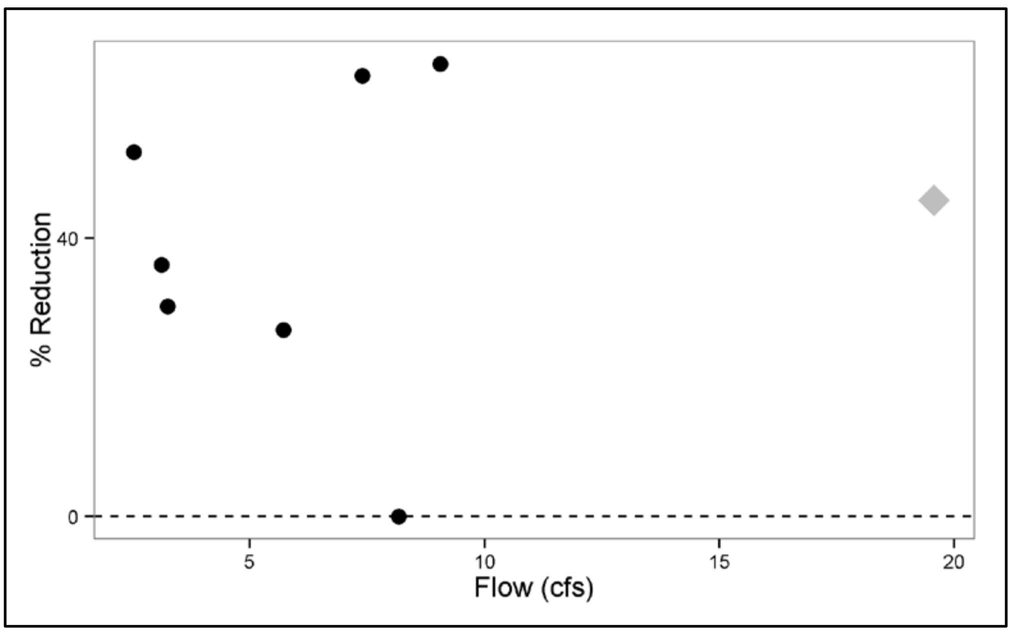

Figure 6-27. Measured TN percent load reductions necessary to achieve the TN TMDL in Grant Creek (2009-2011). The gray diamond represents a median percent reduction value used to calculate existing load and percent reductions in the example TMDL for Grant Creek.

6.6.5.2 Assessment of Loading by Source Categories

The upper third of the Grant Creek sub-watershed is on USFS administered land, while the lower two-thirds are privately owned except for a few State-, City- and County-administered parcels. Grant Creek flows through 4 fairly distinct land uses. From the headwaters through the upper reaches, the stream flows through largely roadless forest (USFS) with some rural residences, which then transitions into rural and suburban residential areas north of the Interstate-90 crossing. From here, high intensity urban commercial-industrial area leads toward the lower reaches where the land use is primarily agriculture mixed with subdivisions. This sub-watershed has the highest percentage of developed land cover of all nutrient impaired streams in the Central Clark Fork Basin Tributaries TMDL Project area and includes some area with high intensity industrial/commercial development.

Grant Creek appears on the Montana Department of Fish, Wildlife and Parks dewatered streams list as being chronically dewatered on the lowermost reaches from river mile 0.0 to 5.0. This list identifies streams that support or contribute to important fisheries that are significantly dewatered, referring to a reduction in streamflow below the point where stream habitat is adequate for fish. Chronically dewatered streams describe where dewatering is a significant problem in virtually all years. Since settlement of the Missoula Valley, Grant Creek has been significantly altered in the lower portions of the watershed to mitigate flood risk and improve fish habitat and passage. A thorough, detailed discussion of the historic changes made to the lower Grant Creek can be found in **Section 5.4.3.5**. The lower reaches of Grant Creek have been diverted since at least the 1950s and the riparian zone of the initial channel can be seen dissipating over time in aerial images. Grant Creek has been altered as an irrigation conduit downstream of International Drive since sometime before 1954 and likely only functions as a natural corridor downstream of Highway 263 (Mullan Road) where it enters the Clark Fork River floodplain (100-year recurrence interval). Through the later part of the 20th century and into the 21st century, the areal extent of irrigated acres in the Grant Creek watershed has steadily declined with increases in residential and commercial land development in many parts of the lower drainage and even over top of the original Grant Creek channel.

There has been no recent fire activity in the Grant Creek sub-watershed that may be contributing nutrients. The most recent fires occurred in the late 1980s, with the 1988 Snowbowl Fire (approximately 88 acres) and the 1989 Grant Creek fire (approximately 13 acres), both of which are a substantial distance from the Grant Creek channel.

Agriculture

Agriculture is the primary land use in the lower reaches of Grant Creek below the Interstate-90 crossing and commercial-industrial development area. The Grant Creek sub-watershed is 18,738 acres, of which 10,600 acres (57%) is public land. However, the Grant Creek sub-watershed does not contain any grazing allotments.

Cultivated cropland, including irrigated cropland, is a potentially significant nutrient source in the Grant Creek sub-watershed. There are readily apparent irrigation withdrawals and diversions in all but the top reach. Analysis of aerial imagery and geospatial land cover data reveals that some alfalfa, summer fallow, and a substantial amount of pasture/hay land exists along lower reaches of Grant Creek, interspersed among the residential subdivisions. Many of these residential lawns are likely irrigated and may be fertilized. Further, water is diverted from the Clark Fork River through a ditch for irrigation purposes in the lower reaches of Grant Creek; the irrigation return flow enters between the lower 2 sites which may be a substantial nutrient source and help explain the increase in nitrogen concentrations seen between the lower 2 monitoring sites. In addition, several small irrigated parcels are seen approximately mid-segment very near the creek, around the Snowbowl Road crossing, although based on field observations most or all of these are irrigated residential lawns.

Much of the agricultural land in these lower reaches are within the Clark Fork River floodplain and the relatively high water table here likely increases the influence of surface water-groundwater interactions. This makes it more likely that, coupled with surface water irrigation return flows, nutrients from crop production and residential lawn care are contributing to the existing Grant Creek TN load. This may, in part, explain the general increase in nitrogen concentrations in the downstream direction, with the highest TN concentrations seen in samples collected just above the mouth of Grant Creek.

Silviculture

Silviculture activities are not a primary land use in the Grant Creek sub-watershed. An analysis of aerial imagery and geospatial land cover data reveals several small parcels in the central western portion of the sub-drainage, although these operations do not appear to be recent and are not within close proximity of the stream channel. Contributions of nutrients to Grant Creek from timber harvest or forest roads are unlikely.

Grant Creek Road runs along much of the stream channel and is in relatively close proximity in some places, particularly north of Interstate-90 where the stream has been channelized in some reaches. However, there exists a substantial riparian buffer between the road and the channel in most places and this road is not thought to be a substantial contributor of nutrients.

Mining

According to DEQ records, there are 3 abandoned mines in the Grant Creek drainage, none of which appear on DEQ's Priority Mine Sites List (Pioneer Technical Services, Inc., 1995). There are 2 stone and pumice lode mines in the lower reaches and a copper and gold prospect mine above the uppermost monitoring site. These sites are having no discernible impacts on nutrient water quality.

Subsurface wastewater disposal and treatment

According to DEQ records, there are 95 individual septic systems in the Grant Creek sub-watershed. This includes only septic systems that are not connected to the city of Missoula sewer system. Most of these septic systems are found approximately mid-segment in the residential neighborhoods surrounding the Snow Bowl road crossing, with others scattered throughout the lower reaches of the Grant Creek sub-watershed. Given the close proximity and high density of individual septic systems in the Grant Creek sub-watershed, septic effluent is considered a moderate contributor to the existing Grant Creek TN daily load. Several septic systems are located near the channel within the Clark Fork River floodplain and the relatively high water table here increases the influence of surface water-groundwater interactions, thereby increasing the likelihood of septic influence. Coupled with the other agricultural and residential land uses in this region, this may, in part, explain the general increase in nutrient concentrations in the downstream direction, with the highest TN concentrations seen in samples collected just above the mouth of Grant Creek.

6.6.5.3 TN TMDL, Allocations, and Current Loading

The TMDL for TN is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the TN TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TN TMDL for Grant Creek uses **Equation 1** with the flow associated with the median concentrations of measured TN values that exceed the target reduction from all sites during 2009-2011 sampling (19.58 cfs, as represented by the gray diamond in Figure 6-27):

TMDL = (0.30 mg/L) (19.58 cfs) (5.4) = 31.72 lbs/day

Equation 4 is the basis for the natural background load allocation for TN. To continue with the example at a flow of 19.58 cfs, this allocation is as follows:

LA_{NB} = (0.095 mg/L) (19.58 cfs) (5.4) = 10.05 lbs/day

As discussed in **Section 6.5.1**, Missoula's MS4 Stormwater System should not be actively discharging during typical summer low flow conditions when nutrient criteria apply; therefore, both the existing load and WLA are defined as 0 (zero) lbs/day for TN. Using a variation of **Equation 3**, the combined human-caused TN allocation at 19.58 cfs can be calculated:

LA_H = TMDL – LA_{NB} – WLA_{MS4} = (31.72 lbs/day) – (10.05 lbs/day) – (0 lbs/day) = 21.67 lbs/day

An example total existing load is calculated as follows using **Equation 6**, the example flow of 19.58 cfs, and the corresponding concentration associated with the median reduction for measured loads that exceed the TMDL for TN in Grant Creek from 2009-2011 (0.55 mg/L):

Total Existing Load = (0.55 mg/L) (19.58 cfs) (5.4) = 58.15 lbs/day

The portion of the existing load attributed to human sources is 48.10 lbs/day, which is determined by subtracting out the 10.05 lbs/day natural background load. As stated previously, the existing load from Missoula's MS4 is defined as 0.0 (zero) lbs/day for TN during summer low flow conditions. This 48.10 lbs/day represents the load measured within the stream after potential nutrient uptake.

Table 6-29 summarizes the example TN TMDL, load allocations, and current loading. **Table 6-29** also contains the percent reduction to human-caused load allocation and wasteload allocation required to meet the water quality target for TN. The percent reduction to natural background and the percent reduction to Missoula's MS4 is 0% based on the typical summer low flow day as discussed above. At the median concentration of measured TN values that exceed the target (0.55 mg/L) and the growing season flow associated with this median concentration (19.58 cfs), the existing load in Grant Creek is greater than the TMDL. Under these example conditions a 54.9% reduction of human-caused sources and an overall 45.5% reduction of TN in Grant Creek would result in the TMDL being met. The source assessment of the Grant Creek sub-watershed indicates that subsurface wastewater disposal and treatment, residential development (e.g., lawn fertilization), and crop production is the most likely source of TN in Grant Creek; load reductions should focus on limiting and controlling TN loading from these sources. Meeting load allocations for Grant Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 7.0**.

This TMDL serves to address the Excess Algal Growth impairment for Grant Creek. By reducing nutrient loads in Grant Creek, it is expected that the potential for algal growth levels will be reduced. By controlling the input of nutrient sources, it is expected that overall nutrient and algae levels will be reduced.

Table 6-29. Grant Creek TN Example TMDL, Load Allocations, Current Loading, and Reductions

Source Category	Allocation & TMDL (lbs/day)[1]	Existing Load (lbs/day)[1]	Percent Reduction
Natural Background	10.05	10.05	0%
Human-caused LA (primarily silviculture, agriculture and subsurface wastewater disposal)	21.67	48.10	54.9%
WLA[2]	0.000	0.000	0.0%
	TMDL = 31.72	**Total = 58.15**	**Total = 45.5%**

[1] Based on a growing season flow of 19.58 cfs.

[2] In this example TMDL, the MS4 is given a WLA of zero as the system should not be actively discharging during the typical summer low flow conditions represented. However, as presented in **Section 6.5.1.2**, a WLA which considers BMP reduction efficiencies has been developed for summer storm events that qualify as producing stormwater discharge (0.25 inches).

6.6.5.4 NO_3+NO_2 TMDL Surrogate

Because nitrate is a component of TN, and because the loading sources and methods to reduce loading sources of nitrate and TN are essentially the same, the above TMDL for TN provides a surrogate TMDL for nitrate in Grant Creek and allocations would apply to the same source categories consistent with the TN allocations.

6.6.6 Tenmile Creek

6.6.6.1 Assessment of Water Quality Results

The source assessment for Tenmile Creek consists of an evaluation of TP concentrations. This is followed by a description of the most significant human caused sources of nutrients. **Figure 6-28** presents the approximate locations of data pertinent to the source assessment in the sub-watershed.

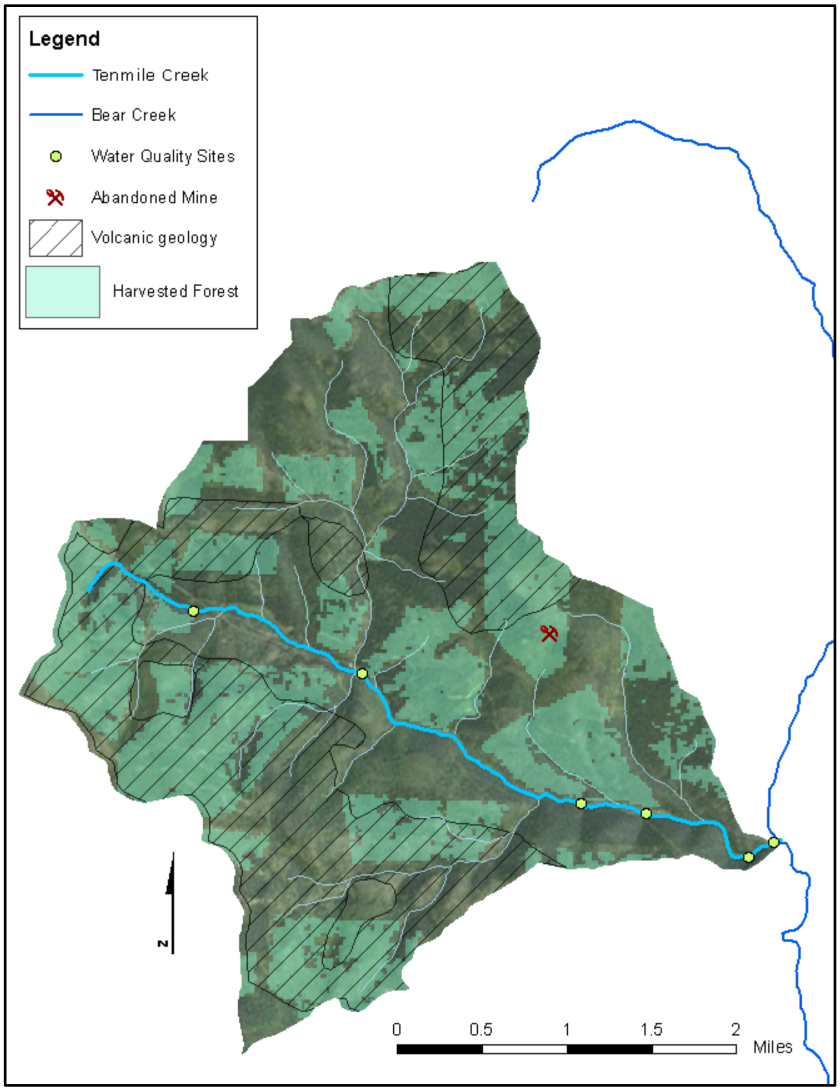

Figure 6-28. Tenmile Creek sub-watershed with water quality sampling locations.

DEQ collected water quality samples from Tenmile Creek during the growing season over the time period 2004-2011 (**Section 6.4.3.6**, **Table 6-14**). Five monitoring site locations were established during the sampling period. **Figure 6-29** presents summary statistics for TP concentrations at sampling sites in Tenmile Creek.

Fourteen TP samples were collected at 5 sites and TP concentrations were in excess of the TP target concentration of 0.03 mg/L in every sample collected. The recent dataset for benthic algae did not indicate excess algal growth, although sampling timing may have missed the periods of peak growth. Macroinvertebrate samples were collected in 2004 and 2011 and HBI scores from all 4 sites were below the threshold.

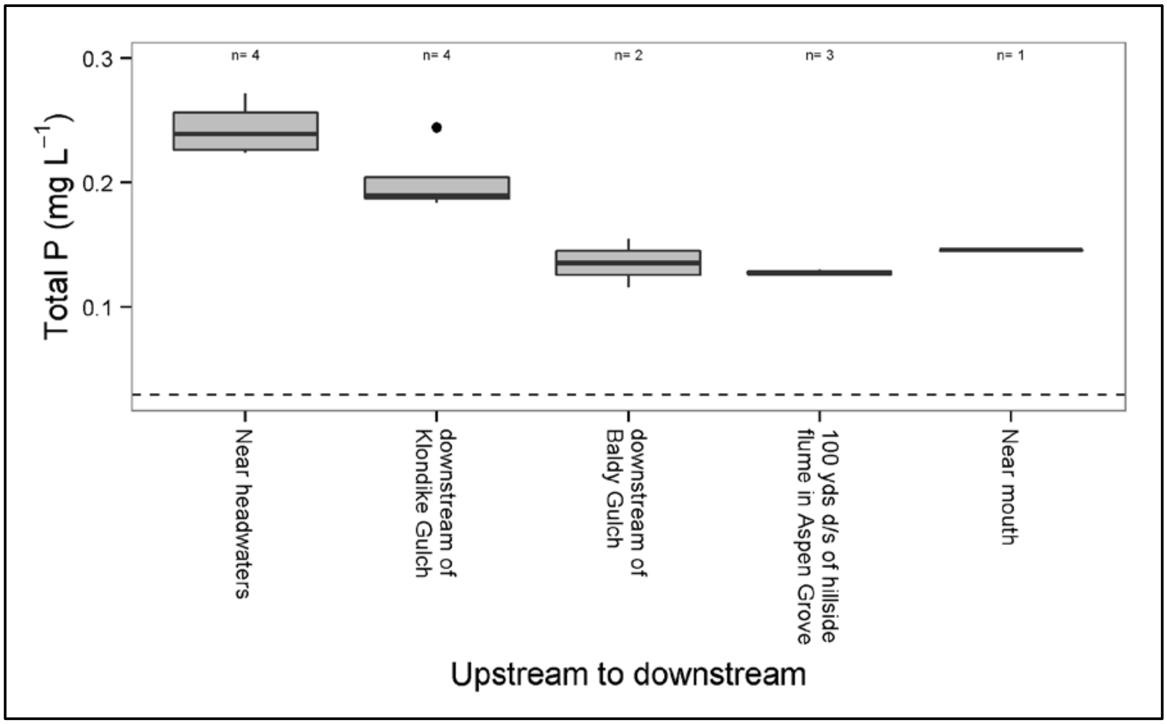

Figure 6-29. TP boxplots for Tenmile Creek.

In general, there is a decrease in TP concentrations when moving in the downstream direction, and TP concentrations at the lowermost 3 sites are very similar. The uppermost site, near the headwaters of Tenmile Creek, had TP concentrations, on average, 8.1 times greater than the target concentration of 0.03 mg/L. The site downstream from Klondike Gulch had TP concentrations, on average, 6.7 times greater than the target. The site downstream of Baldy Gulch had TP concentrations, on average, 4.5 times greater than the target. The site 100 yards downstream of the hillside flume in Aspen Grove had TP concentrations, on average, 4.3 times greater than the target, and the site near the mouth had a TP concentration 4.9 times greater than the target. Target exceedance ratios were plotted for all Tenmile Creek samples, and only nutrient concentrations for which an associated flow value was collected are depicted in these figures. Ratios less than 1.0 indicate sample concentrations below the TP target. Flows ranged from 0.02 cfs to 0.95 cfs (**Figure 6-30**). During 1 visit in September of 2011, the site near the mouth was observed to be dry (no flow). **Figure 6-31** shows the percent reductions for TP loads measured in Tenmile Creek from 2004-2011. Reductions needed to achieve the TMDL range from 74.14% to 88.05% with a median reduction of 82.17%.

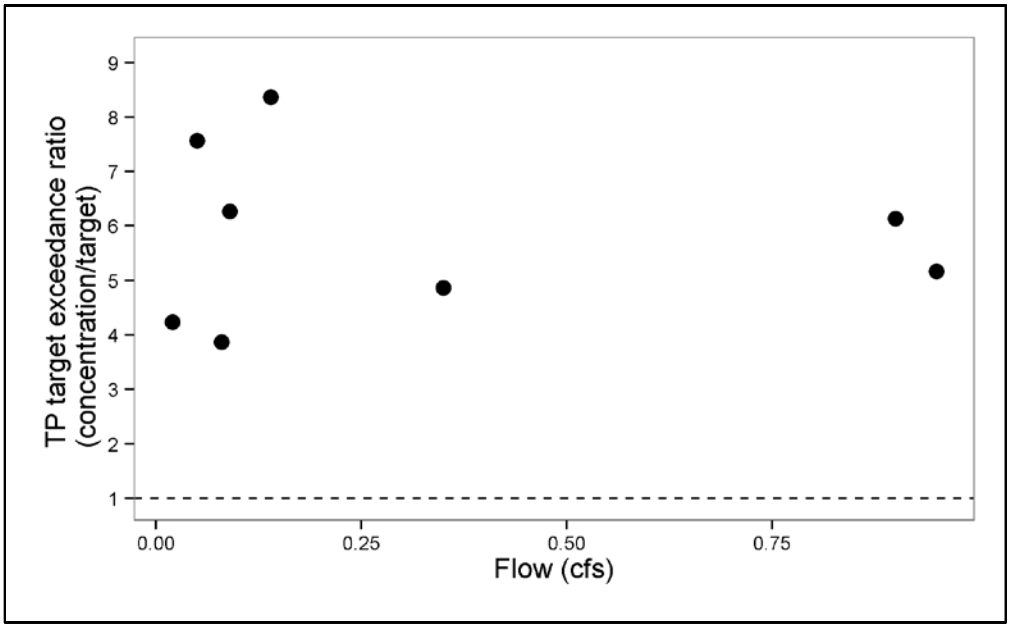

Figure 6-30. TP target exceedance ratio in Tenmile Creek (2004-2011).

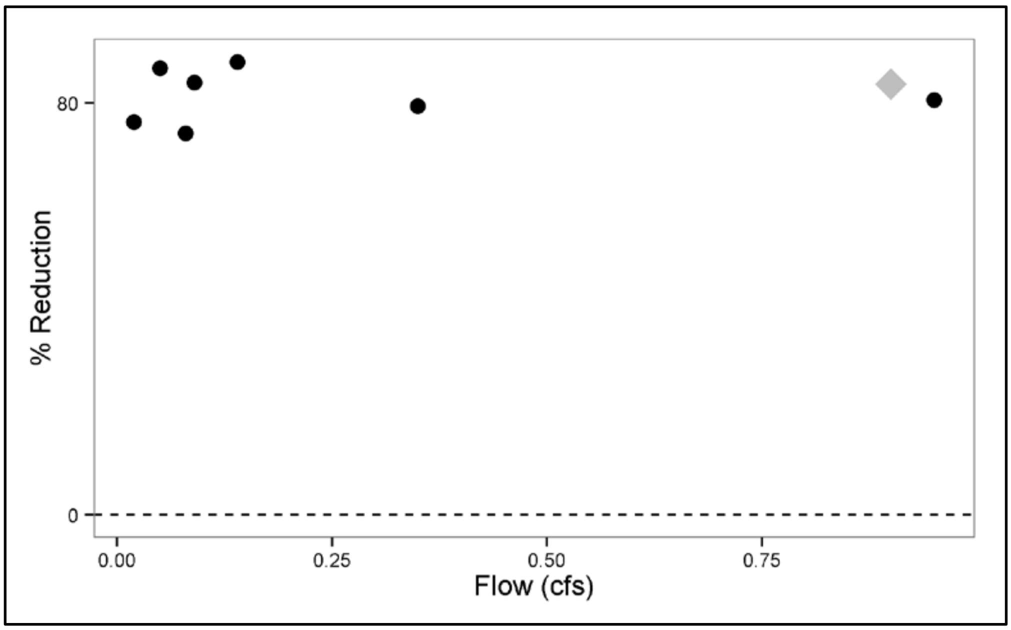

Figure 6-31. Measured TP percent load reductions necessary to achieve the TP TMDL in Tenmile Creek (2004-2011). The gray diamond represents a median percent reduction value used to calculate existing load and percent reductions in the example TMDL for Tenmile Creek.

6.6.6.2 Assessment of Loading by Source Categories

As addressed in **Section 6.4.2** and shown in **Figure 6-28**, the Tenmile Creek soils are volcanic in nature, highly erosive, and likely elevated in phosphorus compared with other soil types encountered in the Middle Rockies Level III ecoregion. There were insufficient data in this area with significant human-caused sources of TP to differentiate between background and human-caused load fractions. Once all reasonable soil, land, and water conservation practices have been implemented in the sub-watershed, further investigation is warranted to establish the background condition based on reference sites within the Tenmile Creek sub-watershed.

Tenmile Creek does not appear on the Montana Department of Fish, Wildlife and Parks dewatered streams list. This list identifies streams that support or contribute to important fisheries that are significantly dewatered, referring to a reduction in streamflow below the point where stream habitat is adequate for fish. However, Tenmile Creek does not have direct surface water connectivity with Bear Creek at all times of the year as its lower reaches flow only intermittently.

A forest fire was burning near the headwaters of Tenmile Creek during the monitoring event in August of 2012, preventing access to the upper monitoring site.

Agriculture

Agriculture is the primary land use and potentially significant nutrient source in the Tenmile Creek sub-watershed, with livestock grazing far more prevalent and likely to be contributing to elevated nutrient concentrations than crop production. With the exception of a very small parcel in the southern corner, the entire Tenmile Creek sub-watershed is encompassed by 2 grazing allotments. The Ten Mile allotment number 07102 is 69,707 acres, of which approximately 6,072 acres (9%) is within the Tenmile Creek sub-watershed. Of the total allotment area, 1,320 acres are within public (mostly BLM administered) land and there are 69 permitted animal unit months (AUMs). The Bonita-Clinton allotment number 07101 is 10,955 acres, of which approximately 379 (3%) is within the Tenmile Creek sub-watershed. Of the total allotment area, 3,793 acres are within public (mostly BLM administered) land and there are 207 permitted animal unit months (AUMs).

The Tenmile Creek sub-watershed is 6,715 acres and 768 acres (11%) of this is public land. These public lands are all within the 2 grazing allotment boundaries described above, which have a maximum of 276 permitted AUMs. While it may be unlikely that all 276 permitted AUMs for the entire allotment areas will be grazed exclusively on public lands within the Tenmile Creek sub-watershed, this represents the maximum AUMs possible at any given time. No attempts were made to verify actual grazing practices or current stocking densities.

Recent field observations, photographs, and comments in the Tenmile Creek assessment records indicate evidence of livestock grazing in the stream channel and along its riparian corridor, including hoof pugging and altered riparian vegetation in most reaches. Bank erosion and failure and channel blow-outs noted in the assessment record were attributed, in part, to heavy grazing. Aerial imagery and geospatial land cover data suggest grazing is most prevalent near the headwaters and along the road that runs alongside the stream channel. There is no irrigated or non-irrigated cropland in the Tenmile Creek sub-watershed. The sub-watershed is predominantly forested with intermittent shrubland, especially around the headwaters.

Silviculture

Silviculture activities are the other primary land use in the Tenmile Creek sub-watershed. An analysis of aerial imagery and geospatial land cover data suggests silviculture activities are extensive in the Tenmile Creek sub-watershed, particularly in the upper half where much of the land is administered by BLM or owned by a private logging company. Timber harvest has occurred on parcels on both sides of the stream channel and aerial images show a multitude of logging roads in the drainage. Further, as noted in DEQ's Tenmile Creek assessment record and apparent in recent site photographs, the logging road that leads up the sub-drainage along the stream was installed in close proximity to the riparian corridor and stream channel itself.

Timber harvest and logging roads exist in close proximity to the stream channel from the headwaters of Tenmile Creek along the stream corridor between the upper and lower site where total phosphorus concentrations decrease in the downstream direction. Runoff from timber harvest activities and potential sedimentation from logging roads in close proximity of the stream are likely introducing phosphorus to the assessment unit. Given the volcanic parent material for soils in the drainage, soils are not only at a greater risk of erosion, but are also likely phosphorus rich compared with other sub-watersheds in the Central Clark Fork Basin Tributaries TMDL Project area.

Mining

According to DEQ records, there is 1 abandoned mine, a lode mine for lead and silver, in the Tenmile Creek sub-watershed; this mine does not appear on DEQ's Priority Mine Sites List (Pioneer Technical Services, Inc., 1995). The mine site is located approximately 1 mile north of the stream channel and is not having a discernable impact on nutrient water quality.

Subsurface wastewater disposal and treatment

According to DEQ records, there is 1 individual septic system in the Tenmile Creek sub-watershed. This septic system is located approximately 800 feet from the stream channel and, as such, septic effluent is not considered a contributor to the existing Tenmile Creek TP load.

6.6.6.3 TP TMDL, Allocations, and Current Loading

The TMDL for TP is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the TP TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TP TMDL for Tenmile Creek uses **Equation 1** with the flow associated with the median concentration of measured TP values that exceed the target reduction from all sites during 2004-2011 sampling (0.90 cfs , as represented by the gray diamond in Figure 6-31):

TMDL = (0.03 mg/L) (0.90 cfs) (5.4) = 0.15 lbs/day

Equation 4 is the basis for the natural background load allocation for TP. To continue with the example at a flow of 0.90 cfs, this allocation is as follows:

LA_{NB} = (0.01 mg/L) (0.90 cfs) (5.4) = 0.05 lbs/day

Using **Equation 5**, the combined human-caused TP allocation at 0.90 cfs can be calculated:

LA_{H} = 0.15 lbs/day – 0.05 lbs/day = 0.10 lbs/day

An example total existing load is calculated as follows using **Equation 6**, the example flow of 0.90 cfs and the corresponding concentration associated with the median reduction for measured loads that exceed the TMDL for TP in Tenmile Creek from 2004-2011 (0.184 mg/L):

Total Existing Load = (0.184 mg/L) (0.90 cfs) (5.4) = 0.89 lbs/day

The portion of the existing load attributed to human sources is 0.84 lbs/day, which is determined by subtracting out the 0.05 lbs/day natural background load. This 0.84 lbs/day represents the load measured within the stream after potential nutrient uptake.

Table 6-30 summarizes the example TP TMDL, load allocations, and current loading. **Table 6-30** also contains the percent reduction to human-caused load allocation required to meet the water quality target for TP. The percent reduction to natural background is 0%. At the median concentration of measured TP values that exceed the target (0.184 mg/L) and the growing season flow associated with this median concentration (0.90 cfs), the existing loading in Tenmile Creek is greater than the TMDL. Under these example conditions an 88.5% reduction of human-caused sources and an overall 83.7% reduction of TP in Tenmile Creek would result in the TMDL being met. The source assessment of the Tenmile Creek watershed indicates that grazing in the riparian zone and sedimentation from silviculture activities and forest roads are the most likely sources of TP in Tenmile Creek; load reductions should focus on limiting and controlling TP loading from these sources. Meeting load allocations for Tenmile Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 7.0**.

Table 6-30. Tenmile Creek TP Example TMDL, Load Allocations, Current Loading, and Reductions

Source Category	Allocation & TMDL (lbs/day)[1]	Existing Load (lbs/day)[1]	Percent Reduction
Natural Background	0.05	0.05	0%
Human-caused (primarily agriculture and silviculture)	0.10	0.84	88.1%
	TMDL = 0.15	**Total = 0.89**	**Total = 83.1%**

[1] Based on a growing season flow of 0.90 cfs.

6.6.7 Deep Creek

6.6.7.1 Assessment of Water Quality Results

The source assessment for Deep Creek consists of an evaluation of NO_3+NO_2 concentrations. This is followed by a description of the most significant human caused sources of nutrients. **Figure 6-32** presents the approximate locations of data pertinent to the source assessment in the sub-watershed.

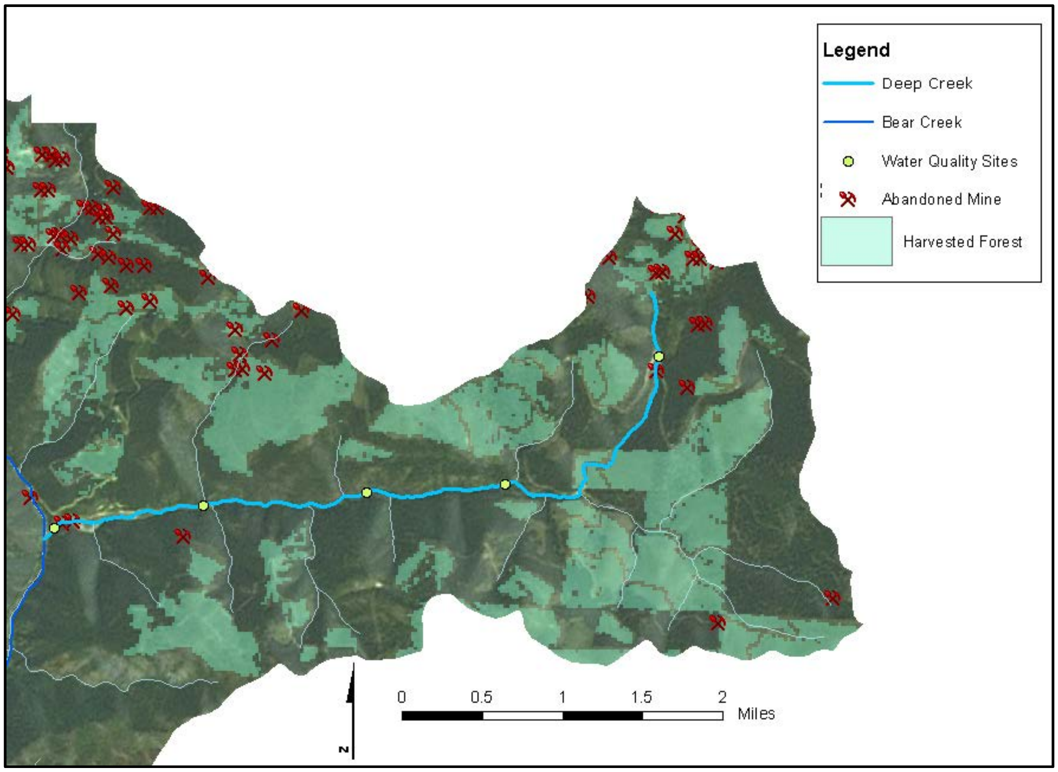

Figure 6-32. Deep Creek sub-watershed with water quality sampling locations.

DEQ collected water quality samples from Deep Creek during the growing season over the time period 2004 to 2011 (**Section 6.4.3.7**, **Table 6-16**). Three monitoring site locations were established during the sampling period. **Figure 6-33** presents summary statistics for NO_3+NO_2 concentrations at sampling sites in Deep Creek.

Sixteen NO_3+NO_2 samples were collected at 3 sites and NO_3+NO_2 concentrations were in excess of the NO_3+NO_2 target concentration of 0.10 mg/L in 13 of 16 samples. The recent dataset for benthic algae did not indicate excess algal growth, although sampling timing may have missed the periods of peak growth. Macroinvertebrate samples were collected in 2004, 2008 and 2011 and 2 of 7 HBI scores were above the threshold.

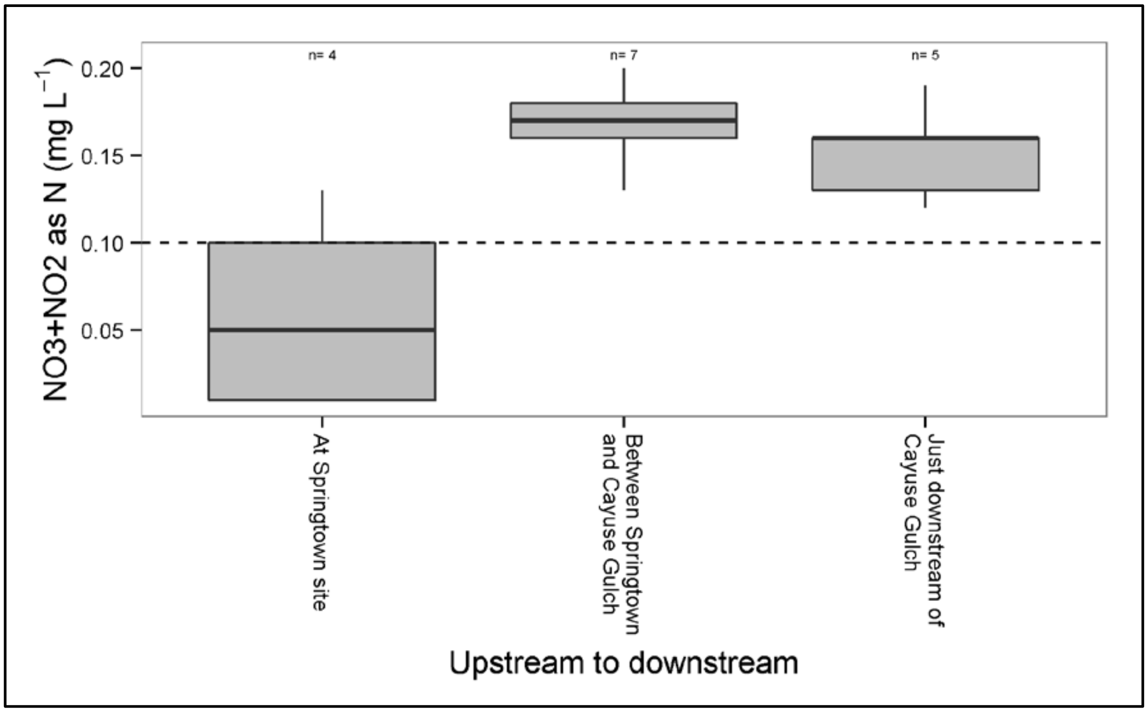

Figure 6-33. NO_3+NO_2 boxplots for Deep Creek.

In general, there is an increase in NO_3+NO_2 concentrations when moving in the downstream direction, and NO_3+NO_2 concentrations at the lower 2 sites are similar. At the uppermost site, or Springtown site, all but 1 of the samples had concentrations below the target concentration of 0.10 mg/L; the only exceedance was 1.3 times greater than the target. The middle site, between the Springtown site and Cayuse Gulch, had NO_3+NO_2 concentrations, on average, 1.7 times greater than the target. The lower site just downstream of Cayuse Gulch had NO_3+NO_2 concentrations, on average, 1.5 times greater than the target. Target exceedance ratios were plotted for all Deep Creek samples and only nutrient concentrations for which an associated flow value was collected are depicted in these figures. Ratios less than 1.0 indicate sample concentrations below the NO_3+NO_2 target. Flows ranged from 0.02 cfs to 1.55 cfs (**Figure 6-34**). **Figure 6-35** shows the percent reductions for NO_3+NO_2 loads measured in Deep Creek from 2004-2011. Reductions needed to achieve the TMDL range from 16.67% to 50.00% with a median reduction of 37.50%.

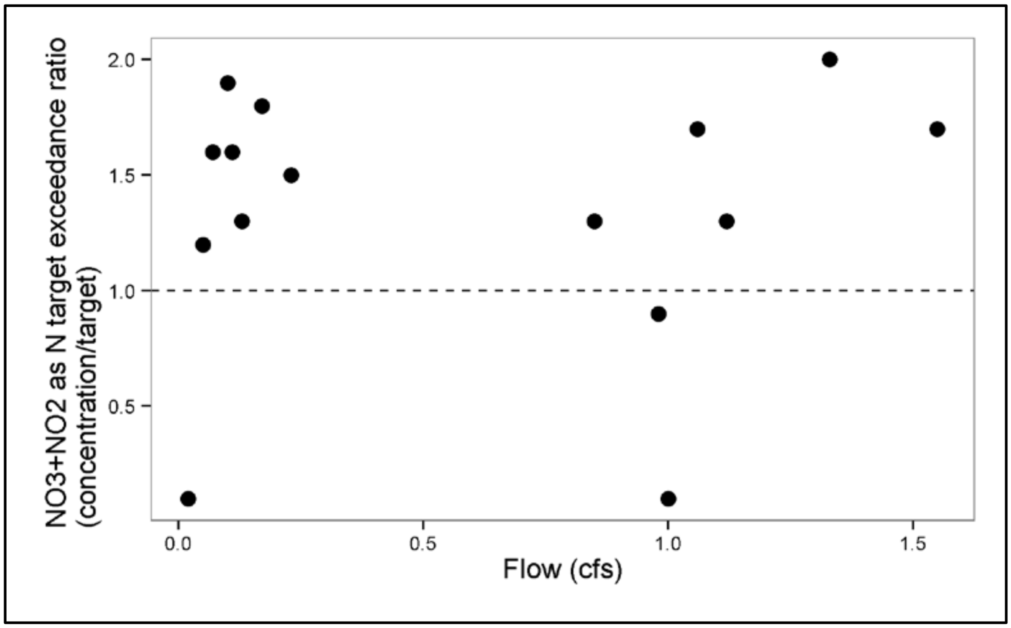

Figure 6-34. NO_3+NO_2 target exceedance ratio in Deep Creek (2004-2011).

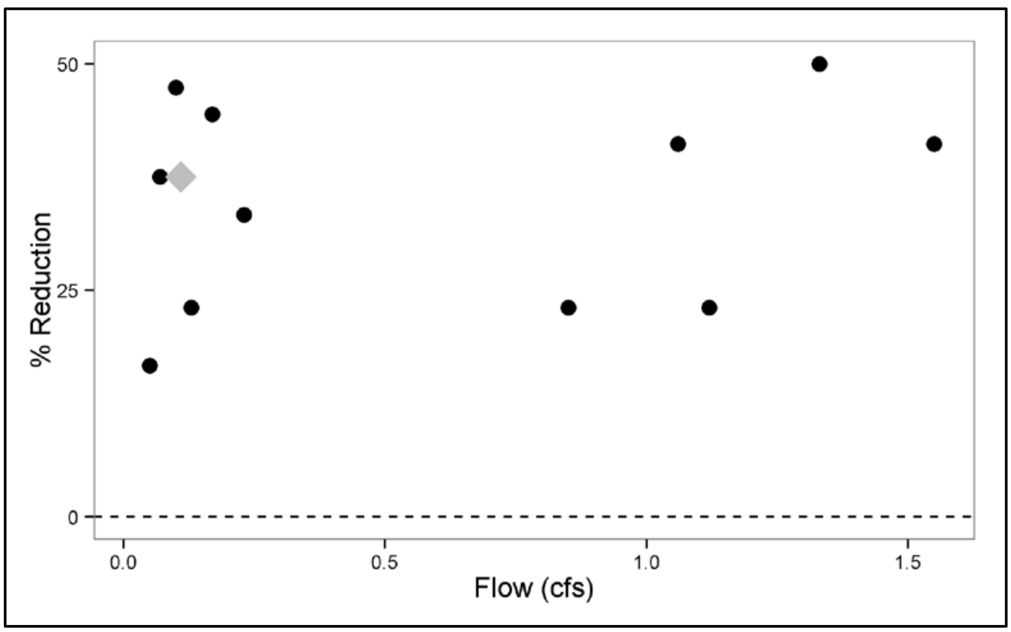

Figure 6-35. Measured NO_3+NO_2 percent load reductions necessary to achieve the NO_3+NO_2 TMDL in Deep Creek (2004-2011). The gray diamond represents a median percent reduction value used to calculate existing load and percent reductions in the example TMDL for Deep Creek.

6.6.7.2 Assessment of Loading by Source Categories

Deep Creek does not appear on the Montana Department of Fish, Wildlife and Parks dewatered streams list. This list identifies streams that support or contribute to important fisheries that are significantly dewatered, referring to a reduction in streamflow below the point where stream habitat is adequate for fish. However, Deep Creek does not have direct surface water connectivity with Bear Creek during some parts of the year and its lower reaches were dry during monitoring visits. It is not known at this time to what degree this dewatering is due to naturally losing reaches as opposed to water diversions in the upper reaches used to supply water for mining activities.

While approximately 80% of the Deep Creek sub-drainage is publicly owned land, a majority of the land surrounding the stream channel itself is privately owned. There has been no recent fire activity in the Deep Creek sub-watershed.

DEQ was unable to gain access permission to flowing sections of Deep Creek in order to conduct a stream assessment in 2012. Based on field notes and site photos taken as part of 2004 and 2012 field work, the channel has been significantly affected by past timber harvesting practices and by historical and current placer mining operations in the channel. There is a reservoir in the upper portion of the Deep Creek drainage out of which Deep Creek flows, with a portion diverted into a pipe for apparent use in a mining operation. Deep Gulch Road parallels Deep Creek along much of its length. Field visits noted that the channel quickly went dry and lost definition in an area of active mining. Flowing water was again observed downstream of the Gambler Creek confluence. In this reach, the channel resembled a small spring creek flowing through wetland vegetation. The stream then became channelized by the road and proceeded to go dry. Further downstream, the channel remained encroached upon by Deep Gulch Road and evidence of historic placer mining was observed, including a portion where a small rock wall had been constructed along both sides of the channel. As the valley opens up, there was no flowing water and no defined channel in an area upstream of the Deep Creek confluence with Bear Creek where extensive mine related disturbance has occurred.

Agriculture

Agricultural land use associated with both grazing and cropland appears minimal in the Deep Creek sub-watershed and is potentially a minor contributor to nutrient concentrations. The entire Deep Creek sub-watershed is encompassed by 3 grazing allotments. The Mulkey West allotment number 07104 is 15,525 acres, of which approximately 7,619 (49%) is within the Deep Creek sub-watershed. Of the total allotment area, 7,619 acres are within public (mostly BLM administered) land and there are 125 permitted animal unit months (AUMs). The Mulkey East allotment number 07108 is 11,561 acres, of which approximately 76 (1%) are within the Deep Creek sub-watershed. Of the total allotment area, 2,758 acres are within public (mostly BLM administered) land and there are 93 permitted animal unit months (AUMs). The Dry Mulkey allotment number 07105 is 2,061 acres, of which approximately 922 (45%) are within the Deep Creek sub-watershed. Of the total allotment area, 889 acres are within public (mostly BLM administered) land and there are 40 permitted animal unit months (AUMs).

The Deep Creek sub-watershed is approximately 6,700 acres and 5,414 acres (81%) of this is public land. These public lands are all within the 3 grazing allotment boundaries described which have a maximum of 258 permitted AUMs. While it may be unlikely that all 258 permitted AUMs for the entire allotment areas will be grazed exclusively on public lands within the Deep Creek sub-watershed, this represents the maximum AUMs possible at any given time. Geospatial land cover data and lack of field observations of heavy grazing suggest this is likely an overestimate, although no attempts were made to verify actual grazing practices or current stocking densities. However, land cover data also suggests that the grazing that does occur in the drainage occurs along or near the stream channel, particularly in the lower reaches.

There is no irrigated or dryland crop production in the Deep Creek sub-watershed. The sub-watershed is predominantly forested with intermittent shrubland.

Silviculture
Silviculture activities are a primary land use in the Deep Creek sub-watershed. An analysis of aerial imagery and geospatial land cover data suggests silviculture activities are extensive in the Deep Creek sub-watershed. Timber harvest is prevalent throughout the entire drainage area, although the logged parcels nearest to the stream channel are located in the upper reaches of the stream, above the uppermost monitoring site location from which water quality samples were collected. Timber harvest has occurred on parcels on both sides of the stream channel and aerial images show a multitude of logging roads in the drainage. Further, as noted in DEQ's Tenmile Creek assessment record and apparent in recent site photographs, the logging road that leads up the sub-drainage along the stream was installed in close proximity to the riparian corridor and stream channel itself. As noted in the assessment records for this stream, there exists a riparian buffer despite this road presence. However, there are portions in the upper reaches where the stream channel has been filled and displaced entirely by the road. This, coupled with water diversion from mining operations, complicates water quality analysis of Deep Creek.

Timber harvest and roads exist in close proximity to the stream channel from the headwaters of Deep Creek along the stream corridor where nitrogen concentrations increase in the downstream direction. Runoff from timber harvest activities and potential sedimentation from logging roads in close proximity of the stream may be a minor contributor of nitrogen to the assessment unit.

Mining
Deep Creek has the most extensive and active mining history of all nutrient impaired streams in the Central Clark Fork Basin Tributaries TMDL Project area. This drainage is part of the Garnet Mining District in Granite County. DEQ records show approximately 27 abandoned mines; these were primarily placer and lode mines which produced gold, as well as copper, silver, mercury, and iron, none of which appear on DEQ's Priority Mine Sites List (Pioneer Technical Services, Inc., 1995). Two of these are in the headwaters of a tributary that joins with the mainstem above the Springtown site; 15 are located around the headwaters of the Deep Creek mainstem, with all but 2 upstream of the headwaters site; 7 are around the headwaters of Cayuse Gulch which joins just above the monitoring site C02DEEPC03; 2 abandoned placer gold mines are just above the site near the mouth of Deep Creek, and 1 stone quarry is located less than a mile upstream from the mouth near the channel.

The Top o' Deep placer gold mine is listed as an active mine by MBMG in 2012, although these records suggest active mining at the Top O'Deep placer was delayed during the season while the owner and operator tested other properties (Montana Bureau of Mines and Geology website). According to previous DEQ assessment records, the lower 2 miles of the stream were both placer and tunnel mined, which was quite detrimental to this section, and the current landowner is preparing to reopen the tunnel mines. Deep Creek is diverted into a pipe after approximately 1 mile of surface flow and is used to run the mining operation. Another pipe releases water just downstream from Cayuse Gulch. Given the extensive history and ongoing active status of mining in the Deep Creek drainage, mining is considered a potentially significant contributor to existing NO_3+NO_2 loads.

Subsurface wastewater disposal and treatment
According to DEQ records, there are 3 individual septic systems in the Deep Creek sub-watershed. One is within 200 feet of the stream above the mouth, 1 is within 150 feet of the stream just below the headwaters and 1 is in the upper portion of the sub-watershed approximately 2,000 feet from the channel. While 2 of these systems are within a few hundred feet of the channel, the majority of these

systems are located outside the main floodway. Septic effluent is considered a minor contributor to the existing Deep Creek NO_3+NO_2 daily load.

6.6.7.3 NO3+NO2 TMDL, Allocations, and Current Loading

The TMDL for NO_3+NO_2 is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the NO_3+NO_2 TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example NO_3+NO_2 TMDL for Deep Creek uses **Equation 1** with the flow associated with the median concentration of measured NO_3+NO_2 values that exceed the target reduction from all sites during 2004-2011 sampling (0.11 cfs , as represented by the gray diamond in Figure 6-35):

TMDL = (0.10 mg/L) (0.11 cfs) (5.4) = 0.06 lbs/day

Equation 4 is the basis for the natural background load allocation for NO_3+NO_2. To continue with the example at a flow of 0.11 cfs, this allocation is as follows:

LA_{NB} = (0.02 mg/L) (0.11 cfs) (5.4) = 0.01 lbs/day

Using **Equation 5**, the combined human-caused TP allocation at 0.11 cfs can be calculated:

LA_H = 0.06 lbs/day – 0.01 lbs/day = 0.05 lbs/day

An example total existing load is calculated as follows using **Equation 6**, the example flow of 0.11 cfs and the corresponding concentration associated with the median reduction for measured loads that exceed the TMDL for NO_3+NO_2 in Deep Creek from 2004-2011 (0.160 mg/L):

Total Existing Load = (0.16 mg/L) (0.11 cfs) (5.4) = 0.10 lbs/day

The portion of the existing load attributed to human sources is 0.09 lbs/day, which is determined by subtracting out the 0.01 lbs/day natural background load. This 0.09 lbs/day represents the load measured within the stream after potential nutrient uptake.

Table 6-31 summarizes the example NO_3+NO_2 TMDL, load allocations, and current loading. **Table 6-31** also contains the percent reduction to human-caused load allocation required to meet the water quality target for NO_3+NO_2. The percent reduction to natural background is 0%. At the median concentration of measured NO_3+NO_2 values that exceed the target (0.160 mg/L) and the growing season flow associated with this median concentration (0.11 cfs), the existing loading in Deep Creek is greater than the TMDL. Under these example conditions, a 42.9% reduction of human-caused sources and an overall 37.5% reduction of NO_3+NO_2 in Deep Creek would result in the TMDL being met. The source assessment of the Deep Creek watershed indicates that mining is the most likely source of NO_3+NO_2 in Deep Creek; load reductions should focus on limiting and controlling NO3+NO2 loading from these sources. Meeting load allocations for Deep Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 7.0**.

This TMDL serves to address the chlorophyll-*a* impairment for Deep Creek. By reducing nutrient loads in Deep Creek, it is expected that the potential for excess algae growth and thus chlorophyll-*a* levels will be reduced. By controlling the input of nutrient sources, it is expected that overall nutrient and algae levels will be reduced.

Table 6-31. Deep Creek NO_3+NO_2 Example TMDL, Load Allocations, Current Loading, and Reductions

Source Category	Allocation & TMDL (lbs/day)[1]	Existing Load (lbs/day)[1]	Percent Reduction
Natural Background	0.01	0.01	0%
Human-caused (primarily mining and silviculture)	0.05	0.09	44.4%
	TMDL = 0.06	**Total = 0.10**	**Total = 40.0%**

[1] Based on a growing season flow of 0.11 cfs.

6.6.8 Rattler Gulch

6.6.8.1 Assessment of Water Quality Results

The source assessment for Rattler Gulch consists of an evaluation of TP concentrations. This is followed by a description of the most significant human caused sources of nutrients. **Figure 6-36** presents the approximate locations of data pertinent to the source assessment in the sub-watershed.

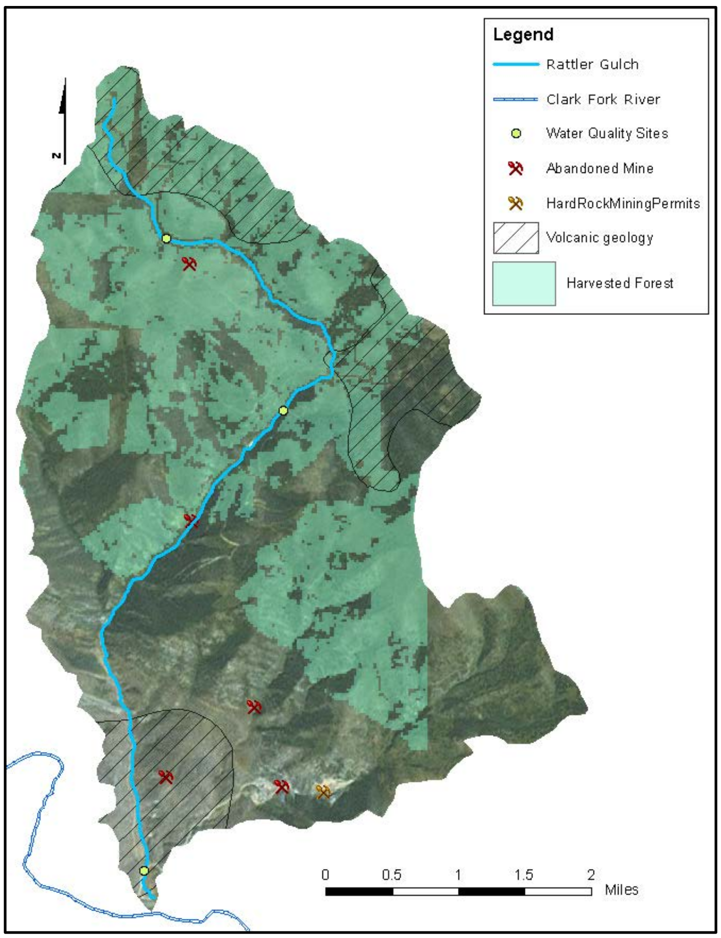

Figure 6-36. Rattler Gulch sub-watershed with water quality sampling locations.

DEQ collected water quality samples from Rattler Gulch during the growing season over the time period 2004-2011 (**Section 6.4.3.8**, **Table 6-18**). Three monitoring site locations were established during the sampling period, although only 2 sites produced nutrient concentration data as the lowermost site near the mouth was dry (no flow) at the time of sampling. **Figure 6-37** presents summary statistics for TP concentrations at sampling sites in Rattler Gulch.

Thirteen TP samples were collected at 2 sites and TP concentrations were in excess of the TP target concentration of 0.03 mg/L in all samples. In general, there is an increase in TP concentrations when moving in the downstream direction, with TP concentrations at the site mid-segment not quite double those sampled at the site approximately 1 mile downstream from the headwaters. The recent dataset for benthic algae did not indicate excess algal growth, although sampling timing may have missed the periods of peak growth. Nutrient concentrations, in excess of the target, present conditions that may lead to excess algal growth and prior observations of heavy benthic algal growth noted in previous assessments support the continued chlorophyll-*a* impairment listing. Macroinvertebrate samples were collected from 2 sites in 2004 and 2011 and 3 of 4 HBI scores exceeded the threshold.

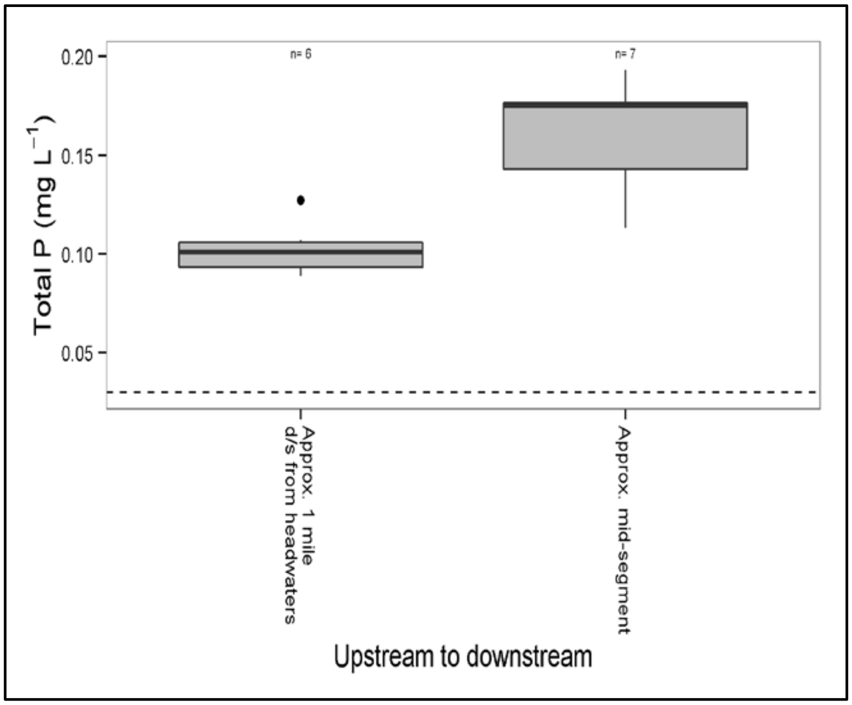

Figure 6-37. TP boxplots for Rattler Gulch.

The uppermost site, approximately 1 mile downstream from the headwaters of Rattler Gulch, had TP concentrations, on average, 3.4 times greater than the target concentration of 0.03 mg/L. The second site from which nutrient samples were collected is approximately mid-segment and has TP concentrations, on average, 5.3 times greater than the target concentration. Target exceedance ratios were plotted for all Rattler Gulch samples and only nutrient concentrations for which an associated flow value was collected are depicted in these figures. Ratios less than 1.0 indicate sample concentrations below the TP target. Flows ranged from 0.02 cfs to 0.24 cfs (**Figure 6-38**). **Figure 6-39** shows the percent reductions for TP loads measured in Rattler Gulch from 2004-2011. Reductions needed to achieve the TMDL range from 66.29% to 83.15% with a median reduction of 74.79%.

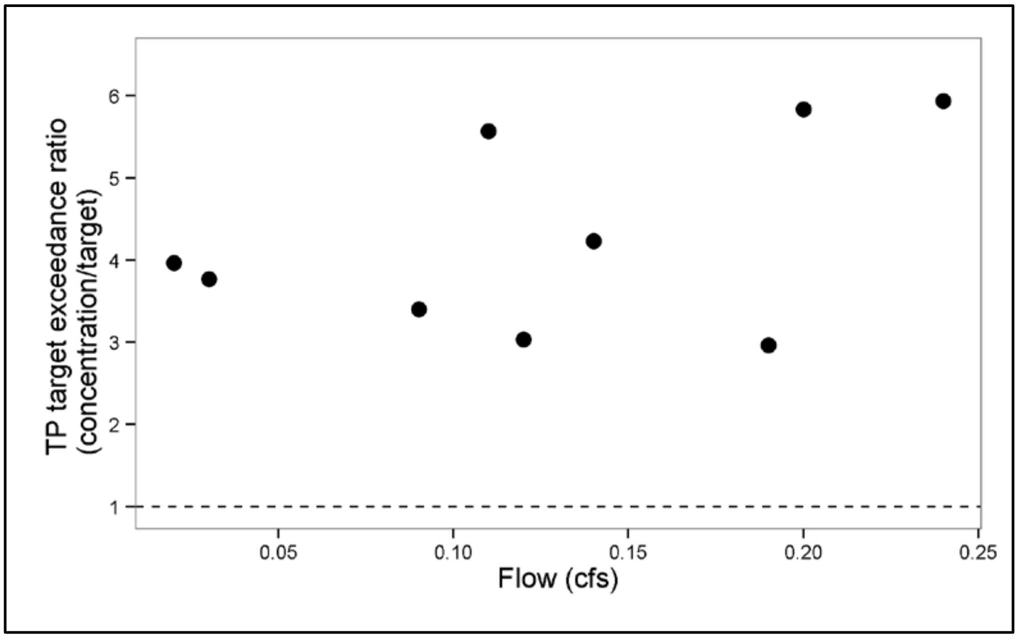

Figure 6-38. TP target exceedance ratio in Rattler Gulch (2004-2011).

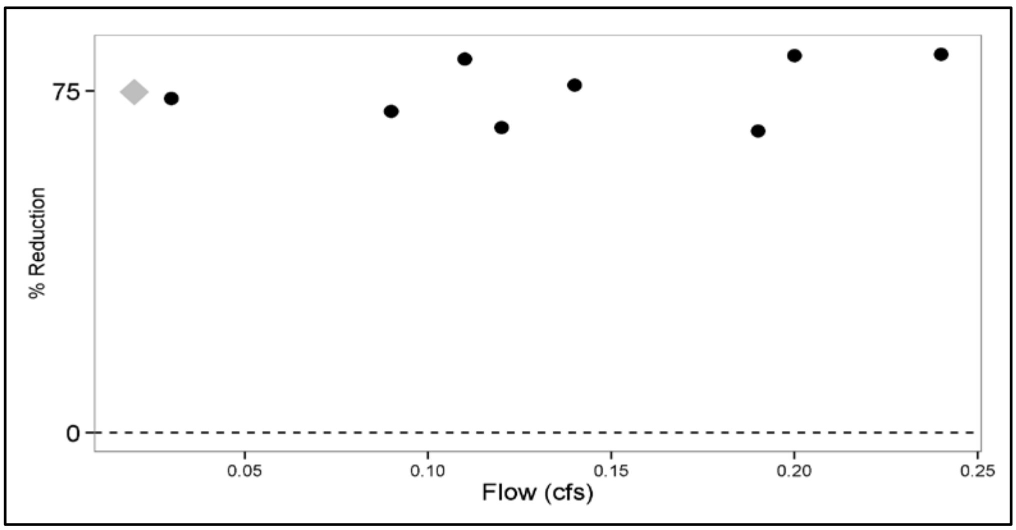

Figure 6-39. Measured TP percent load reductions necessary to achieve the TP TMDL in Rattler Gulch (2004-2011). The gray diamond represents a median percent reduction value used to calculate existing load and percent reductions in the example TMDL for Rattler Gulch.

6.6.8.2 Assessment of Loading by Source Categories

As addressed in **Section 6.4.2** and shown in **Figure 6-36**, the Rattler Gulch soils are volcanic in nature, highly erosive, and likely elevated in phosphorus compared with other soil types encountered in the Middle Rockies Level III ecoregion. There were insufficient data in this area with significant human-caused sources of TP to differentiate between background and human-caused load fractions. Once all reasonable soil, land, and water conservation practices have been implemented in the sub-watershed, further investigation is warranted to establish the background condition based on reference sites within the Rattler Gulch sub-watershed. There has been no recent fire activity in the Rattler Gulch sub-watershed.

Rattler Gulch does not appear on the Montana Department of Fish, Wildlife and Parks dewatered streams list. This list identifies streams that support or contribute to important fisheries that are significantly dewatered, referring to a reduction in streamflow below the point where stream habitat is adequate for fish. However, Rattler Gulch does not have direct surface water connectivity with the Clark Fork River for much of the year as its lower reaches flow only intermittently. This loss of water in the channel to the subsurface appears to be, in part, due to the geology of the sub-drainage where the stream flows across limestone and an alluvial fan near the mouth.

Agriculture

Agriculture is a primary land use and potentially significant nutrient source in the Rattler Gulch sub-watershed, with livestock grazing far more prevalent and likely to be contributing to elevated nutrient concentrations than crop production. With the exception of a very small parcel in the southeastern extent, the entire Rattler Gulch sub-watershed is encompassed by 2 grazing allotments. The Mulkey East allotment number 07108 is 11,561 acres, of which approximately 8,028 acres (69%) are within the Rattler Gulch watershed. Of the total allotment area, 2,758 acres are within public (mostly BLM administered) land and there are 93 permitted animal unit months (AUMs). The Spring Gulch allotment number 07115 is 2,570 acres, of which approximately 1,683 (65%) are within the Rattler Gulch watershed. Of the total allotment area, 1,040 acres are within public (mostly BLM administered) land and there are 64 permitted animal unit months (AUMs).

The Rattler Gulch sub-watershed is 9,841 acres and 3,567 acres (36%) of this is public land. These public lands are all within the 2 grazing allotment boundaries described which have a maximum of 157 permitted AUMs. While it may be unlikely that all 157 permitted AUMs for the entire allotment areas will be grazed exclusively on public lands within the Rattler Gulch sub-watershed, this represents the maximum AUMs possible at any given time. No attempts were made to verify actual grazing practices or current stocking densities.

Recent field observations, photographs and comments in the Rattler Gulch assessment records indicate evidence of livestock grazing in the stream channel and along its riparian corridor, including livestock-caused hummocks and hoof pugging, particularly in the upper reaches.

Land used for pasture and hay production is found interspersed along the entire stream channel but is particularly prevalent in the lower one-third of the stream where there is intermittent flow. A very small portion of irrigated cropland is located near the mouth in the southeastern portion of the drainage although, particularly given lack of connectivity in these lower reaches, this is likely having no discernable impacts on nutrient concentrations in the creek.

Silviculture

Silviculture activities are the other primary land use in the Rattler Gulch sub-watershed. An analysis of aerial imagery and geospatial land cover data suggests silviculture activities are extensive in the Rattler Gulch sub-watershed, particularly in the upper half where much of the land is administered by BLM or owned by a private logging company. Timber harvest has occurred on parcels on both sides of the stream channel and aerial images show a multitude of logging roads in the drainage. Further, as noted in DEQ's Rattler Gulch assessment record and apparent in recent site photographs, the logging road that leads up the sub-drainage along the stream was installed essentially in the middle of the riparian corridor and stream bed itself. Considerable bank alteration and bank instability was noted in stream reaches along this road.

Timber harvest and logging roads exist in close proximity to the stream channel from the headwaters of Rattler Gulch along the stream corridor between the upper and lower site where TP concentrations increase in the downstream direction. Runoff from timber harvest activities and potential sedimentation from logging roads in close proximity of the stream are quite likely introducing phosphorus to the assessment unit. Given the volcanic parent material for soils in the drainage, soils are not only at a greater risk of erosion, but are also likely phosphorus rich compared with other sub-watersheds in the Central Clark Fork Basin Tributaries TMDL Project area.

Mining

According to DEQ records, there are 5 abandoned mines in the Rattler Gulch sub-watershed, none of which appear on DEQ's Priority Mine Sites List (Pioneer Technical Services, Inc., 1995). There is one active permitted mine, Drummond Quarry (limestone), which is situated in the southeastern extent of the Rattler Gulch up a tributary which joins with Rattler Gulch near the mouth. One of the 5 abandoned mines is near the Drummond Quarry, one is just below the uppermost monitoring site location, 1 is above the mouth, 1 is in the south central region of the sub-watershed quite far from the stream channel, and 1, Hitchcock Quarry (calcium), is situated very near the stream channel approximately mid-segment. These sites are having no discernable impact on nutrient water quality.

Subsurface wastewater disposal and treatment

According to DEQ records, there are no individual septic systems in the Rattler Gulch sub-watershed and septic effluent is not a contributor to the existing Rattler Gulch TP load.

6.6.8.3 TP TMDL, Allocations, and Current Loading

The TMDL for TP is based on **Equation 1** and the TMDL allocations are based on **Equation 2**. The value of the TP TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TP TMDL for Rattler Gulch uses **Equation 1** with the flow associated with the median concentration of measured TP values that exceed the target reduction from all sites during 2004-2011 sampling (0.02 cfs , as represented by the gray diamond in Figure 6-39):

TMDL = (0.03 mg/L) (0.02 cfs) (5.4) = 0.003 lbs/day

Equation 4 is the basis for the natural background load allocation for TP. To continue with the example at a flow of 0.02 cfs, this allocation is as follows:

LA_{NB} = (0.01 mg/L) (0.02 cfs) (5.4) = 0.001 lbs/day

Using **Equation 5**, the combined human-caused TP allocation at 0.02 cfs can be calculated:

LA_{H} = 0.003 lbs/day – 0.001 lbs/day = 0.002 lbs/day

An example total existing load is calculated as follows using **Equation 6**, the example flow of 0.02 cfs and the corresponding concentration associated with the median reduction for measured loads that exceed the TMDL for TP in Rattler Gulch from 2004-2011 (0.119 mg/L):

Total Existing Load = (0.119 mg/L) (0.02 cfs) (5.4) = 0.013 lbs/day

The portion of the existing load attributed to human sources is 0.012 lbs/day, which is determined by subtracting out the 0.001 lbs/day natural background load. This 0.012 lbs/day represents the load measured within the stream after potential nutrient uptake.

Table 6-32 summarizes the example TP TMDL, load allocations, and current loading. **Table 6-32** also contains the percent reduction to human-caused load allocation required to meet the water quality target for TP. The percent reduction to natural background is 0%. At the median concentration of measured TP values that exceed the target (0.119 mg/L) and the growing season flow associated with this median concentration (0.02 cfs), the existing loading in Rattler Gulch is greater than the TMDL. Under these example conditions an 81.7% reduction of human-caused sources and an overall 74.8% reduction of TP in Rattler Gulch would result in the TMDL being met. The source assessment of the Rattler Gulch watershed indicates that grazing in the riparian zone and sedimentation from silviculture activities and forest roads is the most likely source of TP in Rattler Gulch; load reductions should focus on limiting and controlling TP loading from these sources. Meeting load allocations for Rattler Gulch may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 7.0**.

This TMDL serves to address the chlorophyll-*a* impairment for Rattler Gulch. By reducing TP loads in Rattler Gulch, it is expected that the potential for excess algae growth and thus chlorophyll-*a* levels will be reduced. By controlling the input of nutrient sources, it is expected that overall nutrient and algae levels will be reduced.

Table 6-32. Rattler Creek TP Example TMDL, Load Allocations, Current Loading, and Reductions

Source Category	Allocation & TMDL (lbs/day)[1]	Existing Load (lbs/day)[1]	Percent Reduction
Natural Background	0.001	0.001	0%
Human-caused (primarily agriculture and silviculture)	0.002	0.012	81.7%
	TMDL = 0.003	**Total = 0.013**	**Total = 74.8%**

[1] Based on a growing season flow of 0.02 cfs.

6.7 Seasonality and Margin of Safety

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

6.7.1 Seasonality

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

- Water quality targets and subsequent allocations are applicable for the summer growing season (July 1 to September 30), to coincide with seasonal algal growth targets.
- Nutrient data used to determine compliance with targets and to establish allowable loads were collected during the summertime period to coincide with applicable nutrient targets.
- Flow values used in calculating example nutrient TMDLs contained in **Section 6.6** were collected during the summer growing season (July 1 to September 30) and are considered representative of low flow conditions during which nutrient concentration and seasonal algal growth targets apply.

6.7.2 Margin of Safety

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

- Static nutrient target values (0.030 mg/L TP, 0.300 mg/L TN, and 0.10 mg/L NO_3+NO_2 for Middle Rockies; 0.025 mg/L TP, 0.275 mg/L TN, and 0.10 mg/L NO_3+NO_2 for Northern Rockies) were used to calculate allowable loads (TMDLs). Allowable exceedances of nutrient targets were not incorporated into the calculation of allowable loads, thereby adding a MOS to established allocations.
- Target values were developed to err on the conservative side of protecting beneficial uses. DEQ's nutrient assessment decision matrix for wadeable streams in mountainous regions of Western Montana considers impacts to both aquatic life/fishes and primary contact recreation, the 2 most sensitive beneficial uses affected by nutrient impairments. The assessment incorporates parameters representing physical (nutrient water chemistry), biological (e.g., periphyton and macroinvertebrates), and aesthetic (benthic algal growth concentrations) properties of these stream systems in a multi-tiered data analysis framework. Further, the nutrient assessment process considers both magnitude and frequency of nutrient target exceedances through the use of 2 statistical tests to help address nutrient uptake. Also, the number of allowable exceedances varies dependent on previous impairment status, taking a "guilty until proven innocent" approach for streams already considered to have water quality problems and to attempt to balance type I (alpha) and type II (beta) errors (Suplee and Sada de Suplee, 2011).
- Seasonality (discussed above) and variability in nutrient loading are considered in target, development, monitoring design, and source assessment.
- An adaptive management approach (discussed below) is recommended to evaluate target attainment and allow for refinement of load allocations, assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development over time.

6.8 Uncertainty and Adaptive Management

Uncertainties in the accuracy of field data, nutrient targets, source assessments, loading calculations, and other considerations are inherent when assessing and evaluating environmental variables for TMDL development. However, mitigation and reduction of uncertainties through adaptive management approaches is a key component of ongoing TMDL implementation and evaluation. The process of adaptive management is predicated on the premise that TMDL targets, allocations, and the analyses supporting them are not static, but are processes subject to modification and adjustment as new information and relationships are understood. Uncertainty is inherent in both the water quality-based and model-based modes of assessing nutrient sources and needed reductions. The main sources of uncertainty are summarized below.

Water Quality Conditions
It was assumed that sampling data for each waterbody segment is representative of conditions in each segment. All segments met the minimum sample size of 12 observations (for previously unlisted AUs) or 13 observations (for previously listed streams). The average sample dataset per AU addressed in **Section 6.4.3** was 15 observations. Future monitoring as discussed in **Section 8.0** should help reduce the uncertainty regarding data representativeness, clarify for streams with TMDLs for both nutrient forms (i.e., TN and TP) whether both forms have a role in causing excess algal growth, improve the understanding of the effectiveness of BMP implementation, and increase the understanding of the loading reductions needed to meet the TMDLs.

It was also assumed that background concentrations are less than the target values, and based on sample data upstream of known sources and from other streams within the Central Clark Fork Basin Tributaries TMDL Project area that are not impaired for nutrients, this appears to be true. However, it is possible that target values are naturally exceeded during certain times or at certain locations in the watershed as was addressed in **Section 6.4.2**. Future monitoring can be designed to help reduce uncertainty regarding background nutrients concentrations particularly in sub-watersheds with volcanic surficial geology.

7.0 Temperature TMDL Components

This portion of the document focuses on temperature as an identified cause of water quality impairment in the Central Clark Fork Tributaries TMDL Project Area. It describes: (1) the mechanisms by which temperature affects beneficial uses of streams; (2) the stream segment of concern; (3) information sources used for temperature TMDL development; (4) temperature target development; (5) assessment of sources contributing to excess thermal loading; (6) existing condition and comparison to targets; (7) the temperature TMDL and allocations; (8) seasonality and margin of safety; and (9) uncertainty and adaptive management.

7.1 Temperature (Thermal) Effects on Beneficial Uses

Human influences that reduce stream shade, increase stream channel width, add heated water, or decrease the capacity of the stream to buffer incoming solar radiation all increase stream temperatures. Warmer temperatures can negatively affect aquatic life that depends upon cool water for survival. Coldwater fish species are more stressed in warmer water temperatures, which increases metabolism and reduces the amount of available oxygen in the water. Coldwater fish and other aquatic life may feed less frequently and use more energy to survive in thermal conditions above their tolerance range, which can result in fish kills. 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). Although the TMDL will address increased summer temperatures as the most likely to cause detrimental effects on fish and aquatic life, human influences on stream temperature, such as those that reduce shade, can lead to lower minimum temperatures during the winter (Hewlett and Fortson, 1982). Lower winter temperatures can lead to the formation of anchor and frazil ice which can harm aquatic life by causing changes in movement patterns (Brown, 1999; Jakober et al., 1998), reducing available habitat, and inducing physiological stress (Brown et al., 1993). Addressing the issues associated with increased summer maximum temperatures will also address these potential winter problems. 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.

7.2 Stream Segments of Concern

Three waterbodies in the Central Clark Fork Tributaries project area appear on the 2014 Montana impaired waters list as having temperature limiting a beneficial use: Nemote Creek, Petty Creek, and Grant Creek (**Section 2.1**, **Figure 2-1**).To help put sampling data into perspective and understand how elevated stream temperatures may affect aquatic life, information on fish presence in these streams and temperature preferences for the most sensitive species are described below.

7.2.1 Fish Presence and Temperatures of Concern

Because different fish species have varying optimal temperature ranges for survival and some are more sensitive than others to elevated stream temperatures, it is important to identify the fish species within each stream segment of concern.

7.2.1.1 Fish Presence in Nemote Creek

Based on a query of the Montana Fisheries Information System (MFISH), rainbow trout and westslope cutthroat trout are common, and brook trout are rare (MFISH, 2014). Although Nemote Creek is a tributary to the Clark Fork River, which is used rarely by migrating bull trout (MFISH, 2014), no bull trout are recorded in Nemote Creek. Nemote Creek is not within identified bull trout core or node areas (MFISH, 2014). According to the Montana Fish, Wildlife, and Parks fisheries resource value ratings, Nemote Creek is considered "Moderate-Value" (rating score 4) from river mile 0 to 3.9 and the remainder to river mile 9.8 is "Substantial" (rating score 3) (MFISH 2014).

7.2.1.2 Fish Presence in Petty Creek

Based on a query of MFISH, Columbia slimy sculpin, rainbow trout, slimy sculpin, and westslope cutthroat trout are abundant to common, and brook trout, brown trout, bull trout, and sucker are rare. Mountain whitefish and rainbow-cutthroat hybrids are reported, but with unknown abundance (MFISH, 2014). Petty Creek is a bull trout core area from river miles 0.123 to 11.6, but is not within a bull trout node area (MFISH, 2014). According to the Montana Fish, Wildlife, and Parks fisheries resource value ratings, the entire length of Petty Creek from river mile 0 to 6.4 and from river mile 6.4 to 11.6 is considered "Outstanding" (rating score 1) (MFISH 2014).

7.2.1.3 Fish Presence in Grant Creek

Based on a query of MFISH, brook trout, brown trout, bull trout, rainbow trout, and westslope cutthroat trout are common, and mountain whitefish and sculpin are rare. Brook-bull trout hybrids are reported, but with unknown abundance (MFISH, 2014). Grant Creek is not within identified bull trout core or node areas (MFISH, 2014). According to the Montana Fish, Wildlife, and Parks fisheries resource value ratings, all of Grant Creek is considered "High-Value" (rating score 2) from river mile 0 to 16.8 (MFISH 2014).

7.2.1.4 Temperature Levels of Concern

Special temperature considerations are warranted for the westslope cutthroat trout, which are identified in Montana as species of concern, and for the bull trout, which are classified as threatened by the US Fish and Wildlife Service. Research by Bear et al. (2007) found that westslope cutthroat maximum growth occurs around 56.5°F, with an optimum growth range (based on 95% confidence intervals) from 50.5–62.6°F. The ultimate upper incipient lethal temperature (UUILT) is the temperature considered to be survivable by 50% of the population over a specified time period. Bear et al. (2007) found the 60-day UUILT for westslope cutthroat trout to be 67.3°F and the 7-day UUILT to be 75.4°F. Considering a higher level of survival, the lethal temperature dose for westslope cutthroat that will kill 10% of the population in a 24-hour period is 73.0°F (Lines and Graham 1988).

Bull trout are listed as threatened under the U.S. Endangered Species Act. UUILT 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), with an optimum growth range of 51.6°F to 59.7°F (Selong et al., 2001).

7.3 Information Sources and Data Collection

As part of this TMDL project, DEQ used several information and data sources to assess temperature conditions in these streams:

- DEQ assessment file information
- 2011 DEQ/EPA stream temperature, flow, riparian shade, and channel geometry data

As discussed in **Appendix B** and **Section 7.4.1**, Montana defines that temperature impairment occurs when human sources cause instream temperatures to exceed a certain threshold above the naturally-occurring water temperature. The naturally-occurring instream temperature is that which results when human sources are implementing all reasonable land, soil, and water conservation practices. Because interpreting the standard is more complex than just comparing measured temperatures to the temperature levels of concern discussed above, a QUAL2K water quality model was needed to determine if human sources are causing the allowable temperature change to be exceeded. Model details are presented in **Appendix G** but the model summary and outcome is provided in **Section 7.5**, **Source Assessment**. To assist with model development and assessment of temperature conditions in these streams, two other categories of data were needed:

- Climate Data
- Montana Department of Natural Resources and Conservation (DNRC) water usage data

7.3.1 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.

7.3.2 Nemote Creek Temperature Related Field Data Collection

7.3.2.1 Temperature Monitoring

In summer 2011, an EPA contractor (Atkins) deployed six temperature loggers in Nemote Creek and two temperature loggers at the mouth of tributaries South Fork Nemote Creek and Miller Creek (**Figure 7-1**). The loggers were deployed on July 12 and 13. All loggers recorded temperatures every 30 minutes until they were retrieved in mid-September (14^{th} and 15^{th}). Water temperature data were collected when streamflow tends to be the lowest and air temperatures the highest because that is when aquatic life are exposed to the highest water temperatures of the year. Temperature monitoring sites on Nemote Creek were selected to bracket stream reaches with similar hydrology, riparian vegetation type, valley type, stream aspect, and channel width. Tributary loggers were deployed in the two major tributaries to help with model development and to identify if those tributaries are having a warming or cooling effect on Nemote Creek. Loggers were deployed following DEQ protocols and a Quality Assurance Project Plan (DEQ 2005a; DEQ 2005b; Atkins 2012). Temperature data can be obtained by contacting DEQ but are summarized within this document and **Attachment A** of **Appendix G**.

7.3.2.2 Streamflow

Streamflow measurements were collected following DEQ protocols at all temperature monitoring sites (**Figure 7-1**) during logger deployment (July) and logger retrieval (September). Additionally, DEQ collected flow measurements to support other studies in August and early September. There was no streamflow just below South Fork Nemote Creek (NMTC-T6), nor at the mouth of that tributary (NMTC-T5), during logger retrieval (**Figure 7-1**).

7.3.2.3 Riparian Shading

Characterization of riparian shade is based on a combination of field data and aerial imagery analysis. EPA and DEQ used a Solar Pathfinder to measure effective shade in September 2011 at six locations on Nemote Creek near the temperature logger sites (**Figure 7-1**). Effective shade is the percent reduction of incoming solar radiation that reaches the stream because of riparian vegetation and topography. Because of the variability in riparian cover and topography throughout the watershed, a GIS-based model called TTools (v.3.0) (Oregon Department of Environmental Quality 2001) was used along with field measurements for trees, shrubs, and herbaceous vegetation and a spreadsheet tool (Shadev3.0.xls) (Washington State Department of Ecology 2012) to estimate the hourly effective shade approximately every 100 feet along the entire stream. The analysis was performed using August 2012 Google Earth aerial imagery to classify vegetation into broad categories (i.e., bare ground/road, herbaceous, shrub, and trees). The 2001 National Land Cover Database identified percent canopy cover for trees, and that information was used to classify trees as sparse, low, medium, or high density. Although the six Solar Pathfinder measurements were sparse compared to the Shade model output, they indicate the model reasonably approximated effective shade along Nemote Creek; the average error between the field measurements and model output was 8%. Additional details regarding the shade assessment are contained in **Attachment A** of **Appendix G**.

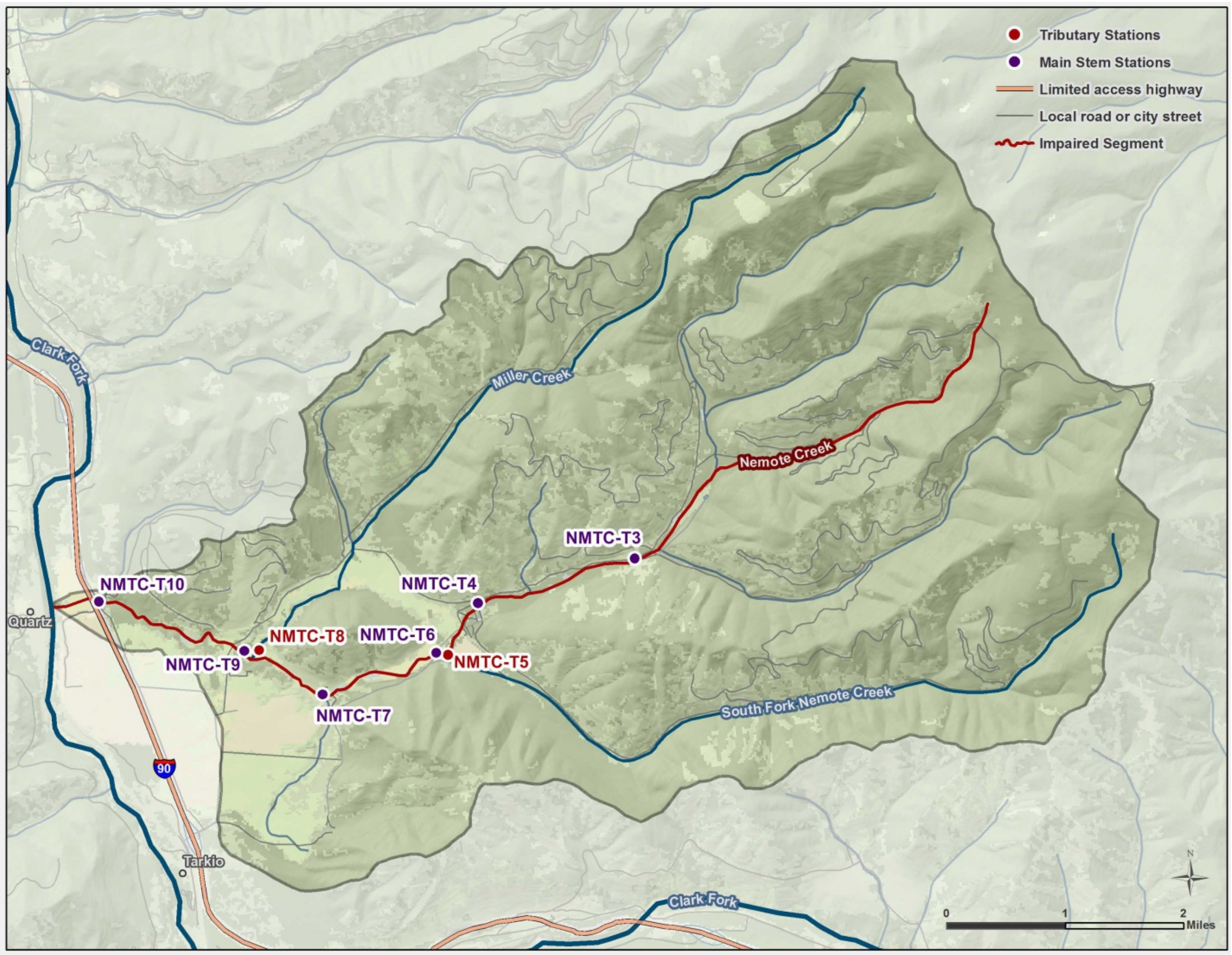

Figure 7-1. Temperature and shade monitoring locations on Nemote Creek

7.3.2.4 Channel Geometry

Channel geometry (i.e., width and depth) can influence the rate of thermal loading and is a necessary input for the QUAL2K model. Wide, shallow streams transfer heat energy faster than narrow, deep streams. Human activities that alter peak flows or disturb the riparian vegetation, streambanks, and/or stream channel have the potential to alter channel geometry. Therefore, channel geometry can be used to identify areas that may be destabilized and more prone to rapid thermal loading, particularly in locations where shading is minimal. Channel width (wetted and bankfull) was collected at each of the Nemote Creek shade sites in 2011 (**Figure 7-1**).

7.3.3 Petty Creek Temperature Related Field Data Collection

7.3.3.1 Temperature Monitoring

In summer 2012, an EPA contractor (Atkins) deployed six temperature loggers in Petty Creek and five temperature loggers at the mouth of major tributaries (**Figure 7-2**). An additional logger was placed in West Fork Petty Creek, but was lost due to bridge construction. The loggers were deployed on June 27 and 28. All loggers recorded temperatures every 30 minutes until they were retrieved on October 11. Water temperature data were collected when streamflow tends to be the lowest and air temperatures the highest because that is when aquatic life are exposed to the highest water temperatures of the year. Temperature monitoring sites on Petty Creek were selected to bracket stream reaches with similar hydrology, riparian vegetation type, valley type, stream aspect, and channel width. Tributary loggers were deployed in the major tributaries of Printers, John's, Ed's, Madison, and Reservoir creeks to help with model development and to identify if those tributaries are having a warming or cooling effect on Petty Creek. Loggers were deployed following DEQ protocols and a Quality Assurance Project Plan (DEQ 2005a; DEQ 2005b; Atkins 2012). In addition to the continuously recording data loggers, Atkins and DEQ collected instantaneous temperature measurements in July, August, and September. Temperature data can be obtained by contacting DEQ but are summarized within this document and **Attachment A** of **Appendix G**.

7.3.3.2 Streamflow

Streamflow measurements were collected following DEQ protocols at all temperature monitoring sites (**Figure 7-2**) during logger deployment (June), mid-season (July 30-August 1), and during logger retrieval (September). Additionally, DEQ collected flow measurements to support other studies in late June, early and late July and early October. By mid-July and August, a segment of Petty Creek between John's Creek and Ed's Creek ran dry, until surface flow began again near Bruce Creek (known locally as Gus Creek). By October, Petty Creek ran dry in the segment with logger PTTYC-T2, upstream of the confluence with West Fork Petty Creek, and between logger PTTYC-T5 and PTTYC-T6. Segments of Madison and Reservoir creeks were also dry channels by October. Interviewed landowners also reported other segments of Petty Creek typically run dry each year.

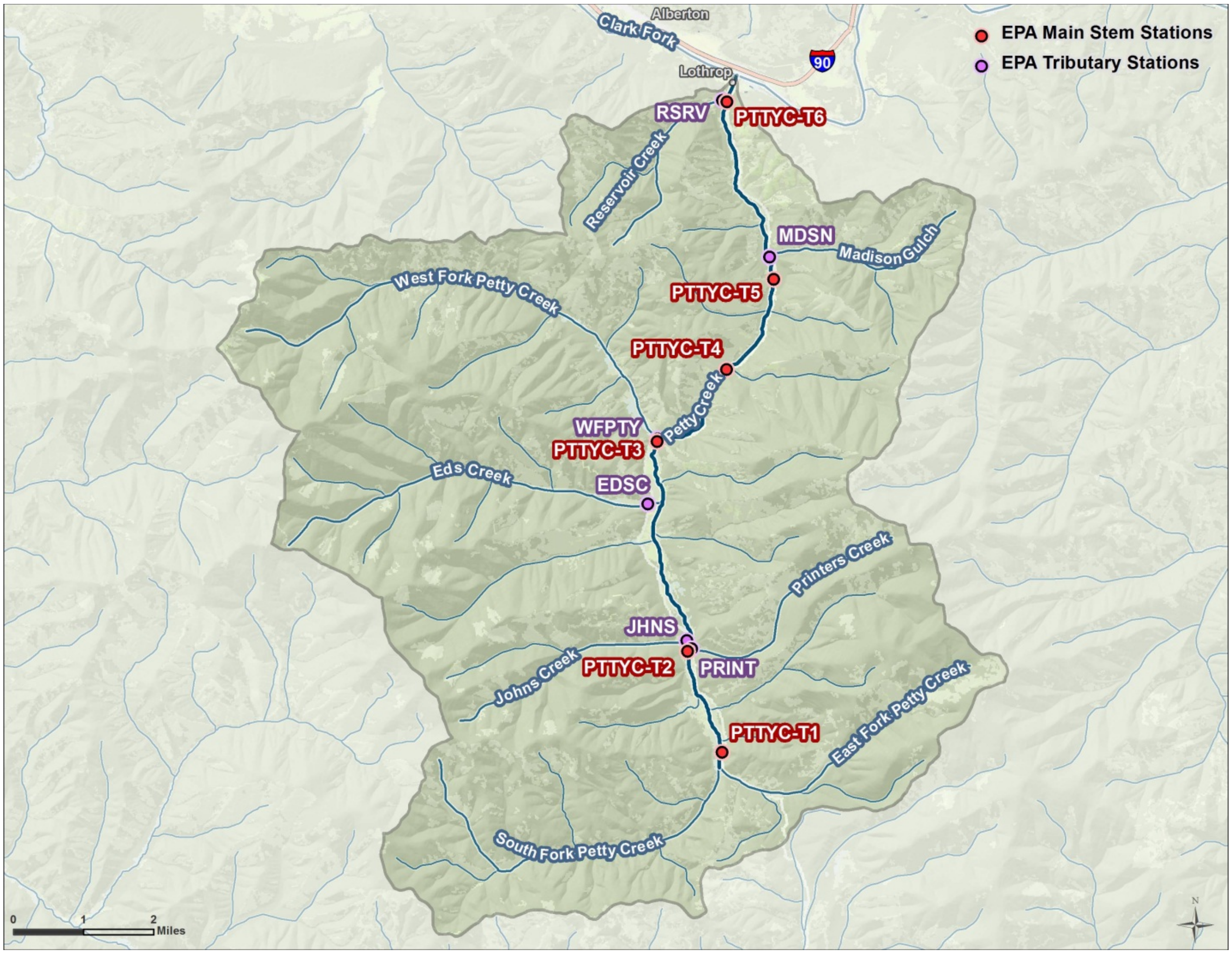

Figure 7-2. Temperature monitoring locations on Petty Creek

7.3.3.3 Riparian Shading

Characterization of riparian shade is based on a combination of field data and aerial imagery analysis. EPA and DEQ used a Solar Pathfinder to measure effective shade on July 30 and August 1, 2012 at ten locations on Petty Creek (**Figure 7-3**). Effective shade is the percent reduction of incoming solar radiation that reaches the stream because of riparian vegetation and topography. Because of the variability in riparian cover and topography throughout the watershed, a GIS-based model called TTools (v.3.0) (Oregon Department of Environmental Quality 2001) was used along with field measurements for trees, shrubs, and herbaceous vegetation and a spreadsheet tool (Shadev3.0.xls) (Washington State Department of Ecology 2012) to estimate the hourly effective shade approximately every 100 feet along the entire stream. The analysis was performed using August 2012 Google Earth aerial imagery to classify vegetation into broad categories (i.e., bare ground/road, herbaceous, shrub, and trees). The 2001 National Land Cover Database identified percent canopy cover for trees, and that information was used to classify trees as sparse, low, medium, or high density. Although the ten Solar Pathfinder measurements were sparse compared to the Shade model output, they indicate the model reasonably approximated effective shade along Petty Creek; the average error between the field measurements and model output was 7%. Additional details regarding the shade assessment are contained in **Attachment A** of **Appendix G**.

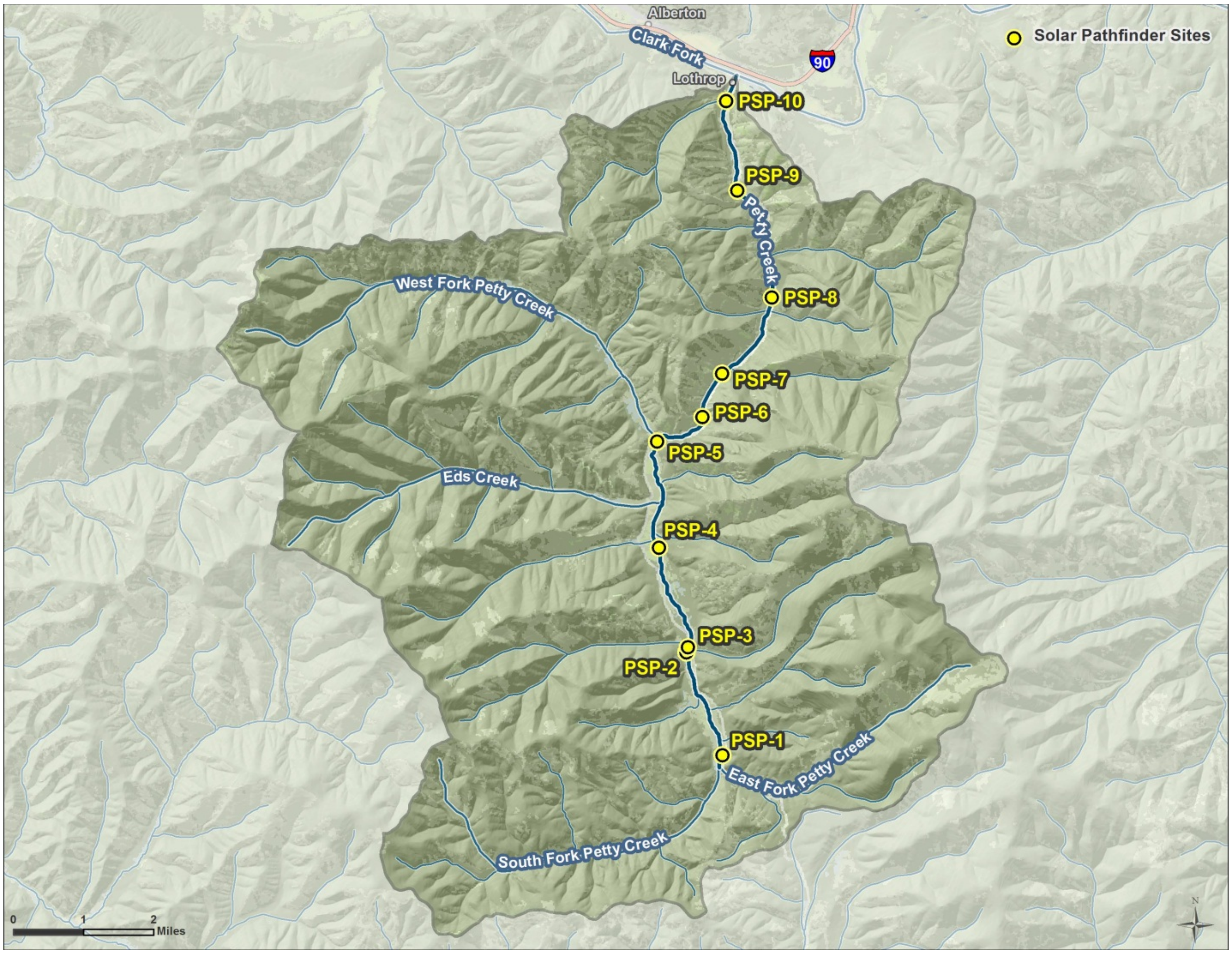

Figure 7-3. Shade monitoring locations on Petty Creek

7.3.3.4 Channel Geometry

Channel geometry (i.e., width and depth) can influence the rate of thermal loading and is a necessary input for the QUAL2K model. Wide, shallow streams transfer heat energy faster than narrow, deep streams. Human activities that alter peak flows or disturb the riparian vegetation, streambanks, and/or stream channel have the potential to alter channel geometry. Therefore, channel geometry can be used to identify areas that may be destabilized and more prone to rapid thermal loading, particularly in locations where shading is minimal. Channel width (wetted and bankfull) was collected at each of the Petty Creek shade sites in 2012 (**Figure 7-2**).

7.3.4 Grant Creek Temperature Related Field Data Collection

7.3.4.1 Temperature Monitoring

In summer 2011, an EPA contractor (Atkins) deployed eight temperature loggers in Grant Creek and one temperature loggers at the mouth of East Fork Grant Creek (**Figure 7-4**). The loggers were deployed on July 11. All loggers recorded temperatures every 30 minutes until they were retrieved on September 20. Water temperature data were collected when streamflow tends to be the lowest and air temperatures the highest because that is when aquatic life are exposed to the highest water temperatures of the year. Temperature monitoring sites on Grant Creek were selected to bracket stream reaches with similar hydrology, riparian vegetation type, valley type, stream aspect, and channel width. A logger was deployed in the major tributary of East Fork Grant Creek to help with model development and to identify if East Fork Grant Creek has a warming or cooling effect on Grant Creek. Loggers were deployed following DEQ protocols and a Quality Assurance Project Plan (DEQ 2005a; DEQ 2005b; Atkins 2012). Due to high flow conditions during deployment in July, the loggers at sites GRTC-T8 and GRTC-T9 could not be placed low enough in the channel, and were subsequently exposed to ambient air by late July as flows declined. The logger at GRTC-T7 was also probably in an isolated pool or exposed by early August, and was definitely dry by late August. In addition to the continuously recording data loggers, DEQ collected instantaneous temperature measurements in September in support of other projects. Temperature data can be obtained by contacting DEQ but are summarized within this document and **Attachment A** of **Appendix G**.

7.3.4.2 Streamflow

Streamflow measurements were collected following DEQ protocols at six temperature monitoring sites (**Figure 7-4**) during logger deployment in July. Water levels at sites GRTC-T3, GRTC-T4, and GRTC-T5 were too high to wade safely, and flow was not measured at these locations in July. Flow was measured at all sites during logger retrieval in September, except for the uppermost station, where flow was estimated.

7.3.4.3 Riparian Shading

Characterization of riparian shade is based on a combination of field data and aerial imagery analysis. EPA and Atkins used a Solar Pathfinder to measure effective shade on September 15, 2011 at six locations on Grant Creek (**Figure 7-4**). Effective shade is the percent reduction of incoming solar radiation that reaches the stream because of riparian vegetation and topography. Because of the variability in riparian cover and topography throughout the watershed, a GIS-based model called TTools (v.3.0) (Oregon Department of Environmental Quality 2001) was used along with field measurements for trees, shrubs, and herbaceous vegetation and a spreadsheet tool (Shadev3.0.xls) (Washington State Department of Ecology 2012) to estimate the hourly effective shade approximately every 100 feet along the entire stream. The analysis was performed using August 2012 Google Earth aerial imagery to classify vegetation into broad categories (i.e., bare ground/road, herbaceous, shrub, and trees). The 2001 National Land Cover Database identified percent canopy cover for trees, and that information was used to classify trees as sparse, low, medium, or high density. Although the six Solar Pathfinder measurements were sparse compared to the Shade model output, they indicate the model reasonably approximated effective shade along Grant Creek; the average error between the field measurements and model output was 8%. Additional details regarding the shade assessment are contained in **Attachment A** of **Appendix G**.

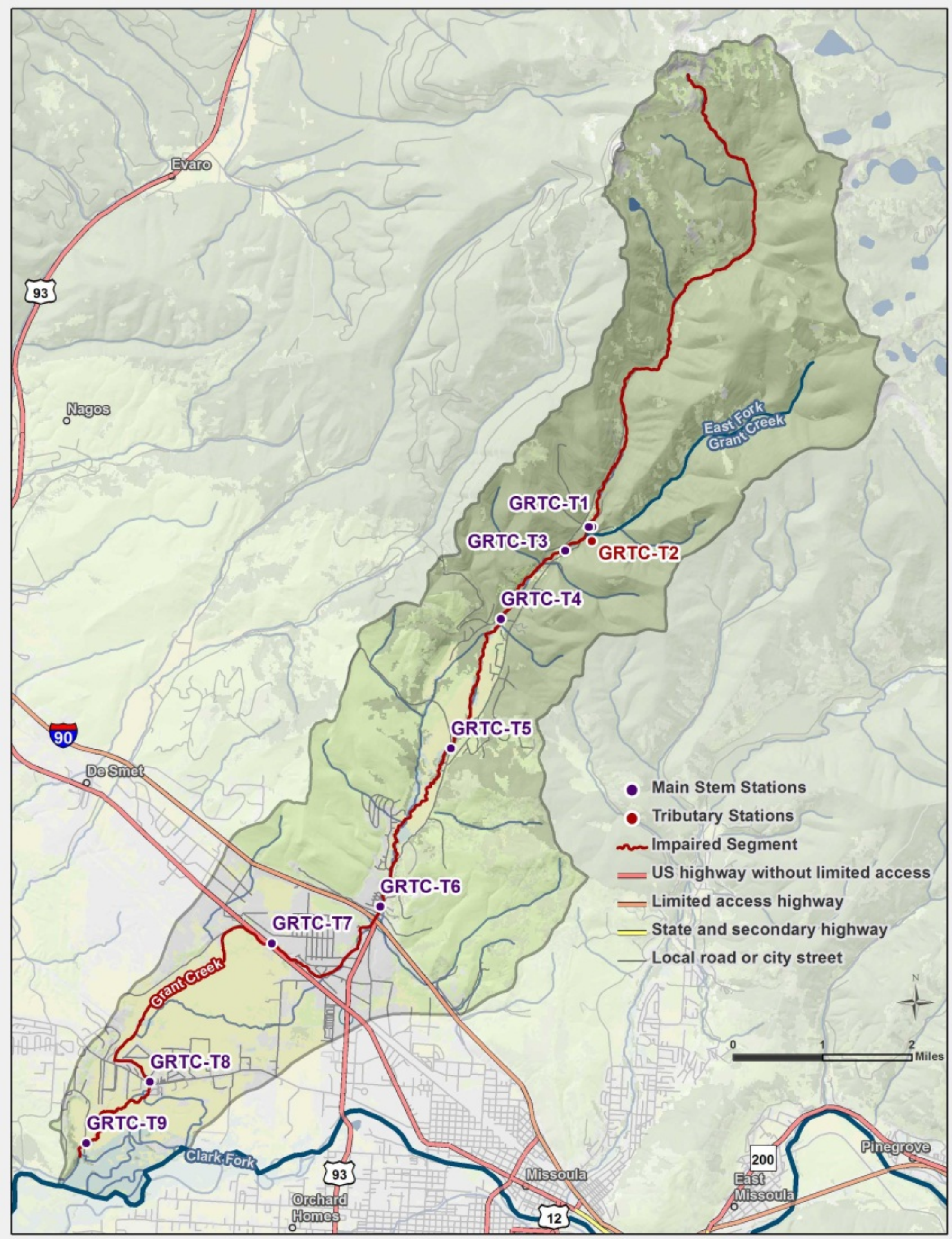

Figure 7-4. Temperature, flow, and shade monitoring locations in Grant Creek

7.3.4.4 Channel Geometry

Channel geometry (i.e., width and depth) can influence the rate of thermal loading and is a necessary input for the QUAL2K model. Wide, shallow streams transfer heat energy faster than narrow, deep streams. Human activities that alter peak flows or disturb the riparian vegetation, streambanks, and/or stream channel have the potential to alter channel geometry. Therefore, channel geometry can be used to identify areas that may be destabilized and more prone to rapid thermal loading, particularly in locations where shading is minimal. Channel width (wetted and bankfull) was collected at each of the Grant Creek shade sites in 2011 (**Figure 7-4**).

7.3.5 Climate Data

Climate data, including air temperature, dew point temperature, wind speed, and cloud cover, are major inputs to the QUAL2K model and are also drivers for stream temperature. Climatic data inputs, including hourly air temperature, were obtained from nearby stations. Although other climate stations were queried, Remote Automatic Weather Stations (RAWS) record data hourly, and data from these stations were used for the QUAL2K models:

- Nemote Creek: Nine Mile RAWS (241507), nine miles east
- Petty Creek: Nine Mile RAWS (241507), nine miles north
- Grant Creek: Missoula RAWS (241513), two miles south

7.3.6 DRNC Water Usage Data

Spatial DNRC water usage data that includes identification of active points of diversion and places of use was obtained from the Natural Resources Information System (NRIS, 2013). This information was necessary because streamflow is an important input for the QUAL2K model and irrigation withdrawals have the potential to influence stream temperatures.

7.3.7 MPDES Permits

EPA's database of regulated discharges was queried. No MPDES-permitted facilities are located on Nemote Creek or Petty Creek. Two permits are associated with Grant Creek. The Missoula Municipal Separate Storm Sewer System (MS4) includes a portion of the Grant Creek Watershed. The Motel Partners I - Econolodge (MT0029840) is permitted to discharge non-contact cooling water from a heat exchanger to Grant Creek. The permit is limited to a discharge of 60 gallons per minute (0.133 cfs) and a maximum temperature of 58°F. The facility is required to monitor effluent flow volume and temperature and must also monitor upstream and instream temperature in Grant Creek.

DEQ isolated areas of the Missoula MS4 that drain to surface water (rather than groundwater via sumps or infiltration ponds) for a previous study (DEQ, 2014). Based on the results of that analysis, an estimated 2.3 square miles (1,471 acres) of the Grant Creek watershed drains stormwater to Grant Creek (**Figure 7-5**). This area is mostly low-to-medium intensity development and grassland.

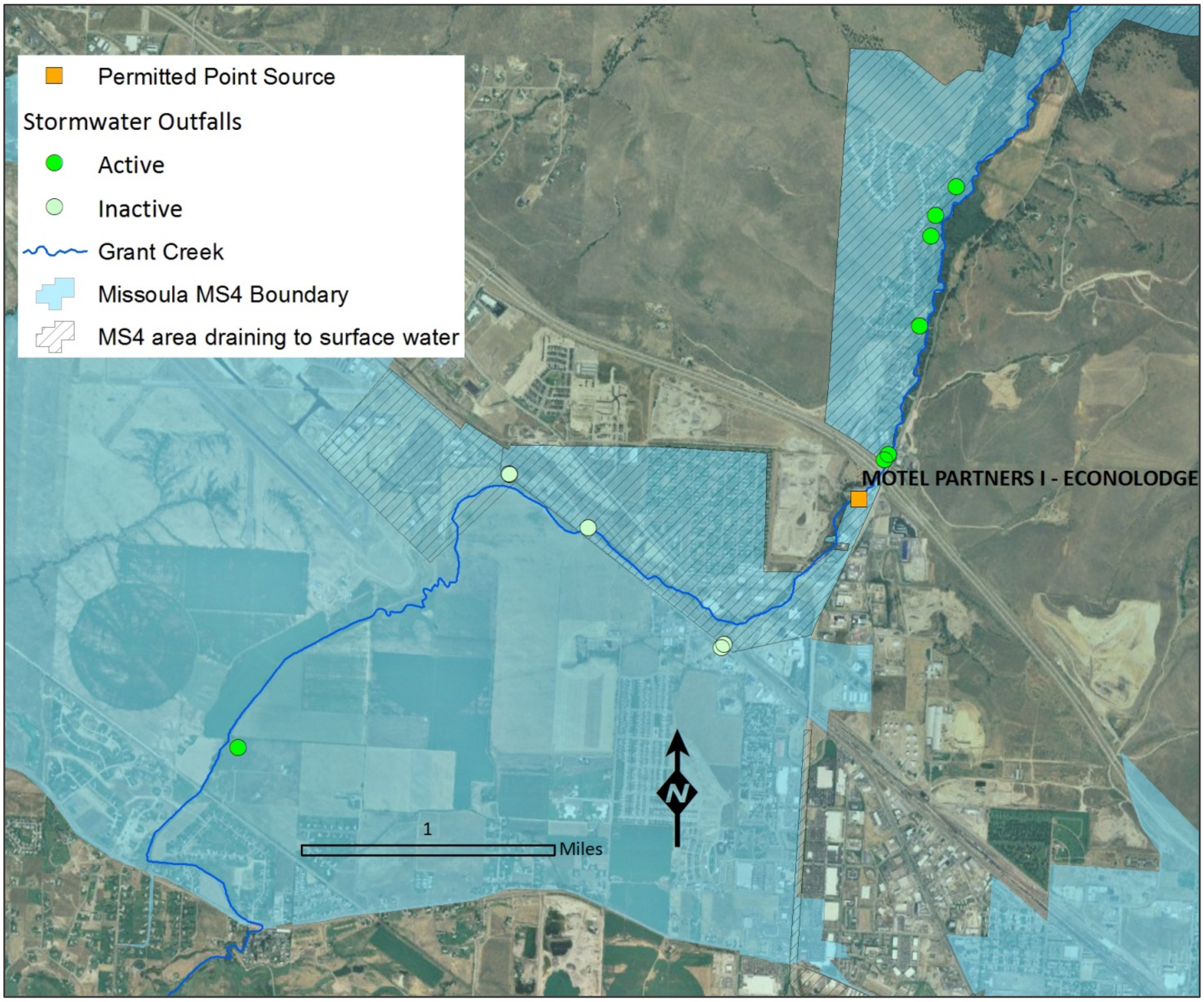

Figure 7-5. Detail of Missoula MS4 area discharging to Grant Creek.

Land use and land cover mapped in the 2006 National Land Cover Database (Fry, et al., 2011) within the MS4 areas of Grant Creek draining to surface water are summarized below in **Table 7-1**.

Table 7-1 Land use and cover in the Grant Creek MS4 areas

Land Cover Type	Acres	Square Miles	Percent
Developed, Low Intensity	359.83	0.562	24%
Grassland/Herbaceous	297.12	0.464	20%
Developed, Medium Intensity	229.51	0.359	16%
Evergreen Forest	204.83	0.320	14%
Pasture/Hay	169.91	0.265	12%
Developed, Open Space	100.52	0.157	6.8%
Woody Wetlands	64.05	0.100	4.4%
Developed, High Intensity	25.58	0.040	1.7%
Cultivated Crops	9.12	0.014	0.6%
Shrub/Scrub	5.12	0.008	0.3%
Mixed Forest	3.34	0.005	0.2%
Deciduous Forest	2.45	0.004	0.2%

7.4 Target Development

The following section describes 1) the framework for interpreting Montana's temperature standard; 2) the selection of target parameters and values used for TMDL development; and 3) a summary of the temperature target values for Nemote, Petty, and Grant Creeks.

7.4.1 Framework for Interpreting Montana's Temperature Standard

Montana's water quality standard for temperature is narrative in that it specifies a maximum allowable increase above the naturally occurring temperature to protect designated beneficial uses, including fish and aquatic life. Under Montana water quality law, naturally occurring temperatures incorporate natural sources and human sources that are applying all reasonable land, soil, and water conservation practices. Naturally occurring temperatures can be estimated for a given set of conditions using QUAL2K or other modeling approaches, but because water temperature changes daily and seasonally, no single temperature value can be identified to represent standards attainment. Therefore, in addition to evaluating if human sources are causing the allowable temperature change to be exceeded, a suite of temperature TMDL targets were developed to translate the narrative temperature standard into measurable parameters that collectively represent attainment of applicable water quality standards at all times. The goal is to set the target values at levels that occur under naturally occurring conditions but are conservatively selected to incorporate an implicit margin of safety that helps account for uncertainty and natural variability. The target values are protective of the use most sensitive to elevated temperatures, aquatic life; as such, the targets are protective of all designated uses for the applicable waterbody segments.

For all three streams, QUAL2K models were used to estimate the extent of human influence on temperature by evaluating the temperature change between existing conditions and naturally occurring conditions. The models used the data described in **Section 7.3** to simulate existing conditions, and then the models were re-run with riparian shade and water use altered to reflect naturally occurring conditions. If the modeled temperature change between the two scenarios (i.e., existing and naturally occurring) is greater than allowed by the water quality standard (i.e., 0.5-1.0°F, depending on the naturally occurring temperature), then the existing temperature impairment is confirmed. This section discusses whether the model outcome supports the existing impairment listing, but model scenario details are presented in **Section 7.5**, **Source Assessment**, and **Appendix G**.

7.4.2 Temperature Target Parameters and Values

The primary temperature target is the allowable human-caused temperature change (i.e., 0.5-1.0°F, depending on the naturally occurring temperature), and the other targets are those parameters that influence temperature and can be linked to human causes. The other targets DEQ normally uses for temperature TMDL development are riparian shade, channel geometry, and improved streamflow conditions, where applicable. If the impacts associated with modest water use improvements are minor, or if water conservation does not appear to be the predominant cause of temperature impairment (as determined via the source assessment modeling discussed below), then instream flow is addressed as a supplemental indicator versus as a formal target. The targets are described in more detail below.

7.4.2.1 Allowable Human-Caused Temperature Change

The target for allowable human-caused temperature change for Nemote, Petty and Grant Creeks links directly to the allowable temperature changes within the numeric portion of numeric portion of

Montana's temperature standard for B-1 streams [**ARM 17.30.623(e)**]: When the naturally occurring temperature is less than 66°F, the maximum allowable increase is 1°F. Within the naturally occurring temperature range of 66–66.5°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. As stated above, naturally occurring temperatures incorporate natural sources, yet also include human sources that are applying all reasonable land, soil, and water conservation practices.

7.4.2.2 Riparian Shade

Increased shading from riparian vegetation reduces sunlight hitting the stream and, thus reduces the 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 (Poole and Berman 2001). In addition, lack of established riparian areas can lead to bank instability, which can result in an overwidened channel.

Two differing approaches were used for developing shade targets. For Petty Creek, the approach is based on a riparian buffer target that will provide the effective shade consistent with a naturally occurring condition. For Nemote and Grant, the target is based on an effective shade value that would result from a naturally occurring riparian buffer.

Petty Creek

To help minimize the influence of upland activities on stream temperature, a riparian buffer close to 100 feet is commonly recommended (Ledwith, 1996; Knutson and Naef 1997; Ellis 2008). However, several studies have shown that most (85-90%) of the maximum shade potential is obtained within the first 50 feet (Brazier and Brown 1973; Broderson, 1973; Steinblums et al. 1984) or 75 feet of the channel (CH2M Hill, 2000; Castelle and Johnson 2000; Christensen 2000). The NRCS Conservation Practice Standard recommends a minimum buffer width of 35 feet, and also includes recommendations to use species with a medium or high shade value and to meet the minimum habitat requirements of aquatic species of concern (NRCS 2011a; 2011b). Based on several literature sources finding that most shade is obtained within a buffer width of 50 feet, and that 50 feet is the minimum buffer width for the Montana Streamside Management Zone (DNRC, 2006), the riparian shade target is a buffer width of 50 feet. Although the target is 50 feet, the USFS abides by Inland Native Fish Strategy standards for Riparian Habitat Conservation Areas, which sets a buffer ranging from a minimum of 50 feet for seasonally flowing streams to a minimum of 300 feet for fish-bearing streams (USFS 1995). The use of a wider buffer accounts for the influence that buffers can have on additional stream health factors, such as large woody debris.

Based on areas of reference riparian health observed in the field, as well as the NRCS recommendation for buffers with medium to high shade value, this 50 foot buffer should consist of medium density trees, dense hydrophytic shrubs, or any vegetation providing equivalent effective shade. The target does not apply to portions where the riparian zone is already at potential or is dominated by vegetation not likely to attain great heights at maturity (e.g., wetland shrub community).

DEQ realizes most healthy riparian buffers are composed of more than a single category of vegetation, but a buffer of medium density trees or dense hydrophytic shrubs is used as the Petty Creek shade target for two reasons: 1) the actual composition of the riparian zone under target shade conditions will vary over time and is too complex to model with QUAL2K, and 2) based on existing vegetation in the watershed and what is known of historical conditions, the effective shade provided by medium density trees or dense hydrophytic shrubs was determined to be a reasonable target. Considering the variability in potential vegetation and shade, these vegetation categories were used as surrogates to represent the average achievable shade condition; effective shade is the result of topography and vegetative height and density, so the target shade condition could be achieved by a large combination of vegetation types and densities. Additionally, the effective shade potential at any given location may be lower or higher than the target depending on natural factors such as fire history, soil, topography, and aspect but also because of human alterations to the near-stream landscape including roads and riprap that may not feasibly be modified or relocated.

Nemote and Grant Creeks
For Nemote Creek and Grant Creek, DEQ used a new approach, identifying reaches where the riparian shade is likely at potential and setting corresponding average effective shade as the target for the shade-deficient reaches. The approach applied to each stream, along with the detailed analysis used to derive the effective shade targets are discussed in more detail below in **Sections 7.5.1.3** and **7.5.3.3**.

The shade target is provided as a quantitative guide for field assessment of standard attainment. Since it is intended to represent a naturally occurring condition after implementation of all reasonable land, soil, and water conservation practices, then application of these practices will eventually result in these streams will be meeting the riparian shade target. Nevertheless, there could be a time lag between application of the reasonable land, soil, and water conservation practices necessary to obtain a healthy stream buffer and meeting the shade targets since it can take years or even decades for trees to grow in areas where they have been removed or negatively impacted.

7.4.3.3 Width/Depth Ratio

A narrower channel with a lower width/ depth ratio results in a smaller contact area with warm afternoon air and is slower to absorb heat (Poole and Berman 2001). Also, a narrower channel increases the effectiveness of shading produced by the riparian canopy. Width/depth targets are discussed in more detail in **Section 5.4.1**. A target for width/depth ratio was developed for the Petty Creek sediment/habitat assessment using Northern Rockies reference data (**Section 5.4.3.4**), and is also applicable to Nemote Creek, which is in the same ecoregion. However, Nemote Creek has not been assessed for sediment/habitat impairment, and width/depth ratio data are not available.

The Grant Creek sediment TMDL incorporates width/depth ratios for the Bitterroot ecoregion (**Section 5.4.3.5**). These width/depth targets will also apply for temperature. Targets for Nemote and Petty creeks are: ≤ 21 for sections with a bankfull width less than 30 feet and ≤ 32 for sections with a bankfull width greater than 30 feet. The target for Grant Creek is a width/depth ratio ≤ 15 for Rosgen stream types A and B, and ≥ 12 ≤ 22 for Rosgen stream types C & E. The target is not intended to be specific to every given point on the stream but to maintain current conditions where the target is generally being met. In areas where the target is not being met, actions that improve riparian shade are anticipated to also lower width/depth ratios.

7.4.3.4 Instream Flow (Water Use)

Because larger volumes of water take longer to heat up during the day, the ability of a stream to buffer incoming solar radiation is reduced as instream water volume decreases. In other words, a channel with little water will heat up faster than an identical channel full of water, even if they have identical shading and are exposed to the same daily air temperatures. The naturally occurring condition referenced in the temperature standard includes the use of all reasonable water conservation practices (ARM 17.30.602(17)). Therefore, DEQ normally conducts water use model scenarios to evaluate the effect that water conservation measures which result in more instream flow would have on temperatures. The source assessment results for each stream show that the impacts associated with modest water use improvements are either minor or are not the predominant cause of temperature impairment. Therefore, instream flow is addressed as a supplemental indicator versus as a formal target.

The Natural Resources Conservation Service Irrigation Guide (NRCS 1997) states that improving an existing irrigation system often increases water application efficiency by more than 30% and installing a new system typically adds an additional 5% to 10% savings. These improvements in efficiency could be used to grow different crops, expand production, or withdraw less water from the stream. Since leaving additional water in-stream could lower the maximum daily temperature, converting efficiency savings to a lower amount of water diverted from the stream is inherent to the reasonable land, soil, and water conservation practice and therefore is the focus of this scenario.

However, per Montana's water quality law, TMDL development cannot be construed to divest, impair, or diminish any water right recognized pursuant to Title 85 (Montana Code Annotated Section 75-5-705), so any voluntary water savings and subsequent in-stream flow augmentation must be done in a way that protects water rights. The water use scenarios use a 15% reduction in withdrawal volumes to simulate the outcome of leaving more water in the stream due to improvements to the irrigation network. Considering the statistics presented above from the NRCS Irrigation Guide and other sources that evaluated efficiency improvements for different irrigation practices (Negri et al. 1989; Howell 2003; Osteen et al. 2012) and savings left instream (Kannan et al. 2011), using efficiency gains to reduce withdrawal volume by 15% was selected for the water use scenario. Fifteen percent was chosen to be a reasonable starting point, but as no detailed analysis was conducted of the irrigation network in these watersheds, these scenarios are not formal efficiency improvement goals; they are examples intended to represent the application of water conservation practices for water withdrawals.

Nemote Creek

There are 17 withdrawal points of diversion on Nemote Creek. The withdrawal volume was estimated using the Irrigation Water Requirements (IWR) program developed by the USDA to estimate crop requirements (NRCS, 2003). The estimates are 2.33 cfs in July, and 1.1 cfs in September.

Petty Creek

There are 25 withdrawal points of diversion on Petty Creek. The withdrawal volume was estimated using the Irrigation Water Requirements (IWR) program developed by the USDA to estimate crop requirements (NRCS, 2003) and assuming the one industrial withdrawal was withdrawing at the maximum permitted rate (roughly 2.5 cfs). The estimates are 4.99 cfs in June, 6.01 cfs in July, and 2.67 cfs in September.

Grant Creek

There are 34 withdrawal points of diversion on Grant Creek. The withdrawal volume was estimated using the Irrigation Water Requirements (IWR) program developed by the USDA to estimate crop requirements (NRCS, 2003). The estimates are 42.35 cfs in July, and 24.63 cfs in September.

7.4.3 Target Values Summary

The allowable human-caused temperature change is the primary target that must be achieved to meet the standard. Alternatively, compliance with the temperature standard can be attained by meeting the temperature-influencing targets (e.g., riparian shade and width/depth ratio). In this approach, if all reasonable land, soil, and water conservation practices are installed or practiced, water quality standards will be met. **Table 7-2** summarizes the temperature targets for these three streams. Note that based on the source assessment results, instream flow improvement is not incorporated as a formal target within **Table 7-2** and is instead used to supplement the source assessment effort, and is also used to define the TMDL allocations within **Section 7.7**.

Table 7-2. Temperature Targets

Nemote Creek	
Target Parameter	Target Value
Primary Target	
Allowable Human-Caused Temperature Change	If the naturally occurring temperature is less than 66ºF, the maximum allowable increase is 1ºF. Within the naturally occurring temperature range of 66–66.5ºF, the allowable increase cannot exceed 67ºF. If the naturally occurring temperature is greater than 66.5ºF, the maximum allowable increase is 0.5ºF.
Temperature-Influencing Targets: Meeting both will meet the primary target	
Riparian Health - Shade	77% - 88% effective shade based on reference reaches
Width/Depth Ratio	Rosgen B & C stream types with bankfull width < 30ft: ≤ 21 Rosgen B & C stream types with bankfull width > 30ft: ≤ 32
Petty Creek	
Target Parameter	Target Value
Primary Target	
Allowable Human-Caused Temperature Change	If the naturally occurring temperature is less than 66ºF, the maximum allowable increase is 1ºF. Within the naturally occurring temperature range of 66–66.5ºF, the allowable increase cannot exceed 67ºF. If the naturally occurring temperature is greater than 66.5ºF, the maximum allowable increase is 0.5ºF.
Temperature-Influencing Targets: Meeting both will meet the primary target	
Riparian Health - Shade	69% - 83% effective shade based on 50 foot buffer with medium density trees between river miles 7.0 and the mouth, and 50 foot buffer with hydrophytic shrubs between river miles 7.0 and upstream
Width/Depth Ratio	Rosgen B & C stream types with bankfull width < 30ft: ≤ 21 Rosgen B & C stream types with bankfull width > 30ft: ≤ 32
Grant Creek	
Target Parameter	Target Value
Primary Target	
Allowable Human-Caused Temperature Change	If the naturally occurring temperature is less than 66ºF, the maximum allowable increase is 1ºF. Within the naturally occurring temperature range of 66–66.5ºF, the allowable increase cannot exceed 67ºF. If the naturally occurring temperature is greater than 66.5ºF, the maximum allowable increase is 0.5ºF.
Temperature-Influencing Targets: Meeting all four will meet the primary target	
Riparian Health - Shade	69%-59% effective shade, based on reference reaches
Width/Depth Ratio	Rosgen types A & B: a width/depth ratio ≤ 15 Rosgen types C & E, where bankfull width > 12ft: a width/depth ratio ≤ 22
Missoula MS4	Follow the minimum control measures provided in the MPDES permit authorization for permit MTR04007, or any updated

Table 7-2. Temperature Targets

	runoff reduction or initial flush stormwater capture control measures in subsequent permit renewals. Renewed permits must contain initial flush mitigation measures.
MPDES Permit MT0029840	No more than a 1.0°F increase when the receiving water is cooler than 66.5°F, no increase above 67°F when the receiving water is 66 – 66.5°F, and no more than a 0.5°F increase under conditions where the receiving water is greater than 66.5°F

7.5 Source Assessment

As discussed above in **Section 7.4.1**, Montana's water quality standard for temperature is narrative. It specifies a maximum allowable increase above the *naturally occurring* temperature. Under Montana water quality law, naturally occurring temperatures incorporate both natural sources as well as human sources that are applying all reasonable land, soil, and water conservation practices. Existing temperatures can be measured. However, the naturally occurring temperature incorporates conservation measures and vegetation that may or may not be in place, and must be estimated. To predict the instream temperatures that would result from different conservation measures, DEQ uses a well-established model known as QUAL2K. Conservation measures generally focus on two factors that can be influenced by human activities and are drivers of stream temperature: instream flow and riparian shade. These are modeled separately (to understand their relative importance), and then in combination (to determine the naturally occurring condition).

All the QUAL2K models start with a baseline scenario that uses the existing conditions in the stream. The model is created using existing hydrology, channel geometry, geography, and vegetation, and is calibrated using measured flow data and corresponding weather. The model is then validated by changing the flow data and weather to that measured later under low flow conditions, and the modeled instream temperatures are compared to the measured instream temperatures. If the model performs well, it can be expected to reasonably predict the effects of conservation practices that alter the riparian shade or instream flows.

7.5.1 Nemote Creek Assessment Using QUAL2K

The source assessment for Nemote Creek largely involved QUAL2K temperature modeling. There are no permitted point sources in the watershed. The watershed has been affected by the road network, present and historic agricultural activities (mostly grazing), and timber harvest. These activities affect temperature via modifications to riparian health and associated shade or via streamflow alterations. Therefore, the source assessment focused on two factors that can be influenced by human activities and are drivers of stream temperature: instream flow and riparian shade. Although channel width and depth can influence stream temperatures, the existing channel dimensions were not changed for any of the scenarios because focus was on the two targets most likely influencing temperature: consumptive water use and riparian shade. Nemote Creek is not yet assessed for a channel width/depth target.

The QUAL2K model was used to determine the extent that human-caused disturbances within the Nemote Creek watershed have increased the water temperature above the naturally occurring level. The evaluation of model results focuses on the maximum daily water temperatures in Nemote Creek during the summer because those are conditions mostly likely to harm aquatic life, the most sensitive beneficial use.

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. Each stream is segmented into reaches within the model that are assigned the same channel and shade characteristics. Segmentation is largely based on the location of field data, tributaries, irrigation withdrawal/returns, and changes in channel conditions or shading.

Within the model, Nemote Creek was segmented into reach lengths of 984 feet (0.186 miles). The water temperature and flow data collected from Nemote Creek and two tributaries in 2011, along with channel measurements, irrigation data, and climate data (**Section 7.3**), were used to calibrate and validate the model. Error rates for the maximum stream temperatures for the calibration and validation were 2.7% and 3.1%, respectively, indicating the model provides a reasonable approximation of maximum daily temperatures in Nemote Creek. While the influence of Nemote Creek tributaries was evaluated, assessing the human influences on tributary water temperatures was outside of the scope of this project. If application of reasonable land, soil, and water conservation practices has the potential to increase shade within one or more tributaries, then there is further potential for lower temperatures within Nemote Creek.

A baseline scenario and three additional scenarios were modeled to investigate the potential influences of human activities on temperatures in Nemote Creek. The following sections describe those modeling scenarios. As discussed above, the existing channel dimensions were not changed for any of the scenarios because Nemote Creek has not been assessed for the channel width/depth target. A more detailed report of the development and results of the QUAL2K model are included in **Appendix G**.

7.5.1.1 Baseline Scenario (Existing Conditions)

The baseline scenario represents stream temperatures under existing shade and channel conditions in July on a hot, dry year and is the scenario that all others are compared against to evaluate the influence of human sources. The calibrated and validated model was set up entirely on measured conditions and corresponding weather data, but because long-term flow data at the nearby St. Joe River gage demonstrated that Nemote Creek summer flows were almost certainly higher than usual (which could result in cooler water temperatures), flow and climate data were adjusted to represent more critical (i.e., hotter and drier) conditions for the baseline scenario. Flow inputs in the model were decreased to represent the 25th percentile flow conditions for July. Climate inputs reflect the median of the warmest two consecutive days in July for the period of record at the Nine Mile RAWS climate station (2000-2012).

Under the baseline scenario, maximum daily temperatures range from 49.5°F near the headwaters to 71.6°F at river mile 2.8 (**Figure 7-6**). Temperatures generally increase in a downstream direction but reset somewhat by decreasing by 4 or more degrees Fahrenheit near river mile 2, where an overstory is present. The area where temperatures decrease is within the narrower timbered section that is used as the reference shade (shade scenario, **Section 7.5.1.3** below).

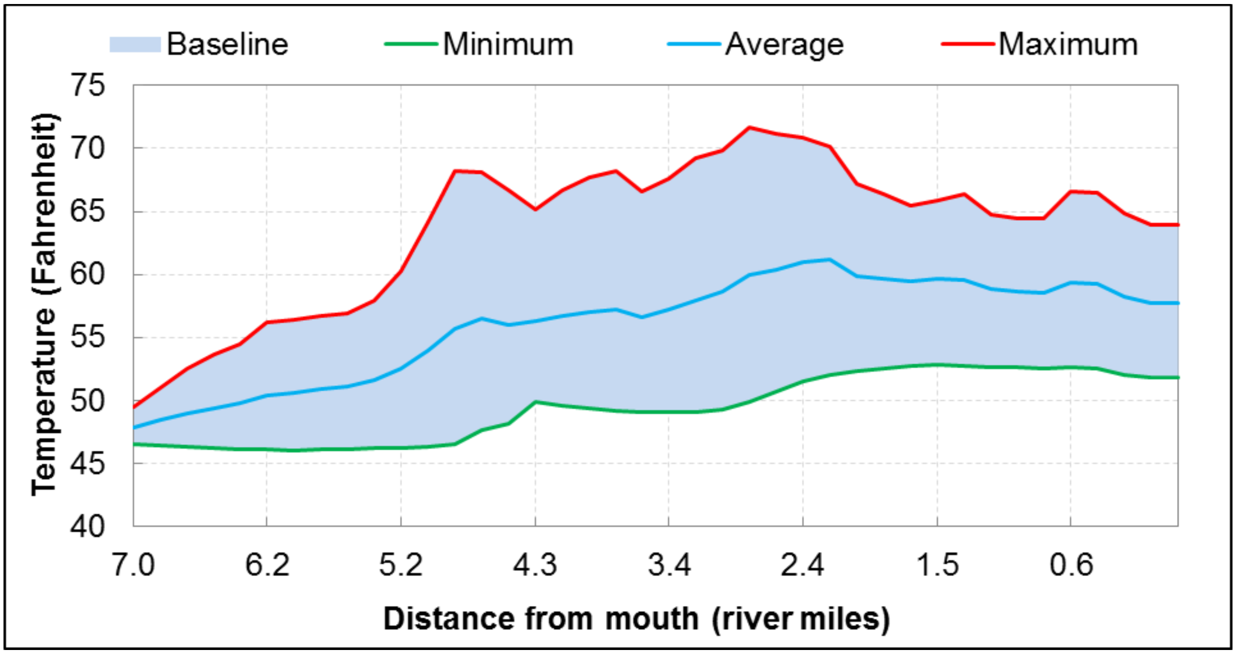

Figure 7-6. Modeled temperatures for the Nemote Creek baseline scenario

7.5.1.2 Water Use Scenario

Although there is no target for consumptive water use relative to instream flow because of the limited amount of water withdrawn for irrigation, the naturally occurring condition referenced in the temperature standard includes the use of all reasonable water conservation practices (ARM 17.30.602(17)). Therefore, a water use scenario was conducted to evaluate the effect that water conservation measures resulting in more instream flow would have on temperatures.

As discussed above in **Section 7.4.3.4**, in this scenario, the total withdrawal attributed to the 17 points of diversion (cumulatively estimated at up to 2.33 cfs daily in July, see **Appendix G**) is reduced by 15% within the model and that savings of 0.35 cfs (2.33 * 0.15 = 0.357) is allowed to remain in the stream. The Natural Resources Conservation Service Irrigation Guide (NRCS 1997) states that improving an existing irrigation system often increases water application efficiency by more than 30% and installing a new system typically adds an additional 5% to 10% savings. These improvements in efficiency could be used to grow different crops, expand production, or withdraw less water from the stream. Since leaving additional water in-stream could lower the maximum daily temperature, converting efficiency savings to a lower amount of water diverted from the stream to supplement streamflow is the focus of this scenario.

However, per Montana's water quality law, TMDL development cannot be construed to divest, impair, or diminish any water right recognized pursuant to Title 85 (Montana Code Annotated Section 75-5-705), so any voluntary water savings and subsequent in-stream flow augmentation must be done in a way that protects water rights.

Withdrawals are distributed from the headwaters to the mouth, but the density increases around river mile 5.2, which is just downstream of monitoring site NMTC-T4 (**Figure 7-1**). Under the water use scenario, improving water use efficiency and withdrawing 15% less water has a minimal effect on temperatures in Nemote Creek. The largest decrease in maximum daily temperature was 0.53°F. Decreases greater than 0.2° F were limited to river miles 2.62 to 2.80 and 4.47 to 5.52. Therefore, consumptive water usage appears to have relatively minor impacts on temperature when evaluated from the perspective of achievable instream flow improvements.

7.5.1.3 Shade Scenario

For the shade scenario, the effective shade inputs to the model were set to represent the target shade condition. The target is derived from the average daily shade in a reference reach (i.e., a segment of Nemote Creek between river miles 1.2 to 2.3 (**Figure 7-7**). This reach displays evidence of timber harvest and human modification, yet still provides high effective shade.

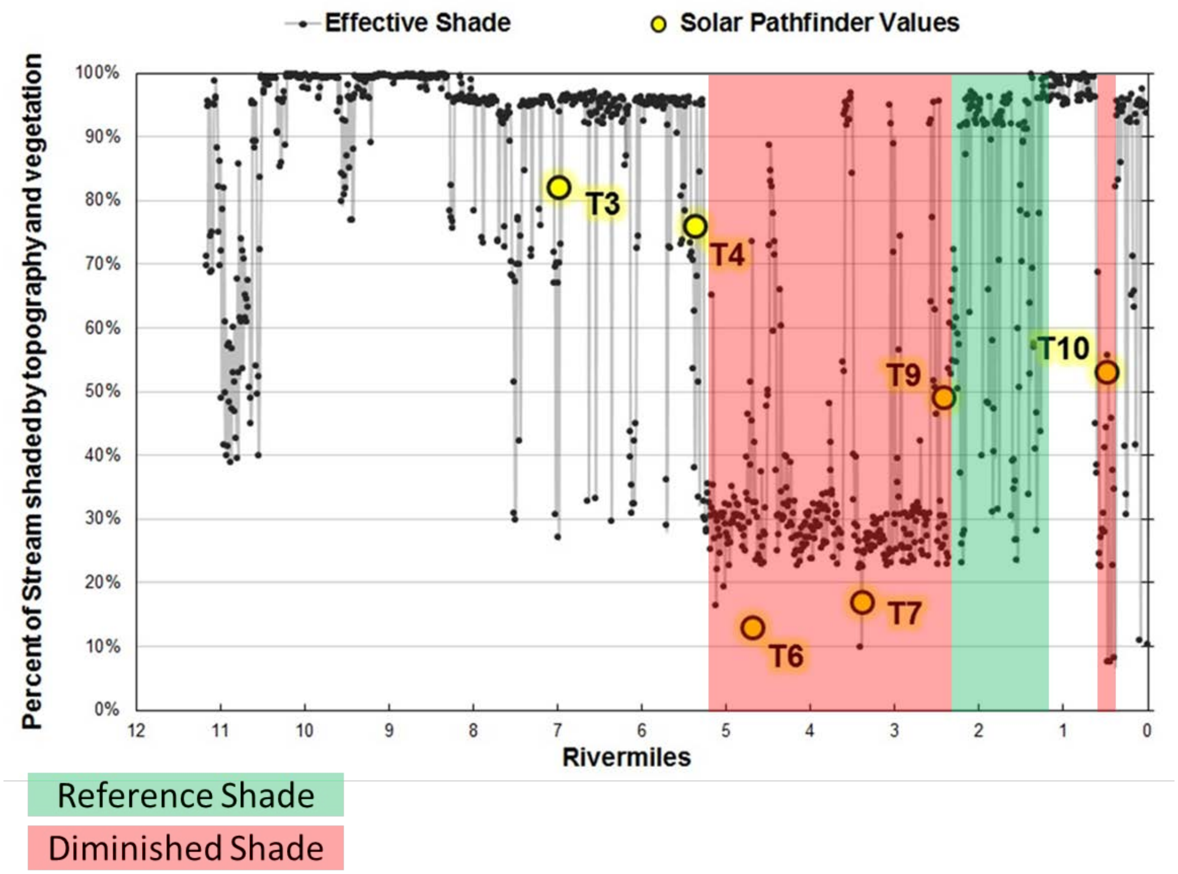

Figure 7-7. Effective shade along Nemote Creek, showing both the baseline and reference conditions

The average daily effective shade for segments with similar vegetation is presented in **Table 7-3** for the baseline scenario and shade scenario.

Table 7-3. Comparison of effective shade between the existing condition and shade scenario

Segment	Baseline condition (scenario 1)	Improved shade (scenario 3)
NMTC-T3 to NMTC-T4	88%	88%
NMTC-T4 to NMTC-T6	50%	70%
NMTC-T6 to NMTC-T7	49%	77%
NMTC-T7 to NMTC-T9	46%	77%
NMTC-T9 to NMTC-T10	77%	78%
NMTC-T10 to mouth	74%	80%

Based on this scenario, the maximum daily stream temperature is very sensitive to improvements in riparian shade. This scenario resulted in maximum daily temperatures decreasing from the baseline scenario by 0.5°F to 8.5°F (**Figure 7-8**). Meeting the shade target caused an average decrease in the maximum daily temperature of 3.06°F from the baseline scenario. The maximum decrease was in the middle watershed between sites NMTC-T4 and NMTC-T9. The shade scenario demonstrates that human changes to the riparian vegetation are the primary source of temperature impairment.

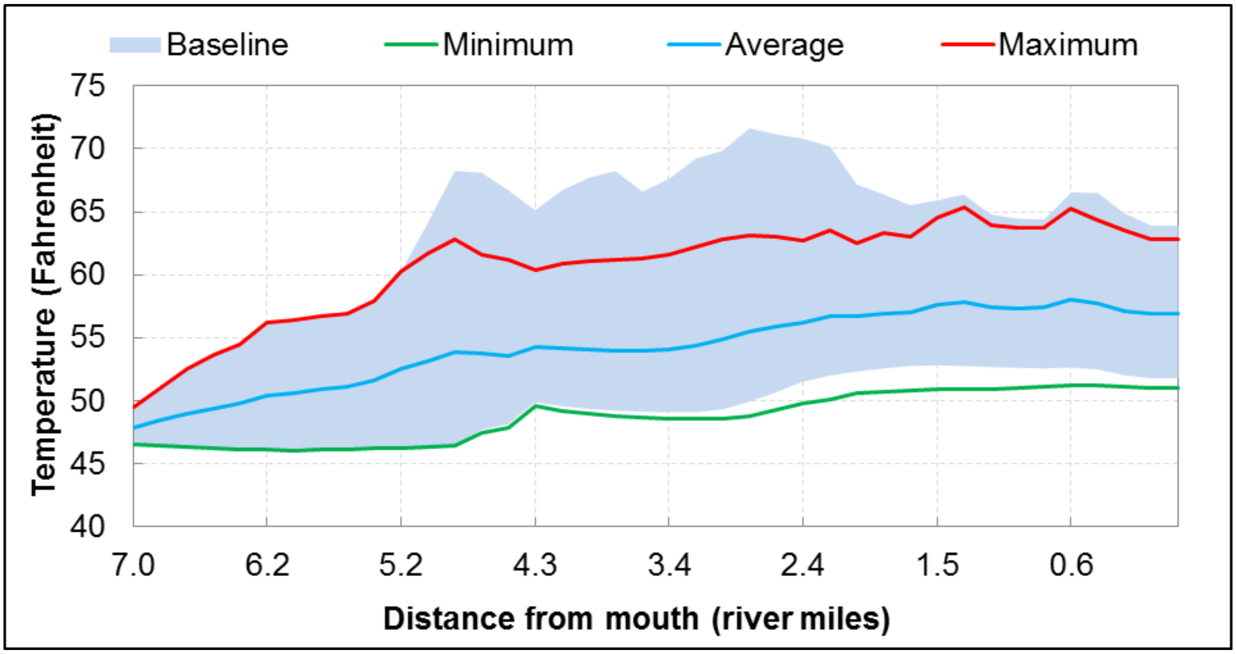

Figure 7-8. Comparison of modeled temperatures between the shade and baseline scenarios

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

The naturally occurring scenario represents Nemote Creek water temperatures when all reasonable land, soil, and water conservation practices are implemented (**ARM 17.30.602**). The naturally occurring scenario is a combination of the shade and water use scenarios.

Given the small influence of water withdrawals, the target for maximum allowable human-influenced temperature change could be achieved entirely by increasing the effective shade. However, water conservation measures resulting in more instream flow would slightly decrease temperatures, meaning slightly less improvement in effective shade would be necessary to meet the water quality standard. The naturally occurring scenario maximum daily temperatures ranged from 49.5°F to 65.2°F, with an average of 60.6°F. Based on these results, the naturally occurring temperature is less than 66.0°F, and an increase of 1°F is allowed from human sources (**Figure 7-9**).

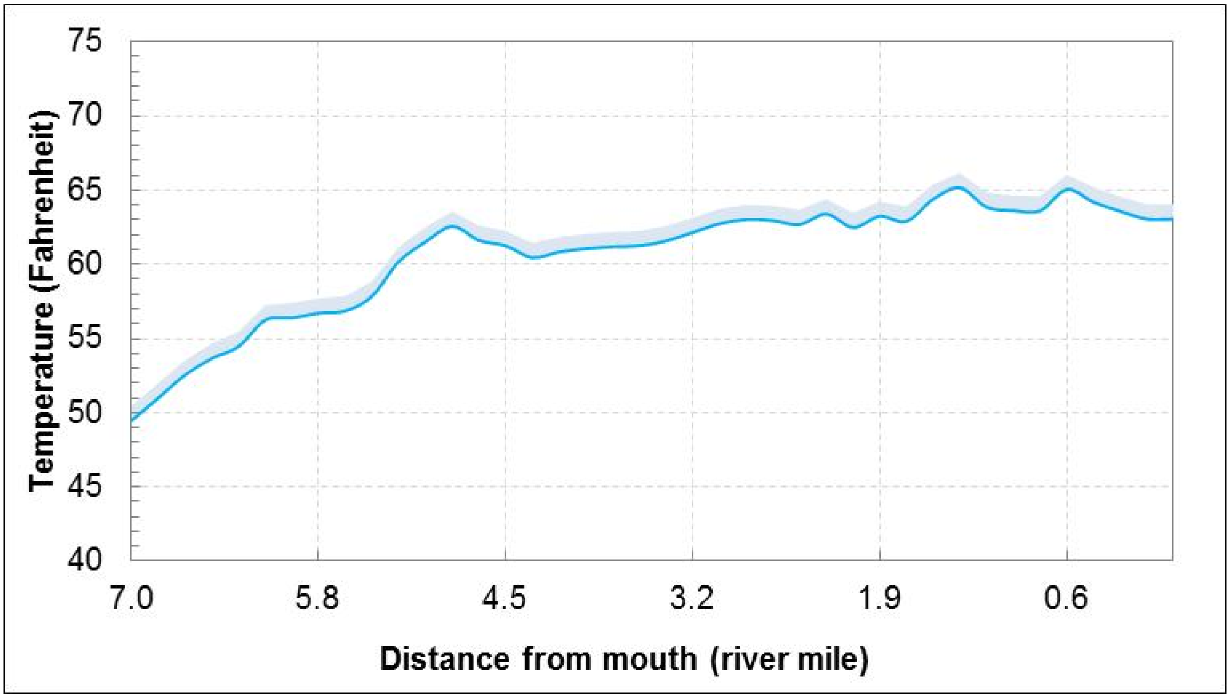

Figure 7-9. Maximum naturally-occurring temperatures in Nemote Creek, and allowable increase

The results of the naturally occurring scenario demonstrate there is the potential for significant reductions in stream temperatures relative to the existing condition (baseline scenario): the potential temperature decreases from this scenario as compared to the baseline scenario ranged from 0.1°F to 8.6°F, with an average decrease of 3.1°F (**Figures 7-10** and **7-11**). Like the shade scenario, the maximum decrease was in the middle watershed between NMTC-T4 and NMTC-T9, and the smallest change was in the reach with reference shade.

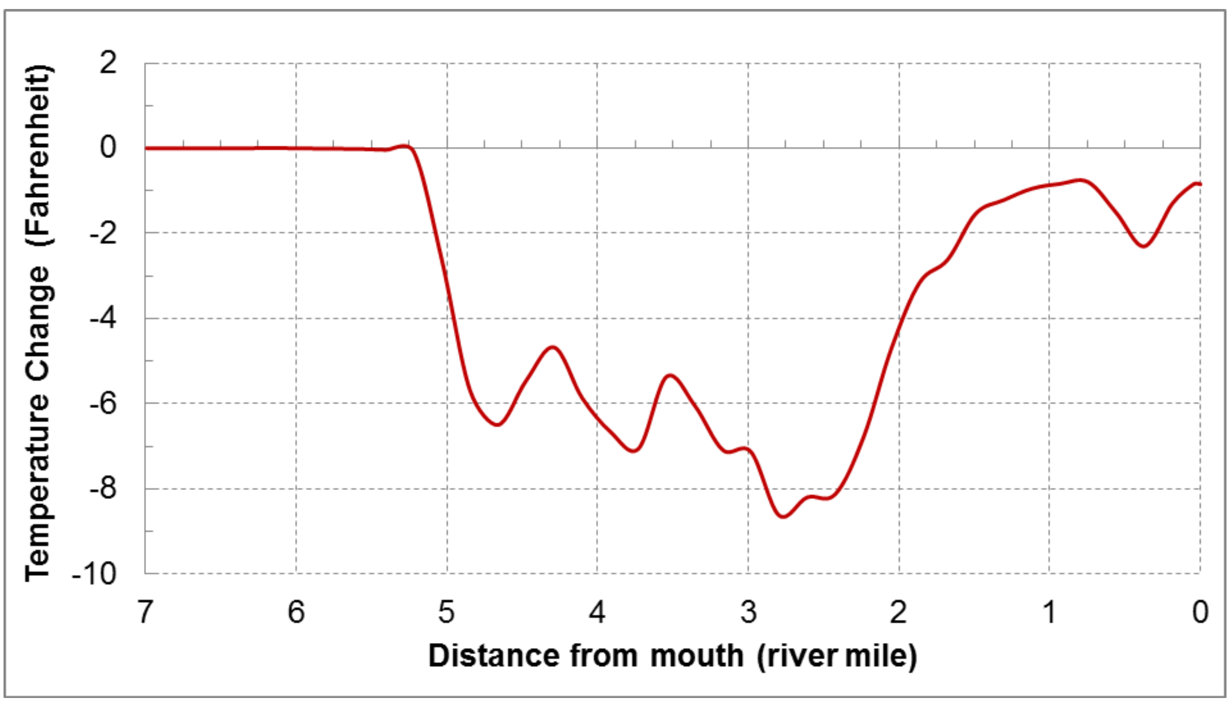

Figure 7-10. Temperature difference between the baseline and naturally occurring scenario

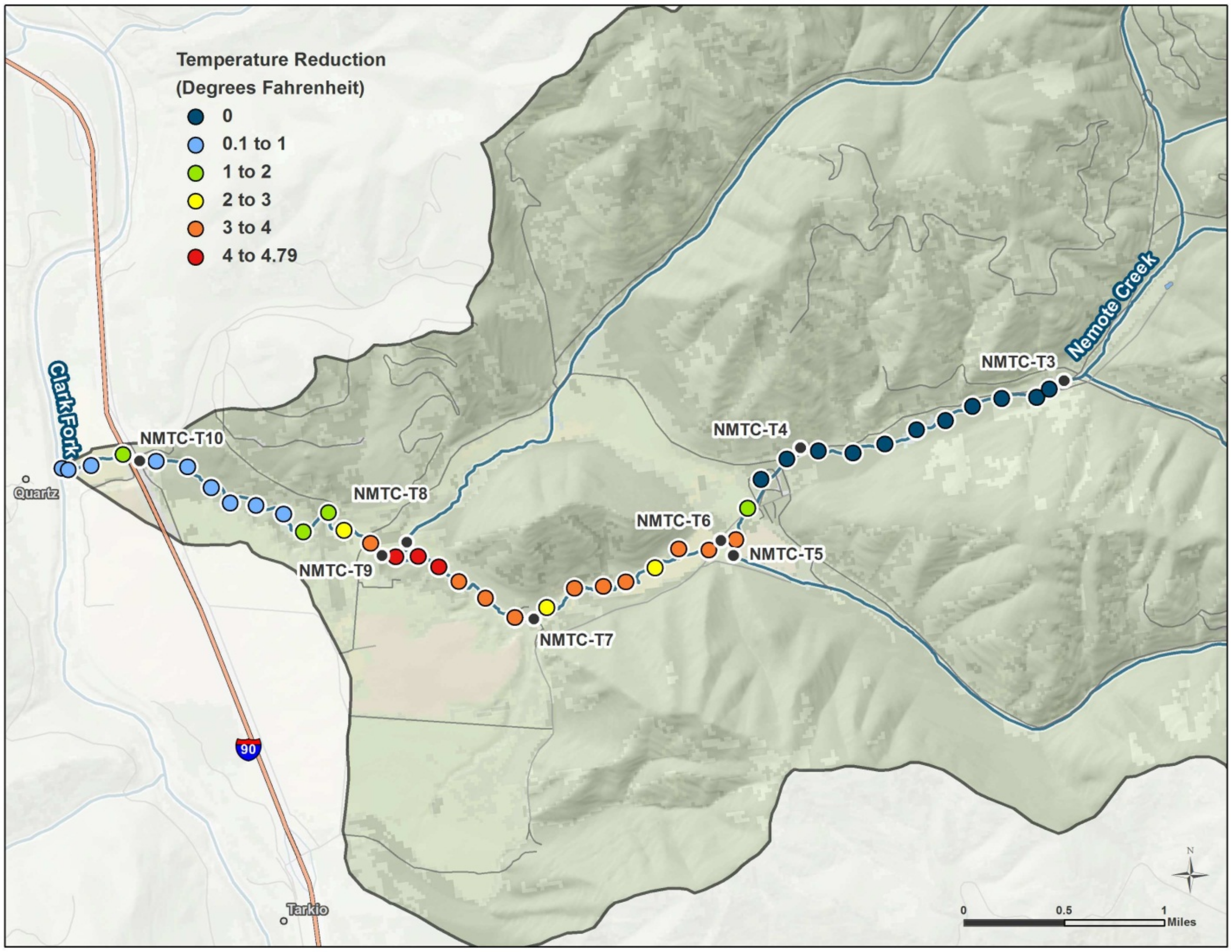

Figure 7-11. Temperature reductions that can be obtained under naturally occurring conditions (relative to the baseline scenario)

7.5.2 Petty Creek Assessment Using QUAL2K

The source assessment for Petty Creek largely involved QUAL2K temperature modeling. There are no permitted point sources on Petty Creek. The watershed has been affected by the road network, present and historic agricultural activities (mostly grazing), and timber harvest. These activities affect temperature via modifications to riparian health and associated shade or via streamflow alterations. Therefore, the source assessment focused on two factors that can be influenced by human activities and are drivers of stream temperature: instream flow and riparian shade. Although channel width and depth can influence stream temperatures, the existing channel dimensions were not changed for any of the scenarios because focus was on the two targets most likely influencing temperature. Petty Creek is meeting the channel width/depth target as discussed in **Section 5.4.3.4**.

The QUAL2K model was used to determine the extent that human-caused disturbances within the Nemote Creek watershed have increased the water temperature above the naturally occurring level. The evaluation of model results focuses on the maximum daily water temperatures in Petty Creek during the summer because those are conditions mostly likely to harm aquatic life, the most sensitive beneficial use.

Within the model, Petty Creek was segmented into eight reaches with lengths ranging from 0.47 miles to 2.85 miles. Element lengths were 820.21 feet (0.25 kilometer). An element size of 820.21 feet was sufficient to incorporate any point inputs to the stream. The water temperature and flow data collected from Petty Creek and five tributaries in 2012, along with channel measurements, irrigation data, and climate data (**Section 7.3**), were used to calibrate and validate the model. Error rates for the maximum stream temperatures for the calibration and validation were 1.2% and 3.2%, respectively, indicating the model provides a reasonable approximation of maximum daily temperatures in Petty Creek. While the influence of Petty Creek tributaries was evaluated, assessing the human influences on tributary water temperatures was outside of the scope of this project. If application of reasonable land, soil and water conservation practices has the potential to increase shade within one or more tributaries, then there is further potential for lower temperatures within Petty Creek.

Flow data at the USGS gage on the nearby South Jocko River (12381400) were evaluated to determine how June streamflow in 2012 (when calibration data were collected) compared to the average June streamflows. The daily average flow on June 29, 2012 at USGS gage 12381400 was high (86th percentile) as compared to the daily average flows on all June 29ths on record. The daily average flow for June 2012 at USGS gage 12381400 was also high (83rd percentile) as compared to the daily average flow for all Junes on record.

A baseline scenario and three additional scenarios were modeled to investigate the potential influences of human activities on temperatures in Petty Creek. The following sections describe those modeling scenarios. As discussed above, the existing channel dimensions were not changed for any of the scenarios because Petty Creek is meeting the channel width/depth target (see **Section 5.4.3.4**). A more detailed report of the development and results of the QUAL2K model are included in **Appendix G**.

7.5.2.1 Baseline Scenario (Existing Conditions)

The baseline scenario represents stream temperatures under existing shade and channel conditions in July on a hot, dry year and is the scenario that all others are compared against to evaluate the influence of human sources. The calibrated and validated model was set up entirely on measured conditions and corresponding weather data from the Nine Mile RAWS climate station (2000-2012).

Under the baseline scenario, maximum daily temperatures range from 57.6°at river mile 8.6 to 48.2°F at river mile 7.4 (**Figure 7-12**). Temperatures generally increase in a downstream direction but reset after the dry segment where cool groundwater creates the temperature trough at mile 7.4. Note that although the baseline scenario temperatures are relatively low, recorded temperatures were occasionally outside of the optimal growth range for westslope cutthroat trout and bull trout as discussed further in **Section 7.6.2**.

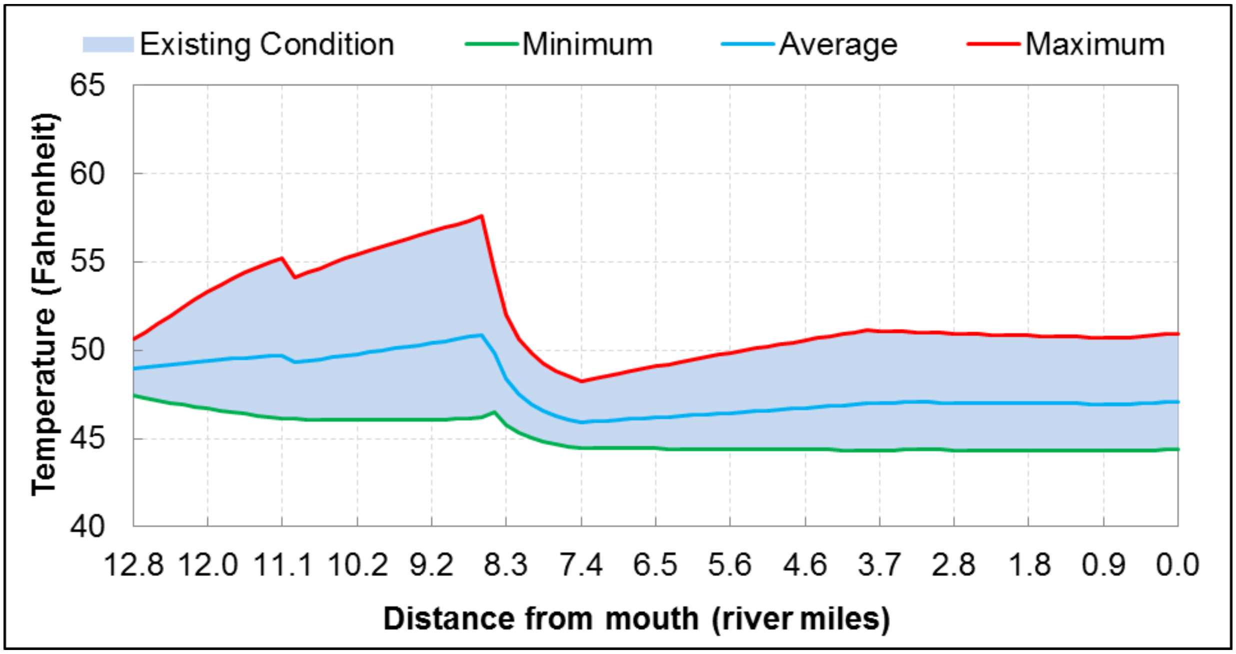

Figure 7-12. Modeled temperatures for the Petty Creek baseline scenario

7.5.2.2 Water Use Scenario

Although there is no target for consumptive water use relative to instream flow because of the limited amount of water withdrawn for irrigation, the naturally occurring condition referenced in the temperature standard includes the use of all reasonable water conservation practices (ARM 17.30.602(17)). Therefore, a water use scenario was conducted to evaluate the effect that water conservation measures resulting in more instream flow would have on temperatures.

As discussed above in **Section 7.4.3.4**, in this scenario, the total withdrawal attributed to the 25 points of diversion (cumulatively estimated at up to 6.01 cfs daily in July, see **Appendix G**) is reduced by 15% within the model and that savings of 0.9 cfs (6.01 * 0.15 = 0.901) is allowed to remain in the stream. The Natural Resources Conservation Service Irrigation Guide (NRCS 1997) states that improving an existing irrigation system often increases water application efficiency by more than 30% and installing a new system typically adds an additional 5% to 10% savings. These improvements in efficiency could be used to grow different crops, expand production, or withdraw less water from the stream. Since leaving additional water in-stream could lower the maximum daily temperature, converting efficiency savings to a lower amount of water diverted from the stream in order to supplement streamflow is the focus of this scenario.

However, per Montana's water quality law, TMDL development cannot be construed to divest, impair, or diminish any water right recognized pursuant to Title 85 (Montana Code Annotated Section 75-5-705), so any voluntary water savings and subsequent in-stream flow augmentation must be done in a way that protects water rights.

Water temperatures in Petty Creek for this scenario generally changed very little. Changes in the maximum daily water temperatures, as compared to the existing condition, ranged from a 0.04° F decrease to a 0.13° F increase. The difference in water temperature was always less than 0.5° F, signifying minimal sensitivity and conditions that are similar to the existing condition. Therefore, consumptive water usage appears to have relatively minor impacts on temperature when evaluated from the perspective of achievable instream flow improvements.

7.5.2.3 Shade Scenario

For the shade scenario, the effective shade inputs to the model were set to represent the target shade condition, which was determined to be 69% - 83% effective shade, based on a modeled 50-foot buffer. The 50-foot buffer scenario consists of the existing condition scenario flow and weather, with increased vegetation (and therefore effective shade) in a 50-foot buffer along the stream channel. All vegetation communities (with the exception of areas with hydrophytic shrubs and roads) from river mile 7.0 to the mouth are transformed to medium density trees within 50 feet of the stream banks. From river mile 7.0 and upstream, all herbaceous communities are transformed to shrubs within 50 feet of the stream banks. Beyond 50 feet, existing condition vegetation remains. The existing condition and improved shade scenarios are compared below in **Figure 7-13** and **Table 7-4**.

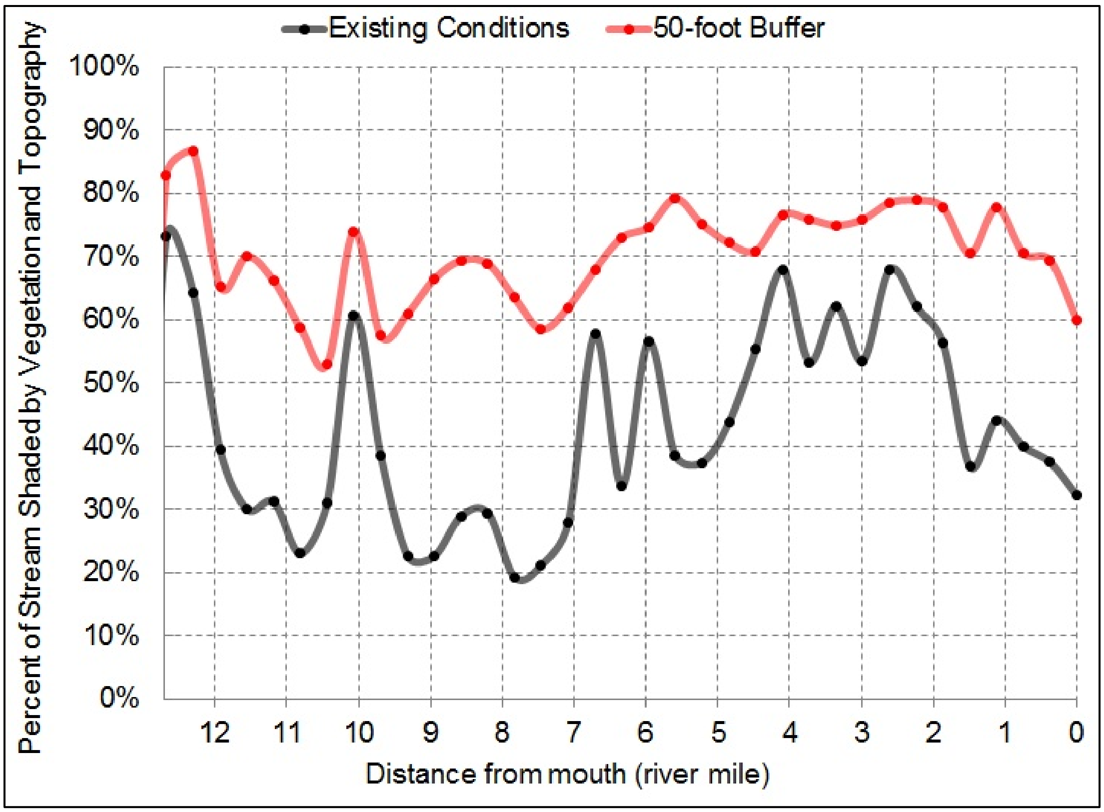

Figure 7-13. Effective shade along Petty Creek, showing both existing and target conditions

Table 7-4. Comparison of effective shade between the existing condition and improved scenarios

Segment	Baseline condition (scenario 1)	Improved shade (scenario 3)
G	54%	80%
F	47%	74%
E	38%	74%
D	59%	80%
C	66%	81%
B	72%	83%
A	63%	82%

AA	43%	69%

Based on this scenario, the maximum daily stream temperature is very sensitive to improvements in riparian shade. This scenario resulted in maximum daily temperatures decreasing from the baseline scenario by 0.5°F to 3.8°F (**Figure 7-14**). Meeting the shade target caused an average decrease in the maximum daily temperature of 3.8°F from the baseline scenario. The maximum decrease was in the upper watershed at river mile 8.6. The shade scenario demonstrates that human changes to the riparian vegetation are the primary source of temperature impairment.

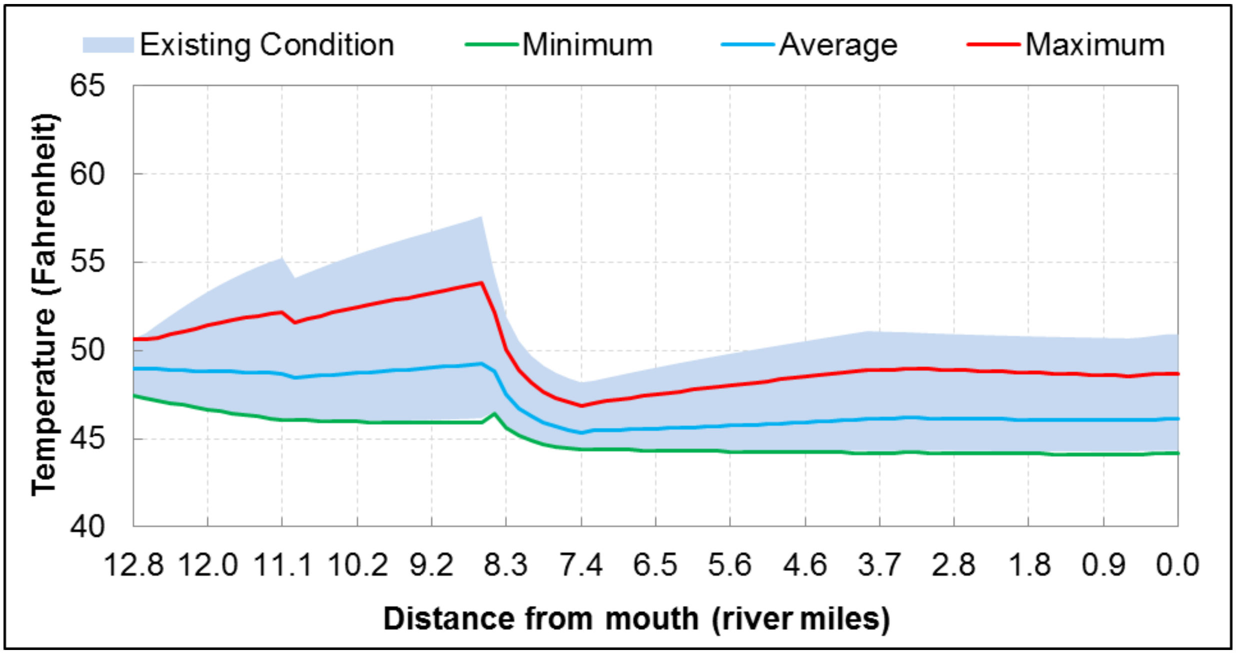

Figure 7-14. Comparison of modeled temperatures between the baseline and improved shade scenarios

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

The naturally occurring scenario represents Petty Creek water temperatures when all reasonable land, soil, and water conservation practices are implemented (**ARM 17.30.602**). Since the current width/depth ratios are meeting the target and reflected in the baseline scenario, the naturally occurring scenario is a combination of the shade and water use scenarios. Although water conservation measures resulting in additional instream flow will only cause a slight decrease in maximum daily stream temperatures (**Section 7.5.2.2**), the conditions applied in the water use scenario were included because water conservation is a component of the naturally occurring condition.

Given the small influence of water withdrawals, the target for maximum allowable human-influenced temperature change could be achieved entirely by increasing the effective shade. However, water conservation measures resulting in more instream flow would slightly decrease temperatures, meaning slightly less improvement in effective shade would be necessary to meet the water quality standard. The naturally occurring scenario maximum daily temperatures ranged from 46.90°F to 53.79°F, with an average of 49.70°F. Based on these results, the naturally occurring temperature is less than 66.0°F, and an increase of 1°F is allowed from human sources (**Figure 7-15**).

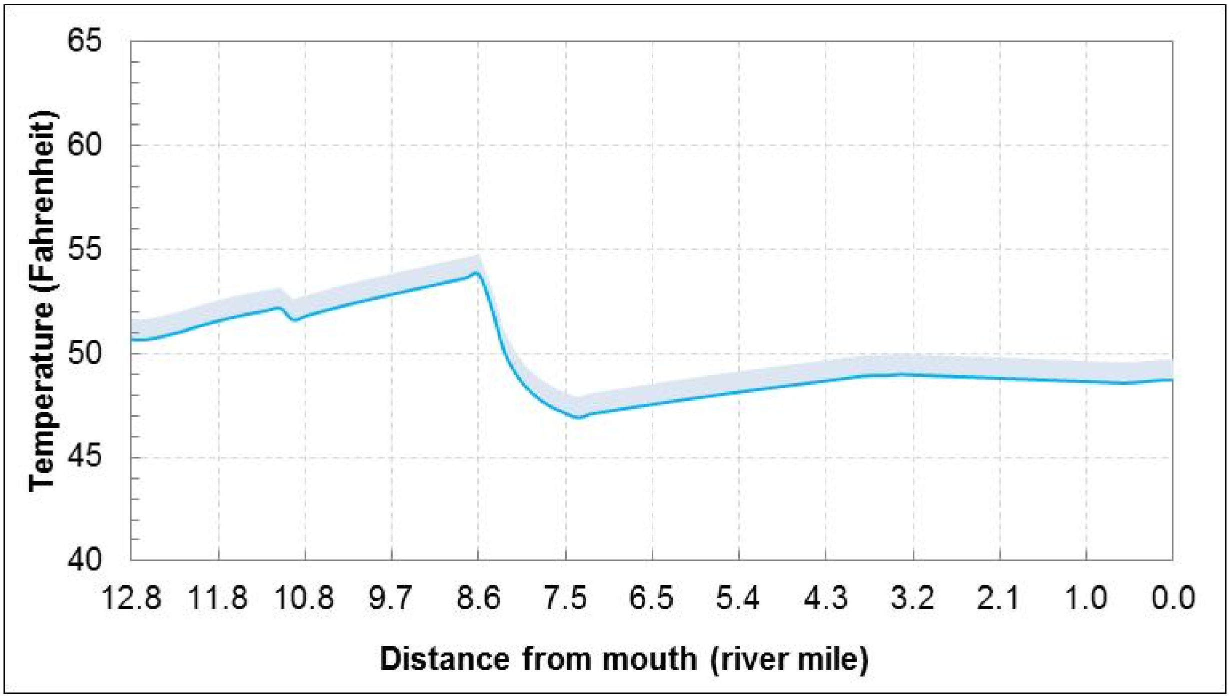

Figure 7-15. Maximum naturally-occurring temperatures in Petty Creek, and allowable increase

The naturally occurring scenario results demonstrate there is the potential for significant reductions in stream temperatures relative to the existing condition (baseline scenario): the potential temperature decreases from this scenario as compared to the baseline scenario ranged from 0.5°F to 3.8°F, with an average decrease of 2.10°F (**Figures 7-16** and **7-17**). Like the shade scenario, the maximum decrease was in the upper watershed at river mile 8.6.

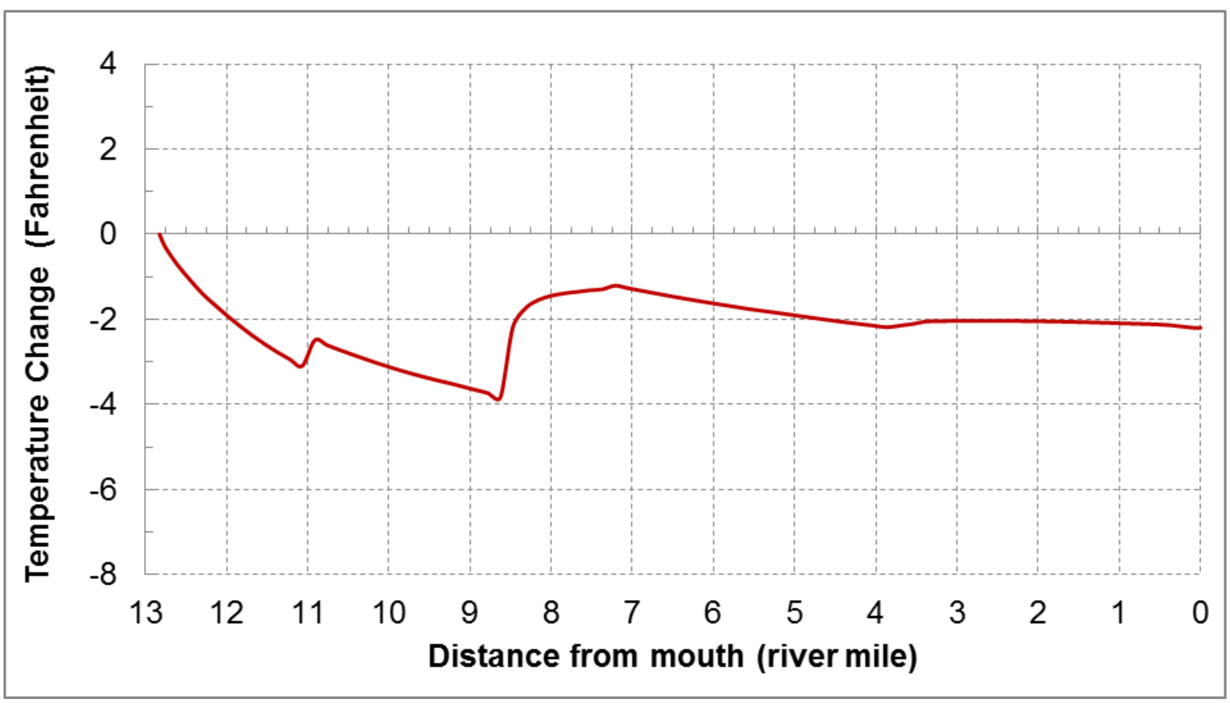

Figure 7-16 Temperature difference between the baseline and naturally occurring scenario

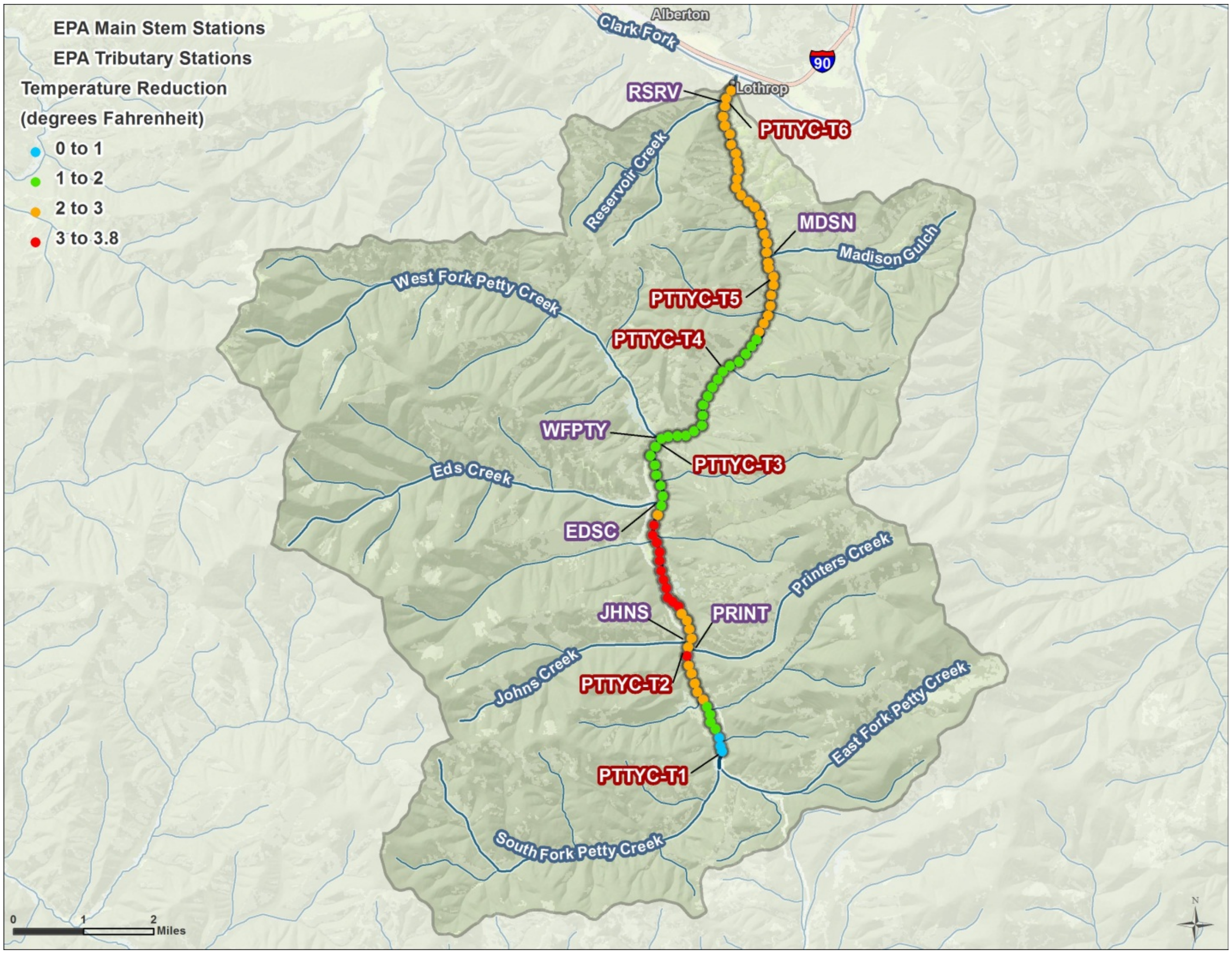

Figure 7-17. Temperature reductions that can be obtained under naturally occurring conditions (relative to the baseline scenario)

7.5.3 Grant Creek Assessment Using QUAL2K

The source assessment for Grant Creek largely involved QUAL2K temperature modeling. There are two permitted point sources in the Grant Creek watershed: a heat exchanger at a hotel, and a MS4 stormwater system. The heat exchanger has negligible negative impact to temperature and the MS4 only has potential for very minor impacts for short durations a few times throughout the year. The watershed also has been affected by the road network, present and historic agricultural activities (mostly grazing), timber harvest, and urban/suburban development. These activities affect temperature via modifications to riparian health and associated shade or via streamflow alterations. Therefore, the source assessment focused on these two primary factors that can be influenced by human activities and are drivers of stream temperature: instream flow and riparian shade Although channel width and depth can influence stream temperatures, the existing channel dimensions were not changed for any of the scenarios because focus was on the two targets most likely influencing temperature. Grant Creek is meeting the channel width/depth target as determined within **Section 5.4.3.5**.

The QUAL2K model was used to determine the extent that human-caused disturbances within the Grant Creek watershed have increased the water temperature above the naturally occurring level. The evaluation of model results focuses on the maximum daily water temperatures in Grant Creek during the summer because those are conditions mostly likely to harm aquatic life, the most sensitive beneficial use.

Within the model, Grant Creek was segmented into reach lengths of 1,640 feet (0.31 miles). The model was calibrated using water temperature and flow data collected from Grant Creek and one tributary (East Fork Grant Creek) in 2011, along with channel measurements, irrigation data, and climate data (**Section 7.3**). The error rate for the maximum stream temperatures for the calibration was 1.4%, indicating the model provides a reasonable approximation of maximum daily temperatures in Grant Creek. While the influence of Grant Creek tributaries was evaluated, assessing the human influences on tributary water temperatures was outside of the scope of this project.

The heat exchanger discharge was included in the Grant Creek QUALT2K model as a point source input of 0.49 cfs with a daily mean temperature of 54.1°F, the 75th percentile value of recorded temperatures. The discharge flow used in the model is erroneously high: the discharge is limited to 0.13 cfs in the permit, and does not exceed that in operation. However, the Econo Lodge discharge enters Grant Creek roughly a mile above the point at which it goes dry, so the erroneous value has no effect on the lower reaches of Grant Creek in the model. Also, between the Econo Lodge discharge and the dry section there are six irrigation withdrawals with an estimated total withdrawal of 6.02 cfs, and the discrepancy between the actual and modeled discharge (0.27 cfs) is likely within the range of error of the estimated withdrawals.

Flow data at the USGS gage on the Black River near Bonner (12340000) were evaluated to determine how September streamflow in 2011 (when data were collected) compared to the average September streamflow; flows were at the 85th percentile for September. However, no other flow data are available for Grant Creek, as it is ungaged.

As discussed above in **Section 7.3.4.2**, flow data were not collected on July 11 and 12, 2011 at three loggers (GRTC-T3, GRTC-T4, and GRTC-T5) because Grant Creek was too deep and swift to wade. Additionally, the first full day of recorded temperatures was July 13, 2011. A 0.38 inch rainfall occurred on July 12, 2011 after logger deployment and flow monitoring but before a full day of continuous temperatures was recorded. As the rainfall had a cooling effect upon in-stream temperatures, it is not appropriate to couple the flows monitored before the rainfall with the temperatures recorded after the rainfall. Due to the lack of monitored flow data at three consecutive sites and the occurrence of a considerable rainfall between flow monitoring and continuous temperature recording, it was determined that insufficient flow data were available to develop a second model period for validation. A baseline scenario and three additional scenarios were modeled to investigate the potential influences of human activities on temperatures in Grant Creek. The following sections describe those modeling scenarios. Grant Creek did not meet the channel width/depth target at the upper and middle sediment sampling sites (which were near the temperature sites GRTC-T1 and GRTC-T6); however DEQ assessors felt that the upper site was likely near its natural condition. Refer to discussion in **Section 5.4.3.5** for more detail. Although channel width and depth can influence stream temperatures, the existing channel dimensions were not changed for any of the scenarios. A more detailed report of the development and results of the QUAL2K model are included in **Appendix G**.

7.5.3.1 Baseline Scenario (Existing Conditions)

The baseline scenario represents stream temperatures under existing shade and channel conditions in September on a hot, dry year and is the scenario that all others are compared against to evaluate the influence of human sources. The calibrated model was set up entirely on measured conditions and corresponding weather data from the Missoula FTS RAWS climate station.

Under the baseline scenario, maximum daily temperatures range from 47.1°F near the headwaters to 57.4°F at river mile 3.13 (**Figure 7-18**). Temperatures generally increase in a downstream direction but reset somewhat by decreasing by 1 or more degrees Fahrenheit near river mile 2.5. Note that although the baseline scenario temperatures are relatively low, recorded temperatures were occasionally outside of the optimal growth range for westslope cutthroat trout as discussed further in **Section 7.6.3**.

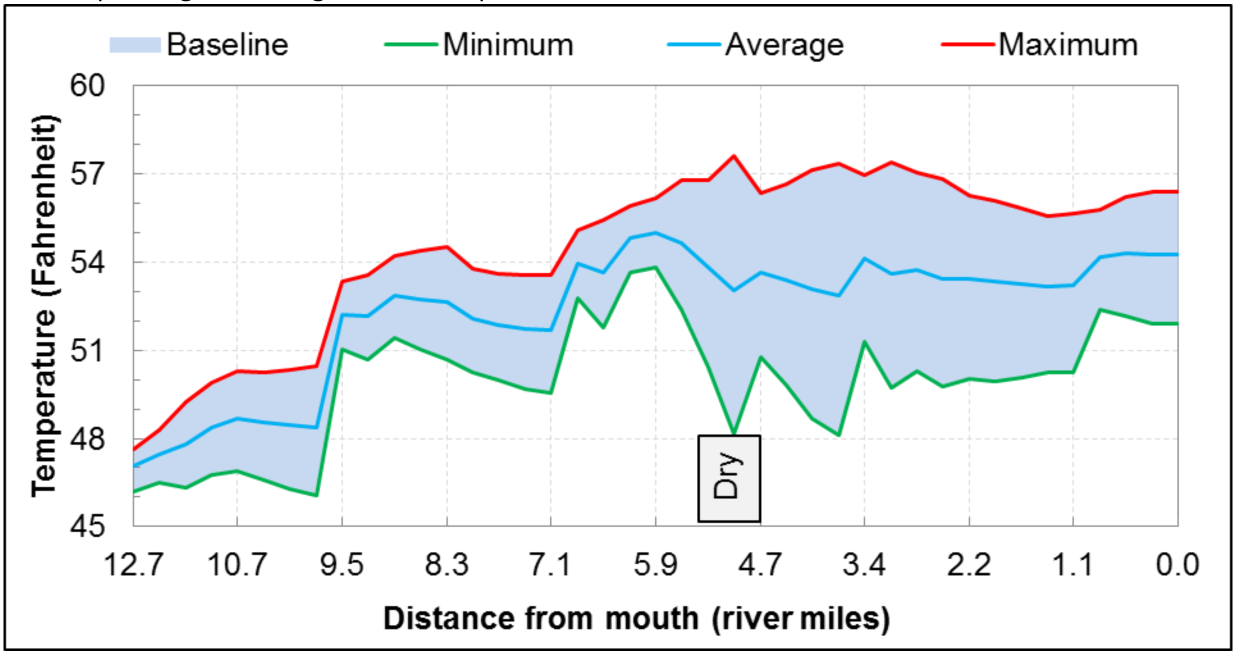

Figure 7-18. Modeled temperatures for the Grant Creek baseline scenario

7.5.3.2 Water Use Scenario

Although there is no target for consumptive water use relative to instream flow, the naturally occurring condition referenced in the temperature standard includes the use of all reasonable water conservation practices (ARM 17.30.602(17)). Therefore, a water use scenario was conducted to evaluate the effect that water conservation measures resulting in more instream flow would have on temperatures.

As discussed above in **Section 7.4.3.4**, in this scenario, the total withdrawal attributed to the 34 points of diversion (cumulatively estimated at up to 42.35 cfs daily in June, and 24.6 cfs daily in September, see **Appendix G**) is reduced by 15% within the model and that savings of 3.69 cfs (24.6 * 0.15 = 3.69) is allowed to remain in the stream. The Natural Resources Conservation Service Irrigation Guide (NRCS 1997) states that improving an existing irrigation system often increases water application efficiency by more than 30% and installing a new system typically adds an additional 5% to 10% savings. These improvements in efficiency could be used to grow different crops, expand production, or withdraw less water from the stream. Since leaving additional water in-stream could lower the maximum daily temperature, converting efficiency savings to a lower amount of water usage is the focus of this scenario.

However, per Montana's water quality law, TMDL development cannot be construed to divest, impair, or diminish any water right recognized pursuant to Title 85 (Montana Code Annotated Section 75-5-

705), so any voluntary water savings and subsequent in-stream flow augmentation must be done in a way that protects water rights.

Withdrawals are distributed along nearly the entire modeled length (**Appendix G**). Under the water use scenario, improving water use efficiency and withdrawing 15% less water has a minimal effect on temperatures in Grant Creek. The largest decrease in maximum daily temperature was 0.55°F, seen at river mile 6.5. Decreases greater than 0.2° F were limited to river miles 6.83 to 5.91 and 0.83 to the mouth. Therefore, consumptive water usage appears to have relatively minor impacts on temperature when evaluated from the perspective of achievable instream flow improvements.

7.5.3.3 Shade Scenario

The riparian plant community blocks incoming solar radiation, which directly reduces the heat load to the stream. A single shade scenario was modeled to evaluate the potential benefits associated with increased shade along certain segments of Grant Creek. An evaluation of shading using the Solar Pathfinder™ measurements, Shade model results, GIS, and aerial imagery determined the following:

1. Vegetation along Grant Creek above logger GRTC-T4 is likely at potential and there is very little opportunity to improve shade. Therefore, the segments upstream of logger GRTC-T4 will not be altered for the shade scenario.
2. Vegetation communities along Grant Creek downstream of logger GRTC-T4 and upstream of I-90 (i.e., near logger GRTC-T6) are impacted by encroachment from agriculture, residential subdivisions, and power line right-of-ways. There is opportunity to convert some of the herbaceous areas to shrubs or trees. Therefore, shade along this segment will be improved to a reference condition, which is conservatively defined as the segment immediately upstream of logger GRTC-T5 that is composed of a narrow band of trees on one side of the creek.
3. Downstream of I-90, Grant Creek flows through mixed residential, commercial, and agricultural lands. There is considerable opportunity to improve the vegetation communities in the agricultural areas. Therefore, shade along this segment will be improved to a reference condition, which is conservatively defined as the segment immediately downstream of logger GRTC-T8 that is composed of shrubs in a 25-foot buffer providing an average of 59% effective shade.

The Shade model results, Solar Pathfinder™ results, and the reference shade values are shown below in **Figure 7-19**.

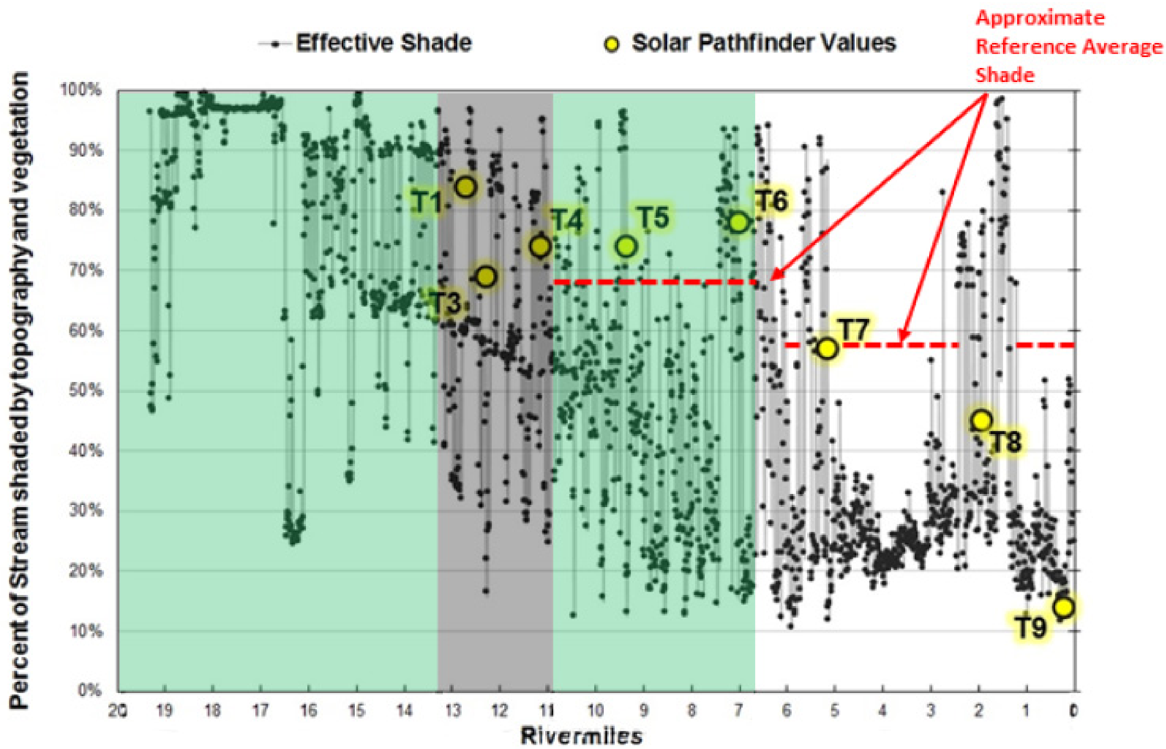

Figure 7-19. Effective shade along Grant Creek, showing both the baseline and reference conditions

The average daily effective shade for segments with similar vegetation is presented in **Table 7-5** for the baseline scenario and shade scenario.

Table 7-5. Comparison of effective shade between the existing condition and shade scenario

Segment	Baseline condition (scenario 1)	Improved shade (scenario 3)
GRTC-T1 to GRTC-T3	69%	69%
GRTC-T3 to GRTC-T4	68%	68%
GRTC-T4 to GRTC-T5	61%	63%
GRTC-T5 to GRTC-T6	50%	70%
GRTC-T6 to GRTC-T7	35%	62%
GRTC-T7 to GRTC-T8	37%	60%
GRTC-T8 to GRTC-T9	35%	60%
GRTC-T9 to mouth	34%	59%

Based on this scenario, the maximum daily stream temperature is very sensitive to improvements in riparian shade. This scenario resulted in maximum daily temperatures decreasing from the baseline scenario by 0.1°F to 2.6°F (**Figure 7-20**). Meeting the shade target caused an average decrease in the maximum daily temperature of 0.8°F from the baseline scenario. The maximum decrease was in the middle and lower watershed between sites GRTC-T7 and GRTC-T9. The shade scenario demonstrates that human changes to the riparian vegetation are the primary source of temperature impairment.

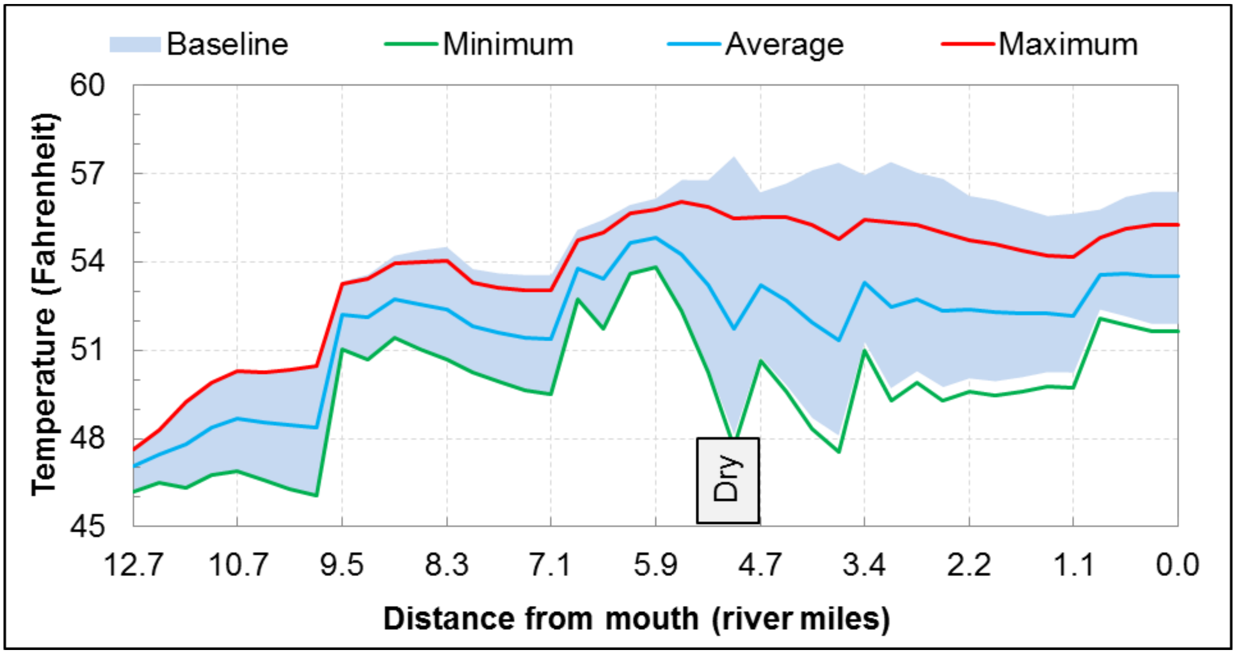

Figure 7-20. Comparison of modeled temperatures for the baseline (scenario 1) and improved shade (scenario 3).

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

The naturally occurring scenario represents Grant Creek water temperatures when all reasonable land, soil, and water conservation practices are implemented (**ARM 17.30.602**). Since the current width/depth ratios are meeting the target and reflected in the baseline scenario, the naturally occurring scenario is a combination of the shade and water use scenarios. Although water conservation measures resulting in additional instream flow will only cause a slight decrease in maximum daily stream temperatures (**Section 7.5.3.2**), the conditions applied in the water use scenario were included because water conservation is a component of the naturally occurring condition.

Given the small influence of water withdrawals, the target for maximum allowable human-influenced temperature change could be achieved entirely by increasing the effective shade. However, water conservation measures resulting in more instream flow would slightly decrease temperatures, meaning slightly less improvement in effective shade would be necessary to meet the water quality standard. The naturally occurring scenario maximum daily temperatures ranged from 47.6°F to 57.6°F, with an average of 54.5°F. Based on these results, the naturally occurring temperature is less than 66.0°F, and an increase of 1°F is allowed from human sources (**Figure 7-21**).

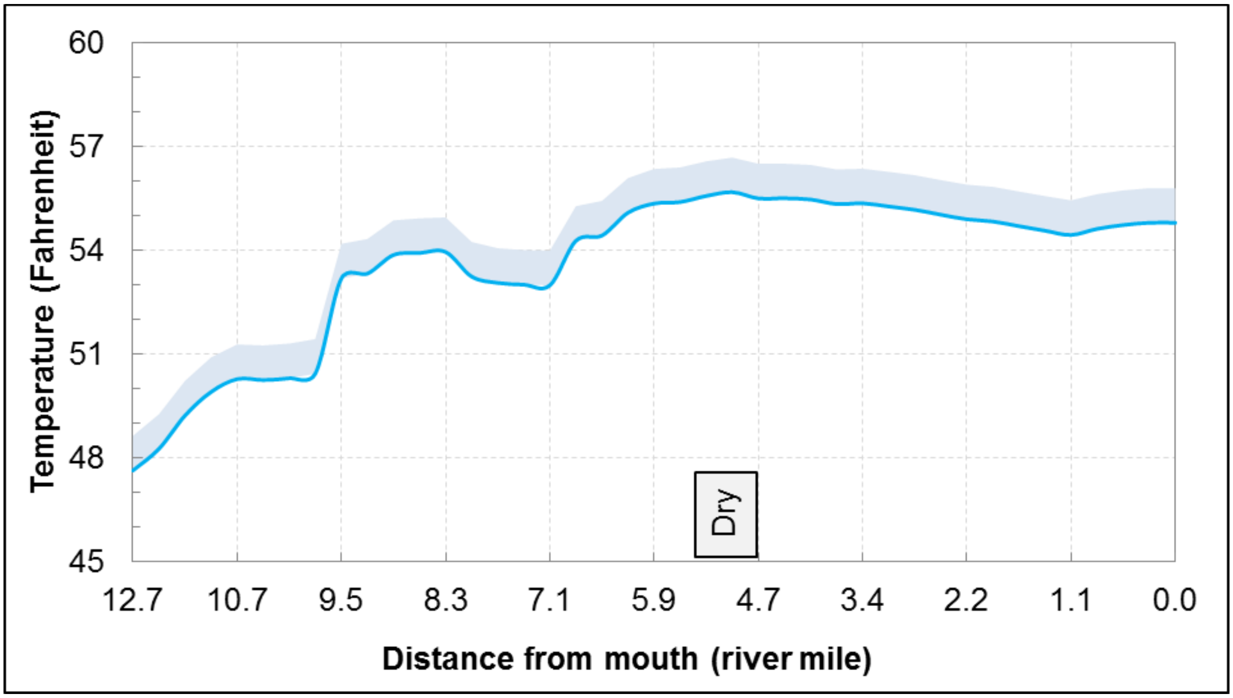

Figure 7-21. Maximum naturally-occurring temperatures in Grant Creek, and allowable increase

The naturally occurring scenario results demonstrate there is the potential for significant reductions in stream temperatures relative to the existing condition (baseline scenario): the potential temperature decreases from this scenario as compared to the baseline scenario ranged from 0.0°F to 2.1°F, with an average decrease of 0.9°F (**Figures 7-22** and **7-23**). Like the shade scenario, the maximum decrease was in the middle and watershed between GRTC-T7 and GRTC-T9, and the smallest change was in the reaches with reference shade.

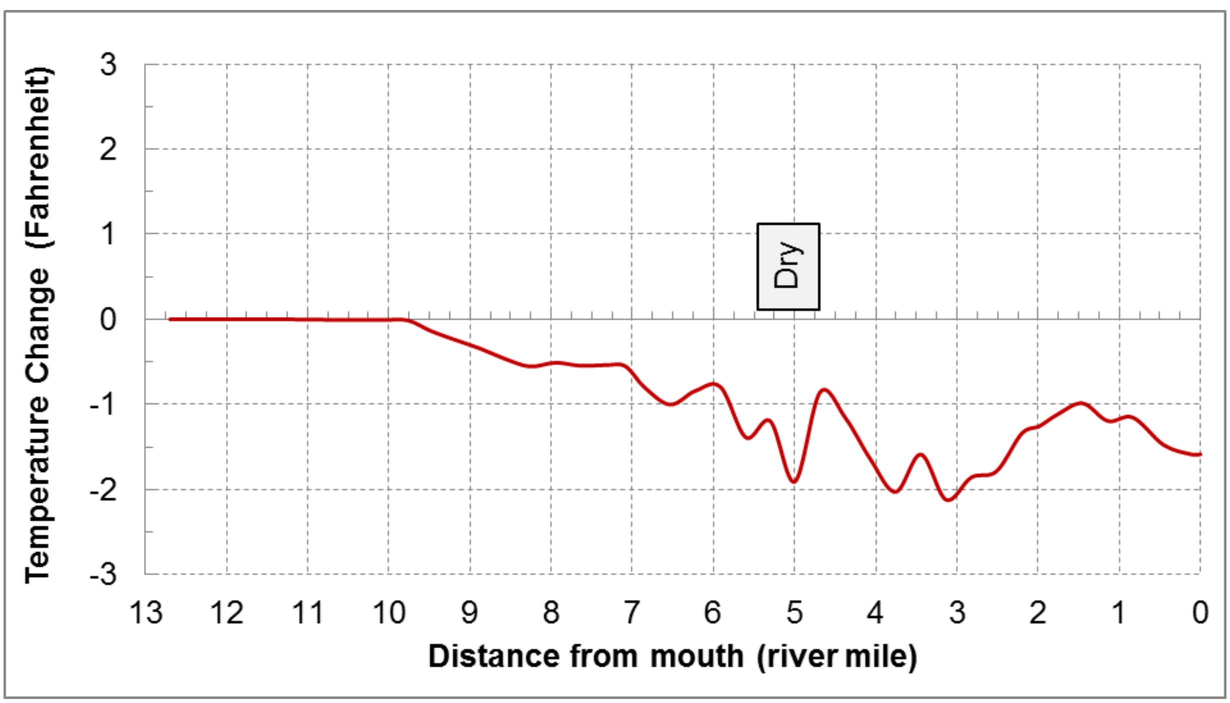

Figure 7-22. Temperature difference between the baseline and naturally occurring scenario

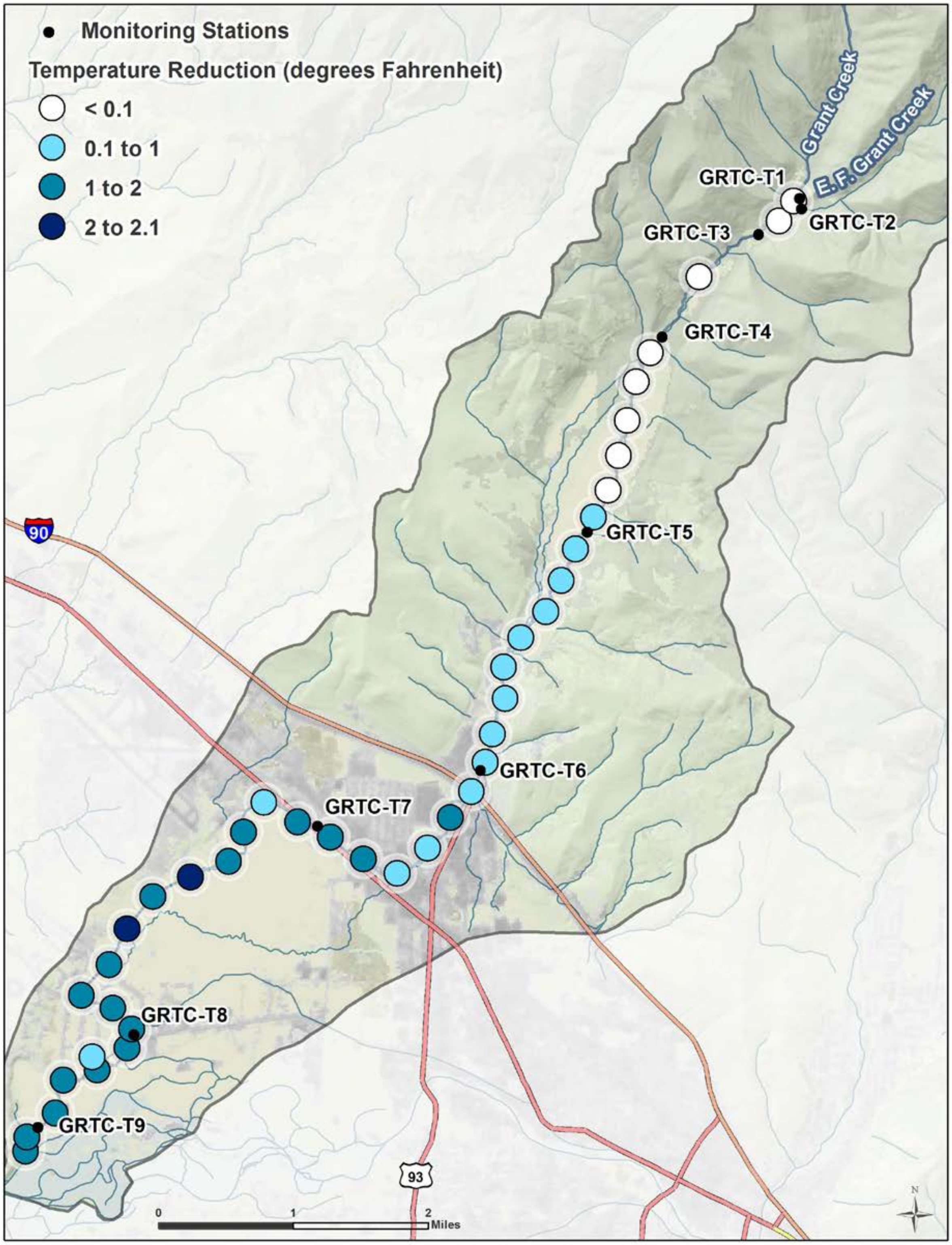

Figure 7-23. Temperature reductions that can be obtained under naturally occurring conditions (relative to the baseline scenario)

7.5.3.5 Point Sources

The two MPDES-permitted point sources discharging to Grant Creek were not addressed via a specific QUAL2K scenario. However, the discharge of non-contact cooling water from the Econo Lodge heat exchanger (MT0029840) was included in the QUAL2K model. The heat exchanger discharge averages 0.12 cfs at an average temperature of 52.1°F. The discharge permit limits the discharge to 0.133 cfs (60 gallons per minute) and 58°F.

The City of Missoula, Missoula County, and Montana Department of Transportation are co-applicants to a MS4 permit (MTR040007) that has 10 identified outfalls to Grant Creek, seven of which are active. (refer to **Figure 7-5**, above in **Section 7.3.7**). The short duration, infrequency, and magnitude of storm events in Montana during the summer makes it likely that any increase in instream temperature due to MS4 discharges will be the result of the initial flush through the system, short-term and sporadic (Kron et al., 2011). Also, any increase in temperature resulting from summer thunderstorm MS4 discharge is likely to be offset by cool runoff from the high elevation headwaters of Grant Creek.

7.5.4 QUAL2K Model Assumptions

The following is a summary of the significant assumptions used during the QUAL2K model development:

- Each stream can be divided into distinct segments, each considered homogeneous for shade, flow, and channel geometry characteristics. Monitoring site locations were selected to be representative of segments within each stream.
- Stream meander and subsurface flow paths (both of which may affect depth-velocity and temperature) are inherently represented during the estimation of various parameters (e.g., stream slope, channel geometry, and Manning's roughness coefficient) for each segment.
- Weather conditions at the Ninemile and Missoula FTS RAWS, which were elevation-corrected, are representative of local weather conditions along these three streams. Adjustments made to streamflow and climate for the baseline scenario adequately represent existing conditions on a hot, dry summer.
- Shade Model results are representative of riparian shading along segments of these three streams.
- All of the cropland associated with water rights is fully irrigated. No field measurements of irrigation withdrawals or returns were available. Application of some water conservation measures resulting in a 15% decrease in water withdrawn is reasonable and consistent with the definition of the naturally occurring condition.

7.6 Existing Conditions and Comparison to Targets

This section includes a comparison of existing data with water quality targets, along with a TMDL development determination for each stream. QUAL2K model results are compared to the allowable human-caused temperature change to determine if the target is being exceeded, but most model details will be presented in **Section 7.5**, **Source Assessment**.

7.6.1 Nemote Creek

Nemote Creek (MT76M002_160) was initially listed in 1996 due to flow alteration and thermal modifications. The temperature listing was reassessed and retained in 2006 based on an instantaneous water temperature more than 3°C (5.4°F) above the upper incipient lethal temperature for westslope cutthroat trout in the lower section of the stream.

Data Summary and Comparison with Water Quality Targets

To help evaluate the extent and implications of impairment it is useful to evaluate the degree to which existing temperatures may harm fish or other aquatic life. Measured temperatures were warmest for the longest period of time in the middle and lower reaches (NMTC-T6, NMTC-T9, and NMTC-T10). These temperatures are not in the lethal range discussed in **Section 7.2.1.4**, but maximum daily temperatures throughout Nemote Creek (**Figure 7-27**) were commonly outside of the optimal growth range for westslope cutthroat trout (i.e., above 62.6°F). The highest recorded temperature in Nemote Creek was 66.1°F. The tributaries Miller Creek and South Fork Nemote Creek were warmer, with the highest temperature recorded (70.9°F) occurring in Miller Creek.

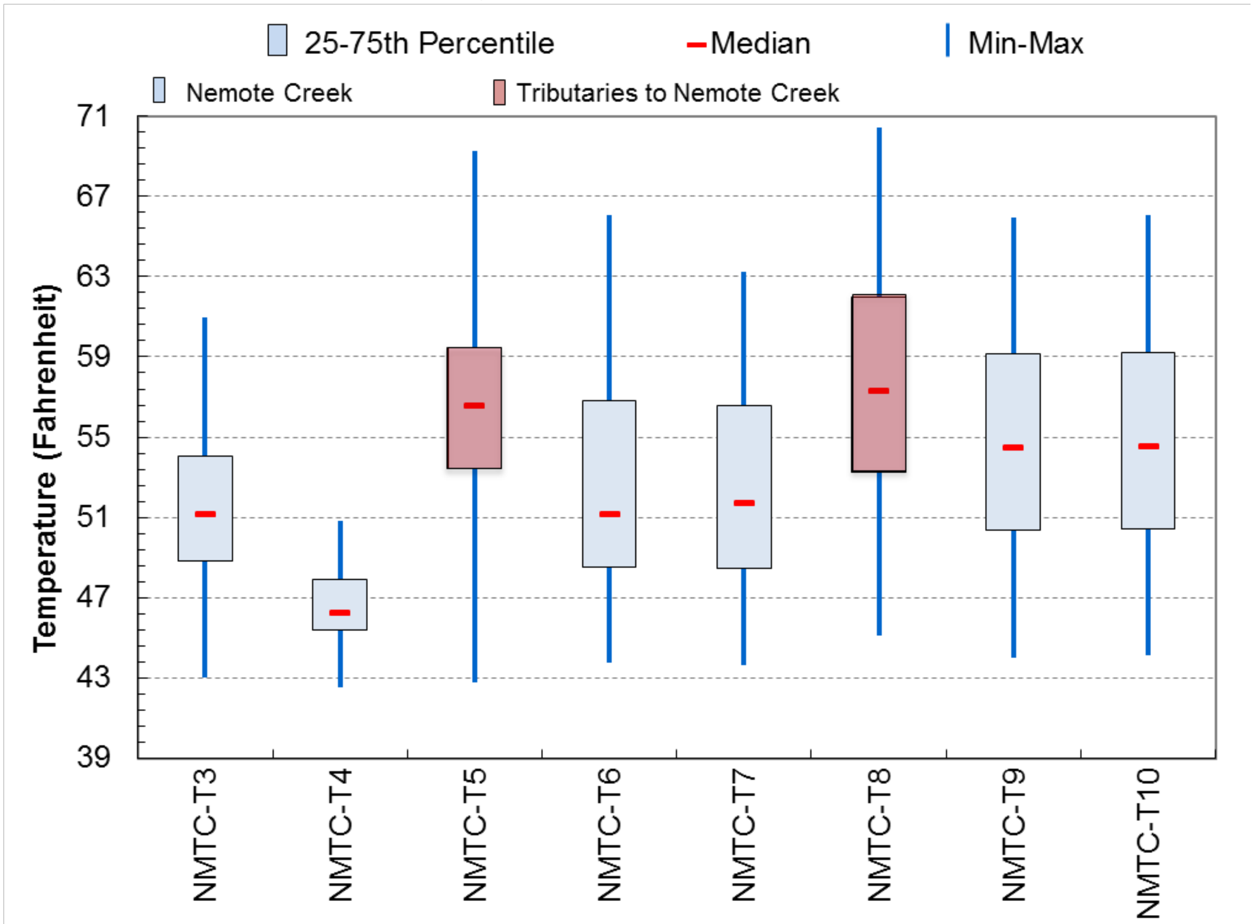

Figure 7-24. 2011 temperature logger monitoring data for Nemote Creek and several tributaries

The QUAL2K model results (discussed above in **Section 7.5.1.4**) demonstrate that the maximum naturally occurring summer temperatures in Nemote Creek are less than 66°F, meaning human sources cannot cause the temperature to be exceeded by more than 1.0°F. Based on the model and temperature data, human sources have caused the allowable change target to be exceeded from mile 5.2 to the mouth, with the increase ranging from 0.8°F to 8.6°F and averaging 3.1°F.

The existing riparian buffer is predominantly herbaceous ground cover and shrubs, followed by medium and high density trees (**Table 7-6**). The reaches characterized by the dark blue dots have overstories of medium and high density trees, whereas the middle reach has no overstory and has limited riparian shrub cover. **Figure 7-25** shows the percent difference between the existing effective shade and the target effective shade (based on the Shade Model results).

Table 7-6. Composition of the existing riparian buffer 50 feet on both sides of Nemote Creek

Land cover type	Area (acres)	Relative area (percent)
Buildings	0.6	0.2%
Herbaceous	152.8	39.4%
Roads	8.0	2.1%
Shrub	21.6	5.6%
Sparse trees	19.4	5.0%
Low density trees	27.2	7.0%
Medium density trees	85.8	22.1%
High density trees	72.6	18.7%

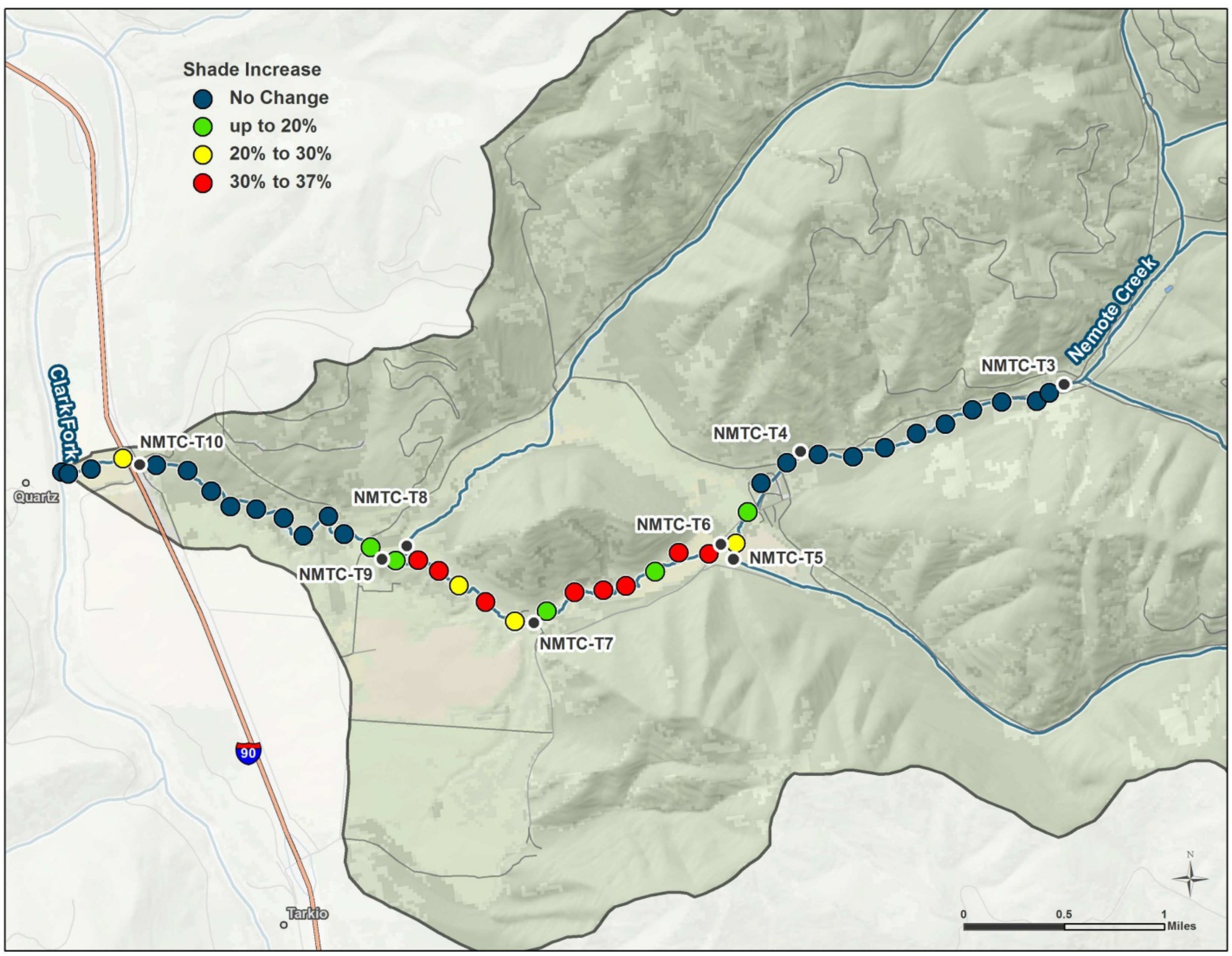

Figure 7-25. The percent of additional effective shade needed to meet the target along Nemote Creek

Summary and TMDL Development Determination

The human-influenced allowable temperature change target is exceeded in the lower 5.2 miles of Nemote Creek. Additionally, the riparian vegetation is generally well under the shade target from river miles 5.1 to 2.3 and 0.5 to 0.4. In contrast, where the overstory remains, upstream of river mile 5.1, as well as the reach between river miles 2.3 and 1.2, the riparian shade is fairly high, despite recent logging activity. The removal of much of the riparian overstory and shrub vegetation in the middle reach continues to limit shade and contribute to elevated water temperatures that are likely limiting its ability to fully support aquatic life. This information supports the existing impairment listing and a temperature TMDL will be developed for Nemote Creek.

7.6.2 Petty Creek

Petty Creek (MT76M002_090) was listed in 2000 for impairment due to flow alteration and thermal modifications. The listing cited “unusually high maximum temperatures for a drainage in this region with a north-facing aspect.”

Data Summary and Comparison with Water Quality Targets

To help evaluate the extent and implications of impairment it is useful to evaluate the degree to which existing temperatures may harm fish or other aquatic life. Measured temperatures were warmest for the longest period of time at PTTYC-T5, where the water temperature reached 59.7°F. These temperatures are not in the lethal range discussed in **Section 7.2.1.4**, but maximum daily temperatures in upper Petty Creek (**Figure 7-26**) were occasionally outside of the optimal growth range for westslope cutthroat trout and bull trout (i.e., above 62.6°F). For tributaries, Madison Gulch was the warmest, with a maximum temperature of 61.2°F.

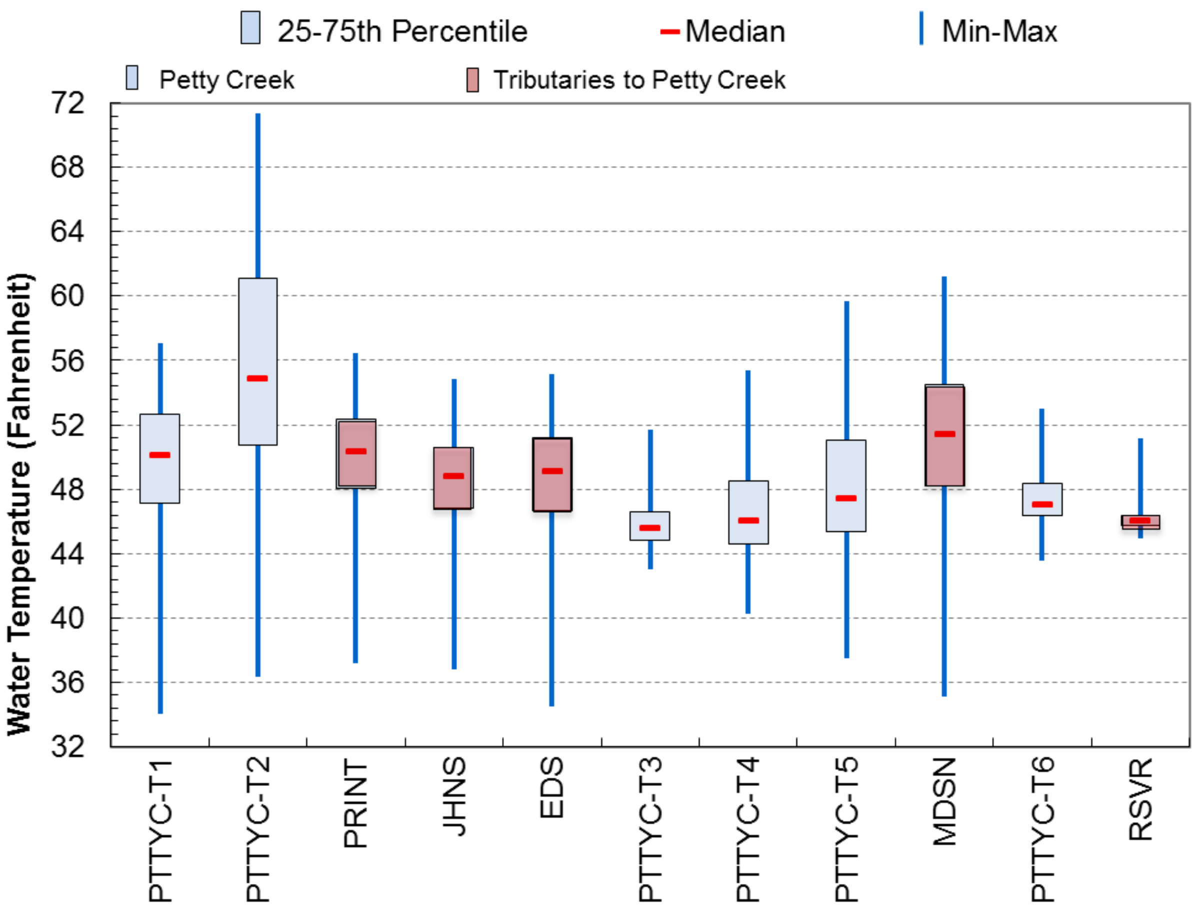

Figure 7-26. 2012 Temperature logger monitoring data for Petty Creek and several tributaries

The QUAL2K model results (discussed above in **Section 7.5.2.4**) indicate that the maximum naturally occurring summer temperatures in Petty Creek are less than 66°F, meaning human sources cannot cause the temperature to be exceeded by more than 1.0°F. Based on the model and temperature data, human sources have caused the allowable change target to be exceeded along the entire modeled reach, from river mile 12.8 to the mouth, with the increase ranging from 0.5°F to 3.8°F and averaging 2.1°F.

Herbaceous vegetation and sparse trees are the most common cover types along Petty Creek, followed by shrubs and low density trees (**Table 7-7**). High and medium density trees, roads, and bare ground cover only a small percentage of the riparian area. From the confluence of the South and East forks, Petty Creek flows through a fairly broad agricultural valley down to the confluence with West Fork Petty Creek. Based on a review of aerial photography, hay fields dominate much of the valley bottom. In many areas it appears that the natural riparian vegetation has been removed along one or both banks. Downstream from the confluence with the West Fork, the valley narrows and the stream is closely paralleled by Petty Creek Road. In some areas, the road has encroached upon the riparian corridor. **Figure 7-27** shows the percent difference between the existing effective shade and the target effective shade (based on the Shade Model results).

Table 7-7. Composition of the existing riparian buffer 50 feet on both sides of Petty Creek

Land cover type	Area	Relative area

	(acres)	(percent)
Bare ground	5.3	1.2%
Herbaceous	203.7	44.5%
Roads	22.5	4.9%
Shrub	59.0	12.9%
Sparse trees	76.0	16.6%
Low density trees	43.5	9.5%
Medium density trees	39.4	8.6%
High density trees	8.5	1.9%

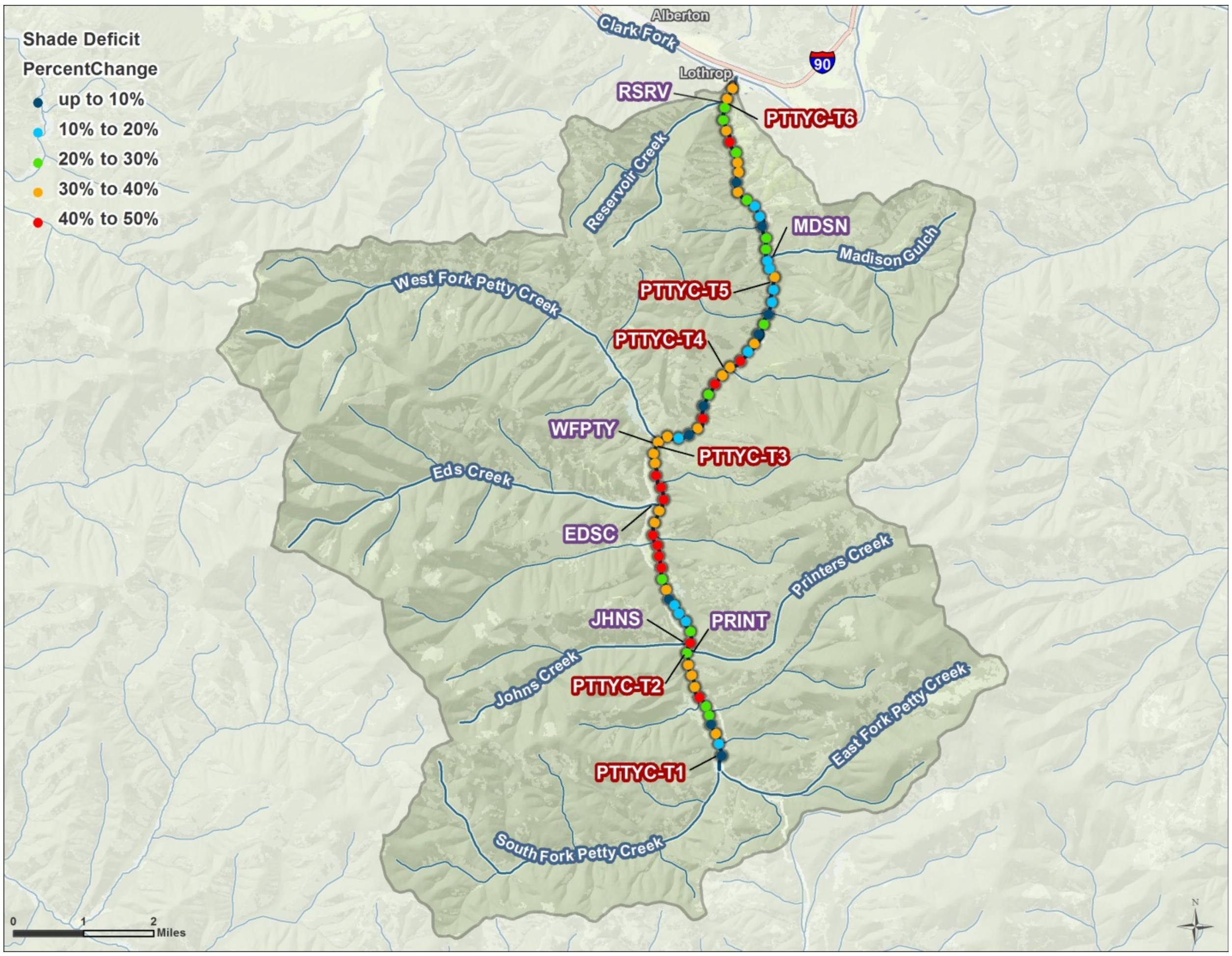

Figure 7-27. The percent of additional effective shade needed to meet the target along Petty Creek

Summary and TMDL Development Determination

The human-influenced allowable temperature change target is being exceeded throughout Petty Creek. Additionally, although width/depth ratios are meeting the target (see **Section 5.4.3.4**), the riparian vegetation is generally well under the shade target for most of the length of the stream. The removal of much of the riparian overstory and shrub vegetation limits shade and contributes to elevated water temperatures that are likely limiting its ability to fully support aquatic life. This information supports the existing impairment listing and a temperature TMDL will be developed for Petty Creek.

7.6.3 Grant Creek

Grant Creek (MT76M002_130) was listed in 1996 due to flow alteration and thermal modifications. The temperature listing was reassessed and retained in 2006 based on an instantaneous water temperature of 21°C, above the upper incipient lethal temperature for westslope cutthroat trout.

Data Summary and Comparison with Water Quality Targets

To help evaluate the extent and implications of impairment it is useful to evaluate the degree to which existing temperatures may harm fish or other aquatic life. Measured temperatures were warmest in the lower reach below I-90 (GRTC-T7, GRTC-T8, and GRTC-T9). These temperatures are not in the lethal range discussed in **Section 7.2.1.4**, but maximum daily temperatures in lower Grant Creek (**Figure 7-28**) were commonly outside of the optimal growth range for westslope cutthroat trout (i.e., above 62.6°F). The highest temperature recorded in Grant Creek was 66.1°F at GRTC-T8.

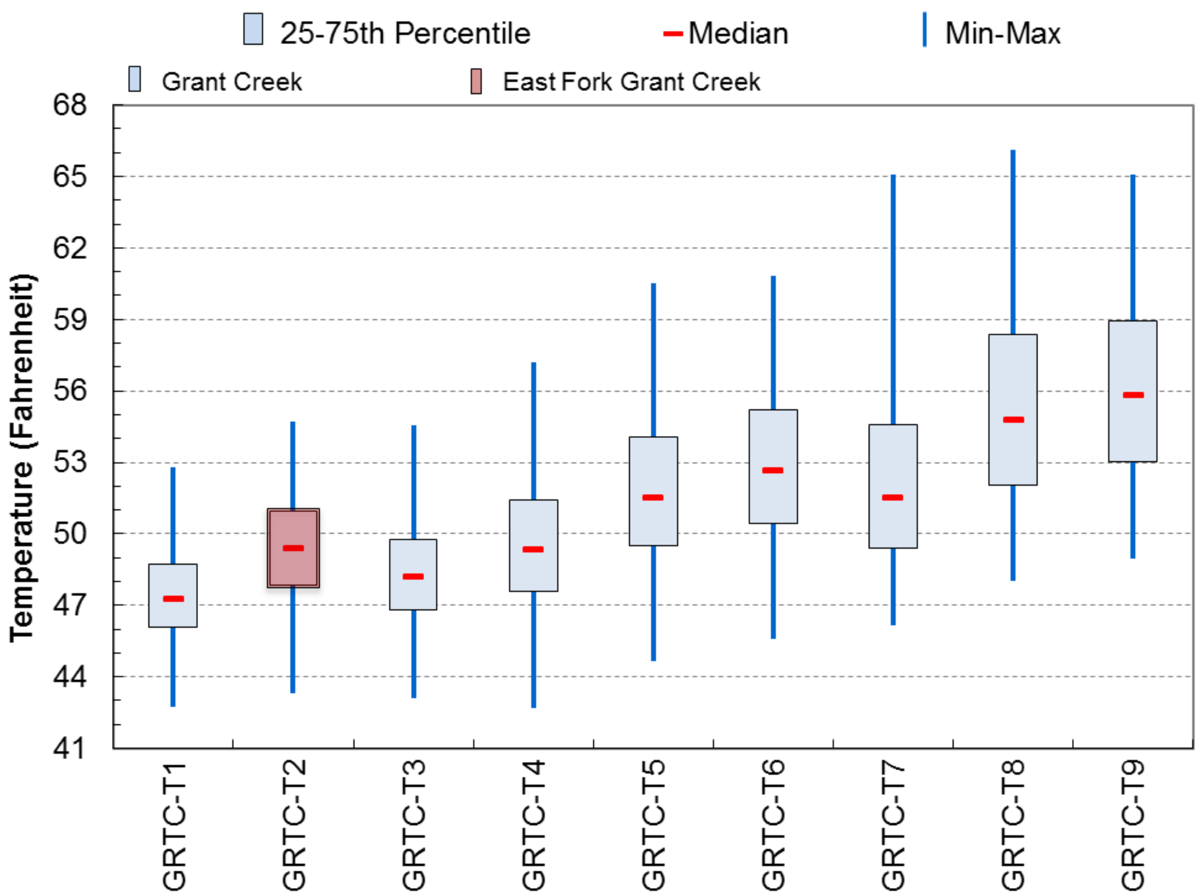

Figure 7-28. 2011 Temperature logger monitoring data for Grant Creek and several tributaries

The QUAL2K model results (discussed above in **Section 7.5.3.4**) indicate that the maximum naturally occurring summer temperatures in Grant Creek are less than 66°F, meaning human sources cannot cause the temperature to be exceeded by more than 1.0°F. Based on the model and temperature data, human sources have caused the allowable change target to be exceeded below station GRTC-T6, from river mile 10.7 to the mouth, with the increase ranging from 0°F to 2.1°F and averaging 0.9°F.

Herbaceous vegetation and low density trees are the most common cover types along Grant Creek, followed by medium and high density trees (**Table 7-8**). Roads, shrubs, bare ground, and buildings compose only a small percentage of the riparian area. The increases in percent effective shade required to meet the target are shown below in **Figure 7-29**.

Table 7-8. Composition of the existing riparian buffer 50 feet on both sides of Grant Creek

Land cover type	Area (acres)	Relative area (percent)
Bare ground	8.1	1.2%
Buildings	6.4	0.9%
Herbaceous	287.6	41.5%
Roads	34.1	4.9%
Shrub	23.3	3.4%
Sparse trees	46.9	6.8%
Low density trees	122.7	17.7%
Medium density trees	81.8	13.0%
High density trees	73.7	10.6%

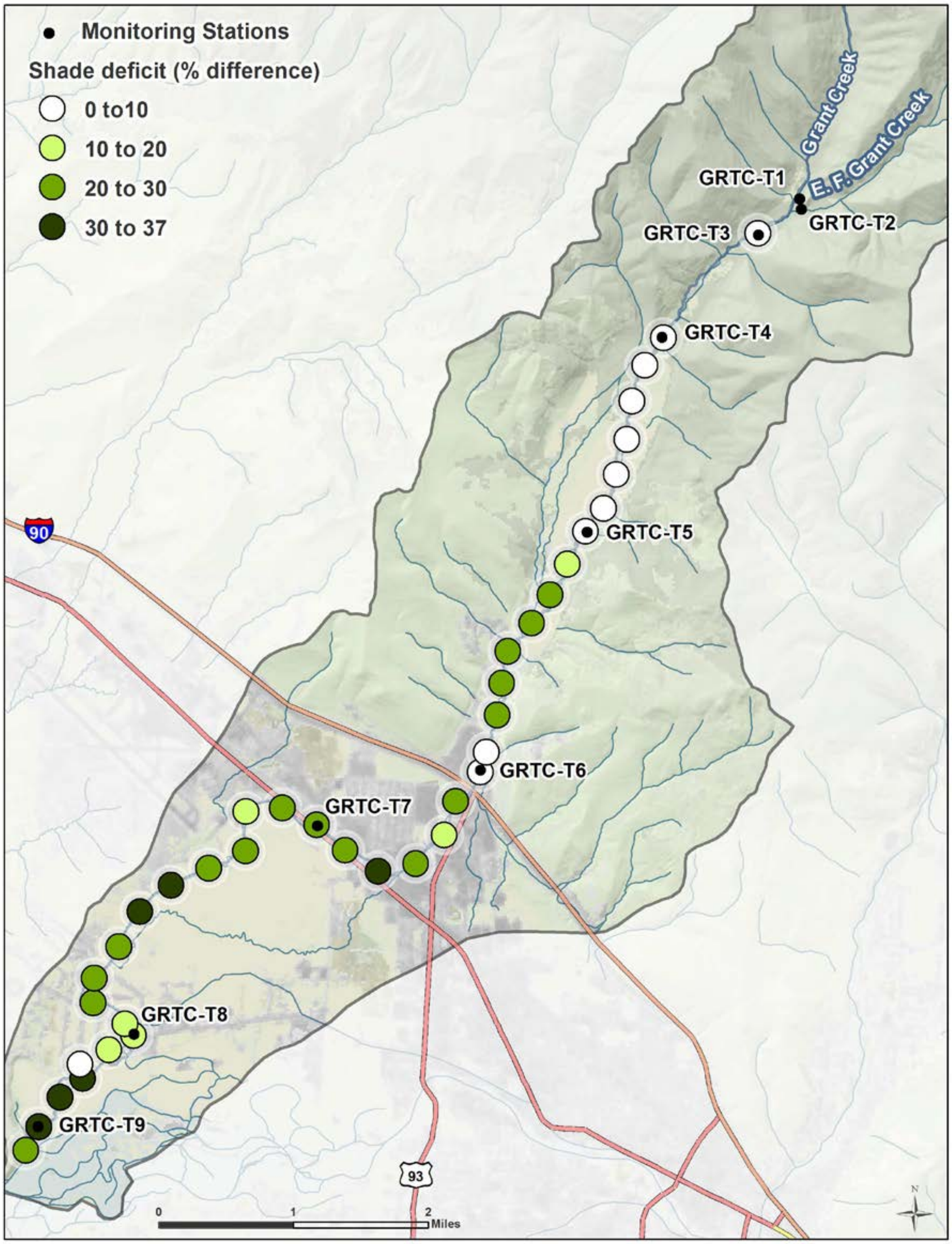

Figure 7-29. The percent of additional effective shade needed to meet the target along Grant Creek

Summary and TMDL Development Determination

The human-influenced allowable temperature change target is being exceeded in lower Grant Creek, below the interstate. Additionally, width/depth ratios are not meeting the target in the upper and middle portion of the stream (see **Section 5.4.3.5**), and the riparian vegetation is generally under the shade target along the lower half of the stream. The removal of much of the riparian overstory and shrub vegetation limits shade and contributes to elevated water temperatures that are likely limiting its ability to fully support aquatic life. This information supports the existing impairment listing and a temperature TMDL will be developed for Grant Creek.

7.7 TEMPERATURE TMDLS 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 (**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.

7.7.1. Temperature TMDL and Allocation Framework

Because stream temperatures change throughout the course of a day, the temperature TMDL is expressed as the instantaneous thermal load associated with the stream temperature when in compliance with Montana's water quality standards. As stated earlier, the temperature standard for Nemote, Petty, and Grant creeks is defined as follows: The maximum allowable increase over the naturally occurring temperature is 1°F, when the naturally occurring temperature is less than 66°F. Within the naturally occurring temperature range of 66–66.5°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 that applies to each of these streams relative to naturally occurring temperatures is depicted in **Figure 7-30**.

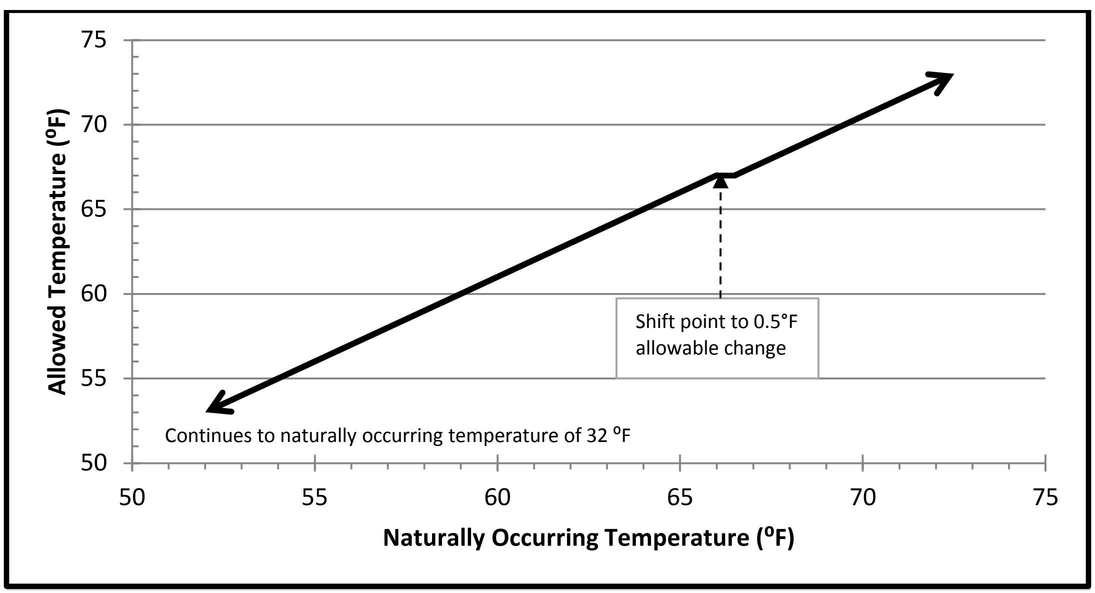

Figure 7-30. Line graph of the temperature standard that applies to Nemote, Petty, and Grant creeks

For any naturally occurring temperature over 32°F (i.e., water's freezing point), the allowable instantaneous thermal total maximum load (kcal/per second) can be calculated using the standard to identify the allowable human-caused increase (stated above and shown in **Figure 7-32**) and **Equation 7-1.**

Equation 7-1: $TMDL = (((T_{NO} + \Delta) - 32) * 5/9) * Q * 28.3$

Where:

TMDL = allowable thermal load (kcal/s) above 32°F
T_{NO} = naturally occurring water temperature (°F)
Δ = allowable increase above naturally occurring temperature (°F)
Q = streamflow (cfs)
28.3 = conversion factor

The instantaneous load is most appropriate expression for a temperature TMDL because water temperatures fluctuate throughout the day and an instantaneous load allows for evaluation of human caused thermal loading during the daytime when fish are most distressed by elevated water temperatures and when human-caused thermal loading would have the most effect. Although EPA encourages TMDLs to be expressed in the most applicable timescale, it also requires TMDLs to be presented as daily loads (Grumbles, Benjamin, personal communication 2006). Any instantaneous TMDL calculated using **Equation 7-1**, which provides a load per second, can be converted to a daily load (kcal/day) by multiplying by 86,400 (which is the number of seconds in a day).

Because calculation of the TMDL on any timescale relies on the identification of the naturally occurring condition, which fluctuates over time and within a stream, it generally requires a water quality model. However, the shade and width/depth targets that will be met when all reasonable land, soil, and water conservation practices are applied and the water conservation efforts that fall under the definition of naturally occurring are also measurable components of meeting the TMDL and water quality standard. Meeting targets for effective shade and width/depth ratio, and applying all reasonable water conservation measures collectively provide an alternative method for meeting and evaluating the TMDL that more directly translates to implementation than an instantaneous or daily thermal load.

Therefore, these temperature-influencing measures are being provided as a surrogate TMDL. An example instantaneous TMDL will also be provided. Conceptually, the allocations for the surrogate TMDL and numeric TMDL are the same: the entire load is allocated to natural sources and nonpoint human sources that influence temperature (by altering effective shade, width/depth ratio, and instream flow). Human sources should follow all reasonable land, soil, and water conservation practices.

7.7.2 Temperature TMDL and Allocations for Nemote Creek

The example TMDL expressed as an instantaneous load is presented in **Table 7-9** and the surrogate TMDL and allocations are presented in **Table 7-10**. The example TMDL is a direct translation of the water quality standard into a thermal load. There are no point sources and the entire allowable load is allocated to natural and human sources that influence temperature. In other words, the TMDL is equal to the $LA_{composite}$. The example TMDL is based on the modeled naturally occurring maximum daily temperature at river mile 2.8 during a hot summer with low flow (2.2 cfs). The naturally occurring temperature used in the example is 63.02°F, which means there is an allowable increase of 1°F and the maximum allowable temperature would be 64.02°F. The maximum daily temperature at river mile 2.8 under the baseline scenario representing critical existing conditions was 71.64°F. The calculation of the example TMDL using E**quation 7-1** is shown below:

TMDL = LA $_{composite}$ = ((63.0 + 1.0) – 32) * 5/9) * 2.2 * 28.3 = 1,107 kcal/second

The surrogate TMDL contains allocations to temperature-influencing factors that will result in standards attainment when met. Because there are no point sources, there is no waste load allocation. There is an implicit margin of safety (MOS); the main factor in the MOS is that although there is an allowable increase over the naturally occurring condition, when implementing the TMDL, human sources should follow all reasonable land, soil, and water conservation practices. Additional details about the MOS are provided in **Section 7.8**.

Table 7-9. Example Instantaneous Temperature TMDL and Allocation for Nemote Creek.

Source Type	Modeled Existing Load (kcal/sec)	TMDL/Load Allocation (kcal/sec)	Percent Reduction Needed
Natural and human sources that influence temperature	1,371	1,107	19%

Table 7-10. Surrogate Temperature TMDL and Allocations for Nemote Creek

Source Type	Surrogate Allocation
Land uses and practices that reduce riparian health and shade provided by near-stream vegetation along Nemote Creek.	Improve to and maintain a 50 foot buffer or any vegetation providing effective shade equivalent to that provided in the reference section (between river miles 1.2 to 2.3).
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	No increase in average width or width/depth ratios due to human-caused sources • Where bankfull width < 30ft, a width/depth ratio ≤ 21 • Where bankfull width > 30ft: a width/depth ratio ≤ 32
Inefficient consumptive water use	Application of all reasonable water conservation practices
Surrogate TMDL	**Application of all reasonable land, soil, and water conservation practices for human sources that could influence stream temperatures. This primarily includes those affecting riparian shade, channel width, and instream flow.**

7.7.2.1 Meeting Temperature Allocations

Since reduced riparian shade is the primary source of the impairment, improving the effective shade will be the primary mechanism for implementing and achieving the TMDL. DEQ realizes that re-establishment of a riparian overstory and meeting the effective shade target will likely take a long time. In most instances, current management practices are meeting the intent of the allocations, and the commitment to improving water quality needs to be maintained so that the existing riparian vegetation can continue to mature. The targets and allocations represent the desired conditions that would be expected in most areas along the stream, but as discussed relative to shade, width/depth ratios, and water conservation in the target and source assessment sections (**7.4.2** and **7.5**), DEQ acknowledges that the allocations may not be achievable at all locations along the stream. The surrogate TMDL provides a measure of conditions that equate to meeting the temperature standard, but the intent and measure of success for all allocations is to follow all reasonable land, soil, and water conservation practices. Future evaluations of TMDL implementation and impairment status will not only assess conservation practices in the watershed but will also use adaptive management (as described in **Section 7.9** and 11.2) to determine if targets applied within this document are still appropriate. Although water conservation measures resulting in additional instream flow will only cause a slight decrease in maximum daily stream temperatures (**Section 7.5.1.2**), the conditions applied in the water use scenario were included because water conservation is a component of the naturally occurring condition. Water users in the Nemote Creek watershed are encouraged to work with the USDA Natural Resource Conservation Service, the Montana Department of Natural Resources and Conservation, the local conservation district, and other local land management agencies to review their irrigation systems, practices, and the variables that may affect overall irrigation efficiency (Negri and Brooks, 1990; NRCS 1997). If warranted and practical, users may consider changes that increase in-stream flows, and/or reduce warm water return flows in Nemote Creek.

7.7.3 Temperature TMDL and Allocations for Petty Creek

The example TMDL expressed as an instantaneous load is presented in **Table 7-11** and the surrogate TMDL and allocations are presented in **Table 7-12**. The example TMDL is a direct translation of the water quality standard into a thermal load. There are no point sources and the entire allowable load is allocated to natural and human sources that influence temperature. In other words, the TMDL is equal to the $LA_{composite}$. The example TMDL is based on the modeled naturally occurring maximum daily temperature at the mouth during a hot summer with low flow (22.2 cfs). The naturally occurring temperature used in the example is 48.71°F, which means there is an allowable increase of 1°F and the maximum allowable temperature would be 49.71°F. The maximum daily temperature at the mouth under the baseline scenario was 50.91°F. The calculation of the example TMDL using E**quation 7-1** is shown below:

$TMDL = LA_{composite} = ((48.7 + 1.0) – 32) * 5/9) * 22.2 * 28.3 = 6,181$ kcal/second

The surrogate TMDL contains allocations to temperature-influencing factors that will result in standards attainment when met. Because there are no point sources, there is no waste load allocation. There is an implicit margin of safety (MOS); the main factor in the MOS is that although there is an allowable increase over the naturally occurring condition, when implementing the TMDL, human sources should follow all reasonable land, soil, and water conservation practices. Additional details about the MOS are provided in **Section 7.8**.

Table 7-11. Example Instantaneous Temperature TMDL and Allocation for Petty Creek.

Source Type	Modeled Existing Load (kcal/sec)	TMDL/Load Allocation (kcal/sec)	Percent Reduction Needed
Natural and human sources that influence temperature	6,603	6,181	6%

Table 7-12. Surrogate Temperature TMDL and Allocations for Petty Creek

Source Type	Surrogate Allocation
Land uses and practices that reduce riparian health and shade provided by	Improve to and maintain a 50 foot buffer with medium density trees from river mile 7.0 to the mouth, and with

Table 7-12. Surrogate Temperature TMDL and Allocations for Petty Creek

Source Type	Surrogate Allocation
near-stream vegetation along Petty Creek.	hydrophytic shrubs from river mile 7.0 upstream, or any vegetation providing equivalent effective shade
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	No increase in average width or width/depth ratios due to human-caused sources • Where bankfull width < 30ft, a width/depth ratio ≤ 21 • Where bankfull width > 30ft: a width/depth ratio ≤ 32
Inefficient consumptive water use	Application of all reasonable water conservation practices
Surrogate TMDL	**Application of all reasonable land, soil, and water conservation practices for human sources that could influence stream temperatures. This primarily includes those affecting riparian shade, channel width, and instream flow.**

7.7.3.1 Meeting Temperature Allocations

Since reduced riparian shade is the primary source of the impairment, improving the effective shade will be the primary mechanism for implementing and achieving the TMDL. DEQ realizes that re-establishment of a riparian overstory and meeting the effective shade target will likely take a long time. In most instances, current management practices are meeting the intent of the allocations, and the commitment to improving water quality needs to be maintained so that the existing riparian vegetation can continue to mature. Water users in the Petty Creek watershed are encouraged to work with the USDA Natural Resource Conservation Service, the Montana Department of Natural Resources and Conservation, the local conservation district, and other local land management agencies to review their irrigation systems, practices, and the variables that may affect overall irrigation efficiency (Negri and Brooks, 1990; NRCS 1997). If warranted and practical, users may consider changes that increase in-stream flows, and/or reduce warm water return flows in Petty Creek. The targets and allocations represent the desired conditions that would be expected in most areas along the stream, but as discussed relative to shade, width/depth ratios, and water conservation in the target and source assessment sections (**7.4.2** and **7.5**), DEQ acknowledges that the allocations may not be achievable at all locations along the stream. The surrogate TMDL provides a measure of conditions that equate to meeting the temperature standard, but the intent and measure of success for all allocations is to follow all reasonable land, soil, and water conservation practices. Future evaluations of TMDL implementation and impairment status will not only assess conservation practices in the watershed but will also use adaptive management (as described in **Section 7.9** and 11.2) to determine if targets applied within this document are still appropriate.

7.7.4 Temperature TMDL and Allocations for Grant Creek

The example TMDL expressed as an instantaneous load is presented in **Table 7-13** and the surrogate TMDL and allocations are presented in **Table 7-14**. The example TMDL is a direct translation of the water quality standard into a thermal load. The example TMDL is based on the modeled naturally occurring maximum daily temperature at river mile 3.13 during a hot summer with low flow (1.23 cfs). The naturally occurring temperature used in the example is 55.3°F, which means there is an allowable increase of 1°F and the maximum allowable temperature would be 56.3°F. The maximum daily temperature at river mile 3.13 under the baseline scenario was 57.4°F. The calculation of the example TMDL using E**quation 7-1** is shown below:

TMDL = ((55.3 + 1.0) – 32) * 5/9) * 1.23 * 28.3 = 450 kcal/second

Because there are two point sources, the TMDL equation includes two wasteload allocations (WLA $_{MS4}$ and WLA $_{MT0029840}$). The entire remaining allowable load is allocated to a composite of natural and all other human sources that influence temperature (LA $_{composite}$).

Therefore, the TMDL equation is set as:

TMDL = LA $_{composite}$ + WLA $_{MS4}$ + WLA $_{MT0029840}$

The WLA $_{MS4}$ is equal to zero under normal flow conditions since there is only loading during storm events which occur infrequently and are generally short in duration. The WLA $_{MT0029840}$ can be calculated based on the permitted discharge temperature (58°) times the permitted discharge (60 gpm or 0.133 cfs).

WLA $_{MT0029840}$ = ((58) – 32) * 5/9) * 0.13 * 28.3 = 53 kcal/second

No thermal load reductions are required for this discharge. Therefore, the LA $_{composite}$ can be determined by subtracting the WLA $_{MT0029840}$ from the TMDL:

LA $_{composite}$ = TMDL – WLA $_{MT0029840}$ = 450 kcal/second – 53 kcal/second = 397 kcal/second

The surrogate TMDL contains allocations to temperature-influencing factors. When these allocations are met, the standards will be attained. There are two waste load allocations provided to point sources. There is an implicit margin of safety (MOS); the main factor in the MOS is that although there is an allowable increase over the naturally occurring condition, when implementing the TMDL, human sources should follow all reasonable land, soil, and water conservation practices. Additional details about the MOS are provided in **Section 7.8**.

Table 7-13. Example Instantaneous Temperature TMDL and Allocation for Grant Creek.

Source Type	Modeled Existing Load (kcal/sec)	TMDL (kcal/sec)	Load Allocation: LA $_{composite}$ (kcal/sec)	Wasteload Allocation: WLA $_{MT0029840}$ (kcal/sec)	Percent Reduction Needed for LA
Natural and human sources that influence temperature	491	450	397	53	20%

Table 7-14. Surrogate Temperature TMDL and Allocations for Grant Creek

Source Type	Surrogate Allocation
Land uses and practices that reduce riparian health and shade provided by near-stream vegetation along Grant Creek.	Improve to and maintain a 50 foot buffer or any vegetation providing effective shade equivalent to that provided in the reference sections (between river miles 12.7 to 9.3 and between river miles 1.2 to 2.3).

Table 7-14. Surrogate Temperature TMDL and Allocations for Grant Creek

Source Type	**Surrogate Allocation**
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	No increase in average width or width/depth ratios due to human-caused sources • Rosgen types A & B: a width/depth ratio ≤ 15 • Rosgen types C & E, where bankfull width > 12ft: a width/depth ratio ≤ 22
Inefficient consumptive water use	Application of all reasonable water conservation practices
Missoula MS4	Follow the minimum control measures provided in the MPDES permit authorization for permit MTR04007, or any updated runoff reduction or initial flush stormwater capture control measures in subsequent permit renewals. Renewed permits must contain initial flush mitigation measures.
MPDES Permit MT0029840	No discharge warmer than 58°F or greater than 0.13 cfs (60 gallons per minute). Current average discharge is 0.12 cfs; current average temperature is 52.1°F.
Surrogate TMDL	**Application of all reasonable land, soil, and water conservation practices for human sources that could influence stream temperatures. This primarily includes those affecting riparian shade, channel width, and instream flow.**

The WLA for the City of Missoula MS4 was not calculated as part of the example TMDL provided above. This was done because storm events during summer occur infrequently and are generally short in duration. The target for the Missoula MS4 in Section 7.4.3 (**Table 7-2**) serves as a surrogate WLA allocation (**Table 7-14**).

7.7.4.1 Meeting Temperature Allocations

Since reduced riparian shade is the primary source of the impairment, improving the effective shade will be the primary mechanism for implementing and achieving the TMDL. DEQ realizes that re-establishment of a riparian overstory and meeting the effective shade target will likely take a long time. In most instances, current management practices are meeting the intent of the allocations, and the commitment to improving water quality needs to be maintained so that the existing riparian vegetation can continue to mature. Water users in the Grant Creek watershed are encouraged to work with the USDA Natural Resource Conservation Service, the Montana Department of Natural Resources and Conservation, the local conservation district, and other local land management agencies to review their irrigation systems, practices, and the variables that may affect overall irrigation efficiency (Negri and Brooks, 1990; NRCS 1997). If warranted and practical, users may consider changes that increase in-stream flows, and/or reduce warm water return flows in Grant Creek. The targets and allocations represent the desired conditions that would be expected in most areas along the stream, but as discussed relative to shade, width/depth ratios, and water conservation in the target and source assessment sections (**7.4.2** and **7.5**), DEQ acknowledges that the allocations may not be achievable at all locations along the stream. The surrogate TMDL provides a measure of conditions that equate to meeting the temperature standard, but the intent and measure of success for all load allocations is to follow all reasonable land, soil, and water conservation practices. Future evaluations of TMDL implementation and impairment status will not only assess conservation practices in the watershed but will also use adaptive management (as described in **Section 7.9** and 11.2) to determine if targets applied within this document are still appropriate.

The City of Missoula, Missoula County, and Montana Department of Transportation are co-applicants to a MS4 permit (MTR040007) that has 10 identified discharge outfalls to Grant Creek, of which seven are active (refer back to **Figure 7-5**, in **Section 7.3.7**). The short duration, infrequency, and magnitude of storm events in Montana during the summer makes it likely that any increase in instream temperature due to MS4 discharges will be the result of the initial flush through the system and short-term (Kron et al., 2011). The target for the City of Missoula MS4 permit will be to follow the minimum control measures provided in the MPDES permit authorization for permit MTR04007, or any updated runoff reduction or initial flush stormwater capture control measures in subsequent permit renewals. Renewed permits must contain initial flush mitigation measures. As long as all BMPs are effectively implemented as described in the permit, discharge will be consistent with naturally occurring conditions.

The discharge from Econo Lodge - Motel Partners I (MPDES permit MT0029840) must be conducted in accordance with the terms of the permit and be no warmer than 58°F. According to a review of available permit reporting data, no operational changes are required to meet this wasteload allocation.

7.8 Seasonality and Margin of Safety

Seasonality and margin of safety are both required elements of TMDL development. This section describes how seasonality and an implicit margin of safety (MOS) were applied during development of the Nemote Creek, Petty Creek, and Grant Creek temperature TMDLs.

Seasonality addresses the need to ensure year-round beneficial use support. Seasonality is addressed for temperature in this TMDL document as follows:

- Temperature monitoring and modeling occurred during the summer, which is the warmest time of the year and when instream temperatures are most stressful to aquatic life.
- Effective shade was based on the August solar path, which is typically the hottest month of the year.
- Although the maximum daily temperature was focused on for the source assessment and impairment characterization because it is mostly likely to stress aquatic life, sources affecting maximum stream temperatures can also alter daily minimum temperatures year-round. Addressing these sources will result in year-round temperature improvements.
- Temperature targets, the TMDLs, and the allocations apply year round, but it is likely that exceedances occur mostly during summer conditions.

The MOS is included 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. The MOS within this document is implicit and is addressed in several ways for temperature as part of this document:

- Although there is an allowable increase from human sources beyond those applying all reasonable land, soil, and water conservation practices, the surrogate allocations are expressed so human sources must apply all reasonable land, soil, and water conservation practices.
- Montana's water quality standards are applicable to any timeframe and any season. The temperature modeling analysis for these streams investigated stream temperatures during summer when effects of increased water temperatures are most likely to have a detrimental

effect on aquatic life. Additionally, flow and climatic conditions were slightly adjusted from the sampling year to represent stream temperatures under more critical conditions than those observed in 2011 and 2012.

- The overall assessment of impacts focuses on the hottest period of the day when impacts from shade and flow are likely most severe. To stress this, the primary time expression of the TMDL is “per second” loading since this can capture the hottest period of the day and the associated impacts.
- Despite the modest improvement in stream temperature that could be expected by implementing conservation measures to leave additional water instream, the source assessment and allocations address consumptive use as a potential human source and recommend the use of all reasonable water conservation measures.
- Compliance with targets and refinement of load allocations are all based on an adaptive management approach (**Section 7.9**) that relies on future monitoring and assessment for updating planning and implementation efforts.

7.9 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.

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.

Uncertainty was minimized during data collection because EPA temperature and field data were collected following a Quality Assurance Project Plan (QAPP) (Atkins 2012) and adhering to DEQ sampling protocols (DEQ 2005a; DEQ 2005b). A QAPP was also completed for the QUAL2K model (Tetra Tech 2012), but there was more uncertainty associated with the model than with the field data because numerous assumptions had to be made to help simulate existing and naturally occurring conditions. Modeling assumptions are briefly described in **Section 7.5.4** but are further detailed within the model reports in **Appendix G**.

The largest source of uncertainty is regarding the targets and conditions used to represent the naturally occurring condition. The targets for width/depth ratio were developed as part of the sediment TMDL process (**Section 5**) and are based on reference data. The target for effective shade from riparian vegetation is intended to represent the reference condition (i.e., highest achievable) and is based on field observations, communication with stakeholders, and best professional judgment. It was selected to be conservative yet achievable, and as discussed in the target and source assessment sections (**7.4** and **7.5**), the ultimate goal and measure of success is implementation of all reasonable land, soil, and water conservation practices. Since little is known regarding current irrigation practices within the watershed, there is also uncertainty regarding current conservation practices and the potential for improvement. This uncertainty is part of the reason there is no set target for improving instream flow or numeric allocation. Literature values were used to estimate the potential for additional instream flow if additional water conservation measures are necessary and implemented. Other areas of uncertainty related to the model are associated with assumptions regarding channel dimensions and groundwater temperatures; limited information for those sources was used and applied throughout the watershed. Riparian shade is highly variable in the watersheds but a comparison between the field measured effective shade values and values simulated via the Shade Model indicate the models reasonably approximated existing shade conditions. Although this uncertainty within the models results in error bars around the modeled temperatures for each scenario, the magnitude of temperature increase caused by human sources still exceeds the allowable change for most of Nemote, Petty, and Grant creeks. Additionally, each stream receives flow from multiple tributaries. While the influences of these tributaries were evaluated in each model, assessing the human influences on tributary water temperatures was outside of the scope of this project. Application of all reasonable land, soil, and water conservation practices within these tributary watersheds may result in additional improvement to the mainstem temperature regimes. Additional details regarding uncertainty associated with the models are contained in **Appendix G**.

The TMDLs and allocations established in this section are meant to apply to recent conditions of natural background and natural disturbance. Under some periodic natural conditions, such as fire, it may not be possible to satisfy all targets, loads, and allocations because of natural short-term affects to temperature. Additionally, fire has the potential to alter the long-term vegetative potential. 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 long-term excess loading during recovery from significant natural events.

Any 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 TMDL 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.

8.0 Turbidity TMDL Components

This portion of the document focuses on turbidity as a cause of water quality impairment in the Central Clark Fork Basin Tributaries TMDL Project Area. It describes: (1) how turbidity impairs beneficial uses, (2) the affected stream segments, (3) the currently available data pertaining to turbidity impairments in the watershed, (4) the sources of turbidity based on recent studies, and (5) the proposed turbidity TMDLs and their rationales.

8.1 Effects of Excess Turbidity on Beneficial Uses

The weathering and erosion of land surfaces and the transport to, and via, streams are natural phenomena and important in building and maintaining streambanks and floodplains. Yet, excessive erosion and/or the absence of natural sediment barriers (e.g., riparian vegetation, woody debris, beaver dams, and overhanging vegetation) can cause high levels of turbidity in streams from a variety of land uses, road networks and/or mining activities. Uncharacteristically high amounts of turbidity in streams can impair beneficial uses, such as support of aquatic life, coldwater fisheries, recreation, and drinking water.

Turbidity is a measure of opacity of a substance; the degree to which light is scattered or absorbed by a fluid. High levels of turbidity reduce light penetration through water, which can limit the growth of aquatic plants. As a result, aquatic insect populations could also decline. In turn, this can limit fish populations. Turbidity is caused by suspended matter or impurities that interfere with the clarity of the water such as clay, silt, finely divided inorganic and organic matter, soluble colored organic compounds (e.g. tannic acids), and plankton and other microscopic organisms.

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

High turbidity in streams decreases recreational use potential and aesthetic appreciation. Excessive sediment can also increase filtration costs for water treatment facilities that provide safe drinking water

8.2 Stream Segments of Concern

One waterbody segment, Trout Creek, in the Central Clark Fork Basin Tributaries TMDL project area appeared on the 2014 Montana 303(d) List for a turbidity impairment (**Figure 8-1**). Classified as a B-1 waterbody, Trout Creek is also impaired for various forms of habitat alterations (**Table 9-1**), which are non-pollutant causes commonly associated with other impairments including turbidity. 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.

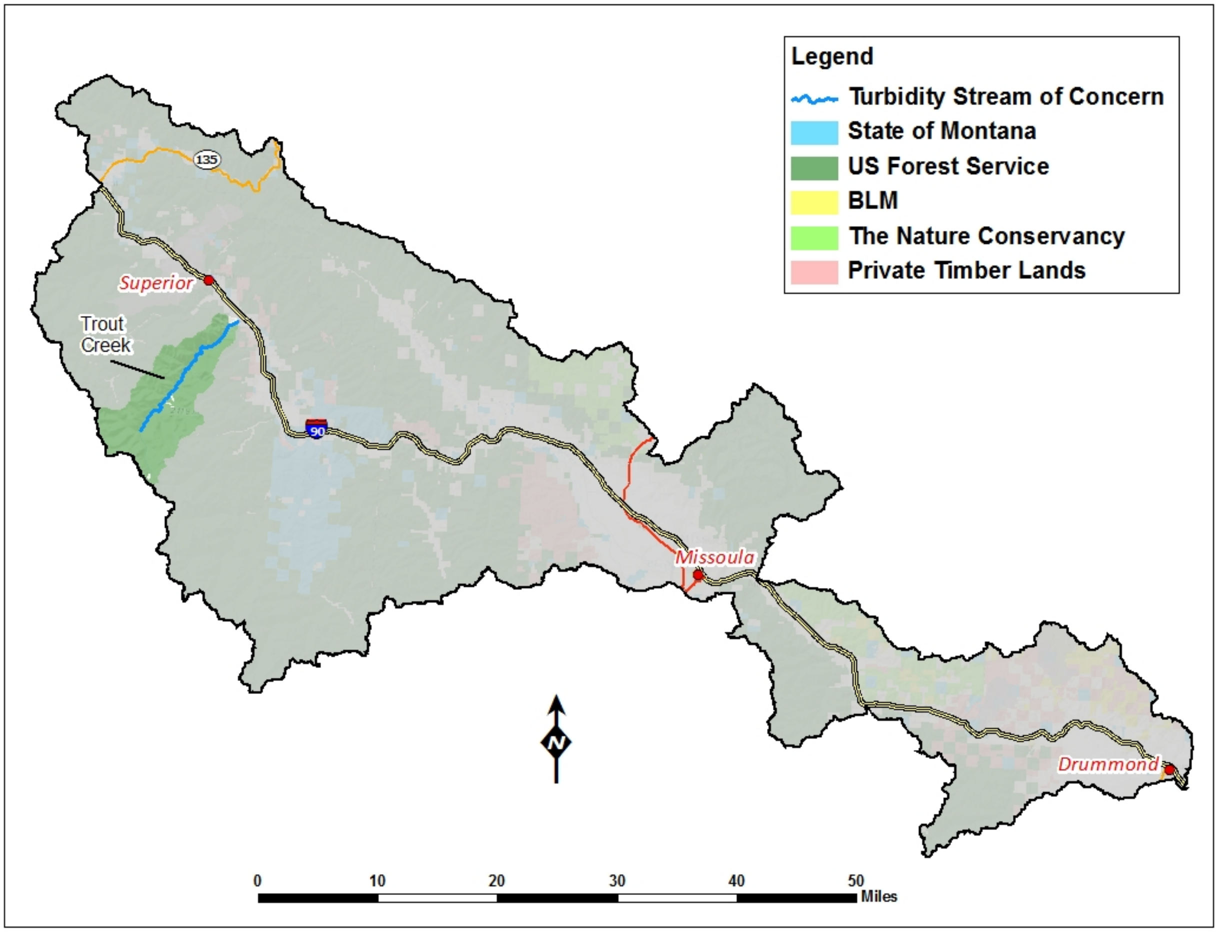

Figure 8-1. Turbidity stream of concern in the Central Clark Fork Tributaries Project Area

8.3 Water Quality Targets

TMDL water quality targets are numeric indicator values used to evaluate attainment of water quality standards. The following section presents turbidity water quality targets as well as data compilations used to define the naturally occurring condition in the Trout Creek watershed.

8.3.1 Turbidity Water Quality Targets

The Montana instream numeric water quality criteria (the Standard) for turbidity are adopted as the turbidity target for Trout Creek in the Central Clark Fork tributaries TPA. The Montana turbidity standard for B-1 waterbodies specifies:

The maximum allowable increase above naturally occurring turbidity is five nephelometric turbidity units except as permitted in 75-5-318, MCA [17.30.623(d)].

Evaluation of target compliance is done by comparing existing water quality conditions to the established water quality target. TMDLs establish a maximum allowable daily pollutant load that will result in the attainment and maintenance of water quality standards. In order to ensure that daily maximum allowable loads do not result in an exceedance of the turbidity standard, the change of five nephelometric turbidity units (NTUs) is used for the calculation of turbidity TMDLs and allocations (**Section 8.7**)

8.3.2 Trout Creek Existing Conditions and Comparison to Targets

Trout Creek (MT76M002_050) is listed for turbidity on the 2014 303(d) List and was first listed on the 2002 303(d) list. In addition, this segment is listed for alteration in streamside or littoral vegetative covers and physical substrate alterations, which are non-pollutant listings commonly linked to sediment impairment. The DEQ assessment file links the turbidity listing to wet weather discharges from non-point source and silviculture activities, which were identified in a 1990 assessment of the stream.

The source of the turbidity was identified in photo documentation from October 1990 as leachate from sawmill log storage areas near the mouth, which were affecting color and turbidity in Trout Creek. There was a large log-processing facility near the mouth of Trout Creek (Clark Fork River). Since 1990, sawmill operations have converted to production of posts and poles, wood pellets, and bark mulch at facilities on the site of the old dimension lumber mill on private lands. Significant evidence of historic and active placer mining in the Trout Creek drainage was noted in the 1990 and 2012 assessment work, which are additional potential sources for increased turbidity.

At the sub-watershed scale, 98.5% of the area surrounding Trout Creek is administered by the U.S. Forest Service with 1.5% in private ownership. Trout Creek has been identified as being critical to Bull Trout recovery in the lower Clark Fork River drainage (Montana Bull Trout Scientific Group, 1996). Bull trout require cold clear streams for survival and propagation.

8.3.2.1 DEQ 1990 Trout Creek Assessment

The 1990 DEQ assessment was conducted on October 3rd. An aerial photograph from August 1990 shows the relative location of the existing log yard and sawmill operation at the mouth of Trout Creek (**Figure 8-2**). It is worth noting that the first sawmill operation at the site was the Diamond Match Mill, which began production in 1953. Precipitation at the NRCS Snotel – Hoodoo Basin (530) weather station recorded 0.7 inches of precipitation on October 1st, 0.2 in on October 2nd and 0.5 in on October 3rd. Weather stations at Superior and St. Regis recorded 0.13 in and 0.19 in of precipitation respectively on October 2nd. These stations did not report measurable precipitation on October 1st or October 3rd.

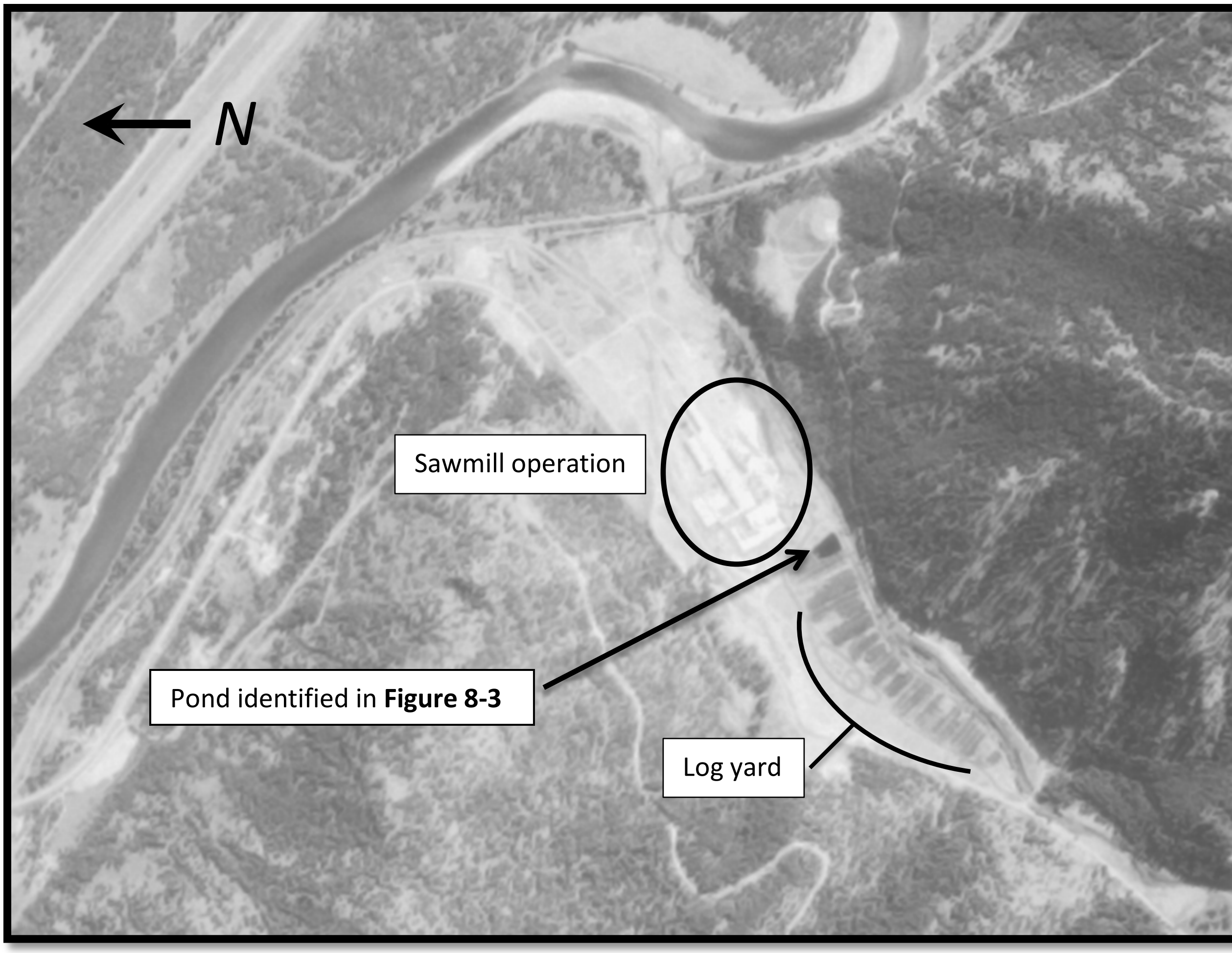

Figure 8-2. Aerial image of wood processing facility at mouth of Trout Creek, 8/6/1990

From the DEQ assessment file (all notes from file are italicized):
No point sources observed, however about 1/5 mile downstream from the upper reach boundary at 16N26W14DDD, several discharges of brown water (wood leachate) observed percolating through rip-rap on left bank. Beginning at the upper influx of brown water, stream turbidity changes from crystal clear to very cloudy brownish-gray (nearly opaque) for entire stream.

Wood leachate run-off needs to be controlled. Note discharge pond in photo T-1 (**Figure 8-3**).

Figure 8-3. Photo T-1 of discharge pond at sawmill operation on Trout Creek, 10/3/1990.

Influx of brown-gray wood-leachate water into stream. Probably organic leachates such as tannins (acidic to stream). Stream becomes completely brown (opaque) from this area to the Clark Fork (see photo T-2) (**Figure 8-4**).

Figure 8-4. Photo T-2 of surface water discharge from log pond to Trout Creek, 10/3/1990.

8.3.3.2 DEQ 2014 Trout Creek Assessment

While the pond in **Figure 8-2** still appears on some maps, a review of aerial photography determined that the pond was filled in sometime between 1995 and 2003 (**Figures 8-5 and 8-6**). The pond in-filling removed the surface water discharge to Trout Creek identified in **Figure 8-4**. The sawmill operation at the site changed ownership in 1993, shuttered in 1994, and was sold in 1995. The facility was severely damaged by fire in November 1996 (as may be seen in changes to the facility in **Figures 8-5 and 8-6**).

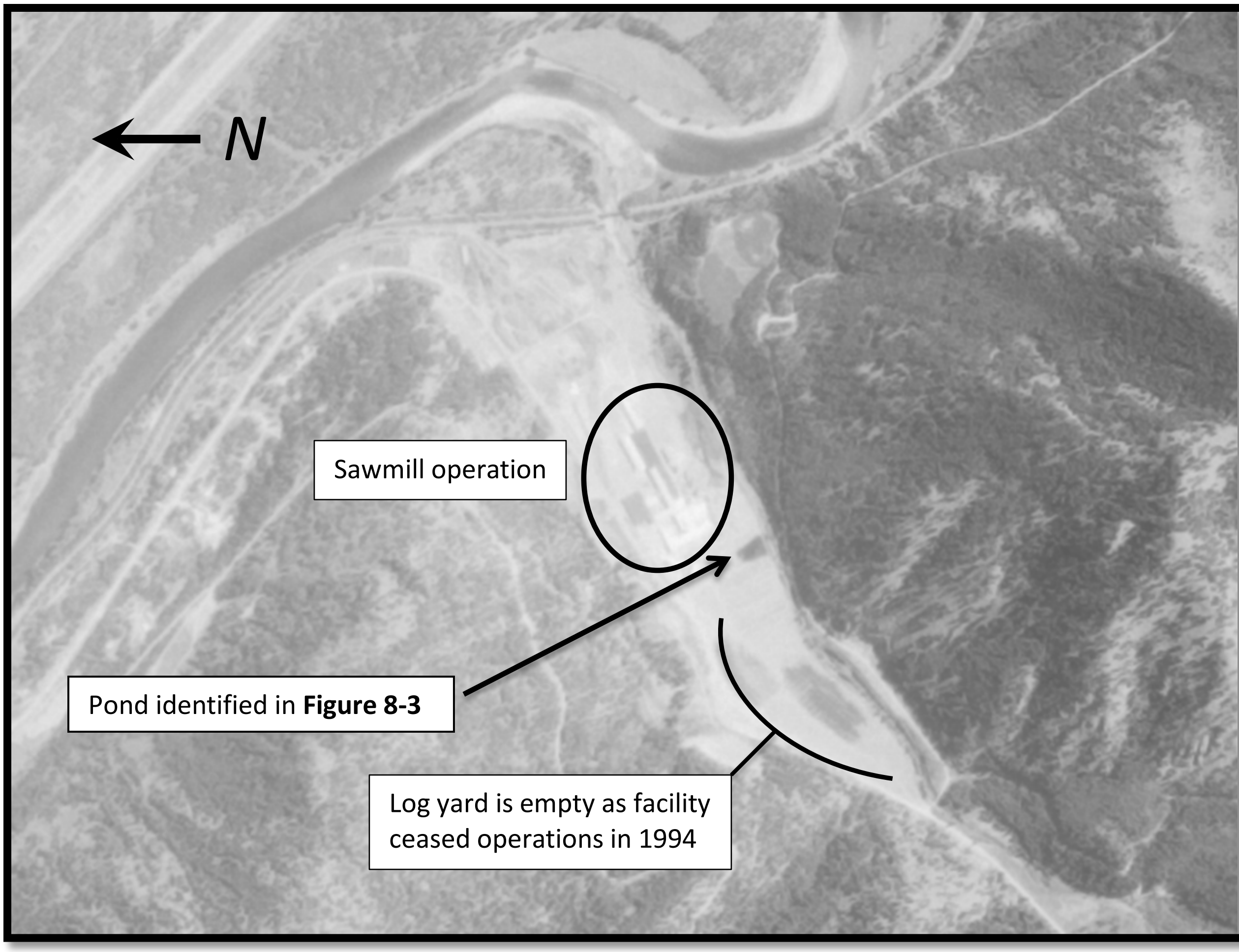

Figure 8-5. Aerial image of wood processing facility at mouth of Trout Creek, 8/25/1995

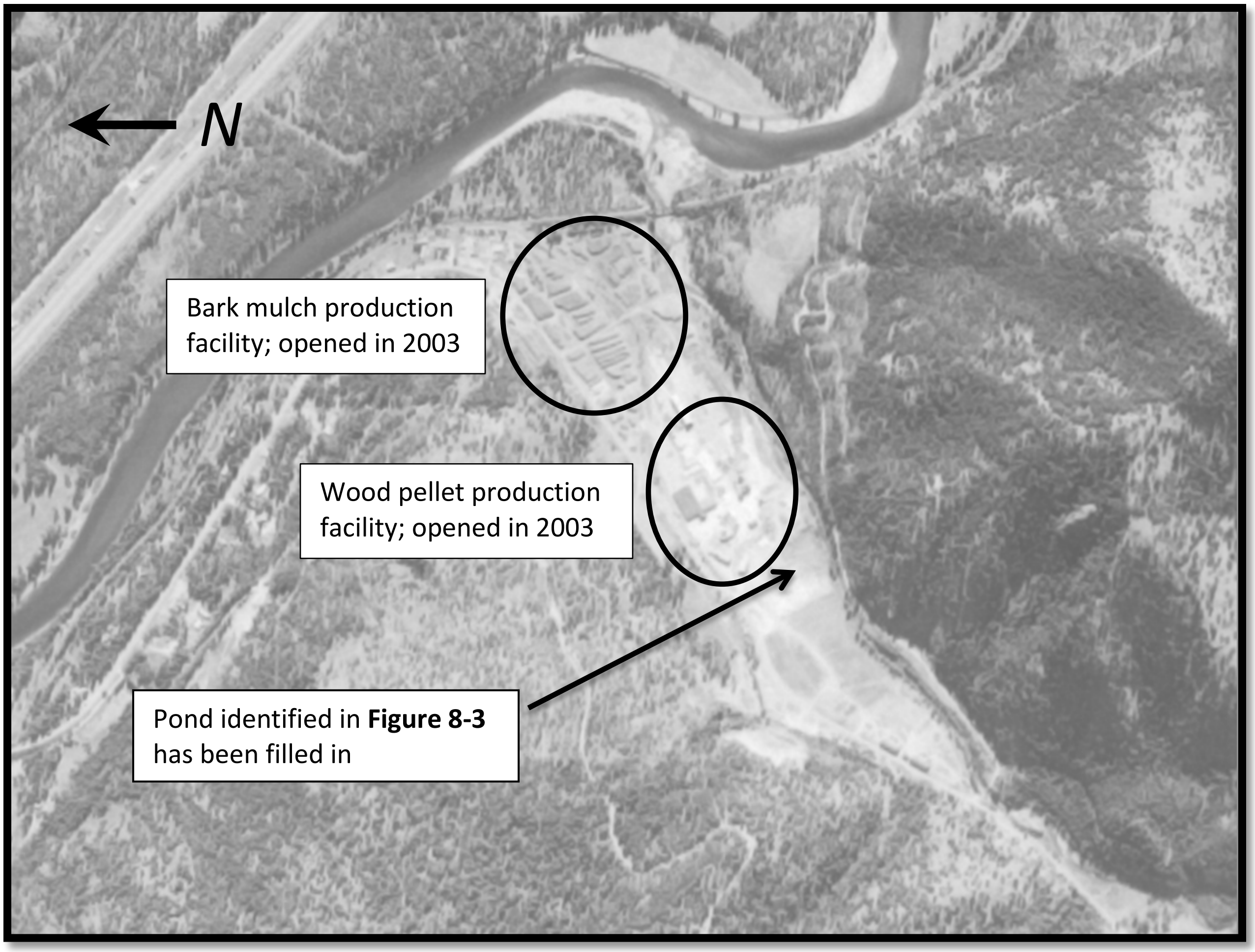

Figure 8-6. Aerial image of wood processing facilities at mouth of Trout Creek, 7/17/2003

Operations at the site have changed since the mid-1990s, with existing facilities producing posts and poles, wood pellets, and bark mulch. As opposed to previous sawmill operations, these facilities all rely on small-diameter timber and its byproducts. There are no ponds currently located at any of the facilities at the mouth of Trout Creek. Imagery from 2011 does suggest that the pellet mill and bark mulch production facilities have both expanded since 2003 and currently have a larger footprint with material storage, particularly mulch piles, less than 50 feet from the Trout Creek channel near the railroad bridge at the mouth (**Figure 8-7**).

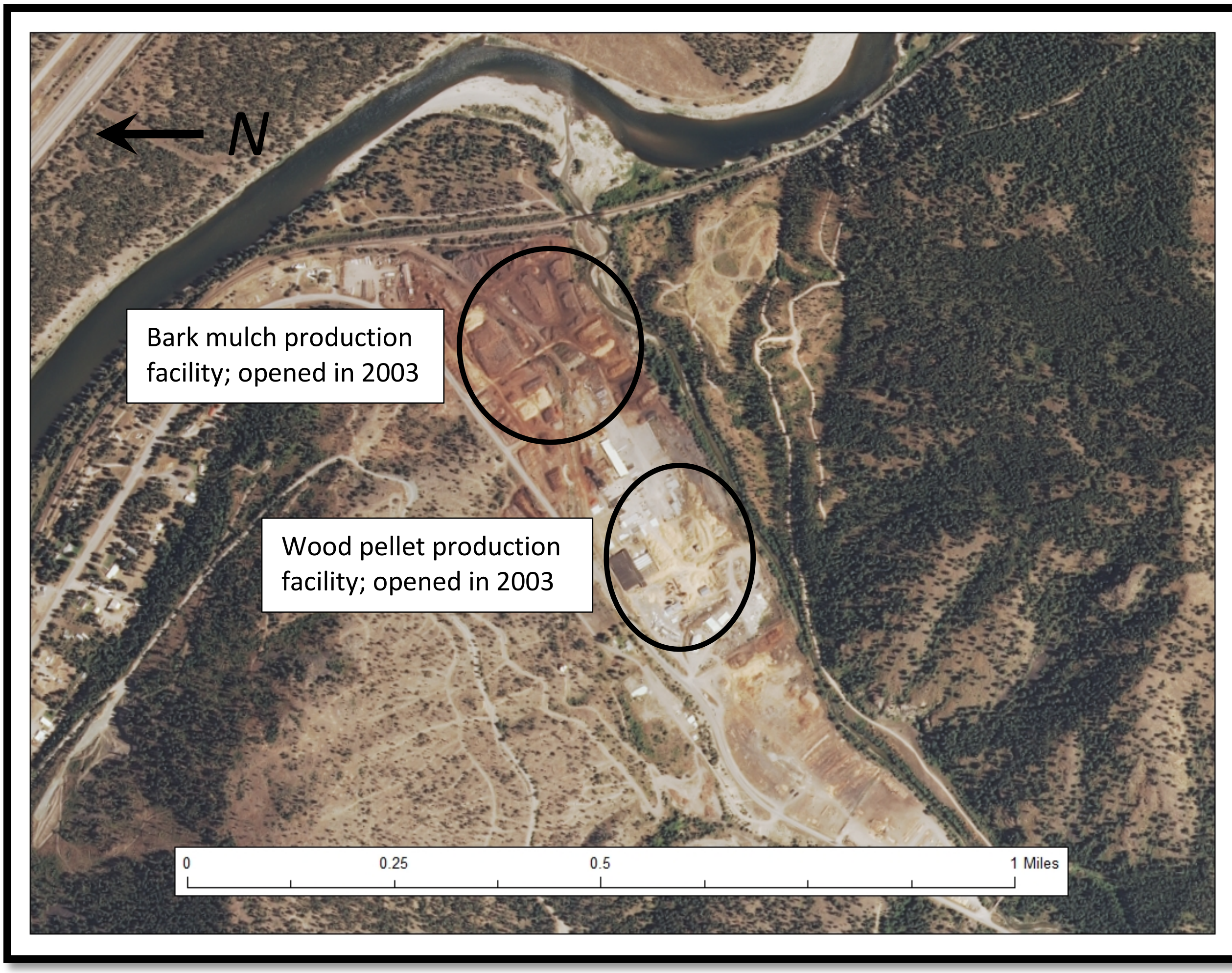

Figure 8-7. 2011 NAIP aerial image of wood processing facilities at mouth of Trout Creek

DEQ completed sediment/habitat sampling on Trout Creek in 2012 in order to assess Trout Creek for sediment impairment. The assessment determined that Trout Creek is not impaired by sediment (**Section 5.4.3.2**). DEQ determined that the original turbidity listing is not linked to fine sediment but rather staining from tannic acids (tannins) in the observed discharge from the pond as documented in October 1990 by DEQ. Discharges from the pond were observed to be causing turbidity and significantly altering the color of Trout Creek at that time.

However, no turbidity data have been collected on Trout Creek and a formal assessment of the turbidity listing on Trout Creek, as it pertains to staining of the creek from tannic acid discharges to Trout Creek, is not possible. The lack of data precludes a possible re-assessment of the impairment listing. Although the production facilities have changed since October 1990, potential sources of tannic acids in the Trout Creek floodplain remain. Therefore, based on the existing listing and potential sources, a turbidity TMDL will be developed for Trout Creek.

8.3.2.3 DEQ 2014 Turbidity Listing Determination

Based on the comparison of existing conditions with water quality targets, one turbidity TMDL will be developed for Trout Creek in the Central Clark Fork tributaries TPA **(Table 8-1**).

Table 8-1 Summary of Turbidity and Color TMDL Development Determinations

Stream Segment	Waterbody #	TMDL Development Determination (Y/N)
TROUT CREEK, headwaters to mouth (Clark Fork River)	MT76M002_050	Y

8.4 Turbidity TMDL and Allocations

The turbidity TMDL for Trout Creek will be based on meeting the applicable water quality standard for turbidity. This approach will apply to the loading allocated among sources as well as to the TMDL for Trout Creek. An implicit MOS will be applied, further discussed in **Section 8.5**.

8.4.1 Estimating turbidity loading in Trout Creek

No turbidity, total suspended solids (TSS), or suspended sediment concentration (SSC) data are available for Trout Creek. As stated in **Section 8.3.3**, the original turbidity listing was based on visual evidence of turbidity impacts from wet weather dischargers. The lack of data specific to Trout Creek preclude a direct estimate of loading in Trout Creek. However, data from the Hayden Creek watershed in the Northern Rockies Level III ecoregion are available to estimate naturally occurring turbidity loading in Trout Creek using suspended sediment concentration as a measure of turbidity. Hayden Creek is located approximately 97 miles west/northwest of Trout Creek in the Upper Spokane subbasin (17010305).

8.4.1.1 Comparison of Hayden Creek (ID) to Trout Creek (MT)

Hayden Creek is located in the northern Idaho panhandle east of Spokane, WA. From 1966-1996, the mean monthly discharge ranged from 4.9 cfs to 79.4 cfs with peak flow occurring in response to snowmelt during April. Hayden Creek was used as a reference watershed for a 2008 sediment/turbidity TMDL on Fish Creek in the Upper Spokane subbasin (Idaho Department of Environmental Quality, 2008). Turbidity and SSC data collected at a now inactive USGS gage on Hayden Creek (12416000) were used for the Fish Creek sediment TMDLs. USGS 12416000 (Hayden Creek below North Fork, near Hayden Lake, Idaho) was a Hydrological Benchmark station that was discontinued in 1997 (Mast and Cluckie, 2000). Hayden Creek drainage characteristics presented in **Table 8-1** are taken from the Fish Creek TMDL document and a USGS Hayden Creek document (Idaho Department of Environmental Quality, 2008) (Mast and Cluckie, 2000).

Table 8-1. Drainage characteristics for Trout Creek, MT and Hayden Creek, ID

	Trout Creek (at mouth)	Hayden Creek (upstream of USGS 12416000
Subbasin	Middle Clark Fork (17010204)	Upper Spokane (17010305)
Watershed type	Third order dendritic stream Rosgen A channel type in headwaters transitioning into B type in middle reaches	Third order dendritic stream Rosgen A channel type in headwaters transitioning into B type in lower reaches
Watershed size (sq. mi.)	71.2	22.0
Level III Ecoregion	Northern Rockies	Northern Rockies
Elevation	7,590 feet to 2,733 feet	5,600 feet to 2,396 feet

	Trout Creek (at mouth)	**Hayden Creek (upstream of USGS 12416000**
Mean Precipitation	30-70 inches	30-60 inches
Geologic Setting	Metasediments of the Belt Supergroup	Metasediments of the Belt Supergroup
Aspect	South/north	*North fork* - north/south *East fork* - east/west
Flow regime	High-volume runoff during spring associated with rain on snow events	High-volume runoff during spring associated with rain on snow events
Land use Type	Forest Road - road density 2.3 mi/mi^2	Forest Road - road density 3.3 mi/mi^2
	Timber harvest/wood products manufacturing near mouth	Timber harvest
Ownership	Mixed ownership: federal government (USFS) (98.5%), private (1.5%)	100% federal ownership (USFS)

Hayden Creek land use and topography upstream of USGS 12416000 is very similar to the Trout Creek watershed, although it is roughly only 1/3 the area of the Trout Creek watershed. However, both drainages are in the Northern Rockies Level III ecoregion, both are administered almost wholly by the USFS, and both have a history of timber harvesting. The climate and elevation of both systems is also very similar. The main difference between the Hayden Creek drainage and the Trout Creek drainage is the presence of wood products manufacturing facilities in the watershed.

Data from the USGS 12416000 in the Hayden Creek drainage were used to establish the reference condition for a sediment TMDL on another Northern Rockies stream in 2008 (Idaho Department of Environmental Quality, 2008). Modeling of Hayden Creek determined that the creek was currently functioning and supporting all beneficial uses at sediment yields 68% above natural background (Idaho Department of Environmental Quality, 2008). This reflects the impacts of forest roads and timber harvesting operations on Hayden Creek sediment loads, which are increased over natural background but not to a level that impairs beneficial uses.

The reference condition from the Hayden Creek watershed will be used to determine the turbidity TMDL for Trout Creek.

8.4.1.2 Use of suspended sediment as a measure for turbidity

Turbidity may be caused by clay, silt, finely divided inorganic and organic matter, soluble colored organic compounds (e.g. tannic acids), and plankton and other microscopic organisms. In the case of the original Trout Creek turbidity listing was based on tannic acids. In order to determine the naturally occurring turbidity in Trout Creek, suspended sediment concentrations from Hayden Creek will be used to establish the expected background turbidity in a forested watershed in the Northern Rockies Level III ecoregion.

In the United States, suspended sediment concentrations are the most common surrogate for turbidity (Gray and Glysson, 2002). However, best prediction of turbidity from SSC measurements is from high frequency, continuous measurements rather than sporadic measurements. The relationship between turbidity and suspended sediment varies with changes in sources of sediment. Christenson determined that a minimum of two years of data consisting of 35 to 55 samples provided a sufficient sample size to correlate surrogate measures at field sites on the Little Arkansas River in Kansas (2000).

Hayden Creek data analysis
Suspended sediment concentration (SSC) and Nephelometric Turbidity Units (NTU) data were collected at USGS 12416000 located on Hayden Creek below North Fork near Hayden Lake, Idaho from May 1980 to June 1996 (**Table 8-2**). There were 57 events where both parameters were collected (after removing an outlier where an SSC value of 1000 mg/L was reported at a flow of 38 cfs (3/21/1985)). It was assumed the outlier was the result of inconsistency between grab samples and water that passed the turbidity sensor as reported elsewhere (Tomlinson and De Carlo, 2003) (Christensen et al., 2000).

Table 8-2. Summary of paired sediment water quality data for USGS 1241600, 1980-1996

Parameter	Min	Max	Mean	75th percentile
SSC (mg/L)	0.0	104.0	4.9	4.0
Turbidity (NTU)	0.1	22.0	1.4	1.3
Discharge (cfs)	2.3	278.0	30.5	36.3

Several data transformations were used as an attempt to identify the most significant relationship between SSC and turbidity for Hayden Creek and between SSC and discharge. However, no improvement was observed for any response variable, a result observed in similar studies (Jones, 2008). A simple linear regression of the available dataset yielded the greatest R^2 value of the analysis.

For Hayden Creek, the relationship between SSC and turbidity is stated in **Equation 1** as:

$$SSC\ (mg/L) = 4.5973(Turbidity\ (NTU)) - 1.3107 \qquad (R^2 = 0.95) \qquad \textbf{(Eq. 1)}$$

Where:
SSC = suspended sediment concentration (mg/L)
Turbidity = nephelometric turbidity units

In order to calculate a load based on a sediment concentration, the relationship between discharge and SSC for Hayden Creek was also determined. Fitted through the origin, this relationship is stated in **Equation 2** as:

$$SSC\ (mg/L) = 0.1567\ (Q(cfs)) \qquad (R^2 = 0.54) \qquad \textbf{(Eq. 2)}$$

Where:
SSC = suspended sediment concentration (mg/L)
Q = streamflow (cfs)

The relationship between SSC and discharge is not as strong as that between SSC and NTU for the Hayden Creek dataset. However, the relatively poor prediction of SSC as a function of discharge is commonly identified in other works (Tomlinson and De Carlo, 2003; Jones, 2008; Stogner, Sr. et al., 2013).

For the purpose of the turbidity TMDL, SSC is used to determine naturally occurring turbidity. SSC will also be used to calculate an example loading scenario in Trout Creek, however, the Trout Creek TMDL will be expressed in turbidity units. It is recognized that the original impairment listing was based on discharges of tannic acids from milling operations near the mouth. Even with using SSC as a measure of naturally occurring turbidity, land management activities in the Trout Creek watershed cannot violate the water quality standard by increasing turbidity more than 5 NTUs above the naturally occurring condition under any flow.

8.4.2 Permitted Point Source

There is one active MPDES permit in the Trout Creek watershed.

8.4.2.1 Suction Dredge Permit (MTG370000)

A suction dredge permit (MTG370343) is in the Trout Creek sub-watershed. The WLA for the suction dredge permit will be part of the turbidity TMDL for Trout Creek. The general permit has special conditions to minimize harmful conditions caused by elevated suspended sediment concentrations including no disturbance of streambanks, dredging only within the wetted channel, no wheeled equipment in the stream while dredging, and avoiding dredging areas where silt and clay are concentrated.

Additionally, no visual increase in turbidity is allowed at the end of the mixing zone (i.e., 10 stream widths downstream), and the permittee must keep a daily log to demonstrate compliance with this condition. In addition, permit MTG370343 has a seasonal restriction which allows operation only from July 1 to August 31 to protect sensitive Bull Trout life stages in Trout Creek. Because only sediment within the wetted channel is permitted and no visual increase in turbidity is allowed beyond the mixing zone, if the permit conditions are followed, no turbidity loading is anticipated from this permit and a WLA of 0 will be provided.

8.4.3 Trout Creek Turbidity TMDL

As outlined in **Section 8.4.1**, the reference turbidity condition from a comparable watershed (Hayden Creek) is used.

In **Table 8-3**, target loads for turbidity (expressed as SSC) are calculated based on an example flow (a) and the Hayden Creek SSC/NTU and SSC/Q regression equations (**Equations 1 and 2**) in columns (c) and (b) respectively. In column (d) of **Table 8-3**, the water quality standard is used to determine the maximum turbidity level for Trout Creek based on the relative discharge. In column (e) and (f), the equivalent SSC concentration is determined and the TMDL is calculated.

Table 8-3. Respective calculations used to calculate the Trout Creek turbidity TMDL using SSC as a surrogate measure of turbidity

Trout Creek Discharge	SSC (mg/L) (*Eq. 2*)	Turbidity (NTU) (*Eq. 1*)	MT standard (≤ 5 NTU increase)	Equivalent SSC (mg/L) (*Eq. 1*)	TMDL (lbs/day) (SSC as surrogate for turbidity)
(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**
10	1.6	0.6	5.6	24.4	1,325.9
25	3.9	1.1	6.1	26.7	3,632.0
50	7.8	2.0	7.0	30.8	8,321.8
100	15.7	3.7	8.7	38.7	20,874.5
200	31.3	7.1	12.1	54.3	58,672.6

Figure 8-2 provides a graphical representation of the Trout Creek turbidity TMDL and how it changes with changes in discharge.

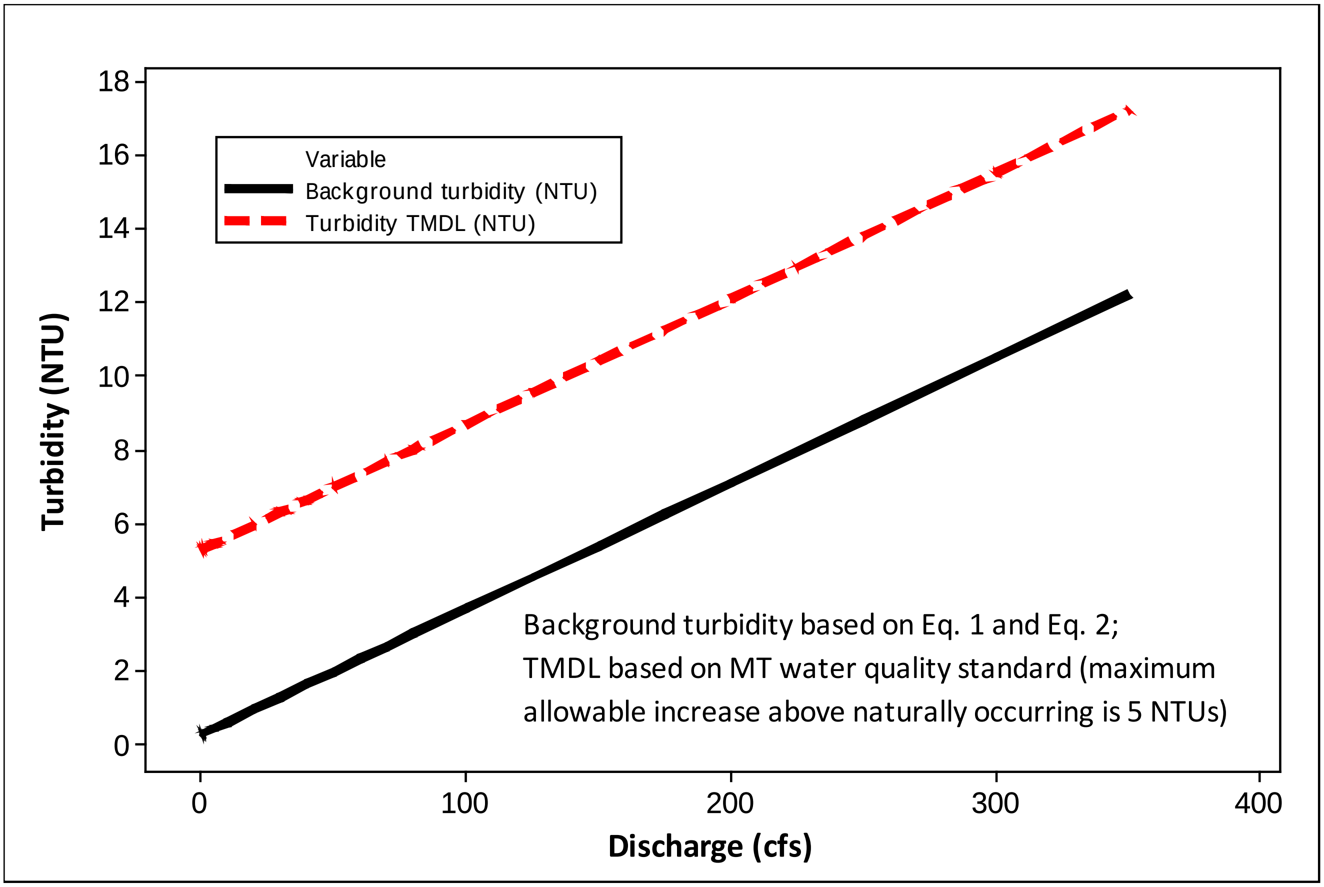

Figure 8-2. Trout Creek turbidity TMDL and naturally occurring background turbidity

The Trout Creek turbidity TMDL is presented in **Equation 3** as:

$Turbidity\ TMDL = LA_{(NO)} + 2\ NTUs(LA_{composite} + WLA_{MTG370343}) + 3\ NTU\ (MOS)$ **(Eq. 3)**

Where:
$LA_{(NO)}$ = naturally occurring turbidity (NTUs)
$LA_{composite}$ = composite load allocation to all nonpoint sources including forest operations, roads, mining
$WLA_{MTG370343}$ = waste load allocation to a suction dredge permit
MOS = margin-of-safety

As no data were available for Trout Creek, a formal assessment of existing conditions could not be made allocations are provided but estimated existing conditions or reductions are not outlined. The rationale for implementing an explicit margin-of-safety is based on the assumption that standard stormwater BMPs using benchmark values at the wood products manufacturing facilities and appropriate suction dredge operations will not exceed an increase of two NTUs in the stream. Allocations used in the turbidity TMDL are based on assumptions outlined in an example SSC loading scenario outlined in the following section. The explicit MOS recognizes that future land uses in the drainage may include discharges that will affect turbidity values. The intent of the turbidity standard is to address storm events and other temporary instream disturbances. It is not intended to allow elevated turbidity at all times of the year which may impact other standards (i.e. color, sediment, temperature).

8.4.4 Trout Creek Example TMDL using SSC

An exceedance of the turbidity water quality standard may be caused by a range of pollutants such as clay, silt, finely divided inorganic and organic matter, soluble colored organic compounds (e.g. tannic acids), and plankton and other microscopic organisms. In Montana, suspended sediment is the most common cause of turbid conditions in the water column. An example load scenario using the same analysis outlined in **Section 8.4.1.2** is provided below and incorporates estimated annual sediment loading from identified sources in the Trout Creek watershed.

Wood products manufacturing facilities in the Trout Creek watershed

Although there are no existing industrial storm water permits in the Trout Creek watershed, the wood products manufacturing facilities at the mouth of Trout Creek may require such permits in the future. For this reason, a load was calculated for the approximate impacted area occupied by these facilities near the mouth of Trout Creek. The load allocation is based on how an industrial stormwater permitted load is calculated in TMDLs. The calculation approach and rationale are laid out below.

According to **Attachment B** (Monitoring Parameter Benchmark Concentrations) within the general stormwater permit, the benchmark value for TSS is 100 mg/L. The benchmark value will serve as the LA for the facilities. As the turbidity TMDL for Trout Creek will use SSC as a surrogate, the TSS benchmark value was converted to SSC. The Hayden Creek dataset included <10 paired TSS and SSC samples. Therefore, the TSS to SSC conversion is based on a linear regression of paired TSS/SSC data collected at USGS gage stations in Montana. This dataset includes 209 pairs collected from 1969 to 2011. A simple liner regression through the origin yielded a relationship of (**Equation 4**):

$$TSS = 0.6256(SSC) \qquad R^2 = 0.80 \qquad \textbf{(Eq. 4)}$$

Where established benchmark for TSS = 100mg/L, and when converted based on Eq. 3 the benchmark value is 160 mg/L SSC (TSS benchmark of 100/0.6256). Based on the site size (acres), an average annual precipitation rate of 17 inches (Superior, MT, 1981-2010) and the benchmark value of 160 mg/L SSC, the maximum allowable annual sediment load for each site is 0.22 tons/ac/yr (**Table 8-4**).

Table 8-4. Sediment Loading and Reductions from Permitted Construction Sites

Watershed	Permit[a]	Loading Rate (tons/ac/yr)	Approximate impacted area (ac)	LA under a BMP Sediment Load scenario (tons/yr)
Trout Creek	NA	0.22	124	27.3

[a] Analysis assumes a future permit holder implements a Storm Water Pollution Prevention Plan and does not discharge in excess of benchmark values

For example load scenario using SSC, the load is converted to a daily load. Therefore, the load under the BMP sediment scenario is 0.075 tons/day or 150.0 lbs/day.

Wasteload Allocation for a Suction Dredge Permit

As identified in **Section 8.4.2.1**, a suction dredge permit in the Trout Creek watershed has a WLA of zero because only sediment within the wetted channel is permitted and no visual increase in turbidity is allowed beyond the mixing zone.

Example Trout Creek TMDL using SSC
In order to provide an example TMDL loading scenario, SSC is used as a measure for turbidity using a flow condition of 25 cfs which represents a late summer period flow condition in Trout Creek. This example is meant to inform and does not replace the turbidity TMDL outlined in **Equation 3**.

From **Table 8-3**, at a discharge of 25 cfs, the naturally occurring SSC load is 526.5 lbs/day (3.9 mg/L SSC * 25 cfs * 5.4 (conversion factor)). The TMDL at 25 cfs is 3,632.0 lbs/day (Column (f) in **Table 8-3**). The example TMDL for Trout Creek is presented in **Table 8-5** based on approaches outlined in **Section 8.3**.

Table 8-5. Trout Creek example SSC TMDL, LAs, and WLAs

Allocation	Source Category	Allocation and TMDL (lbs/day)[1]
LA	Naturally occurring	526.5
LA	Human-caused (timber harvesting, forest roads, mining)	2,946.5
WLA	Suction dredge permit (MTG370343)[2]	0.0
LA	Wood products manufacturing facilities	150.0
		TMDL = 3,623.0

[1]Based on a flow of 25 cfs; [2] WLA of 0.0 applies at the end of the mixing zone (10 stream widths downstream of permit operation location)

This analysis using SSC was used to inform the decision to allocate two NTUs to the existing sources ($LA_{composite} + WLA_{MTG370343}$) as the analysis indicated that, following existing and prospective future permits, the sediment load from wood products manufacturing facilities and the suction dredge permit are relatively small when compared with the total allowable increase above naturally occurring conditions at the example flow condition of 25 cfs. This analysis does assume a linear relationship between discharge and SSC.

8.5 Seasonality and Margin of Safety

Seasonality and MOS are both required elements of TMDL development. This section describes how seasonality and MOS were applied during development of the Central Clark Fork Basin Tributaries project area turbidity TMDL for Trout Creek.

8.5.1 Seasonality

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

- The 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 hydrologic cycle specific to Trout Creek. The resulting loads are expressed as average daily loading rates.

8.5.2 Margin of Safety

Natural systems are inherently complex. Any approach used to quantify or define the relationship between pollutant loading rates and the resultant water quality effects, no matter how rigorous, will include some level of uncertainty or error. To compensate for this uncertainty and ensure water quality standards are attained, a MOS is required as a component of each TMDL. The MOS may be applied implicitly by using conservative assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading (U.S. Environmental Protection Agency, 1999a). This plan incorporates an implicit MOS in a variety of ways:

- This approach addresses some of the uncertainty associated with sampling variability and site representativeness and recognizes that capabilities to reduce sediments exist throughout the watershed.
- Turbidity impairment is typically identified based on excess fine sediment, tannic acids, and/or organics but the targets and TMDLs address both coarse and fine sediment delivery using SSC as a surrogate for turbidity.
- By properly incorporating seasonality into target development, source assessments, and TMDL allocations (details provided in **Section 8.5.1**).
- By using an adaptive management approach to evaluate target attainment and allow for refinement of LA, targets, modeling assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development (discussed in **Sections 8.9**, **9.0**, and **10.0**).
- By developing TMDLs at the watershed scale to address all potentially significant human-related sources beyond just the impaired waterbody segment scale. This approach should also reduce loading and improve water quality conditions within other tributary waterbodies throughout the watershed.

8.9 Uncertainty and Adaptive Management

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

As noted in **Section 8.5.2**, adaptive management represents an important component of the implicit MOS. This document provides a framework to satisfy the MOS by including sections focused on TMDL implementation, monitoring, and adaptive management (**Sections 9.0** and **10.0**). Furthermore, state law (ARM 75-5-703) requires monitoring to gage progress toward meeting water quality standards and satisfying TMDL requirements. These TMDL implementation monitoring reviews represent an important component of adaptive management in Montana.

Perhaps the most significant uncertainties within this document involve the accuracy and representativeness of (a) Hayden Creek field data to Trout Creek and (b) the accuracy and representativeness of the Montana TSS/SSC relationship to potential future stormwater conditions in Trout Creek. These uncertainties were addressed in the document in **Sections 8.4.1 and 8.4.2.2**.

9.0 Non-Pollutant Impairments

Water quality issues are not limited simply to those streams where TMDLs are developed. In some cases, streams have not yet been reviewed through the water quality assessment process and do not appear on Montana's list of impaired waters, even though they may not be fully supporting all of their beneficial uses. In other cases, a stream may be listed as impaired, but does not require TMDL development because it is determined not to be impaired for a pollutant, but for a non-pollutant (TMDLs are only required for pollutant causes of impairment). Non-pollutant causes of impairment such as "alteration in streamside or littoral vegetative covers" are often associated with sediment, nutrient, or temperature issues, but may be having a deleterious effect on beneficial uses without a clearly defined quantitative measurement or direct linkage to a pollutant. Other examples of non-pollutant causes of impairment can be related to alteration in streamflow regimes and human constructed barriers that prevent fish passage to certain parts of a stream.

Non-pollutant impairments have been recognized by DEQ as limiting their ability to fully support all beneficial uses and are important to consider when improving water quality conditions in both individual streams, and the project area as a whole. **Table 9-1** shows the non-pollutant impairments in the Central Clark Fork Tributaries Project Area on Montana's 2014 list of impaired waters. They are being summarized in this section to increase awareness of the non-pollutant impairment definitions and typical sources. Additionally, the restoration strategies discussed in **Section 10.0** inherently address some of the non-pollutant listings and many of the BMPs necessary to meet TMDLs will also address non-pollutant sources of impairment. As mentioned above, these impairment causes should be considered during planning of watershed scale restoration efforts.

Table 9-1. Waterbody segments with non-pollutant impairments on the 2014 Water Quality Integrated Report

Waterbody & Location Description	Waterbody ID	Impairment Cause
Dry Creek, headwaters to mouth (Clark Fork River)	MT76M002_170	Alteration in stream-side or littoral vegetative covers
		Low flow alterations
Flat Creek, headwaters to mouth (Clark Fork River)	MT76M002_180	Physical substrate habitat alterations
Trout Creek, headwaters to mouth (Clark Fork River)	MT76M002_050	Alteration in stream-side or littoral vegetative covers
		Physical substrate habitat alterations
Nemote Creek, headwaters to mouth (Clark Fork River)	MT76M002_160	Chlorophyll-*a*
		Low Flow Alterations
West Fork Petty Creek, headwaters to mouth (Petty Creek)	MT76M002_100	Chlorophyll-*a*
Petty Creek, headwaters to mouth (Clark Fork River)	MT76M002_090	Alteration in stream-side or littoral vegetative covers
		Low flow alterations

Waterbody & Location Description	Waterbody ID	Impairment Cause
Grant Creek, headwaters to mouth (Clark Fork River)	MT76M002_130	Alteration in stream-side or littoral vegetative covers
		Excess Algal Growth
		Low flow alterations
Cramer Creek, headwaters to mouth (Clark Fork River)	MT76E004_020	Cause Unknown
		Physical substrate habitat alterations
Tenmile Creek, headwaters to mouth (Bear Creek)	MT76E004_030	Alteration in stream-side or littoral vegetative covers
Deep Creek, headwaters to mouth (Bear Creek)	MT76E004_070	Chlorophyll-*a*
		Low Flow Alterations
Rattler Gulch, headwaters to mouth (Clark Fork River)	MT76E004_060	Alteration in stream-side or littoral vegetative covers
		Chlorophyll-*a*
		Low Flow Alterations

9.1 Non-Pollutant Impairment Causes Descriptions

Non-pollutants are often used as a probable cause of impairment when available data at the time of a water quality assessment does not 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 list of impairment causes for a waterbody; however a non-pollutant impairment cause may appear independently of a pollutant cause. 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. Such instances may be riparian vegetation removal for a road or utility corridor, or overgrazing by livestock along the stream. As a result of altering the streamside vegetation, destabilized banks from loss of vegetative root mass could lead to overwidened stream channel conditions, elevated sediment and/or nutrient loads, and the resultant lack of canopy cover can lead to increased water temperatures.

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.

Cause Unknown
A cause unknown impairment occurs when biological indicators suggest that a beneficial use is impaired, but no specific cause of impairment has been determined at that particular time. In the case of Cramer Creek, the cause unknown impairment refers to a sediment related impairment that was caused by past logging practices. The lack of appropriate timber harvest BMPs has caused aggradation of sediment in the stream channel and causes Cramer Creek to become an intermittent stream channel in areas (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012). The cause unknown impairment for Cramer Creek is addressed by the sediment TMDL in **Section 5.9.3.5** of this document**.**

Chlorophyll-*a* and Excess Algal Growth
A chlorophyll-*a* or excess algal growth impairment occurs when excess levels of chlorophyll-*a* or algae in the stream impairs aquatic life and/or primary contact recreation (Suplee et al., 2009). These high levels of chlorophyll-*a* or algae are caused by excess concentrations of nutrients in the stream which increases algal biomass (Suplee and Sada de Suplee, 2011). Chlorophyll-*a* and excess algal growth impairments are typically addressed by nutrient TMDLs, which are found in **Section 6.0** of this document.

Low Flow Alterations
Flow alteration refers to a change in the flow characteristics of a waterbody relative to natural conditions. Streams are typically listed as impaired for low flow alterations when irrigation withdrawal management leads to base flows that are too low to support the beneficial uses designated for that system. This could result in dry channels or extreme low flow conditions unsupportive of fish and aquatic life. It could also result in lower flow conditions which absorb thermal radiation more readily and increase stream temperatures, which in turn creates dissolved oxygen conditions too low to support some species of fish.

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 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.

9.2 Monitoring and BMPs for Non-Pollutant Affected Streams

Habitat alteration impairments (i.e., alteration in streamside or littoral vegetative covers) can be linked to sediment TMDL development for Flat, Petty, Grant, Cramer, and Tenmile Creeks, as well as Rattler Gulch. It is likely that meeting the sediment TMDL targets will also equate to addressing the habitat impairment conditions in each of these streams. For streams with habitat alteration impairments that do not have a sediment TMDL, meeting the sediment targets applied to streams of similar size will likely equate to addressing the habitat impairment condition for each stream.

Chlorophyll-*a* and excess algal growth impairments can be linked to nutrient TMDL development in Nemote, West Fork Petty, Grant, and Deep Creeks, as well as Rattler Gulch. It is likely that meeting the nutrient TMDL targets will also equate to addressing chlorophyll-*a* and excess algal growth impairments in each of these streams.

Streams listed for non-pollutant impairments 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 is not well defined. 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 Central Clark Fork Tributaries project area with TMDLs in this document, and they are equally applicable to streams listed for the above non-pollutant impairment causes.

10.0 Water Quality Improvement Plan

10.1 Purpose of Improvement Strategy

This section describes an overall strategy and specific on-the-ground measures designed to restore water quality beneficial uses and attain water quality standards in the Central Clark Fork Tributaries TMDL project area streams. The strategy includes general measures for reducing loading from each identified significant pollutant source.

This section should assist stakeholders in developing a watershed restoration plan (WRP) that will provide more detailed information about restoration goals within the watershed. The WRP may also encompass broader goals than the water quality improvement strategy outlined in this document. The intent of the WRP is to serve as a locally organized "road map" for watershed activities, prioritizing types of projects, sequences of projects, and funding sources towards achieving local watershed goals. Within the WRP, local stakeholders identify and prioritize streams, tasks, resources, and schedules for applying 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 Montana Department of Environmental Quality (DEQ) does not implement TMDL pollutant-reduction projects for nonpoint source activities, but may provide technical and financial assistance for stakeholders interested in improving their water quality by doing such activities. Successful implementation of TMDL pollutant-reduction projects requires collaboration among private landowners, land management agencies, and other stakeholders. DEQ will work with participants to use the TMDLs as a basis for developing locally-driven WRPs, administer funding specifically to help support water quality improvement and pollution prevention projects, and help identify other sources of funding.

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

- Clark Fork Coalition
- Missoula Conservation District
- Granite Conservation District
- Five Valleys Land Trust
- Montana Aquatic Resources Services
- Montana Bureau of Mines and Geology
- Montana Department of Environmental Quality (DEQ)
- Montana Department of Natural Resources and Conservation (DNRC)
- Montana Department of Transportation
- Montana Fish, Wildlife and Parks (FWP)
- Montana Mining Association
- Montana State University Extension Water Quality Program
- Montana Trout Unlimited

- Montana Water Center (at Montana State University)
- Natural Resources and Conservation Service (NRCS)
- Stimson Lumber Company
- Missoula County
- Mineral County
- Granite County
- U.S. Army Corp of Engineers
- U.S. Environmental Protection Agency (EPA)
- U.S. Fish & Wildlife Service (USFWS)
- U.S. Forest Service (USFS)
- University of Montana Watershed Health Clinic
- The Nature Conservancy
- U.S. Bureau of Land Management (BLM)

10.3 Water Quality Restoration Objectives

The water quality restoration objective for the Central Clark Fork Tributaries project area is to reduce pollutant loads as identified throughout this document in order to meet the water quality standards and TMDL targets for full recovery of beneficial uses for all impaired streams. Meeting the TMDLs provided in this document will achieve this objective for all identified pollutant-impaired streams. Based on the assessment provided in this document, the TMDLs can be achieved through proper implementation of appropriate BMPs.

A WRP can provide a framework strategy for water quality restoration and monitoring in the Central Clark Fork Tribs Project Area, focusing on how to meet conditions that will likely achieve the TMDLs presented in this document, as well as other water quality issues of interest to local communities and stakeholders. WRPs 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 provide more detailed information about restoration goals and spatial considerations but may also encompass broader 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 EPA requires nine minimum elements for a WRP. A complete description can be found at http://www.epa.gov/region9/water/nonpoint/9elements-WtrshdPlan-EpaHndbk.pdf and are summarized here:

1. Identification of the causes and sources of pollutants
2. Estimated load reductions expected based on implemented management measures
3. Description of needed nonpoint source management measures
4. Estimate of the amounts of technical and financial assistance needed
5. An information/education component
6. Schedule for implementing the nonpoint source management measures
7. Description of interim, measurable milestones
8. Set of criteria that can be used to determine whether loading reductions are being achieved over time

9. A monitoring component to evaluate effectiveness of the implementation efforts over time

This document provides, or can serve as an outline, for many of the required elements. Water quality goals for sediment, nutrients, temperature, and turbidity pollutants are detailed in **Sections 5, 6, 7**, **and 8**, respectively. These goals include water quality and habitat targets as measures for long-term effectiveness monitoring. These targets specify satisfactory conditions to ensure protection and/or recovery of beneficial uses of waterbodies in the Central Clark Fork Tribs Project Area. It is presumed that meeting all water quality and habitat targets will achieve the water quality goals for each impaired waterbody. **Section 11** identifies a general monitoring strategy and recommendations to track post-implementation water quality conditions and measure restoration successes.

Additional guidance for developing WRPs can be found in regional Habitat Conservation Plans (HCPs). HCPs are long-term management plans developed under authorization of the Endangered Species Act and directed toward conservation of key species such as the bull trout and westslope cutthroat trout. In 2010, the USFWS approved a Native Fish Habitat Conservation Plan (NHCP) developed by Plum Creek Timber Company, Inc. (Plum Creek) for approximately 900,000 acres of company land. Plum Creek was a large private landowner within the Central Clark Fork Tributaries project area prior to selling lands as part of the Montana Legacy Project. The NHCP contains mitigation measures to protect coldwater fisheries and includes detailed management prescriptions for grazing, timber harvest, and road construction and maintenance activities. Provisions of the NHCP were transferred with the land as part of the Montana Legacy Project sales. The UFWS also approved an HCP for the Montana Department of Natural Resources and Conservation (DNRC) in 2010, which includes 548,500 acres of state trust land. The DNRC HCP contains similar conservation, implementation, monitoring, and adaptive management approaches to the NHCP. These HCPs provide valuable input and can serve as a model for WRPs developed in the Central Clark Fork Tribs Project Area.

10.4 Overview of Management Recommendations

TMDLs were completed for nine waterbody segments for sediment, eight waterbody segments for nutrients, three waterbody segments for temperature, and one for turbidity. Other streams in the project area may be in need of restoration or pollutant reduction, but insufficient information about them precludes TMDL development at this time. The following sub-sections describe some generalized recommendations for implementing projects to achieve the TMDLs. 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.**

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

10.4.1 Sediment Restoration Approach

Sediment TMDLs have been written for nine streams listed as impaired in the Central Clark Fork Tribs Project Area. An effective sediment restoration strategy for applying appropriate BMPs will help address sediment and other causes of impairment. The goal of the sediment restoration strategy is to limit the availability, transport, and delivery of excess sediment by a combination of minimizing sediment delivery, reducing the rate of runoff, and intercepting sediment transport. Monitoring data used to develop targets and determine impairments are described in **Section 5** and in **Appendices C and D** and **Attachment A**. Sediment restoration activities on impaired stream segments will help reduce the amount of fine sediment, reduce width/depth ratio, increase residual pool depth, increase pool frequency, increase the amount of large woody debris (LWD), increase riparian understory shrub cover, reduce impacts of human-caused sediment sources, and restore appropriate macroinvertebrate assemblages. These are indicators of successful restoration activities targeted toward sediment reduction and need to be considered together and within the context of stream potential in comparison to appropriate reference sites. For example, LWD and pool frequency tend to decline as stream size increases; therefore, indicators for these parameters will vary. General targets for these indicators are summarized in **Table 5-2**.

Streamside riparian and wetland vegetation restoration and long term management are crucial to achieving the sediment TMDLs. Native streamside riparian and wetland vegetation provides root mass that holds 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. 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, floodplain and streambank stabilization, revegetation efforts, and instream channel and habitat restoration where necessary. 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).

Unpaved roads are a small source of sediment at the watershed scale; however, sediment derived from roads may cause significant localized impact in some stream reaches. Restoration approaches for unpaved roads near streams primarily include measures that divert water to 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 of unpaved roads (particularly near stream crossings) and proper sizing and maintenance of culverts, are crucial components to limiting sediment production from roads.

Mining was not discussed in detail in the source assessment, but waste materials can be a component of upland and in-channel sediment loading. The goal of the sediment restoration strategy is to limit the input of sediment to stream channels from abandoned mine sites and other mining-related sources. Goals and objectives for future restoration work include the following:

- Prevent waste rock and tailings materials/sediments from migrating into adjacent surface waters, to the extent practicable.
- Reduce or eliminate concentrated runoff and discharges that transport sediment to adjacent surface waters, to the extent practicable.
- Identify, prioritize, and select response and restoration actions of areas affected by historical mining, based on a comprehensive source assessment and risk analysis.

10.4.2 Temperature Restoration Approach

Temperature TMDLs have been written for Grant, Nemote, and Petty Creeks. The goal of the temperature restoration approach is to reduce water temperatures where possible to be consistent with naturally occurring conditions. The most significant mechanism for reducing water temperatures in Grant, Nemote, and Petty Creeks is increasing riparian shade. Other factors that will help are: using water conservation measures to maximize water left in the stream, improving over-widened portions of the stream, improving urban stormwater management, and maintaining conditions where theses creeks are currently meeting the targets.

Increases in shade can be accomplished through passive restoration and protection of shade-providing vegetation within the riparian corridor. This type of vegetation can also have the added benefit of improving streambank stabilization to reduce bank erosion, slowing lateral river migration, and providing a buffer to prevent pollutants from upland sources from entering the stream. There are numerous BMPs that provide guidelines for reducing impacts in these areas to help restore riparian vegetation, such as exclosure fencing, zoning and setback regulations, and off-highway vehicle management. Other areas may require planting, active bank restoration, and protection from browse to establish vegetation.

Portions of Petty and Nemote Creeks ran dry by the end of the summer during data collection. It is unknown to what extent instream flow could be increased. If increases in instream summer flows are possible, they 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 in the stream. This TMDL document cannot, nor is it intended to, prescribe limitations on individual water rights owners and users. 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 following 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 active physical restoration, but size, scale, and cost of restoration in most cases are limiting factors to applying this type of remedy.

The above approaches give only the broadest description of activities to help reduce water temperatures. The temperature assessment described in **Section 7** looked at possible scenarios based on limited information at the watershed scale. Those scenarios showed that improvements in stream temperatures can primarily be made by improvements to riparian shade. It is strongly encouraged that resource managers and land owners continue to work to identify all potential areas of improvement and develop projects and practices to reduce stream temperatures in Grant, Nemote, and Petty Creeks, as well as other streams in the Central Clark Fork Tributaries project area that show the potential for elevated water temperatures. Bull trout are present in Grant Creek and Petty Creek is within FWP core or nodal bull trout areas. In addition, several streams within the Central Clark Fork Tributaries project area are designated bull trout critical habitat by the USFWS. Bull trout rely on cold water temperatures for survival and propagation. The HCPs described in **Section 10.3,** provide further recommendations for restoration and maintenance of stream temperatures.

10.4.3 Nutrients Restoration Approach

Nutrient TMDLs have been written for eight waterbodies in the Central Clark Fork Tribs Project Area.

- Deep Creek has a TMDL for Nitrate/Nitrite
- Dry Creek has a TMDL for Total Nitrogen
- Grant Creek has a TMDL for Total Nitrogen
- Nemote Creek has TMDLs for Total Nitrogen and Total Phosphorous
- Rattler Gulch has a TMDL for Total Phosphorous
- Stony Creek has a TMDL for Total Phosphorous
- Tenmile Creek has a TMDL for Total Phosphorous
- West Fork Petty Creek has a TMDL for Total Phosphorous

An effective nutrient restoration strategy is needed for these streams in order implement BMPs to meet the established TMDLs. 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 mined areas (including impoundments and other storage facilities). The source assessment conducted to support TMDL development (**Section 6.5**) can help provide a starting point for where most loading is occurring but additional analysis and source identification will likely be required to identify site-specific delivery pathways and to develop restoration plans.

Development of an effective nutrient and irrigation management plans along with cropland filter strip extension, vegetative restoration, and long-term filter area maintenance are vital BMPs for agricultural areas. Grazing systems with the explicit goal of increased post-grazing vegetative ground cover are needed to address the same nutrient loading from rangelands. Grazing prescriptions that enhance the filtering capacity of riparian filter areas offer a second tier of controls on the sediment content of upland runoff. Grazing and pasture management adjustments should consider:

- The timing, frequency, and duration of near-stream grazing
- The spacing and exposure duration of on-stream watering locations
- Provision of off-stream 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
- Incorporation of streamside vegetation buffer to irrigated croplands and animal feeding areas

In general, these are sustainable grazing and cropping practices that can reduce nutrient inputs while meeting production goals. The appropriate combination of BMPs will differ according to landowner preferences and equipment but are recommended as components of a comprehensive plan for farm and ranch operators. Sound planning combined with effective conservation BMPs should be sought whenever possible. 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 (http://offices.sc.egov.usda.gov/locator/app?service=page/CountyMap&state=MT&stateName=Montana&stateCode=30) and county conservation district offices (http://macdnet.org/) are geared to offer both planning and implementation assistance.

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, particularly where excess phosphorus is a problem. All of the nutrient impaired streams in the Central Clark Fork Tributaries project area are also impaired by sediment. Additional sediment-related BMPs are presented in **Section 10.5.**

10.4.4 Turbidity Restoration Approach

A turbidity TMDL has been written for Trout Creek. An effective restoration strategy for turbidity is needed for Trout Creek in order implement BMPs to meet the established TMDLs. Turbidity is often associated with excess suspended sediment or solids and, therefore linked to a sediment impairment. Trout Creek is also listed for sediment; therefore, the restoration strategy outlined in Section 10.4.1 will address excess turbidity associated with suspended sediment and solids by minimizing sediment delivery, reducing the rate of runoff, and intercepting sediment transport. However, source assessment for Trout Creek points to wood leachate run-off from a holding pond on the site of a former sawmill operation as the primary source of turbidity. The holding pond has been filled and site has been converted to a facility producing posts and poles, wood pellets, and bark mulch since the original TMDL assessment was conducted. However, current operations still have the potential for wood leachate run-off and increases in turbidity above the standard.

As with sediment, streamside riparian and wetland vegetation restoration and long term management are crucial to achieving the turbidity TMDL. In addition, stormwater control measures should be implemented in order to reduce runoff from sawmill or wood product production operations. These can include: detention ponds to allow particles and associated pollutants to settle; turbidity curtains, which minimize turbidity transport from a disturbed area adjacent to a body of water; and other practices designed to prevent water from entering or exiting the site.

10.4.5 Non-Pollutant Restoration Approach

Although TMDL development is not required for non-pollutant listings, they are frequently linked to pollutants, and addressing non-pollutant causes, such as flow and habitat alterations, is an important component of TMDL implementation. Non-pollutant listings within the Central Clark Fork Tributaries project area are described in **Section 9**. Typically, habitat impairments are addressed during implementation of associated pollutant TMDLs. Therefore, if restoration goals within the Central Clark Fork Tributaries project area are not also addressing non-pollutant impairments, additional non-pollutant related BMP implementation should be considered.

10.5 Restoration Approaches by Source

General management recommendations are outlined below for the major sources of human caused pollutant loads in the Central Clark Fork Tribs Project Area: agricultural sources including grazing, residential development, forestry and timber harvest, riparian and wetland vegetation removal, roads, and mining. Applying BMPs is the core of the nonpoint source pollutant reduction strategy, but BMPs are only part of a watershed restoration strategy. For each major source, BMPs will be most effective as part of a comprehensive management strategy. The WRP developed by local watershed groups should contain more detailed information on restoration goals and specific management recommendations that may be required to address key pollutant sources. BMPs are usually identified as a first effort and further monitoring and evaluation of activities and outcomes, as part of an adaptive management approach will be used to determine if further restoration approaches are necessary to achieve water quality standards. Monitoring is an important part of the restoration process, and monitoring recommendations are outlined in **Section 11.0**.

10.5.1 Agriculture Sources

Reduction of pollutants from upland agricultural sources can be accomplished by limiting the amount of erodible soil, reducing the rate of runoff, and intercepting eroding soil and runoff before it enters a waterbody. Not all agricultural sources of pollutants discussed in this section were identified in the Central Clark Fork Tribs Project Area, however, the recommendations below provide a useful guideline for a variety of agricultural activities. The main BMP recommendations for the Central Clark Fork Tributaries project area include nutrient management plans, irrigation water management plans, riparian buffers, wetland restoration, and vegetative 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 strip-cropping. Additional BMP information, design standards and effectiveness, and details on the suggested BMPs can be obtained from your local USDA Service Center and in Montana's Nonpoint Source Management Plan (Montana Department of Environmental Quality, 2012e).

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 Conservation Practice Standard 590 and 590-1, Nutrient Management) (NRCS, 2005):

- 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 environmentally sensitive areas, including streams, wetlands, springs, or other locations that deliver surface runoff to groundwater or surface water
- Guidelines for operation and maintenance

10.5.1.1 Grazing

Grazing has the potential to increase sediment and nutrient loads, as well as stream temperatures (by altering channel width and riparian vegetation), but these effects can be mitigated with appropriate management. Development of riparian grazing management plans should be a goal for any landowner 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. Riparian grazing management does not necessarily eliminate all grazing in riparian corridors. In some areas however, a more limited management strategy may be necessary for a period of time in order to accelerate reestablishment of a riparian community with the most desirable species composition and structure.

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

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

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

- Minimizing or preventing livestock grazing in riparian and wetland areas
- Providing off-stream watering facilities or using low-impact water gaps to prevent 'loafing' in wet areas
- Managing riparian pastures separately from upland pastures
- Installing salt licks, feeding stations, and shelter fences in areas that prevent 'loafing' in riparian areas and help distribute animals
- Replanting trodden down banks and riparian and wetland areas with native vegetation (this should always be coupled with a reduction in grazing pressure)
- Rotational grazing or intensive pasture management that takes season, frequency, and duration into consideration

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

- Plum Creek Timber Company's Native Fish Habitat Conservation Plan (http://www.plumcreek.com/Environment/nbspSustainableForestrySFI/nbspSFIImplementation/HabitatConservationPlans/tabid/153/Default.aspx)
- USDA, Natural Resources Conservation Service
  Offices serving Eastern Sanders and Flathead Counties are located in Plains and Kalispell (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): Nonpoint Source Management Plan (http://deq.mt.gov/wqinfo/nonpoint/NonpointSourceProgram.mcpx)

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 Central Clark Fork Tributaries project area 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 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 flush sediment and attenuate other 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 water quality 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. 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 on flood irrigation methods. Occasionally head gates and ditches leak, which can decrease the amount of water in diversion flows. The following recommended activities could potentially 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, if appropriate) to increase ditch conveyance efficiency

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.

10.5.1.3 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 Central Clark Fork Tributaries project area are vegetated filter strips 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% for the filter strips and 50% for the buffers (Montana Department of Environmental Quality, 2012e). 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. BMPs that reduce sediment delivery are also effective for decreasing nutrient loads to streams. However, developing a nutrient management plan is also recommended for cropland agricultural activities. 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, 2012e).

10.5.2 Forestry and Timber Harvest

The Central Clark Fork Tributaries project area has been impacted by recent and historical timber harvest activities. 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.

The SMZ Law protects against excessive erosion and therefore is appropriate for helping meet sediment load allocations. USFS INFISH Riparian Habitat Conservation Area guidelines provide significant sediment protection as well as protection from elevated thermal loading (i.e., elevated temperature) by providing adequate shade. This guidance improves upon Montana's SMZ law and includes an undisturbed 300 foot buffer on each side of fish bearing streams and 150 foot buffer on each side of non-fish bearing streams with limited exclusions and BMP guidance for timber harvest, roads, grazing, recreation and other human sources (U.S. Department of Agriculture, Forest Service, 1995). The Lolo National Forest adheres to these guidelines. The Native Fish Habitat Conservation Plan (NFHCP) developed by Plum Creek Timber includes a riparian management section that supplements the SMZ riparian buffer rules to help Plum Creek minimize impacts from timber harvest in riparian areas. It includes specific commitments to leave more trees in locations that provide the maximum benefit, such as channel migration zones and provide for an additional caution area outside of the SMZ. Many of the requirements of the NFHCP are still attached to lands purchased as part of the Montana Legacy Project.

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, increased use, construction, and maintenance of unpaved roads associated with forestry and timber harvest activities should be addressed with appropriate BMPs discussed in **Section 10.5.6**. Finally, noxious weed control should be actively pursued in all harvest areas and along all forest roads.

10.5.3 Riparian Areas, Wetlands, and Floodplains

Healthy and functioning 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. Human 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 Central Clark Fork Tribs Project Area.

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:

- Harvesting and transplanting locally available sod mats with an existing dense root mass provides immediate promotion of bank stability and filtering nutrients and sediments
- 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
- 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

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 described 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 Residential/Urban Development

There are multiple sources and pathways of pollution to consider in residential and urban areas. Destruction of riparian areas, pollutants from both functioning and failing septic systems, and stormwater generated from impervious areas and construction sites are discussed below.

10.5.4.1 Riparian Degradation

Residential development adjacent to streams can affect the amount and health of riparian vegetation, the amount of large woody debris available in the stream, and might result in placement of riprap on streambanks (see **Section 10.5.5**). As discussed in the above section on riparian areas, wetlands, and floodplains, substantially degraded riparian areas do not effectively filter pollutants from upland runoff. Riparian areas that have been converted to lawns or small acreage pastures for domestic livestock may suffer from increased contributions of nutrients, sediment, and bacteria, as well as increased summer stream temperatures, increased channel erosion, and greater damage to property from flooding (DEQ 2012).

For landowners, conservation easements can be a viable alternative to subdividing land and can be facilitated through several organizations such as The Nature Conservancy, the Trust for Public Land, and FWP. Further information on conservation easements and other landowner programs can be obtained from FWP (http://fwp.mt.gov/fishAndWildlife/habitat/wildlife/programs/landownersGuide.html).

DEQ encourages the consideration of adopting local zoning or regulations that protect the functions of floodplains and riparian and wetland areas where future growth may occur. Requirements for protecting native vegetation riparian buffers can be an effective mechanism for maintaining or improving stream health. Local outreach activities to inform new residential property owners of the effects of riparian degradation may also prevent such activities from occurring, including providing information on: appropriate fertilizer application rates to lawns and gardens, regular septic system maintenance, preserving existing riparian vegetation, native vegetation for landscaping, maintaining a buffer to protect riparian and wetland areas, and practices to reduce the amount of stormwater originating from developed property. Montana's Nonpoint Source Management Plan contains suggested BMPs to address the effects of residential and urban development, and also contains an appendix of setback regulations that have been adopted by various cities and counties in Montana (DEQ 2012). Planning guides and informational publications related to wetlands and native plant species in Montana can be found on DEQ's Wetlands Conservation website at: http://deq.mt.gov/wqinfo/Wetlands/default.mcpx.

10.5.4.2 Septic

There are 95 identified septic systems within the Central Clark Fork Tribs Project Area, the majority of which are within the Grant, West Fork Petty, and Stony Creek watersheds. This number is likely to increase with future residential development within the Central Clark Fork Tribs Project Area. Nutrient loading values for septic systems vary depending on soil type and distance to the nearest stream, but typical values for nitrate and total phosphorous loads from individual septic systems are 30.5 lbs/yr and 6.44 lbs/yr, respectively (Montana Department of Environmental Quality, 2009). However, septic systems should already have minimum design/installation requirements, which should serve as a basic BMP. Older systems should be upgraded and all new systems should meet these minimum requirements.

10.5.4.3 Stormwater

Where precipitation from rain or snowmelt events does not infiltrate soils in urban areas and at construction sites, it drains off the landscape as stormwater, which can carry pollutants into waterways. As the percentage of impervious surfaces (e.g., streets, parking lots, roofs) increases, so does the volume of stormwater and pollutant loads delivered to waterbodies. Although rain and snowmelt events contribute to pollutant loads, stormwater is not currently identified as a major source of pollutant contributions for the streams discussed in this document. Grant Creek and Petty Creek have point source contributions of sediment with associated wasteload allocations and reductions identified in Section 5.9.3. Nutrient and temperature loads can also be affected by stormwater runoff from these point sources. However, DEQ assumes that the WLAs will be met by adhering to the permit requirements, and the WLAs are not intended to add load limits to these permits. Although no load allocations are provided for nonpoint contributions, stormwater management should be a consideration when identifying water quality improvement objectives within the watershed restoration plan. The primary method to control stormwater discharges is the use of BMPs. Additional information can be found in Montana's Nonpoint Source Management Plan (DEQ 2012). A guide to stormwater BMPs can be found on EPA's National Menu of Stormwater Best Management Practices at: http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm. The Montana Water Center also has a website dedicated to stormwater control for construction activities: http://stormwater.montana.edu/.

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 local land use planning initiatives.

Bank stabilization using natural channel design techniques can provide both bank stability and aquatic 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 Unpaved Roads and Culverts

Unpaved roads contribute sediment (as well as nutrients and other pollutants) to streams in the Central Clark Fork Tribs Project Area. The road sediment reductions provided in this document, and detailed in **Appendix D**, represent an estimate of the sediment load that would remain once additional road BMPs are applied. The main focus of the BMPs used to estimate reduction in loading was to reduce the contributing length to the maximum extent practicable at each crossing. 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, 2012e). Examples include:

- Providing adequate ditch relief upgrade of stream crossings
- Constructing waterbars, where appropriate, and up-grade of stream crossings
- Using rolling dips on downhill grades with an embankment on one side to direct flow to the ditch
- Insloping roads along steep banks with the use of cross slopes and cross culverts
- Outsloping low traffic roads on gently sloping terrain with the use of a cross slope
- Using ditch turnouts and vegetative filter strips to decrease water velocity and sediment carrying capacity in ditches
- For maintenance, grading materials to the center of the road and avoid removing the toe of the cutslope
- Preventing disturbance to vulnerable slopes
- Using topography to filter sediments; flat, vegetated areas are more effective sediment filters
- Where possible, limiting road access during wet periods when drainage features could be damaged

Undersized and improperly installed and maintained culverts can be a substantial source of sediment to streams, and a barrier to fish and other aquatic organisms. 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 (**Appendix D**) found that approximately 88% of the culverts pass the discharge of a 100-year flood 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 17 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 event 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, none of 12 assessed culverts with flowing water had a high probability of allowing fish passage; all of the culverts were classified as fish passage barriers. 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.

10.5.7 Mining

The Central Clark Fork Tributaries project area and Montana more broadly, have a legacy of mining that continues today. Mining activities may have impacts that extend beyond increased metal concentrations in the water. Channel alteration, riparian degradation, and runoff and erosion associated with mining can lead to sediment, habitat, nutrient, and temperature impacts as well. The need for further characterization of impairment conditions and loading sources is addressed through the monitoring plan in **Section 11.3**.

10.6 Potential Funding and Technical Assistance Sources

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

10.6.1 Section 319 Nonpoint Source Grant Program

DEQ issues a call for proposals every year to award Section 319 grant funds administered under the federal Clean Water Act. The primary goal of the 319 program is to restore water quality in waterbodies whose beneficial uses are impaired by nonpoint source pollution and whose water quality does not meet state standards. 319 funds are distributed competitively to support the most effective and highest priority projects. In order to receive funding, projects must directly implement a DEQ-accepted watershed restoration plan and funds may either be used for the education and outreach component of the WRP or for implementing restoration projects. Project sponsors must be either a governmental entity or a 501(c)(3) nonprofit organization. A governmental entity is a local, state, or federal office that has been established and authorized by law. The recommended range for 319 funds per project proposal is $10,000 to $30,000 for education and outreach activities and $50,000 to $300,000 for implementation projects. All funding has a 40% cost share requirement, and projects must be administered through a governmental entity such as a conservation district or county, or a nonprofit organization. For information about past grant awards and how to apply, please visit http://deq.mt.gov/wqinfo/nonpoint/319GrantInfo.mcpx.

10.6.2 Future Fisheries Improvement Program

The Future Fisheries grant program is administered by FWP and offers funding for 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 Central Clark Fork Tributaries project area include restoring streambanks, improving fish passage, and restoring/protecting spawning habitats. For additional information about the program and how to apply, please visit http://fwp.mt.gov/fishAndWildlife/habitat/fish/futureFisheries/.

10.6.3 Watershed Planning and Assistance Grants

The 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. For additional information about the program and how to apply, please visit http://dnrc.mt.gov/cardd/LoansGrants/WatershedPlanningAssistance.asp.

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, 2012e) 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. For additional information about the program and how to apply, please visit http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/.

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 DNRC that can provide up to $300,000 to address environmental related issues. This money can be applied to sites included on the DEQ Abandoned Mine Lands (AML) priority list, but of low enough priority where cleanup under AML is uncertain. RIT/RDG program funds can also be used for conducting site assessment/characterization activities such as identifying specific sources of water quality impairment. RIT/RDG projects typically need to be administered through a non-profit or local government such as a conservation district, a watershed planning group, or a county. For additional information about the program and how to apply, please visit http://dnrc.mt.gov/cardd/ResourceDevelopment/rdgp/ReclamationDevelopmentGrantsProgram.asp.

10.6.6 Montana Partners for Fish and Wildlife

Montana Partners for Fish and Wildlife is a program under the U.S. Fish & Wildlife Service that assists private landowners to restore wetlands and riparian habitat by offering technical and financial assistance. For additional information about the program and to find your local contact for the Central Clark Fork Tribs area, please visit: http://www.fws.gov/mountain-prairie/pfw/montana/.

10.6.7 Wetlands Reserve Program

The Wetlands Reserve Program is a voluntary conservation program administered by the NRCS that offers landowners the means to restore, enhance, and protect wetlands on their property through permanent easements, 30 year easements, or Land Treatment Contracts. The NRCS seeks sites on agricultural land where former wetlands have been drained, altered, or manipulated by man. The landowner must be interested in restoring the wetland and subsequently protecting the restored site. For additional information about the program and how to apply, please visit http://www.nrcs.usda.gov/wps/portal/nrcs/main/mt/programs/easements/wetlands/

10.6.8 Montana Wetland Council

The Montana Wetland Council is an active network of diverse interests that works cooperatively to conserve and restore Montana's wetland and riparian ecosystems. Please visit their website to find dates and locations of upcoming meetings, wetland program contacts, and additional information on potential grants and funding opportunities: http://deq.mt.gov/wqinfo/wetlands/wetlandscouncil.mcpx.

10.6.9 Montana Natural Heritage Program

The Montana Natural Heritage Program is a valuable resource for restoration and implementation information including maps. Wetlands and riparian areas are one of the 14 themes in the Montana Spatial Data Infrastructure. The Montana Wetland and Riparian Mapping Center (found at: http://mtnhp.org/nwi/) is creating a statewide digital wetland and riparian layer as a resource for management, planning, and restoration efforts.

10.6.10 Montana Aquatic Resources Services, Inc.

Montana Aquatic Resources Services, Inc. (MARS) is a nonprofit organization focused on restoring and protecting Montana's rivers, streams and wetlands. MARS identifies and implements stream, lake, and wetland restoration projects, collaborating with private landowners, local watershed groups and conservation districts, state and federal agencies, and tribes. For additional information about the program, please visit http://montanaaquaticresources.org/.

11.0 Monitoring Strategy and Adaptive Management

11.1 Monitoring Purpose

The monitoring strategies discussed in this section are an important component of watershed restoration, and a requirement of TMDL implementation under the Montana Water Quality Act (MCA 75-5-703(7)), 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. The scale of the watershed analysis, coupled with constraints on time and resources, often result in necessary compromises that include estimations, extrapolation, and a level of uncertainty in TMDLs. The margin of safety (MOS) (**Section 4.4**) 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, the amount of reduction of instream pollutants (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 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 the water quality improvement goals outlined in this document. Funding for future monitoring is uncertain and can vary with economic and political changes. Prioritizing monitoring activities depends on funding opportunities and stakeholder priorities for restoration. Once restoration measures have been implemented for a waterbody with an approved TMDL and given time to take effect, DEQ will conduct a formal evaluation of the waterbody's impairment status and determine whether TMDL targets and water quality standards are being met.

11.2 Adaptive Management and Uncertainty

In accordance with the Montana Water Quality Act (MCA 75-5-703 (7) and (9)), DEQ is required to assess the waters for which TMDLs have been completed and restoration measures, or best management practices (BMPs), have been applied to determine whether compliance with water quality standards has been attained. This aligns with an adaptive management approach that is incorporated into DEQ's assessment and water quality impairment determination process.

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

For an in-depth look at the adaptive management approach, view the U.S. Department of the Interior's (DOI) technical guide and description of the process at: http://www.doi.gov/archive/initiatives/AdaptiveManagement/. DOI includes **Figure 11-1** below in their technical guide as a visual explanation of the iterative process of adaptive management (Williams and Shapiro, 2009).

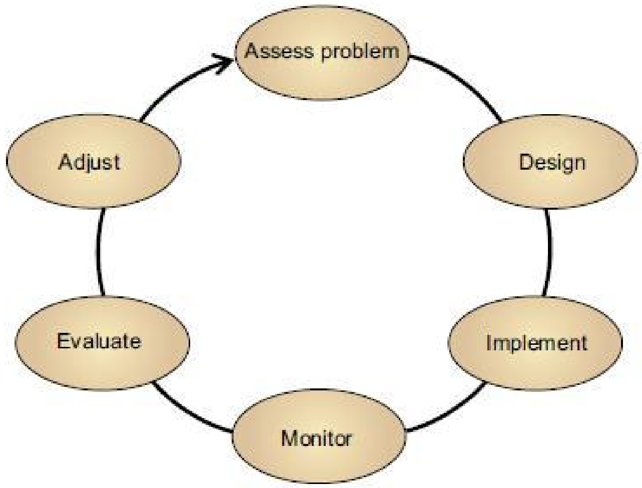

Figure 11-1. Diagram of the adaptive management process

11.3 Future Monitoring Guidance

The objectives for future monitoring in the Central Clark Fork Tributaries project area include:

- Strengthen the spatial understanding of sources for future restoration work, which will also improve source assessment analysis for future TMDL review
- Gather additional data to supplement target analysis, better characterize existing conditions, and improve or refine assumptions made in TMDL development
- Coordinate among agencies and watershed groups to ensure that information is comparable to the established water quality targets and allows for common threads in discussion and analysis
- Expand the understanding of streams and nonpoint source pollutant loading throughout the Central Clark Fork Tributaries project area beyond those where TMDLs have been developed and address issues
- Track restoration projects as they are implemented and assess their effectiveness

11.3.1 Strengthening Source Assessment

In the Central Clark Fork Tribs Project Area, the identification of pollutant sources was conducted largely through reviewing and analyzing available data, tours of the watershed, assessments of aerial photographs, the incorporation of geographic information system information, and the review of published scientific studies. In many cases, assumptions were made based on known watershed conditions and extrapolated throughout the project area. As a result, the level of detail often does not provide specific areas on which to focus restoration efforts, only broad source categories to reduce pollutant loads from each of the discussed streams and subwatersheds. Strategies for strengthening source assessments for each of the pollutant categories are outlined below.

Sediment

- Field surveys of all roads and road crossings to identify specific contributing segments and crossings, their associated loads, and prioritize those road segments/crossings of most concern.
- Reviews of land use practices within the specific 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 streambank erosion conditions and investigation of related contributing factors for each subwatershed of concern through site visits and subwatershed-scale bank erosion hazard index (BEHI) assessments. Additionally, the development of bank erosion retreat rates specific to the Central Clark Fork Tributaries project area 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 landscape settings 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

- Field surveys to better identify and characterize riparian area conditions and potential for improvement
- Identification of possible areas for improvement in shading along major tributaries
- Collection of flow measurements at all temperature monitoring locations during the time of data collection
- Investigation of groundwater influence on instream temperatures, and relationships between groundwater availability and water use in the Nemote, Petty, and Grant Creek watersheds and the entire Central Clark Fork Tribs Project Area
- Assessment of irrigation practices and other water use in Nemote, Petty, and Grant Creek watershed and Central Clark Fork Tributaries project area and potential for improvements in water use that would result in increased instream flows
- Use of additional collected data to evaluate and refine the temperature targets

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 cattle grazing practices and the number of animals grazed in the Central Clark Fork Tribs Project Area
- A more detailed understanding of nutrient contributions from historical and current mining within the watershed
- A better understanding of septic system contributions to nutrient loads, specifically in the Grant, Stony, and West Fork Petty Creek watersheds
- A review of land management practices specific to subwatersheds of concern to determine where the greatest potential for improvement can occur for the major land use categories
- Additional sampling in streams that have limited data

Turbidity

- A better understanding of background turbidity levels on Trout Creek and other streams within the Central Clark Fork Tribs TMDL Project Area
- A more detailed and updated assessment of sources of turbidity on Trout Creek

11.3.2 Increasing Available Data

While the Central Clark Fork Tributaries project area has undergone remediation and restoration activities, data are still often limited depending on the stream and pollutant of interest. Infrequent sampling events at a small number of sampling sites may provide some indication of overall water quality and habitat condition. However, regularly scheduled sampling at consistent locations, under a variety of seasonal conditions is the best way to assess overall stream health and monitor change.

Sediment

For sediment investigation in the Central Clark Fork Tribs Project Area, each of the streams of interest was stratified into unique reaches based on physical characteristics and human-caused influences. A total of 17 sites were sampled throughout the watershed, which is 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. It would also provide more specific information on a per-stream basis and for the Central Clark Fork Tributaries project area as a whole, and can be used for reach by reach comparisons and assessing potential influencing factors and resultant outcomes that exist throughout the project area.

Temperature

Temperature investigation for Nemote, Petty, and Grant Creek watersheds included a total of 28 data loggers, deployed throughout these streams and selected tributaries in summer months of either 2011 or 2012. Increasing the number of data logger locations and the number of years of data, including collection of associated flow data, would improve our understanding of instream temperature changes and better identify influencing factors on those changes. Collecting additional stream temperature data in sections with the most significant temperature changes and/or largest spatial gaps between loggers will also help refine the characterization of temperature conditions in Nemote, Petty, and Grant Creeks. In addition, riparian shade data were collected using a combination of field data and aerial imagery analysis. A Solar Pathfinder was used to measure effective shade on dates during the late summer at 22 sites. Since shade is the major focus of the allocations, a more detailed assessment of existing riparian conditions and identification of areas for passive and active restoration of riparian vegetation on Nemote, Petty, and Grant Creeks and their major tributaries is recommended. Finally, coordinating with other organizations to incorporate suitable temperature data will improve future assessments of Central Clark Fork Tributaries project area streams.

Nutrients

Water quality sampling locations for nutrients were distributed spatially along each stream in order to best delineate nutrient sources and provide a comprehensive upstream to downstream view of nutrient concentrations. Sampling occurred over several seasons from 2003 through 2012, with most data collected after 2011. Additional water column and biological sampling is recommended to help refine the impairment cause(s) and sources. To better evaluate nutrient loading, source refinement will continue to be necessary on all streams with nutrient TMDLs and those that have not yet been assessed in the project area. With changing land uses and/or new permitted discharges to surface waters, it will be important to continually assess nutrient sources in a watershed.

11.3.3 Consistent Data Collection and Methodologies

Data have been collected throughout the Central Clark Fork Tributaries project area for many years and by many different agencies and entities; however, the type and quality of information is often variable. Wherever possible, it is recommended that the type of data and methodologies used to collect and analyze the information are consistent so as to allow for comparison to TMDL targets and track progress toward meeting TMDL goals.

DEQ is the lead agency for developing and conducting impairment status monitoring; however, other agencies or entities may work closely with DEQ to provide compatible data. Water quality impairment determinations are made by DEQ, but data collected by other sources can be used in the impairment determination process. The information in this section provides general guidance for future impairment status monitoring and effectiveness tracking. Future monitoring efforts should consult DEQ on updated monitoring protocols. Improved communication between agencies and stakeholders will further improve accurate and efficient data collection. The development of a DEQ approved Sampling and Analysis Plan (SAP) and a Quality Assurance Project Plan (QAPP) will ensure that the data collected meet DEQ standards for data quality.

It is important to note that monitoring recommendations are based on TMDL related efforts to protect water quality beneficial uses in a manner consistent with Montana's water quality standards. Other regulatory programs with water quality protection responsibilities may impose additional requirements to ensure full compliance with all appropriate local, state, and federal laws.

Sediment

Sediment and habitat assessment protocols consistent with the DEQ field methodologies that serve as the basis for sediment targets and assessments within this TMDL document 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, 2012c). 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 Central Clark Fork Tributaries project area 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

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 that were not developed as targets but were reviewed where available during the development of these TMDLs.

Temperature

It is important that temperature data are collected in consistent locations and using consistent methods. 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 methodology.

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 so 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

Parameter*	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			
Chlorophyll a &	A 10200 H	n/a	n/a	21(pH≥ 7)/ASA	Filter	Freeze
Ash-Free Dry Weight	A 10300 C(5)	n/a	n/a			
Periphyton	PERI-1/PERI-1mod	n/a	n/a	n/a	50 cm^3 centrifuge tube	Formalin (40% formaldehyde solution)
Macroinvertebrates	EMAP	n/a	n/a	n/a	1L Acid-washed HDPE	Ethanol

*Preferred analytical methods and required reporting limits may change in the future (e.g., become more stringent); consult with DEQ prior to any monitoring effort in order to ensure you use the most current methods.

11.3.4 Effectiveness Monitoring for Restoration Activities

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

Due to the natural high variability in water quality conditions, trends in water quality are difficult to define and even more difficult to relate directly to restoration or other changes in management. Improvements in water quality or aquatic habitat from restoration activities will most likely be evident in fine sediment deposition and channel substrate embeddedness, changes in channel cumulative width/depths, improvements in bank stability and riparian habitat, 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 project area, pre and post monitoring to understand the change that follows implementation will be necessary to track the effectiveness of specific projects. Monitoring activities should be selected such that they directly investigate those subjects that the project is intended to effect, and when possible, linked to targets and allocations in the TMDL. For example, as bank erosion is 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 Central Clark Fork Tributaries project area should not be confined to only those streams addressed within this document. The water quality targets presented in this document are applicable to all streams in the watershed, and the absence of a stream from the state's impaired waters list does not necessarily imply that the stream fully supports all beneficial uses. Furthermore, as conditions change over time and land management changes, 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

This section will be completed prior to EPA submittal.

13.0 References

Andrews, E. D. and J. M. Nankervis. 1995. "Effective Discharge and the Design of Channel Maintenance Flows for Gravel-Bed Rivers: Natural and Anthropogenic Influences in Fluvial Geomorphology," in *Natural and Anthropogenic Influences in Fluvial Geomorphology: The Wolman Volume*, Costa, John E., Miller, Andrew J., Potter, Kenneth W., and Wilcock, Peter R. Geophysical Monograph Series, Ch. 10: American Geophysical Union): 151-164.

Bahls, Loren L. 1988. Montana Nonpoint Source Assessment Report. Helena, MT: Montana Department of Helath and Environmental Sciences, Water Quality Bureau.

Baigun, C. 2003. Characteristics of Deep Pools Used by Adult Summer Steelhead in Steamboat Creek, Oregon. *North American Journal of Fisheries Management.* 23(4): 1167-1174.

Bauer, Stephen B. and Stephen C. Ralph. 1999. Aquatic Habitat Indicators and Their Application to Water Quality Objectives Within the Clean Water Act. Seattle, WA: US Environmental Protection Agency, Region 10. EPA 910-R-99-014.

Bilby, R. E. and J. W. Ward. 1989. Changes in Characteristics and Function of Woody Debris With Increasing Size of Stream in Western Washington. *Transactions of the American Fisheries Society.* 118: 368-378.

Bjorn, T. C. and D. W. Reiser. 1991. "Habitat Requirements of Salmonids in Streams," in *Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats*, Special Publication 19 ed., (Bethesda, MD: American Fisheries Society): 83-138.

Bonneau, J. L. and D. L. Scarnecchia. 1998. Seasonal and Diel Changes in Habitat Use by Juvenile Bull Trout (Salvelinus Confluentus) and Cutthroat Trout (Oncorhynchus Clarki) in a Mountain Stream. *Canadian Journal of Zoology.* 76: 783-790.

Bryce, S. A., G. A. Lomnicky, and Philip R. Kaufmann. 2010. Protecting Sediment-Sensitive Aquatic Species in Mountain Streams Through the Application of Biologically Based Streambed Sediment Criteria. *North American Benthological Society.* 29(2): 657-672.

Christensen, V. G., X. Jian, and A. C. Ziegler. 2000. Regression Analysis and Real-Time Water-Quality Monitoirng to Estiamte Constituent Concentrations, Loads, and Yields in the Little Arkansas River, South-Central Kansas, 1995-1999.

Cover, Matthew R., Christine L. May, William E. Dietrich, and Vincent H. Resh. 2008. Quantitative Linkages Among Sediment Supply, Streambed Fine Sediment, and Bethic Macroinvertebrates in Northern California Streams. *Journal of the North American Benthological Society.* 27(1): 135-149.

Federal Emergency Management Agency. 2011. Grant Creek Letter of Map Revision Determination Document; Case No.: 11-08-0184P.

Geosyntec Consultants and Wright Water Engineers, Inc. 2008. Overview of Performance by BMP Category and Common Pollutant Type (International Stormwater Best Management Practices Database [1999-2007]). Water Environment Research Foundation; American Society of Civil Engineers; U.S.E.P.A.; Federal Highway Administration; American Public Works Association. http://www.bmpdatabase.org/Docs/Performance%20Summary%20Cut%20Sheet%20June%202008.pdf.

-----. 2011. Internationational Stormwater Best Management Practices Database Pollutant Category Summary: Solids (TSS, TDS, and Turbidity). www.bmpdatabase.org.

Gray, John R. and G. Douglas Glysson. 2002. Proceedings of the Federal Interagency Workshop on Turbidity and Other Sediment Surrogates. In.

Grumbles, Benjamin. 2006. Letter From Benjamin Grumbles, US EPA, to All EPA Regions Regarding Dail Load Development. U.S. Environmental Protection Agency.

Hargrave, Phyllis A., Mike D. Kerschen, C. McDonald, John J. Metesh, and Robert Wintergerst. 2003. Abandoned-Inactive Mines on Lolo National Forest Administered Lands. Open-File Report 476.

Harmon, Dan J. 2007. Grant Creek Environmental Restoration and Flood Control Project Joint Application for Proposed Work in Montana's Water Bodies. Kleitz, Todd.

Harmon, Dan J. and HDR Engineering, Inc. 2010. Project Summary Report - Letter of Map Revision: Grant Creek LOMR Missoula County, Montana. Federal Emergency Management Agency, LOMC Clearinghouse.

Heckenberger, Brian. 2009. Personal Communication. Kusnierz, Lisa. Accessed 5/2009.

Idaho Department of Environmental Quality. 2008. Fish Creek Watershed Assessment and Total Maximum Daily Loads.

Irving, J. S. and T. C. Bjorn. 1984. Effects of Substrate Size Composition on Survival of Kokanee Salmon and Cutthroat Trout and Rainbow Trout Embryos. Moscow, ID: University of Idaho. Technical Report 84-6.

Jones, Amber Spackman. 2008. Estimating Total Phosphorus and Total Suspended Solids Loads From High Frequency Data.

Kershner, Jeffrey, Brett Roper, Nicolaas Bouwes, Richard Henderson, and Eric Archer. 2004. An Analysis of Stream Habitat Conditions in Reference and Managed Watersheds on Some Federal Lands

Within the Columbia River Basin. *North American Journal of Fisheries Management.* 24: 1363-1375.

Knighton, David. 1998. Fluvial Forms and Processes: A New Perspective, New York, New York: John Wiley and Sons Inc.

MacDonald, Lee H., Alan W. Smart, and Robert C. Wissmar. 1991. Monitoring Guidelines to Evaluate Effects of Forestry on Streams in the Pacific Northwest and Alaska. Seattle, WA: U.S.Environmental Protection Agency. EPA 910/9-91-001.

Mast, M. Alisa and Ian D. Cluckie. 2000. Environmental Characteristics and Water-Quality of Hydrologic Benchmark Network Stations in Teh Western United States, U.S. Geological Survey Circular 1173-D.

May, Christine L. and Danny C. Lee. 2004. The Relationship Between In-Channel Sediment Storage, Pool Depth, and Summer Servival of Juvenile Salmonids in the Oregon Coast Range. *American Fisheries Society Journals.* 24(3): 761-774.

MCS Environmental, Inc. 2004. Flat Creek Tailings, Final Site Investigation Report.

Mebane, C. A. 2001. Testing Bioassessment Metrics: Macroinvertebrate, Sculpin, and Salmonid Responses to Stream Habitat, Sediment, and Metals. *Environmental Monitoring and Assessment.* 67(3): 293-322.

Montana Bull Trout Scientific Group. 1996. Lower Clark Fork River Drainage: Bull Trout Status Report (Cabinet Gorge Dam to Thompson Falls). Helena, MT: The Montana Bull Trout Scientific Group.

Montana Department of Environmental Quality. 2009. How to Perform a Nondegradation Analysis for Subsurface Wastewater Treatment Systems (SWTS) Under the Subdivision Review Process. Helena, MT: Montana Department of Environmental Quality. http://deq.mt.gov/wqinfo/nondeg/HowToNonDeReg.mcpx. Accessed 6/14/2013.

-----. 2011. Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments. Helena, MT: Montana Department of Environmental Quality.

-----. 2012a. Circular DEQ-7: Montana Numeric Water Quality Standards. Helena, MT: Montana Department of Environmental Quality. http://deq.mt.gov/wqinfo/Circulars.mcpx. Accessed 1/15/2013a.

-----. 2012b. Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments.

-----. 2012c. Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments.

-----. 2012d. Little Blackfoot 2011 Metals, Sediment & Nutrients TMDL Development History and Archive. Montana Department of Environmental Quality.

-----. 2012e. Montana Nonpoint Source Management Plan. Helena, MT: Montana Department of Environmental Quality.

-----. 2013. Bonita-Superior Metals TMDLs.

Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8. 2011. Little Blackfoot River Watershed TMDLs and Framework Water Quality Improvement Plan: Final. Helena, MT: Montana Department of Environmental Quality. C01-TMDL-03A-F.

Montana Department of Environmental Quality, Planning, Prevention and Assistance Division. 2010. Upper Clark Fork River Tributaries Sediment, Metals, and Temperature TMDLs and Framework for Water Quality Restoration. Helena, MT: Montana Dept. of Environmental Quality. C01-TMDL-02a-F.

Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau. 2011a. Bitterroot Temperature and Tributary Sediment Total Maximum Daily Loads and Framework Water Quality Improvement Plan: Final. Helena, MT: Montana Department of Environmental Quality. C05-TMDL-03aF.

-----. 2011b. Water Quality Assessment Method. Helena, MT: Montana Department of Environmental Quality. Revision 3.0.

-----. 2012. Montana 2012 Final Water Quality Integrated Report. Helena, MT: Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau. WQPBIMTSR-004f.

-----. 2014. Montana 2014 Draft Water Quality Integrated Report. Helena, MT: Montana Department of Environmental Quality. WQPBIMTSTR-009d.

Montana State University, Extension Service. 2001. Water Quality BMPs for Montana Forests. Bozeman, MT: MSU Extension Publications.

Muhlfeld, Clint C. and David H. Bennett. 2001. Summer Habitat Use by Columbia River Redband Trout in the Kootenai River Drainage, Montana. *North American Journal of Fisheries Management.* 21(1): 223-235.

Muhlfeld, Clint C., David H. Bennett, and Brian L. Marotz. 2001. Fall and Winter Habitat Use and Movement by Columbia River Redband Trout in a Small Stream in Montana. *North American Journal of Fisheries Management.* 21(1)

Nielson, J. L., T. E. Lisel, and V. Ozaki. 1994. Thermally Stratified Pools and Their Use by Steelhead in Northern California Streams. *Transactions of the American Fisheries Society.* 123(4): 613-626.

Overton, C. Kerry, Sherry P. Wollrab, Bruce C. Roberts, and Michael A. Radko. 1997. R1/R4 (Northern/Intermountain Regions) Fish and Fish Habitat Standard Inventory Procedures Handbook. Ogden, UT: USDA Forest Service, Intermountain Research Station.

Relyea, C. B., G. W. Minshall, and R. J. Danehy. 2000. Stream Insects As Bioindicatores of Fine Sediment. In: Watershed 2000. Water Environment Federation Specialty Conference. Boise, ID: Idaho State University.

Rosgen, David L. 1996a. Applied River Morphology, Pagosa Springs, CO: Wildland Hydrology.

-----. 1996b. Applied River Morphology, Pagosa Springs, CO: Wildland Hydrology.

-----. 2006. Watershed Assessment of River Stability and Sediment Supply (WARSSS). Fort Collins, CO: Wildland Hydrology.

Rowe, Mike, Don Essig, and Benjamin Jessup. 2003. Guide to Selection of Sediment Targets for Use in Idaho TMDLs. Pocatello, ID: Idaho Department of Environmental Quality.

Schmidt, Larry J. and John P. Potyondy. 2004. Quantifying Channel Maintenance Instream Flows: An Approach for Gravel-Bed Streams in the Western United States. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. General Technical Report RMRS-GTR-128.

Shepard, B. B., Stephen A. Leathe, Thomas M. Weaver, and M. D. Enk. 1984. Monitoring Levels of Fine Sediment Within Tributaries of Flathead Lake, and Impacts of Fine Sediment on Bull Trout Recruitment. In: Wild Trout III Symposium; Yellowstone National Park, WY.

Stogner, Robert W., Sr., Jonathan M. Nelson, Richard R. McDonald, Paul J. Kinzel, and David P. Mau. 2013. Prediction of Suspended-Sediment Concentrations at Selected Sites in the Fountain Creek Watershed, Colorado, 2008-2009. Denver, CO: U.S. Geological Survey. Scientific Investigations Report 2012-5102.

Sullivan, S. M. P. and M. C. Watzin. 2010. Towards a Functional Understanding of the Effects of Sediment Aggradation on Stream Fish Conditions. *Rier Research and Applications.* 26(10): 1298-1314.

Suplee, Michael W. and Rosie Sada de Suplee. 2011. Assessment Methodology for Determining Wadeable Stream Impairment Due to Excess Nitrogen and Phosphorus Levels. Helena, MT: Montana Department of Environmental Quality Water Quality Planning Bureau. WQPMASTR-01.

Suplee, Michael W., Vicki Watson, Mark E. Teply, and Heather McKee. 2009. How Green Is Too Green? Public Opinion of What Constitutes Undesirable Algae Levels in Streams. *Journal of the American Water Resources Association.* 45(1): 123-140.

Suttle, K. B., M. E. Power, J. M. Levine, and C. McNeeley. 2004. How Fine Sediment in Riverbeds Impairs Growth and Survival of Juvenile Salmonids. *Ecological Applications.* 14(4): 969-974.

Tomlinson, M. S. and E. H. De Carlo. 2003. The Need for High Resolution Time Series Data to Characterize Hawaiian Streams. *Journal of American Water Resources Association.*(39): 113-123.

U.S. Department of Agriculture, Forest Service. 1995. Inland Native Fish Strategy: Interim Strategies for Managing Fish-Producing Watersheds in Eastern Oregon and Washington, Idaho, Western Montana and Portions of Nevada. Washington, D.C.: USDA Forest Service.

U.S. Department of Transportation, Federal Highway Administration, Western Federal Lands Highway Division. 2010. Petty Creek Road Improvement Project, MT PFH 71-1(1), Amended Environmental Assessment. http://www.wfl.fhwa.dot.gov/projects/mt/petty-creek/documents/petty-creek-ea.pdf:

U.S. Environmental Protection Agency. 1999a. Protocol for Developing Nutrient TMDLs. Washington, D.C.: Office of Water, U.S. Environmental Protection Agency. EPA 841-B-99-007.

-----. 1999b. Protocol for Developing Sediment TMDLs. Washington, D.C.: Office of Water, United States Environmental Protection Agency. EPA 841-B-99-004.

-----. 1999c. Protocol for Developing Sediment TMDLs. Washington, D.C.: U.S. Environmental Protection Agency. EPA 841-B-99-004.

-----. 2009. Development Document for Final Effluent Guidelines and Standards for the Contruction & Development Category. U.S. Environmental Protection Agency. http://water.epa.gov/scitech/wastetech/guide/construction/upload/2009_12_8_guide_construction_files_chapters.pdf.

-----. 2012. Record of Decision for Flat Creek/IMM Superfund Site Operable Unit 1 Mineral County, Montana. http://www2.epa.gov/sites/production/files/documents/fcimm_ou1rod_jul2012.pdf.

United States Environmental Protection Agency. 2011. Flat Creek IMM Superfund Site Operable Unit 1, Superior Montana: Proposed Plan.

Weaver, Thomas M. and John Fraley. 1991. Fisheries Habitat and Fish Populations in Flathead Basin Forest Practices Water Quality and Fisheries Cooperative Program. Kalispell, MT: Flahead Basin Commission.

Zweig, L. D. and C. F. Rabeni. 2001. Biomonitoring for Deposited Sediment Using Benthic Invertebrates: A Test on Four Missouri Streams. *Journal of the North American Benthological Society.* 20: 643-657.

(Barbour et al., 1999)
Barbour, Michael T., Jeroen Gerritsen, Blaine D. Snyder, and James B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish: Second Edition. Washington, DC: United States Department of Environmental Protection, Office of Water. EPA 841-B-99-002.

Bureau of Land Management website factsheet
Title: Fact Sheet on the BLM's Management of Livestock Grazing
Author: Bureau of Land Management (BLM)
Date Last Accessed: April 17, 2014
Web Address: http://www.blm.gov/wo/st/en/prog/grazing.print.html

Green and Kauffman, 1989
Green, D. M. and J. B. Kauffman. 1989. "Nutrient Cycling at the Land-Water Interface: The Importance of the Riparian Zone," in *Practical Approaches to Riparian Resource Management: An Education Workshop*, Gresswell, R. E., Barton, B. A., and Kershner, Jeffrey L., (Billings, MT: U.S. Bureau of Land Management): 61-68.

Feller and Kimmins, 1984
Feller, M. C. and J. P. Kimmins. 1984. Effects of Clearcutting and Slash Burning on Streamwater Chemistry and Watershed Nutrient Budgets in Southwestern British Columbia. *Water Resources Research.* 20: 29-40.

(Geosyntec Consultants and Wright Water Engineers, Inc., 2011
Geosyntec Consultants and Wright Water Engineers, Inc. 2008. Overview of Performance by BMP Category and Common Pollutant Type (International Stormwater Best Management Practices Database [1999-2007]). Water Environment Research Foundation; American Society of Civil Engineers; U.S.E.P.A.; Federal Highway Administration; American Public Works Association. http://www.bmpdatabase.org/Docs/Performance%20Summary%20Cut%20Sheet%20June%202008.pdf.

{Harmon, 2010 6301 /id}
same as Christian's sediment section 5 in this Central Clark Fork Tributaries TMDL document

Jacobson, 2004
Jacobson, R. B. 2004. Downstream Effects of Timber Harvest in the Ozarks of Missouri. *Toward Sustainability For Missouri Forests*: 106-1260.

Likens et al., 1978;
Likens, G. E., Ft H. Bormann, R. S. Pierce, and W. A. Reiners. 1978. Recovery of a Deforested Ecosystem. *Science.* 199(4328): 492-496.

personal communication, Erik Makus, 2014

Martin and Harr, 1989
Martin, C. W. and R. D. Harr. 1989. Logging of Mature Douglas-Fir in Western Oregon Has Little Effect on Nutrient Output Budgets. *Canadian Journal of Forest Research.* 19(1): 35-43.

Montana Bureau of Mines and Geology website
Title: Montana Mines and Exploration – 2012.
Author: Montana Bureau of Mines and Geology
Data Last Accessed: April 17, 2014
Web Address: http://www.mbmg.mtech.edu/gmr/gmr-mines_exploration.asp

Pioneer Technical Services, Inc.
Title: Abandoned Hardrock Mine Priority Sites: 1995 Summary Report
Author: Montana Department of Environmental Quality
Year: 1995
Reference #: 96
Web Address (might not need this as online resources since it's in the library but just in case you do): http://deq.mt.gov/AbandonedMines/priority.mcpx
Date Last Accessed: April 17, 2014

Montana Department of Environmental Quality, 2011a
Montana Department of Environmental Quality. 2011a. Sample Collection and Laboratory Analysis of Chlorophyll-*a* Standard Operation Procedure, Revision 5. Helena, MT: Montana Department of Environmental Quality. Report WQPBWQM-011.

Montana Department of Environmental Quality, 2011b
Montana Department of Environmental Quality. 2011b. Periphyton Standard Operating Procedure.
Helena, MT: Montana Department of Environmental Quality. Report WQPVWQM-010.

Montana Department of Environmental Quality, 2013
Title: Draft Department Circular DEQ-12A. Montana Base Numeric Nutrient Standards.
Author: Montana Department of Environmental Quality

Montana Department of Environmental Quality CWAIC website
Title: Clean Water Act Information Center (CWAIC)
Author: Montana Department of Environmental Quality.
Date Last Accessed: April 17, 2014
Web Address: http://deq.mt.gov/wqinfo/CWAIC/default.mcpx

Montana Department of Environmental Quality, 2014
Montana Department of Environmental Quality. 2014. Montana 2014 Draft Water Quality Integrated Report. Helena, MT: Montana Dept. of Environmental Quality.

Priscu, 1987
Priscu, John C. 1987. Environmental Factors Regulating the Dynamics of Blue-Green Algal Blooms in Canyon Ferry Reservoir, Montana. Bozeman, MT: Montana Water Resources Research Institute. Report # 159.

Suplee et al., 2008a
Suplee, Michael W., Arun Varghese, and Joshua Cleland. 2008a. Developing Nutrient Criteria for Streams: An Evaluation of the Frequency Distribution Method. *Journal of the American Water Resources Association.* 43(2): 456-472.

Suplee et al., 2008b
Suplee, Michael W., Vicki Watson, Arun Varghese, and Joshua Cleland. 2008b. Draft Scientific and Technical Basis of the Numeric Nutrient Criteria for Montana's Wadeable Streams and Rivers. Helena, MT: Montana Department of Environmental Quality.

Suplee et al., 2009
Suplee, Michael W., Vicki Watson, Mark E. Teply, and Heather McKee. 2009. How Green Is Too Green? Public Opinion of What Constitutes Undesirable Algae Levels in Streams. *Journal of the American Water Resources Association.* 45(1): 123-140.

Suplee and Sada de Suplee, 2011
Suplee, Michael W. and Rosie Sada de Suplee. 2011. Assessment Methodology for Determining Wadeable Stream Impairment Due to Excess Nitrogen and Phosphorus Levels. Helena, MT: Montana Department of Environmental Quality Water Quality Planning Bureau. WQPMASTR-01.

Suplee, 2013
Suplee, Michael W. 2013. Technical Memorandum: Benchmark for nitrate + nitrite in assessing ambient surface water. Reference #**14346**

Suplee and Watson, 2013
Suplee, Michael W. and Vicki Watson. 2013. Scientific and Technical Basis of the Numeric Nutrient Criteria for Montana's Wadeable Streams and Rivers—Update 1. Helena, MT: Montana Department of Environmental Quality.

U.S. Environmental Protection Agency, 1999
U.S. Environmental Protection Agency. 1999. Protocol for Developing Nutrient TMDLs. Washington, D.C.: Office of Water, U.S. Environmental Protection Agency. EPA 841-B-99-007.

U.S. Environmental Protection Agency, 2002
US EPA. 2002**.** Memorandum: Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs.
REFMAN 17973

U.S. Environmental Protection Agency, 2010
U.S. Environmental Protection Agency. 2010. Using Stressor-Response Relationships to Derive Numeric Nutrient Criteria. Washington, DC: Office of Science and Technology, Office of Water, EPA. EPA-820-S-10-001.

U.S. Environmental Protection Agency website
Title: National Nutrient Strategy

Author: Environmental Protection Agency (EPA)
Date Last Accessed: April 17, 2014
Web Address: http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/strategy/

(World Health Organization, 2003
World Health Organization. 2003. Guidelines for Safe Recreational Water Environments, Volume 1: Coastal and Fresh Waters. Geneva, Switzerland: World Health Organization. http://www.who.int/water_sanitation_health/bathing/srwe1/en/.

APPENDIX A

Table A-1: Status of Waterbody Impairments in the Central Clark Fork Tributaries TPA based on the 2014 Integrated Report

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impairment Cause Status [1, 2]
Dry Creek, headwaters to mouth (Clark Fork River)	MT76M002_170	Alteration in stream-side or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by a TN TMDL in this document
		Nitrogen (Total)	Nutrients	TN TMDL contained in this document
		Low flow alterations	Not Applicable; Non-Pollutant	Partially addressed in Section 9 of this document
Hall Gulch, headwaters to mouth (Flat Creek)	MT76M002_200	Antimony	Metals	Antimony TMDL completed in a previous document (2013)
		Arsenic	Metals	Arsenic TMDL completed in a previous document (2013)
		Iron	Metals	Iron TMDL completed in a previous document (2013)
		Lead	Metals	Lead TMDL completed in a previous document (2013)
		Zinc	Metals	Zinc TMDL completed in a previous document (2013)
Flat Creek, headwaters to mouth (Clark Fork River)	MT76M002_180	Antimony	Metals	Antimony TMDL completed in a previous document (2013)
		Arsenic	Metals	Arsenic TMDL completed in a previous document (2013)
		Cadmium	Metals	Cadmium TMDL completed in a previous document (2013)
		Lead	Metals	Lead TMDL completed in a previous document (2013)
		Mercury	Metals	Mercury TMDL completed in a previous document (2013)
		Physical substrate habitat alterations	Not Applicable; Non-Pollutant	Addressed by a sediment TMDL in this document
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document

		Zinc	Metals	Zinc TMDL completed in a previous document (2013)
Trout Creek, headwaters to mouth (Clark Fork River)	MT76M002_050	Alteration in stream-side or littoral vegetative covers	Not Applicable; Non-Pollutant	Partially addressed in Section 9 of this document
		Physical substrate habitat alterations	Not Applicable; Non-Pollutant	Partially addressed in Section 9 of this document
		Turbidity	Sediment	Turbidity TMDL contained in this document
Nemote Creek, headwaters to mouth (Clark Fork River)	MT76M002_160	Chlorophyll-*a*	Not Applicable; Non-Pollutant	Addressed by TN & TP TMDLs contained in this document
		Low Flow Alterations	Not Applicable; Non-Pollutant	Partially addressed in Section 9 of this document
		Nitrogen (Total)	Nutrients	TN TMDL contained in this document
		Phosphorus (Total)	Nutrients	TP TMDL contained in this document
		Temperature, water	Temperature	Temperature TMDL contained in this document
West Fork Petty Creek, headwaters to mouth (Petty Creek)	MT76M002_100	Chlorophyll-*a*	Not Applicable; Non-Pollutant	Addressed by a TP TMDL contained in this document
		Phosphorus (Total)	Nutrients	TP TMDL contained in this document
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document
Petty Creek, headwaters to mouth (Clark Fork River)	MT76M002_090	Alteration in stream-side or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by a sediment TMDL in this document
		Low flow alterations	Not Applicable; Non-Pollutant	Partially addressed in Section 9 of this document
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document
		Temperature, water	Temperature	Temperature TMDL contained in this document
Stony Creek, headwaters to mouth (Ninemile Creek)	MT76M004_020	Phosphorus (Total)	Nutrients	TP TMDL contained in this document
		Sedimentation/Siltation	Sediment	Sediment TMDL contained a previous document
Grant Creek, headwaters to mouth (Clark Fork River)	MT76M002_130	Alteration in stream-side or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by a sediment TMDL in this document

		Excess Algal Growth	Not Applicable; Non-Pollutant	Addressed by a TN TMDL in this document
		Low flow alterations	Not Applicable; Non-Pollutant	Partially addressed in Section 9 of this document
		Nitrate/Nitrite (Nitrite + Nitrate as N)	Nutrients	Addressed by a TN TMDL in this document
		Nitrogen (Total)	Nutrients	TN TMDL contained in this document
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document
		Temperature, water	Temperature	Temperature TMDL contained in this document
Wallace Creek, headwaters to mouth (Clark Fork River)	MT76E004_010	Copper	Metals	Copper TMDL completed in a previous document (2013)
Cramer Creek, headwaters to mouth (Clark Fork River)	MT76E004_020	Aluminum	Metals	Aluminum TMDL completed in a previous document (2013)
		Lead	Metals	Lead TMDL completed in a previous document (2013)
		Cause Unknown	Not Applicable; Non-Pollutant	*Addressed by a sediment TMDL in this document
		Physical substrate habitat alterations	Not Applicable; Non-Pollutant	Addressed by a sediment TMDL in this document
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document
Tenmile Creek, headwaters to mouth (Bear Creek)	MT76E004_030	Alteration in stream-side or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by a sediment TMDL in this document
		Phosphorus (Total)	Nutrients	TP TMDL contained in this document
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document
Deep Creek, headwaters to mouth (Bear Creek)	MT76E004_070	Chlorophyll-*a*	Not Applicable; Non-Pollutant	Addressed by a NO_2+NO_3 TMDL contained in this document
		Low Flow Alterations	Not Applicable; Non-Pollutant	Partially addressed in Section 9 of this document
		Nitrate/Nitrite (Nitrite + Nitrate as N)	Nutrients	NO_2+NO_3 TMDL contained in this document

		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document
Mulkey Creek, headwaters to mouth (Clark Fork River)	MT76E004_050	Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document
Rattler Gulch, headwaters to mouth (Clark Fork River)	MT76E004_060	Alteration in stream-side or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by a sediment TMDL in this document
		Chlorophyll-*a*	Not Applicable; Non-Pollutant	Addressed by a TP TMDL contained in this document
		Low Flow Alterations	Not Applicable; Non-Pollutant	Partially addressed in Section 9 of this document
		Phosphorus (Total)	Nutrients	TP TMDL contained in this document
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document

[1] TN = Total Nitrogen, TP = Total Phosphorus, NO_2 + NO_3 = Nitrite + Nitrate
[2] Metals TMDLs were previously completed in this project area and can be found in the 2013 "Bonita-Superior Metals TMDLs." Sediment TMDLs were previously completed in this project area and can be found in the 2005 "Water Quality Restoration Plan and Total Maximum Daily Loads for the Ninemile Planning Area".