Thompson Project Area Metals, Nutrients, Sediment, and Temperature TMDLs and Water Quality Improvement Plan

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ACRONYM LIST

Acronym	Definition
AFDM	Ash Free Dry Mass
AMB	Abandoned Mine Bureau
AML	Abandoned Mine Lands
ARM	Administrative Rules of Montana
BEHI	Bank Erosion Hazard Index
BFW	Bankfull Width
BLM	Bureau of Land Management (Federal)
BMPS	Best Management Practices
CECRA	[Montana] Comprehensive Environmental Cleanup and Responsibility Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CWA	Clean Water Act
DEQ	Department of Environmental Quality (Montana)
DNRC	Department of Natural Resources & Conservation (Montana)
DOI	Department of the Interior (federal)
DQO	Data Quality Objectives
EA	Environmental Assessment
EPA	Environmental Protection Agency (U.S.)
EQIP	Environmental Quality Incentives Program
FWP	Fish, Wildlife & Parks (Montana)
GIS	Geographic Information System
HBI	Hilsenhoff Biotic Index
HCP	Habitat Conservation Plans
HDPE	high-density polyethylene
HUC	Hydrologic Unit Code
INFISH	Inland Native Fish Strategy
IR	Integrated Report
LA	Load Allocation
LWD	Large Woody Debris
MARS	Montana Aquatic Resources Services, Inc.
MBMG	Montana Bureau of Mines and Geology
MCA	Montana Code Annotated
MFISH	Montana Fisheries Information System
MOS	Margin of Safety
MPDES	Montana Pollutant Discharge Elimination System
NCAWOS	National Climate Automated Weather Observation Station
NFHCP	Native Fish Habitat Conservation Plan
NLCD	National Land Cover Dataset
NPS	Nonpoint Source
NRCS	Natural Resources Conservation Service
NWIS	National Water Information System
PAS	Pan American Silver
PIBO	PACFISH/INFISH Biological Opinion
QAPP	Quality Assurance Project Plan

Acronym	Definition
RAWS	Remote Automatic Weather Stations
RIT/RDG	Resource Indemnity Trust / Reclamation and Development Grants Program
SAP	Sampling and Analysis Plan
SMCRA	Surface Mining Control & Reclamation Act
SMZ	Streamside Management Zone
STORET	EPA STOrage and RETrieval database
SWPPP	Storm Water Pollution Prevention Plan
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TPA	TMDL Planning Area
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFWS	US Fish and Wildlife Service
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation
UUILT	Ultimate Upper Incipient Lethal Temperature
VCRA	Voluntary Cleanup and Redevelopment Act
WEPP	Water Erosion Prediction Project
WFW	West Flathead Well
WLA	Wasteload Allocation
WRP	Watershed Restoration Plan

DOCUMENT SUMMARY

This document presents a total maximum daily load (TMDL) and framework water quality improvement plan for nine impaired streams in the Thompson Project Area, including Henry Creek, Lazier Creek, Little Bitterroot River, Little Thompson River, Lynch Creek, McGinnis Creek, McGregor Creek, Sullivan Creek, and Swamp Creek (see **Figures A-1 and A-2** found in **Appendix A**).

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

The Thompson Project Area is made up of a combination of impaired tributary watersheds within multiple TMDL Planning Areas (TPAs) including the entire Thompson TPA and portions of the Lower Flathead and Middle Clark Fork Tributaries TPAs. The area does not include any of the streams within the Flathead reservation because the state of Montana does not have jurisdiction over TMDL development within the reservation boundary.

The majority of the Thompson Project Area is located within Sanders County, with a portion in the north extending into Lincoln and Flathead Counties. The largest population centers are the towns of Plains, Paradise and Marion. Thompson Falls is located less than five miles to the west. The project area is bounded to north by the Fisher River drainage, to the south by the Coeur d'Alene Mountains and to the east by the Flathead Reservation due to jurisdictional boundaries. Some water drains to the lower Flathead River through the reservation but most of the streams within the project area drain to the Clark Fork River either directly or through the Thompson River. The project area encompasses approximately 1,185 square miles with federal, state, and private land ownership.

DEQ determined that nine waterbodies do not meet the applicable water quality standards. The scope of the TMDLs in this document addresses problems with metals, nutrients, sediment, and temperature (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 all nine of the waterbodies identified in this document, which includes: Sullivan, Henry, Lynch, Swamp, Lazier, McGinnis, and McGregor creeks as well as the Little Bitterroot and Little Thompson rivers. 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 water 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 one permitted point source. To meet the

TMDLs, permit conditions must be followed for the point source and nonpoint sources must implement all reasonable land, soil, and water conservation practices. The Thompson Area sediment TMDLs indicate that reductions in sediment loads ranging from 28% - 47% 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 six of the waterbodies identified in this document. Total nitrogen (TN) and total phosphorous (TP) are causing impairment on Lynch, Swamp, and Sullivan Creeks as well as the Little Bitteroot and Little Thompson Rivers. TMDLs will be written for each of these waterbody pollutant combinations. Swamp Creek, Lazier Creek, and the Little Bitteroot River are also impaired by nitrate/nitrite (nitrate); this impairment cause will be addressed by the TN TMDLs for these waterbodies.

Timber harvest and livestock grazing are potential sources of nutrients impairment to all listed segments. Development and septic systems are potential sources for the Little Bitterroot River, Lynch Creek, and Swamp Creek. BMPs for timber harvest, grazing, development, and septic systems 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**.

TMDL examples based on monitoring data show that measured TN loads require reductions of up to 79% to meet the TMDL and measured TP loads require reductions of up to 70%. There were situations where data for TN and/or TP indicated that values were below targets, but the impairment determinations were retained because of exceedances of biometric indicators (macroinvertebrates and diatoms), the uncertainty in nutrient limitation and uptake within the streams, and previous impairment determinations. As a result, data for some waterbody segments with a nutrient TMDL indicate that targets are being attained.

Metals

Metals were identified as impairing aquatic life and drinking water on Sullivan Creek. The metals of concern are aluminum, cadmium, copper, and zinc; TMDLs will be written for each of these pollutants. Water quality restoration goals for metals are established based on numeric water quality criteria defined in Montana's Numeric Water Quality Standards. DEQ believes that once these water quality goals are met, all water uses currently affected by metals will be restored.

Metals loads are quantified for natural background conditions, abandoned mines, and diffuse sources (e.g., land management practices that increase erosion of mineralized soils). The metals TMDLs require reductions in metals loads ranging from 59% to 99%, which mostly rely on reclamation of inactive and abandoned mines. State and federal programs, as well as potential funding resources, to address metals sources are summarized in this plan.

Temperature

Temperature was identified as impairing aquatic life on Lynch Creek and McGregor Creek; TMDLs will be written for each. 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 instream 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.

Lynch Creek and McGregor Creek exceed naturally occurring maximum daily water temperatures ranging from 0.1°F to 13.45°F, with average exceedances of 2.58°F on Lynch Creek and 4.92°F on McGregor Creek. The example TMDLs for Lynch and McGregor Creeks, provided in Table 7-5 show necessary percent reduction of 27% and 19%, 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.

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 U.S. Environmental Protection Agency (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 Thompson Project Area with Completed Sediment, Nutrients, Metals, and Temperature TMDLs Contained in this Document

Waterbody & Location Description	TMDL Prepared	TMDL Pollutant Category	Impaired Use(s)*
HENRY CREEK, headwaters to mouth (Clark Fork River)	Sediment	Sediment	Aquatic Life
LAZIER CREEK, headwaters to mouth (Thompson River)	Sediment	Sediment	Aquatic Life
	Total Nitrogen	Nutrients	Aquatic Life, Primary Contact Recreation
	Total Phosphorus	Nutrients	Aquatic Life, Primary Contact Recreation
LITTLE BITTERROOT RIVER, Hubbart Reservoir to Flathead Reservation Boundary	Sediment	Sediment	Aquatic Life
	Total Nitrogen	Nutrients	Aquatic Life, Primary Contact Recreation
	Total Phosphorus	Nutrients	Aquatic Life, Primary Contact Recreation

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

Waterbody & Location Description	TMDL Prepared	TMDL Pollutant Category	Impaired Use(s)*
LITTLE THOMPSON RIVER, headwaters to mouth (Thompson River)	Sediment	Sediment	Aquatic Life
	Total Nitrogen	Nutrients	Aquatic Life, Primary Contact Recreation
	Total Phosphorus	Nutrients	Aquatic Life, Primary Contact Recreation
LYNCH CREEK, headwaters to mouth (Clark Fork River)	Sediment	Sediment	Aquatic Life
	Temperature	Temperature	Aquatic Life
	Total Nitrogen	Nutrients	Aquatic Life, Primary Contact Recreation
	Total Phosphorus	Nutrients	Aquatic Life, Primary Contact Recreation
McGINNIS CREEK, headwaters to mouth (Little Thompson River)	Sediment	Sediment	Aquatic Life
McGREGOR CREEK, McGregor Lake to mouth (Thompson River)	Sediment	Sediment	Aquatic Life
	Temperature	Temperature	Aquatic Life
SULLIVAN CREEK, headwaters to Flathead Reservation	Aluminum	Metals	Aquatic Life
	Cadmium	Metals	Aquatic Life, Drinking Water
	Copper	Metals	Aquatic Life
	Sediment	Sediment	Aquatic Life
	Total Nitrogen	Nutrients	Aquatic Life, Primary Contact Recreation
	Total Phosphorus	Nutrients	Aquatic Life, Primary Contact Recreation
	Zinc	Metals	Aquatic Life, Drinking Water
SWAMP CREEK, West Fork Swamp Creek to mouth (Clark Fork River)	Sediment	Sediment	Aquatic Life
	Total Nitrogen	Nutrients	Aquatic Life, Primary Contact Recreation
	Total Phosphorus	Nutrients	Aquatic Life, Primary Contact Recreation

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

1.0 PROJECT OVERVIEW

This document presents an analysis of water quality information and establishes total maximum daily loads (TMDLs) for metals, nutrients, sediment, and temperature problems in the Thompson Project Area. This document also presents a general framework for resolving these problems. **Figure A-2**, found in **Appendix A** shows a map of waterbodies in the Thompson Project Area with metals, nutrients, sediment, and temperature pollutant listings. This project addresses streams from the Thompson TMDL planning area as well as streams in the Lower Flathead and Middle Clark Fork Tributaries TMDL planning areas, as is thus called the Thompson Project Area.

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 Thompson Project Area from Montana's 2012 303(d) List, and includes non-pollutant impairment causes included in Montana's "2012 Water Quality Integrated Report" (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012a). **Table A-1** provides the current status of each impairment cause, identifying whether it has been addressed by TMDL development.

Both Montana state law ((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 "2012 Water Quality Integrated Report" (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012a) that are addressed in this document (also see **Table A-1** in **Appendix A**). Each pollutant impairment falls within a TMDL pollutant category (e.g., metals, nutrients, sediment, or temperature), and this document is organized by those categories.

New data assessed during this project identified new nutrient and metals impairment causes for two waterbodies. These impairment causes are identified in **Table 1-1** and noted as not being on the 2012 303(d) List (within the integrated report). Instead, these waters will be documented within DEQ assessment files and incorporated into the 2014 IR. Total Nitrogen (TN) was not listed as an impairment to Sullivan Creek in the 2012 IR and although there was a very high exceedance value in recent testing, there was insufficient data gathered to warrant a listing on the 2014 IR. However, a TMDL has been developed in this document for TN to address the high exceedance value. Because the DEQ has not formally identified TN as a cause of impairment for Sullivan Creek, the TN TMDL is considered a "protective TMDL". Further information on the reasoning behind developing protective TMDLs is in Section 4.3.

TMDLs are completed for each waterbody – pollutant combination, and this document contains 25 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.

This document only addresses those identified in **Table 1-1**. **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 Thompson Area Addressed within this Document

Waterbody & Location Description [1]	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status [2]	Included in 2012 Integrated Report [3]
HENRY CREEK, headwaters to mouth (Clark Fork River)	MT76N003_170	Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
		Low flow alterations	Not Applicable; Non-Pollutant	Addressed within document (**Section 9**); not linked to a TMDL	Yes
		Sedimentation / Siltation	Sediment	Sediment TMDL completed	Yes
LAZIER CREEK, headwaters to mouth (Thompson River)	MT76N005_060	Nitrate/Nitrite (Nitrite + Nitrate as N)	Nutrients	Addressed by TN TMDL	Yes
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
		Nitrogen (Total)	Nutrients	TN TMDL completed	Yes
		Phosphorus (Total)	Nutrients	TP TMDL completed	Yes
		Sedimentation / Siltation	Sediment	Sediment TMDL completed	Yes
LITTLE BITTERROOT RIVER, Hubbart Reservoir to Flathead Reservation Boundary	MT76L002_060	Chlorophyll-*a*	Not Applicable; Non-Pollutant	Addressed by TN and TP TMDL	Yes
		Nitrate/Nitrite (Nitrite + Nitrate as N)	Nutrients	Addressed by TN TMDL	Yes
		Nitrogen (Total)	Nutrients	TN TMDL completed	Yes
		Other flow regime alterations	Not Applicable; Non-Pollutant	Addressed within document (**Section 9**); not linked to a TMDL	Yes
		Phosphorus (Total)	Nutrients	TP TMDL completed	Yes
		Sedimentation / Siltation	Sediment	Sediment TMDL completed	Yes
LITTLE THOMPSON RIVER, headwaters to mouth (Thompson River**)**	MT76N005_040	Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
		Nitrogen (Total)	Nutrients	TN TMDL completed	No
		Phosphorus (Total)	Nutrients	TP TMDL completed	Yes
		Sedimentation / Siltation	Sediment	Sediment TMDL completed	Yes
LYNCH CREEK, headwaters to mouth (Clark Fork River)	MT76N003_010	Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
		Low flow alterations	Not Applicable; Non-Pollutant	Addressed within document (**Section 9**); not linked to a TMDL	Yes
		Nitrogen (Total)	Nutrients	TN TMDL completed	Yes
		Phosphorus (Total)	Nutrients	TP TMDL completed	Yes
		Sedimentation / Siltation	Sediment	Sediment TMDL completed	Yes
		Temperature, water	Temperature	Temperature TMDL completed	Yes

Table 1-1. Water Quality Impairment Causes for the Thompson Area Addressed within this Document

Waterbody & Location Description [1]	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status [2]	Included in 2012 Integrated Report [3]
McGINNIS CREEK, headwaters to mouth (Little Thompson River)	MT76N005_070	Fish-Passage Barrier	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
		Phosphorus (Total)	Nutrients	Not impaired based on updated assessment	Yes
		Sedimentation / Siltation	Sediment	Sediment TMDL completed	Yes
McGREGOR CREEK, McGregor Lake to mouth (Thompson River)	MT76N005_030	Other flow regime alterations	Not Applicable; Non-Pollutant	Addressed within document (**Section 9**); not linked to a TMDL	Yes
		Phosphorus (Total)	Nutrients	Not impaired based on updated assessment	Yes
		Sedimentation / Siltation	Sediment	Sediment TMDL completed	Yes
		Temperature, water	Temperature	Temperature TMDL completed	Yes
SULLIVAN CREEK, headwaters to Flathead Reservation	MT76L002_070	Alteration in stream-side or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
		Aluminum	Metals	Aluminum TMDL completed	Yes
		Cadmium	Metals	Cadmium TMDL completed	Yes
		Copper	Metals	Copper TMDL completed	No
		Escherichia coli	Pathogens	Not impaired based on updated assessment	Yes
		Nitrogen (Total)	Nutrients	TN TMDL completed	No
		Phosphorus (Total)	Nutrients	TP TMDL completed	Yes
		pH	Metals	Addressed by Copper TMDL	Yes
		Sedimentation / Siltation	Sediment	Sediment TMDL completed	Yes
		Zinc	Metals	Zinc TMDL completed	Yes
SWAMP CREEK, West Fork Swamp Creek to mouth (Clark Fork River)	MT76N003_160	Alteration in stream-side or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
		Nitrate/Nitrite (Nitrite + Nitrate as N)	Nutrients	Addressed by TN TMDL	Yes
		Nitrogen (Total)	Nutrients	TN TMDL completed	Yes
		Phosphorus (Total)	Nutrients	TP TMDL completed	Yes
		Sedimentation / Siltation	Sediment	Sediment TMDL completed	Yes

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

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 metals, nutrients, sediment, and temperature. 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 Thompson 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 Thompson 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, Nutrients, Metals, and Temperature 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 Other Identified Issues or Concerns:
Describes other problems that could potentially be contributing to water quality impairment and how the TMDLs in the plan might address some of these concerns. This section also provides recommendations for combating these problems.

Section 10.0 Water Quality Improvement Plan:
Discusses water quality restoration objectives and a strategy to meet the identified objectives and TMDLs.

Section 11.0 Monitoring Strategy and Adaptive Management:
Describes a water quality monitoring plan for evaluating the long-term effectiveness of the Thompson Project Area Metals, Nutrients, Sediment, and Temperature 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 THOMPSON PROJECT AREA DESCRIPTION

This section includes a summary of the physical, ecological and cultural profile of the Thompson Project Area and is intended to provide background information to support total maximum daily load (TMDL) development. The maps referenced in this discussion are contained in **Appendix A, Table of Waterbody Impairments and Project Area Description Maps**.

2.1 PHYSICAL CHARACTERISTICS

The following information describes the physical profile of the Thompson TMDL Project Area and includes a discussion of location, topography, geology, soils, surface water, groundwater and climate.

2.1.1 Location

The project area encompasses approximately 1,185 square miles in northwestern Montana as shown in **Figure A-1**. Most of the project area resides in Sanders County however a portion in the north extends into Lincoln and Flathead Counties. The largest population centers are the towns of Plains, Paradise and Marion. Thompson Falls is located less than five miles to the west. The project area is bounded to north by the Fisher River drainage, to the south by the Coeur d'Alene Mountains and to the east by the Flathead Reservation. Due to jurisdictional boundaries created by the reservation, two larger hydrologic basins are combined into one uniquely shaped TMDL project area. Some water drains to the lower Flathead River through the reservation but most of the streams within the project area drain to the Clark Fork River either directly or through the Thompson River. The Montana Department of Environmental Quality (DEQ) divides the state into TMDL Planning Areas (TPAs) for workload purposes based on topographic drainage boundaries. In some instances, when TMDLs are developed these planning areas are realigned into project areas. In this case, portions of the Middle Clark Fork Tributaries TPA and Lower Flathead TPAs were added to the Thompson TPA to create the Thompson Project Area (see **Figure A-2**). Because the project area contains the entire Thompson River watershed, it was named the Thompson Project Area. It is important to note that the Clark Fork River is not a part of this TMDL project, therefore **Section 2.0** does not include a profile of the river.

2.1.2 Topography

Elevations in the Thompson Project Area range from approximately 2,400 feet above sea level where the Clark Fork River flows out of the project area, to approximately 7,460 feet atop the summit of Baldy Mountain in the Cabinet Range. Valley bottom elevations average around 3,000 feet. The landscape is dominated by mountain ranges intercepted by the Thompson River Valley and the even larger, Clark Fork River Valley. Elevation is mapped on **Figure A-3**. Like topography, slopes in the project area vary greatly. The flat valley bottoms register 0° slopes but slopes as steep as 77° are also present, prominently seen in the cliffs near the mouth of the Thompson River in an area known as the Eddy Narrows. **Figure A-4** shows slopes in the project area calculated from the 30-meter National Elevation Dataset.

2.1.3 Geology

Figure A-5 and **Figure A-6** provide an overview of the generalized geology based on a 1:500,000 scale geologic map of Montana (Raines and Johnson, 1996). The first map displays standard geologic units and the second map indicates the dominant rock type found in each unit.

Bedrock

Rocks belonging to the Belt Supergroup are the oldest and most widespread bedrock in the Thompson Project Area. These sedimentary rocks formed during the Precambrian Eon (~1,500 to 800 million years ago) while the current landmass was under a massive shallow sea and had a tropical climate. While this bedrock experienced uplift during the creation of the Rocky Mountains, it is relatively unchanged since its formation and mudcracks, ripple marks and other aquatic features are still clearly visible in some locations. The Belt rocks underlying the project area can be divided into three general series in order of age: the Prichard Formation, the Ravalli Group and the Wallace Formation. The oldest of these, the Prichard Formation, is characterized as dark-gray, generally argillaceous rock with localized sand, quartz and schist. The Ravalli Group formed on top of the Prichard Formation and is composed of clastic rocks typically deposited in shallow water systems that developed into siltstone, limestone and agrillite. Next in succession is the Wallace Formation, which is a heterogeneous unit containing dark colored argillite, limestone, dolomite and quartzite. Small units of intrusive igneous rock containing diabase, metagabbro and diorite also formed during the Precambrian Eon in the area surrounding Henry Creek. Later in the Cenozoic Era (~65 - million years ago), the Belt Supergroup was punctuate by igneous extrusions in a portion of the project area near Sullivan Creek. These extrusions are associated with latite, andesite and basalt, and were formed as lava cooled on the earth's surface. Ore deposits found in Ravalli Group limestone in contact with this volcanic formation were mined for precious metals discussed further in **Section 2.3.5** (Montana Department of Environmental Quality, 2009).

Glaciation

The Thompson Project Area also has geologic features derived from glaciers modifying these Precambrian Belt rocks. The Cordilleran ice sheet extended into the northern portion of the project area around 15,000 to 20,000 years ago, as evidenced by the moraine left just south of Marion. A separate glacial phenomenon was witnessed along the Clark Fork River Valley around the same time period. When the Purcell Trench Lobe of the ice sheet extended into the Idaho Panhandle as far south as present day Lake Pend Oreille, it created a massive ice dam that backed up over 500 cubic miles of water that was more than 2,000 feet deep in places (Ice Age Floods Institute, 2013). This massive body of water, named Glacial Lake Missoula, extended from Idaho down the Clark Fork River Valley submerging Missoula, MT and the Flathead and Bitterroot Valleys to the north and south. The Clark Fork River Valley within the Thompson Project Area was flooded as part of this lake. Eventually the ice dam failed rapidly sending forth a flood of epic proportions. Within a matter of days, more water than all the world's current rivers combined surged through the Clark Fork Valley on its way to the Pacific Ocean, leaving evidence of the extreme event along the way (Lomax, 2010). A gigantic whirlpool just east of the project area along Montana Route 28 dug a 1.5 mile long hole eventually forming Rainbow Lake, unique for having no inlet or outlet. The material excavated by the whirlpool was deposited in the Thompson Project Area. Within the project area the constricted valley known as the Eddy Narrows were shaped as the flood water sheered topsoil and rock to form the vertical cliffs observable today (Lomax, 2010). This process of an ice dam in the Clark Fork Valley forming and eventually failing causing massive floods is thought to have occurred multiple times. Quaternary glacial and alluvial deposits are the most recently created geologic units in the project area.

2.1.4 Soil

The U.S. General Soil Map developed by the National Cooperative Soil Survey and based on the STATSGO2 dataset was used to evaluate soil properties in the Thompson Project Area. **Figure A-7** depicts coverage of the four soil orders that exist within the project area. Soil orders are the broadest level of soil taxonomy and combine soils into units with similar physical and chemical attributes. Soils of the same order typically share properties because they formed under similar scenarios. Investigating the distribution of soil orders in the project area can help better understand soil behavior and potential effects to water quality.

Inceptisols are the most common soil order accounting for 70% of the project area. Inceptisols are the second least developed of the 12 soil orders and have only a slight degree of weathering either because they are considered geologically young or because the conditions under which they exist have only led to a slight modification from their original state. While glaciation has impacted a small portion of the project area, the semi-arid and cold climate of the Thompson Project Area is likely the major driver for the immature soil profiles seen in the Inceptisol class. Alfisols are the second most widespread soil order (15%) and are known for being more weathered than Inceptisols. These soils are moderately leached and characterized by a subsurface silicate clay horizon. Alfisols can be susceptible to erosion, especially if the soil is high in sand content and the natural litter layer is disturbed (Brady and Weil, 2002). Mollisols account for six percent of the project area and the principal grouping of this soil order surrounds the Clark Fork River Valley. Mollisols are defined by a humus-rich surface horizon and are some of the most agriculturally productive soils in the world. These soils typically develop under grasslands and the subcategory present in the Thompson Project Area is distinguished from other Mollisols because it forms in climates that have dry summers and wet winters. The remaining soils either lack data and are not mapped or fall into the Andisol order. No streams with TMDLs established in this document contain Andisol soils in their watersheds, however Andisols have a high water-holding capacity, are moderately weathered and are distinguished by an accumulation of silicate clay (Brady and Weil, 2002).

A soil's susceptibility to erosion is a property especially relevant to TMDLs when reviewing upland pollutant sources. Erodibility is mapped in **Figure A-8** using the K-factor from the Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978). The K-factor is an inherent property of soil that is independent of rainfall, slope, vegetation cover, and management differences. Values range from 0 to 1, with a greater value corresponding to greater potential for erosion. Soil erodibility is assigned to the following ranges: low (0.0-0.2), moderate-low (0.21-0.30) and moderate-high (0.31-0.40). Values greater than 0.4 are considered highly susceptible to erosion. The majority of the project area has soils identified as having a low susceptibility to erosion (46%). Moderate-low susceptibility soils (26%) and moderate-high susceptibility soils (22%) have near equal representation across the project area. Lastly, only 0.4% of the soils are considered highly susceptible to erosion, although that includes a portion of the Little Bitterroot watershed. Areas with these extreme K-factors are Alfisols, which supports the general properties described previously for that soil order. The remaining area is either open water or lacks data to determine K-factors.

2.1.5 Surface Water

This project combines a portion of Lower Clark Fork watershed (HUC 17010213) with a portion of the Lower Flathead watershed (HUC 17010212). Most rain falling in the northern half to the project area is transported to the Clark Fork River via the Thompson River. There are also numerous smaller tributaries feeding directly into the Clark Fork River. The watershed outlet for these sources is where the Clark Fork River flows out of the project area in a northwesterly direction. A smaller portion of the project area in the east flows through the Flathead Reservation to the Flathead River. This water is eventually transported through the project area because the Flathead River empties into the Clark Fork River just south of Paradise, MT. The entire project area is part of the much larger Columbia River basin which eventually discharges into the Pacific Ocean. No stream pertinent to this document has received protections granted by the National Wild and Scenic River Act. **Figure A-9** displays impaired waterbodies in the project area according updated assessments to the 2012 303(d) List undertaken as part of this TMDL process. Pending U.S. Environmental Protection Agency (EPA) approval of the next Integrated Report, these impairment designations are representative of the 2014 303(d) List.

The United States Geological Survey (USGS) has established numerous monitoring and gaging stations in the project area. **Figure A-9** indicates which sites are actively recording continuous data and which have been retired. Two active sites monitor the outflow from bodies of water important for irrigation planning (Hubbart Reservoir and Little Bitterroot Lake) but not directly applicable to this TMDL project. Another site monitors the Clark Fork River near Plains, MT. The monthly mean discharge from a fourth active gaging station, set at the mouth of the Thompson River (12389500), is listed in **Table 2-1**.

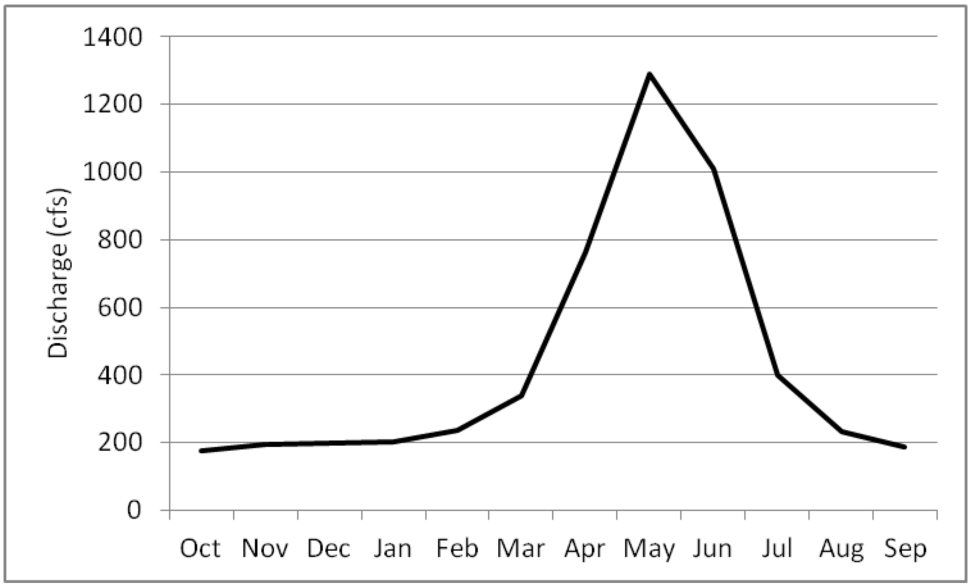


Figure 2-1. Monthly Average Hydrograph for the Thompson River (1956-2013)

Fifty-six years of recorded data at this site indicate flows most often peak during May and reach a minimum in October (**Figure 2-1**). Discharge is relatively constant from October through February, after which time a large increase in flows is observed until baseflow returns six months later. This pattern is typical of snowmelt - dominated stream systems in Montana and although streams subject to TMDLs in this document do not have a streamflow dataset as robust, they are expected to have a similarly timed hydrograph but of a smaller in magnitude. A few non-active USGS sites appear on **Figure A-9** to be located on streams of interest to this project however the data from these sites is significantly dated. The Little Thompson River (12389400) was sampled for water quality in the 1970s; a tributary to McGregor Creek (12389150) had peak streamflow recorded in the 1970s and a site on the Little Bitterroot River (12374000) was monitored in the early 1900s. Also recognize that the monitoring sites and datasets use to determine impairments and establish TMDLs are discussed in later sections of this document and are significantly more comprehensive than these ten USGS sites.

2.1.6 Groundwater

Figure A-10 depicts groundwater wells and distinguishes those with water quality data available online from the Montana Bureau of Mines and Geology (MBMG) Groundwater Information Center. As of July 2013 there are approximately 1,831 wells in the Thompson Project Area; 16 have associated water quality information. As one would expect, well distribution largely follows population density (see **Figure A-15**) with the highest concentrations surrounding Montana Route 200 and the towns of Plains and Marion. Whether delivered by an individual well or a public drinking water supply system, groundwater is the source of drinking water for all residences in the project area. MBMG's database of well drilling records indicate that the average distance water is found below land surface when a well is not pumping is 52 feet; the median is 27 feet. These results, and the location of most groundwater wells, indicate that shallow alluvial aquifers adjacent to surface waters are the most commonly utilized groundwater resource. These aquifers undoubtedly interact with surface waters and contribute a significant amount of streamflow to small creeks during the summer baseflow time period.

2.1.7 Climate

The Thompson Project Area's climate is characterized by cool winters and relatively short, temperate summers. Across the project area, precipitation varies dramatically from 14 inches a year in the Clark Fork Valley near Swamp Creek, up to 92 inches a year in the Cabinet Mountains. Precipitation trends closely follow elevation: significant moisture falls in the mountains and the quantity gradually decreases with elevation. Average annual precipitation isolines for the time period 1981-2010 are mapped on **Figure A-11** using data provided by Oregon State University's PRISM Group (PRISM Climate Group, 2013).

At least five weather stations have collected climate data in the project area recently, and four are still collecting continuous information. These stations are plotted in **Figure A-11** and symbolized according to the monitoring network they belong to. Remote Automatic Weather Stations, or RAWS, is a multi-agency collaboration that focuses on recording conditions relevant to wildland fires. The National Weather Service administers the Hydrometerorological Automated Data System (HADS) which monitors weather and river data at select sites nationally. Additional climate data is available for the airport in Plains, MT at a National Climate Automated Weather Observation Station (NCAWOS). Finally, one Automatic Position Reporting System WX NET/Citizen Weather Observer Program or APRSWXNET/CWOP site is located within the project area near Marion, MT. The parameters collected at each site vary depending on the associated monitoring network, but all have temperature and precipitation data.

Monthly climate averages are presented in **Table 2-1** for a RAWs station run by the Montana Department of Natural Resources and Conservation on the north shore of the Little Bitterroot Lake. As shown by this data, temperatures in the project area tend to peak when precipitation is lowest in July and August and the coldest temperatures are observed in December, although freezing conditions have been recorded every month of the year. Precipitation totals are highest during the spring in May and June, and the climate is characterized by an extended winter season with a significant snowpack that melts and effects streamflow starting in April as noted in **Section 2.1.5**.

Table 2-1. Monthly climate summary for Boorman Weather Station (2002-2014)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg High Temp (°F)	33	36	44	50	60	68	81	79	69	53	39	30
Avg Low Temp (°F)	12	12	18	24	31	38	42	39	33	26	20	11
Avg Temp (°F)	22	24	31	38	47	54	63	60	51	38	30	21
Avg Precip (in)	1.06	0.86	1.85	1.55	2.09	2.93	0.87	0.91	2.22	1.32	1.28	1.29

2.2 Ecological Characteristics

The following information describes the ecological profile of the Thompson Project Area and includes a discussion of ecoregions, fires, aquatic life and terrestrial life.

2.2.1 Ecoregion

Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources (Woods et al., 2002). The classification incorporates a wide array of subjects including geology, physiography, vegetation, climate, soils, land use, wildlife and hydrology. There are multiple levels, each successive tier more detailed than the previous. Levels III and IV are most commonly used for these types of environmental analyses. Besides providing a basic description of the environment, ecoregions are additionally important to TMDL investigations because numeric nutrient criteria depend on the ecoregion a stream segment is located in.

The entire Thompson Project Area is associated with the Level III Northern Rockies ecoregion. Progressing directly into the more detailed Level IV classification, a majority of the project area is considered part of the Salish Mountains ecoregions, as shown in **Table 2-2**. This ecoregion is typified by forested mountains rarely exceeding 7,000 feet above sea level underlain by volcanic, Precambrian Belt rocks. The Salish Mountains ecoregion also contains some glacially derived till deposits. Logging and recreation are listed as the most common land uses. The second most prevalent Level IV ecoregion is Grave Creek Range-Nine Mile Divide. The southern quarter of the project area falling into this category has similar elevation ranges, precipitation and geology as the Salish Mountains but it is generally described as less rugged. Subalpine fir, Douglas-fir, grand fir and ponderosa pine are listed as the climax vegetation in the Grave Creek Range-Nine Mile Divide. In addition to logging and recreation, mining is indicated as a common land use in this ecoregion. The Clark Fork Valley and Mountains ecoregion and the High Northern Rockies ecoregion combine to make up roughly 10% of the project area but neither are within a TMDL stream's watershed therefore they not directly applicable to this project and not further discussed. Following similar logic, the Flathead Hills and Mountains ecoregion comprises less than half a percent of the total landscape but three TMDL streams (i.e., Sullivan Creek, Henry Creek and the Little Thompson River) have small portions of their channels that cross the unit so the ecoregion is detailed here. The Flathead Hills and Mountains ecoregion is similar to the two ecoregions previously discussed however it is more arid due to the fact that it is in the rain shadow of the Salish Mountains. This in turn results in sparser forests. **Figure A-12** maps the spatial extent of Level IV ecoregions.

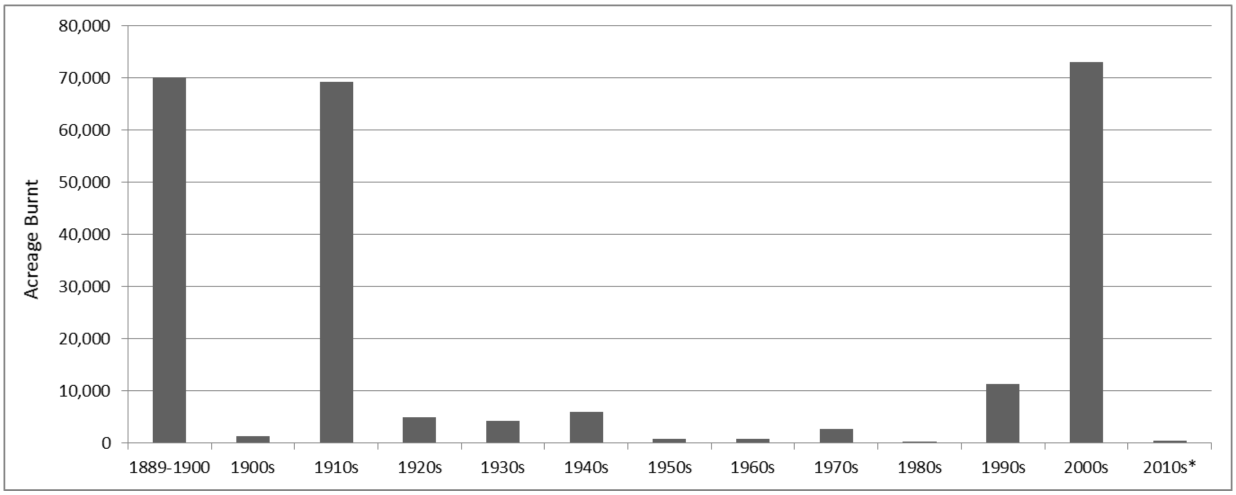
Table 2-2. Ecoregion distribution in the Thompson Project Area

Level III Ecoregion	Level IV Ecoregion	Acres	Square Miles	% Total
Northern Rockies	Salish Mountains	482,695	754	63.6%
Northern Rockies	Grave Creek Range-Nine Mile Divide	195,478	305	25.8%
Northern Rockies	Clark Fork Valley and Mountains	68,495	107	9.0%
Northern Rockies	High Northern Rockies	8,981	14	1.2%
Northern Rockies	Flathead Hills and Mountains	3,063	5	0.4%
Total		758,712	1,185	100%

2.2.2 Fire

The timing and extent of wildfires are important to understand for TMDL investigations because burnt landscapes behave differently from a water quality and pollutant loading perspective. The largest fire year on record is 1889 in which an estimated 66,600 acres or nearly 9% of the project area burnt. The 1910 fires, notorious for their destruction and prevalence across the Western United States, burnt over

42,000 acres. As portrayed in **Figure 2-2**, active fire suppression by land management organizations kept wildfire numbers and acreage artificially low from the 1910s through the 1980s. In 2007 the Chippy Fire ignited burning more than 64,400 acres including a large portion of the Little Thompson River drainage. A fire the size of that size had not seen in almost 120 years. The most recent fire, the Black Tail Ridge fire, occurred in 2012 and burnt 300 acres along Combest Creek. No fires occurred during the most recent 2013 fire season. **Figure A-13** depicts all known fire perimeters to have burnt in the project area since 1889.



*Incomplete decade (2010-2013)

Figure 2-2. Estimated acreage burnt in the Thompson Project Area per decade

2.2.3 Aquatic and Terrestrial Life

The State of Montana, specifically a committee of experts representing the Montana Natural Heritage Program and Montana Fish Wildlife and Parks, designates species of concern that are considered at risk because of declining population trends, threats to their habitats or restricted distribution. Within the Thompson Project Area three fish species are identified as such: bull trout, westslope cutthroat trout and pygmy whitefish.

Of these three, bull trout populations are the most threatened. The US Fish and Wildlife Service (USFWS) has listed bull trout as threatened under the federal Endangered Species Act since 1998 due to habitat loss and degradation, introduction of non-native fish, fragmentation from dams and other barriers, and historical overharvesting. In 2000 the Plum Creek Timber Company, the largest private landholder in the project area, finalized a 30-year agreement with the USFWS committing to specific conservation actions aimed at minimizing and mitigating impacts to bull trout from forest management activities on their land (Plum Creek Timber Co., 2000). An independent ten-year review indicated bull trout habitat has benefited from the partnership. Plum Creek's work to date has included culvert replacement, stream channel restoration and the implementation of best management practices. The Montana Department of Natural Resources and Conservation finalized a similar Native Fish Habitat Conservation Plan in 2010 (Montana Department of Natural Resources and Conservation, 2010) for activities on state trust land scattered across the project area.

Like the bull trout, westslope cutthroat trout are sensitive to excess fine sediment and require cold water to survive. In 1977 the Governor of Montana signed a law designating cutthroat trout Montana's state fish. The symbolic act has helped raise awareness of the species imperiled status. Habitat loss and degradation is a significant factor for population declines although westslope cutthroat trout are further threatened by their ability hybridize with introduced rainbow trout (Montana Natural Heritage Program and Montana Fish, Wildlife and Parks, 2013b). Finally, the pygmy whitefish is a small salmonid that lives in deep cold-water lakes and their tributaries. In the Thompson Project Area, pygmy whitefish are only known to exist in Little Bitterroot Lake and they provide a significant food source for larger predatory fishes (Montana Natural Heritage Program and Montana Fish, Wildlife and Parks, 2013a). Fish distributions are displayed in **Figure A-14** based on data provided by Montana Fish, Wildlife, and Parks (FWP) from 2010.

The Thompson Project Area also encompasses the range of several terrestrial species of concern. The US Fish and Wildlife Service (USFWS) has listed three species as threatened under the Endangered Species Act: grizzy bear, Canada Lynx and spalding's catchfly (U.S. Department of the Interior, Fish and Wildlife Service, 2012). Spalding's catchfly, a flowering perennial plant, is only known to exist in three locations in Montana and most observances have occurred at the Lost Trail National Wildlife Refuge located a mere two miles outside of the Thompson Project Area, northwest of Marion (Montana Natural Heritage Program, 2013). Two more species, the wolverine and whitebark pine, have been proposed as candidates for protections under the Endangered Species Act.

2.3 Cultural Characteristics

The following information describes the cultural profile of the Thompson Project Area and includes a discussion of population, transportation networks, land ownership, land cover/use, mining, and point sources.

2.3.1 Population

Overall, the Thompson Project Area is rural and sparsely populated, as shown in **Figure A-15**. The population is clustered around the towns of Plains and Marion and follows the major transportation routes as discussed in the next section. The largest town, Plains, had a population of 1,048 people in 2010, which amounted to a seven percent decrease from the 2000 census. Thompson Falls, population 1,324, is located less than five miles west of the project area and the larger population center of Kalispell, population 19,962, is 15 miles northeast. For a coarse estimate of the total Thompson Project Area population, the 2010 census block densities were multiplied by their area which resulted in a total approximation of 4,700 people. The demographics of Plains closely follow that of the greater Sanders County vicinity: the median age is in the late-40s, over 91% of the population identifies as white, nearly 90% hold a high school degree, the median annual income is slightly above $30,000, and 21.2% of the population lives below the poverty line. The largest employer in the region is the education/health/social services industry accounting for 20% of the workforce followed by the agriculture/forestry/mining industry at 13%. Nearly 63% work for a private entity while 18% are employed in the public sector.

Septic systems have the ability to affect the quality of nearby surface water if not properly functioning or maintained. When nitrogen in household wastewater is exposed to oxygen in soil, nitrate, a more mobile form of nitrogen, is produced which can migrate to surface waters thereby damaging aquatic life resources or nitrate can pose human health risks if drinking water wells are pulling from contaminated groundwater. As **Figure A-16** shows, septic system distribution in the project area closely matches the population density map. Septic systems are most common in the Marion area surrounding the Little Bitterroot and McGregor Lakes, along the Montana Route 200 corridor, and extending up the Lynch Creek Valley from Plains. Residents and businesses within the city limits of Plains are serviced by a sewer system that treats wastewater through lagoons before discharging into the Clark Fork River. The city has a discharge permit through DEQ to carry out this activity (MT0030465).

2.3.2 Transportation Networks

Two major transportation routes bisect the project area from east to west as shown in **Figure A-15**. Montana Route 200 follows the Clark Fork River Valley in the southern portion of the project area and runs through the towns of Paradise, Plains, Weeksville and Eddy. One can travel this route west and arrive in Sandpoint, ID or drive southeast and reach Missoula, MT. A junction in Plains connects to the town of Hot Springs via Montana Route 28. Montana Rail Link owns an active railroad line that follows MT 200 through the Clark Fork Valley. The second major transportation route is US Highway 2 in the northern portion of the project area. US Highway 2 connects the urban areas of Libby and Kalispell and runs along McGregor Creek, a stream subject to TMDLs in this document. Unpaved roads built for accessing timber stands and private property are also common. This network of unpaved roads will be further characterized as part of the source assessment for streams investigated for sediment impairments (**Section 5.5** and **Attachment C**). There are also four airports listed in the project area. Two of these are unpaved, private landing strips located just south of US Highway 2. The town of Plains has a small, paved, public airport and a heliport owned by the Clark Fork Valley Hospital.

2.3.3 Land Ownership

Private timber lands and National Forests dominate land ownership in the Thompson Project Area as shown in **Figure A-17** and detailed in **Table 2-3**. The project area includes portions of three National Forests. The Lolo National Forest manages the majority of the US Forest Service (USFS) acreage including large tracks of contiguous land out of the Plain/Thompson Falls Ranger District Office. A smaller patchwork of National Forest lands in the northwest corner of the project area is managed by the Kootenai National Forest's Libby District and finally, USFS lands in the northern most arm of the project area are administered by the Swan Lake Ranger District and the Tally Lake Ranger Districts of the Flathead National Forest. The USFS manages lands for sustainable forest harvest and resource extraction, a diverse array of recreational activities, the recovery of threatened and endangered species, and for overall ecological integrity. All three forest list meeting water quality standards as a goal in their overarching forest plans (U.S. Forest Service, 2011; U.S. Department of Agriculture, Forest Service, Flathead National Forest, 2001; United States Forest Service, 1986). No lands within the project area have been designated wilderness however the Cabinet Mountains Wilderness is only 13 miles to the northwest. Another special use designation, roadless areas, has been inventoried and proposed for over 102,000 acres of the Thompson Project Area as identified in the 2001 Roadless Area Conservation Rule (U.S. Forest Service, 2000).

Table 2-3. Land ownership in the Thompson Project Area

Owner	Acres	Square Miles	% Total
Private Timber	313,421	490	41.3%
US Forest Service	311,051	486	41.0%
Other Private	84,570	132	11.1%
Montana State Trust Lands	47,059	74	6.2%
Montana Fish, Wildlife and Parks	1,762	3	0.2%
US Fish and Wildlife Service	801	1	0.1%

Private timber lands are extensive and are largely found in the valleys, as opposed to the National Forests which are more common in the higher elevations. These lands are actively managed to produce wood products by private companies although most have additional directives concerned with protecting natural resources such as the Native Fish Habitat Conservation Plan (NFHCP), approved by the US Fish and Wildlife Service (USFWS), to protect native salmonid fish species in Northwest Montana (Plum Creek Timber Co., 2000). Some TMDL streams are almost completely contained in private timber ownership (e.g., Little Bitterroot River, McGregor Creek, Lazier Creek). Other private land is the third most widespread ownership category accounting for 11% of the project area. These lands are also common in the low elevations and mostly follow the major transportation routes of US Highway 2 and Montana Route 200. The other private category is especially common surrounding the town of Plains. The next largest land owner is the State of Montana which manages over 47,000 acres to help fund public schools and another 1,700 acres administered by the state wildlife and recreation agency, including Logan State Park on the Thompson chain of lakes. All other ownership categories account for less than half a percent of the project area.

2.3.4 Land Cover and Use

Land cover within the project area is dominated by evergreen forests as indicated in **Table 2-4** and depicted in **Figure A-18**. Distributions are identified using the Montana Natural Heritage Program's Level 2 Land Cover spatial coverage (Montana Natural Heritage Program and Montana Fish, Wildlife and Parks, 2013b). This conifer forest class is broken into a drier habitat category (xeric-mesic) typified by lodgepole and ponderosa pine, and a wetter habitat category (mesic-wet) typified by spruce and fir, which combined, make up 65% of the total project area. The next most common land cover is classified as montane grasslands, where grasses and forbs are more common than woody vegetation. Montane grasslands represent 9% of the total project area but exist in higher densities within some TMDL watersheds, especially Sullivan and Lynch Creek. Areas recovering from fires account for another 9% of the project area; the majority of which were originally forested. More information on fires can be found in **Section 2.2.2**. The abundance of forested lands allows for timber harvest to be a significant regional land use. These activities have impacted almost 8% of the landscape recently which is now undergoing various phases of regrowth. Deciduous shrubland, described as native woody vegetation taller than half a meter tall, is evenly distributed across the project area and represents 2.5% of the total area. Residential and commercial land uses are clustered around the towns of Plains and Marion; combined with the road network, these developed areas encompass nearly 20 square miles or 1.6% of the project area. And lastly, open water rounds out the top eight land cover classes. Lakes such as the Little Bitterroot, McGregor, and Thompson chain, along with the wide Clark Fork River help this class account for 1.2% of the project area. The other 15 land cover classes each account for less than one percent of the total project area. Private agricultural land use is present along the lower portions of Lynch Creek, McGregor Creek, and Swamp Creek. These areas are composed primarily of cultivated crops, hay, and pastureland. Livestock grazing also occurs on both private and public lands throughout the project area.

Table 2-4. Land cover distribution in the Thompson Project Area

Land Cover	Acres	Square Miles	% of Total
Conifer-dominated Forest and Woodland (xeric-mesic)	269,970	421.8	35.58%
Conifer-dominated Forest and Woodland (mesic-wet)	227,995	356.2	30.05%
Montane Grasslands	70,640	110.4	9.31%
Recently Burnt	69,291	108.3	9.13%
Harvested Forest	58,927	92.1	7.77%
Deciduous Shrubland	18,688	29.2	2.46%
Developed	12,425	19.4	1.64%
Open Water	9,209	14.4	1.21%
Floodplain and Riparian	6,372	10.0	0.84%
Agriculture	5,058	7.9	0.67%

Table 2-4. Land cover distribution in the Thompson Project Area

Land Cover	Acres	Square Miles	% of Total
Wet Meadow	3,777	5.9	0.50%
Cliff, Canyon and Talus	3,092	4.8	0.41%
Introduced Vegetation	2,245	3.5	0.30%
Herbaceous Marsh	556	0.9	0.07%
Mixed Deciduous/Coniferous Forest and Woodland	144	0.2	0.02%
Sagebrush-dominated Shrubland	121	0.2	0.02%
Bog or Fen	50	0.1	0.01%
Sagebrush Steppe	49	0.1	0.01%
Mining and Resource Extraction	41	0.1	0.01%
Bluff, Badland and Dune	40	0.1	0.01%
Forested Marsh	10	0.0	0.00%
Alpine Grassland and Shrubland	9	0.0	0.00%
Deciduous Dominated Forest and Woodland	5	0.0	0.00%

2.3.5 Mining

Mining in the Thompson Project Area started as early as the 1880s but activity and prospecting did not get underway in earnest until the railroad arrived a decade or so later. Activity has been sporadic since then with the most recent production ceasing in the 1970s. Most ore deposits are associated with sedimentary rocks of the Belt Series although veins along igneous rock were mined in the Sullivan Creek area. The massive floods associated with Glacial Lake Missoula (see **Section 2.1.3**) scoured the Belt Series sediments exposing valuable minerals to future miners.

MBMG's abandoned and inactive mines database estimates 59 abandoned mines within the Thompson Project Area boundary. DEQ's abandoned mine inventory has information on 23 mines. These sites are overlain on the geology map in **Figure A-5**. The location of most mines rules out their possibility to affect TMDL streams addressed in this document, however, Lazier, McGregor and Henry Creeks each have one abandoned mine noted in their watershed. The Sales Prospect Mine, located in the headwaters of Lazier Creek, operated a copper-precipitating plant in the 1920s and developed 600 feet of tunnels accessed by two adits (Montana Department of Environmental Quality, 2009). No information is available in MBMG or DEQ databases for the mine identified near McGregor Creek and aerial photos do not show any surface disturbance. The description for the Henry Creek mine is similarly vague, only noting that an unnamed prospect explored for silver and copper. The west fork of Swamp Creek was subject to slightly more mineral exploration and processing. At least three prospects developed galena and arsenopyrite-bearing quartz veins beginning in the 1900s and were reworked in the 1960s. The most developed of these mines, the Johnny Miller Mine, excavated over 800 feet of tunnels (Montana Department of Environmental Quality, 2009).

By far the most significant mining in the project area applicable to TMDL streams in this document occurred in the basin draining Sullivan Creek, which was included on the 2012 303(d) List for metals-related impairments. The Sullivan Creek watershed contains roughly 12 mines clustered in a two mile radius. Production in this area, known as the Hog Heaven Mining District, peaked in the 1930s and 1940s and estimates of the total yield are valued around $6 million. The most prolific mine, the Hog Heaven Mine (sometimes referred to historically as the Flathead Mine), was one of the largest silver producers in the Pacific Northwest and employed and housed some 50 men at one time (Montana Department of Environmental Quality, 2009). Zinc, copper, gold and lead were also recovered from other developed lode deposits, some of which had their own mills for ore processing.

The state of Montana identified the Hog Heaven Mine a high priority abandoned mine site. Originally ranked number 25th in the state, the designation is based on human and environmental health risks and the ranking system is intended to prioritize mine reclamation work. DEQ has not pursued reclamation at the Hog Heaven Mine because although the mine is currently inactive, the site is not abandoned and the owner, Pan-American Silver, may decide to start mining again in the future. DEQ issued an operating permit for the mine in 1984 but the company has not posted the required bond or begun mining. When DEQ investigated the complex in 1993, the site was comprised of 455 cubic yards of tailings and 89,980 cubic yards of waste rock, both of which tested many times elevated above background concentrations for numerous metal parameters (Pioneer Technical Services, Inc., 1995). Another factor to the priority designation was the existence of numerous physical hazards including collapsing structures and open stopes and adits, at least three of which were discharging acidic water. The Little Bitterroot River headwaters also has a few mines shown in **Figure A-5,** but they were smaller prospect mines or clay and stone quarries.

2.3.6 Point Sources

There are three active point sources permitted under the Montana Pollutant Discharge Elimination System (MPDES) in the Thompson Project Area according to EPA's Integrated Compliance Information System database as of December 2013. None of these point sources discharge into or upstream of stream segments investigated for this TMDL project and are therefore not particularly relevant, however in order to be comprehensive they are briefly discussed. One general permit allows the permittee to apply pesticides for noxious weed and pest control in Middle Thompson Lake (MTG870049). A second general permit has been issued to a rock quarry operation that discharges stormwater into McGregor Lake (MTR000517). The only individual permit in the Thompson Project Area belongs to the Town of Plain's wastewater treatment plant (MT0030465). This publicly owned facility discharges into the Clark Fork following treatment through a lagoon system.

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 and 302), and Montana's Surface Water Quality Standards and Procedures (Administrative Rules of Montana (ARM) 17.30.601 thru 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 Thompson Project Area are classified as B-1, except for the Little Bitterroot River. Waters classified as B-1 are to be maintained suitable for the following uses:

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

The Little Bitterroot River is classified as B-2, are to be maintained for the same uses as B-1, except the Aquatic Life standard is: Growth and *marginal* propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers.

While some of the waterbodies might not actually be used for a designated use (e.g., 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.** Department of Environmental Quality's (DEQ) 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 is aquatic life; for temperature is aquatic life; for metals are drinking water and/or aquatic life; and for nutrients is aquatic life and primary contact recreation. DEQ determined that nine waterbody segments in the Thompson Project Area do not meet the sediment, temperature, metals, and/or nutrients water quality standards (**Table 3-1**).

Table 3-1. Impaired Waterbodies and their Impaired Designated Uses in the Thompson Area

Waterbody & Location Description	Waterbody ID	Impairment Cause *	Impaired Use(s)
HENRY CREEK, headwaters to mouth (Clark Fork River)	MT76N003_170	Sedimentation/Siltation	Aquatic Life
LAZIER CREEK, headwaters to mouth (Thompson River)	MT76N005_060	Nitrogen (Total)	Aquatic Life Primary Contact Recreation
		Phosphorus (Total)	Aquatic Life Primary Contact Recreation
		Sedimentation/Siltation	Aquatic Life
LITTLE BITTERROOT RIVER[1], Hubbart Reservoir to Flathead Reservation Boundary	MT76L002_060	Nitrogen (Total)	Aquatic Life Primary Contact Recreation
		Phosphorus (Total)	Aquatic Life Primary Contact Recreation
		Sedimentation/Siltation	Aquatic Life
LITTLE THOMPSON RIVER, headwaters to mouth (Thompson River**)**	MT76N005_040	Nitrogen (Total)	Aquatic Life Primary Contact Recreation
		Phosphorus (Total)	Aquatic Life Primary Contact Recreation
		Sedimentation/Siltation	Aquatic Life
LYNCH CREEK, headwaters to mouth (Clark Fork River)	MT76N003_010	Nitrogen (Total)	Aquatic Life Primary Contact Recreation
		Phosphorus (Total)	Aquatic Life Primary Contact Recreation
		Sedimentation/Siltation	Aquatic Life
		Temperature, water	Aquatic Life
MCGINNIS CREEK, headwaters to mouth (Little Thompson River)	MT76N005_070	Phosphorus (Total)	Aquatic Life Primary Contact Recreation
		Sedimentation/Siltation	Aquatic Life
McGREGOR CREEK, McGregor Lake to mouth (Thompson River)	MT76N005_030	Phosphorus (Total)	Aquatic Life Primary Contact Recreation
		Sedimentation/Siltation	Aquatic Life
		Temperature, water	Aquatic Life
SULLIVAN CREEK, headwaters to Flathead Reservation	MT76L002_070	Nitrogen (Total)	Aquatic Life Primary Contact Recreation
		Phosphorus (Total)	Aquatic Life Primary Contact Recreation
		Aluminum	Aquatic Life
		Cadmium	Aquatic Life
		Copper	Aquatic Life
		Zinc	Aquatic Life Drinking Water
		Sedimentation/Siltation	Aquatic Life
SWAMP CREEK, West Fork Swamp Creek to mouth (Clark Fork River)	MT76N003_160	Nitrogen (Total)	Aquatic Life Primary Contact Recreation
		Phosphorus (Total)	Aquatic Life Primary Contact Recreation
		Sedimentation/Siltation	Aquatic Life

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

Table 3-1. Impaired Waterbodies and their Impaired Designated Uses in the Thompson Area

Waterbody & Location Description	Waterbody ID	Impairment Cause *	Impaired Use(s)

[1]Little Bitteroot River is classified as a B-2 water

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 and nutrients). 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 Thompson Project area, a combination of numeric and narrative standards are applicable. The numeric standards apply to metals and nutrients, and narrative standards are applicable for sediment, temperature, nutrients, as well as metals. 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.

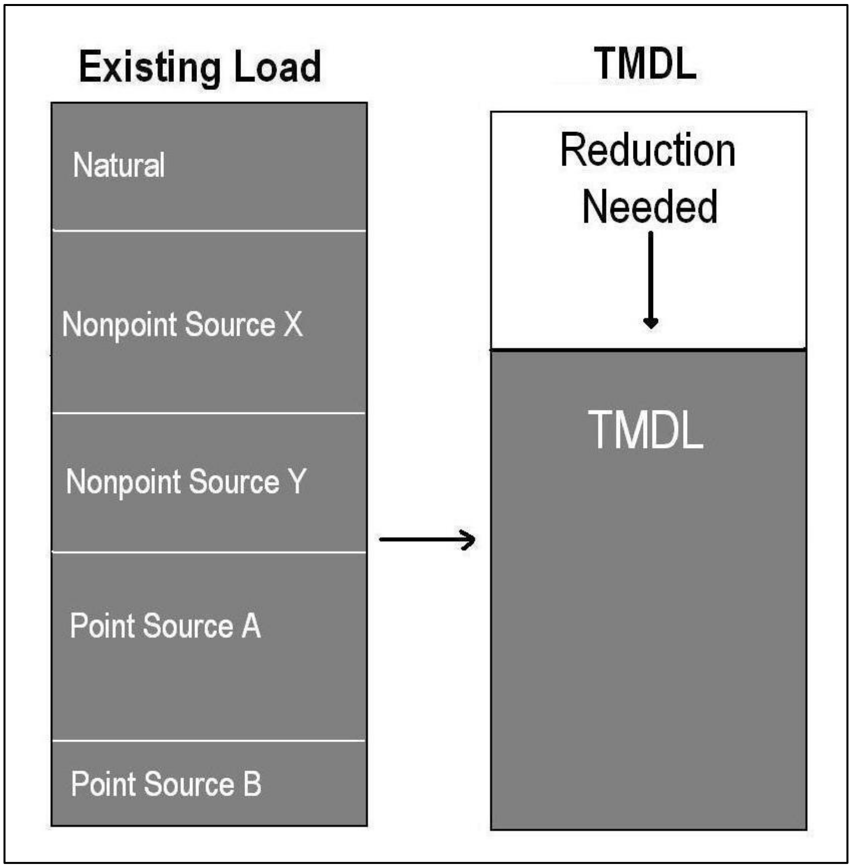


Figure 4-1. Schematic Example of TMDL Development

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., timber or grazing). 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 (Code of Federal Regulation (CFR) 40 Section 130.2(l)). Montana TMDL development often includes a combination of approaches, depending on the level of desired certainty for setting allocations and guiding implementation activities.

4.3 Establishing the Total Allowable Load

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

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

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

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

The federal Clean Water Act indicates in section 303(d)(3) that in a waterbody that has not been identified as impaired by a specific pollutant, for the specific purpose of developing information, a protective TMDL may be developed. Consistent with 40 CFR Section 130.7(e), U.S. Environmental Protection Agency (EPA) approval is not required for a protective TMDL. Continued monitoring of a waterbody with a protective TMDL may determine whether there is an impairment and the TMDL should be submitted to EPA for approval or whether it should remain a protective TMDL.

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.

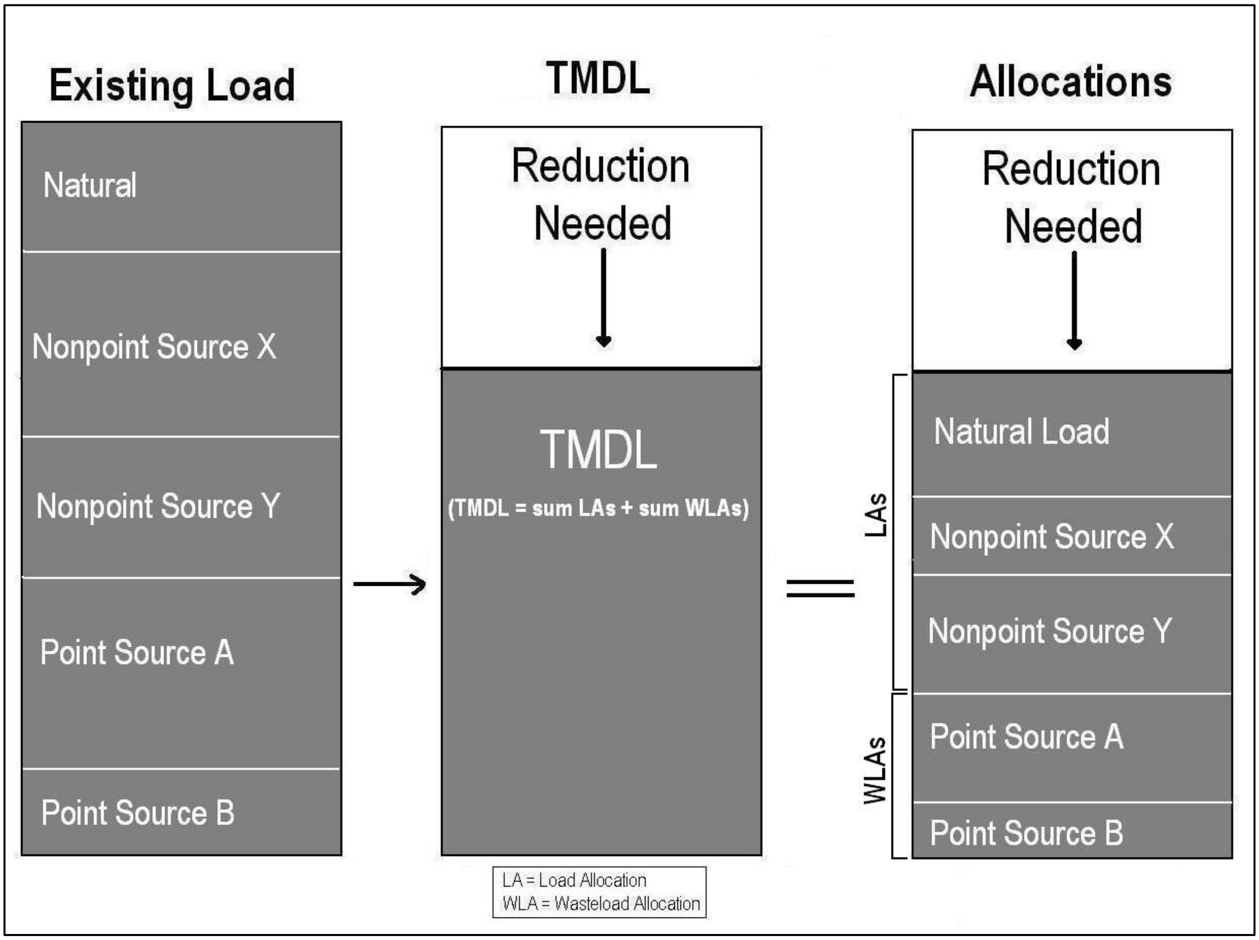


Figure 4-2. Schematic Diagram of a TMDL and its Allocations

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, 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.

4.5 Implementing TMDL Allocations

The Clean Water Act (CWA) and Montana state law (Section 75-5-703 of the Montana Water Quality Act) require wasteload allocations to be incorporated into appropriate discharge permits, thereby providing a regulatory mechanism to achieve load reductions from point sources. Nonpoint source reductions linked to load allocations are not required by the CWA or Montana statute, and are primarily implemented through voluntary measures. This document contains several key components to assist stakeholders in implementing nonpoint source controls. **Section 10.0** discusses a restoration and implementation strategy by pollutant group and source category, and provides recommended best management practices (BMPs) per source category (e.g., grazing, cropland, urban, etc.). **Section 10.5** discusses potential funding sources that stakeholders can use to implement BMPs for nonpoint sources. Other site specific pollutant sources are discussed throughout the document, and can be used to target implementation activities. Department of Environmental Quality's (DEQ) Watershed Protection Section helps to coordinate nonpoint implementation throughout the state and provides resources to stakeholders to assist in nonpoint source BMPs. Montana's Nonpoint Source Management Plan (available at http://www.deq.mt.gov/ wqinfo/nonpoint/nonpointsourceprogram.mcpx) further discusses nonpoint source implementation strategies at the state level.

DEQ uses an adaptive management approach to implementing TMDLs to ensure that water quality standards are met over time (outlined in **Section 11.0**). This includes a monitoring strategy and an implementation review that is required by Montana statute (see **Section 11.3**). 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 Thompson 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 support of aquatic life, coldwater fisheries, recreation, and drinking water.

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

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

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

5.2 STREAM SEGMENTS OF CONCERN

A total of nine waterbody segments in the Thompson Project Area appeared on the 2012 Montana 303(d) List for sediment impairments (**Appendix A**, **Figure A-8**): Henry Creek, Lazier Creek, Little Bitterroot River, Little Thompson River, Lynch Creek, McGinnis Creek, McGregor Creek, Sullivan Creek, and Swamp Creek. Sullivan Creek and the Little Bitterroot River are tributaries to the lower Flathead River but flow into the Flathead Reservation before reaching the river. Henry, Lynch, and Swamp creeks are tributaries to the Clark Fork River, and the remaining four stream segments of concern (i.e., Lazier Creek, Little Thompson River, McGinnis Creek, and McGregor Creek) are within the Thompson River watershed. All but McGinnis and McGregor Creeks are also impaired for alterations in stream-side or littoral vegetative covers (**Table A-1**), which is a non-pollutant cause commonly associated with sediment impairment. Lynch Creek, Little Bitterroot River, and McGregor Creek are also impaired by flow-related causes (**Table A-1**), which are also non-pollutants that may be associated with sediment impairment because streamflow is an important factor in sediment movement and export through a stream. 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.

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 2011. The below listed data sources represent the primary information used to characterize water quality and/or develop TMDL targets.

- Department of Environmental Quality (DEQ) Assessment Files
- U.S. Environmental Protection Agency (EPA) 2011 Sediment and Habitat Assessments
- 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 on most waterbodies in 2004 (denoted as “DEQ Monitoring Sites” in **Figures 5-1 and 5-2**) as well as other historical information collected or obtained by DEQ. The most common quantitative data that will be incorporated from the assessment files are pebble counts and macroinvertebrate index scores. The files also include information on sediment water quality characterization and potentially significant sources of sediment, as well as information on non-pollutant impairment determinations and associated rationale.

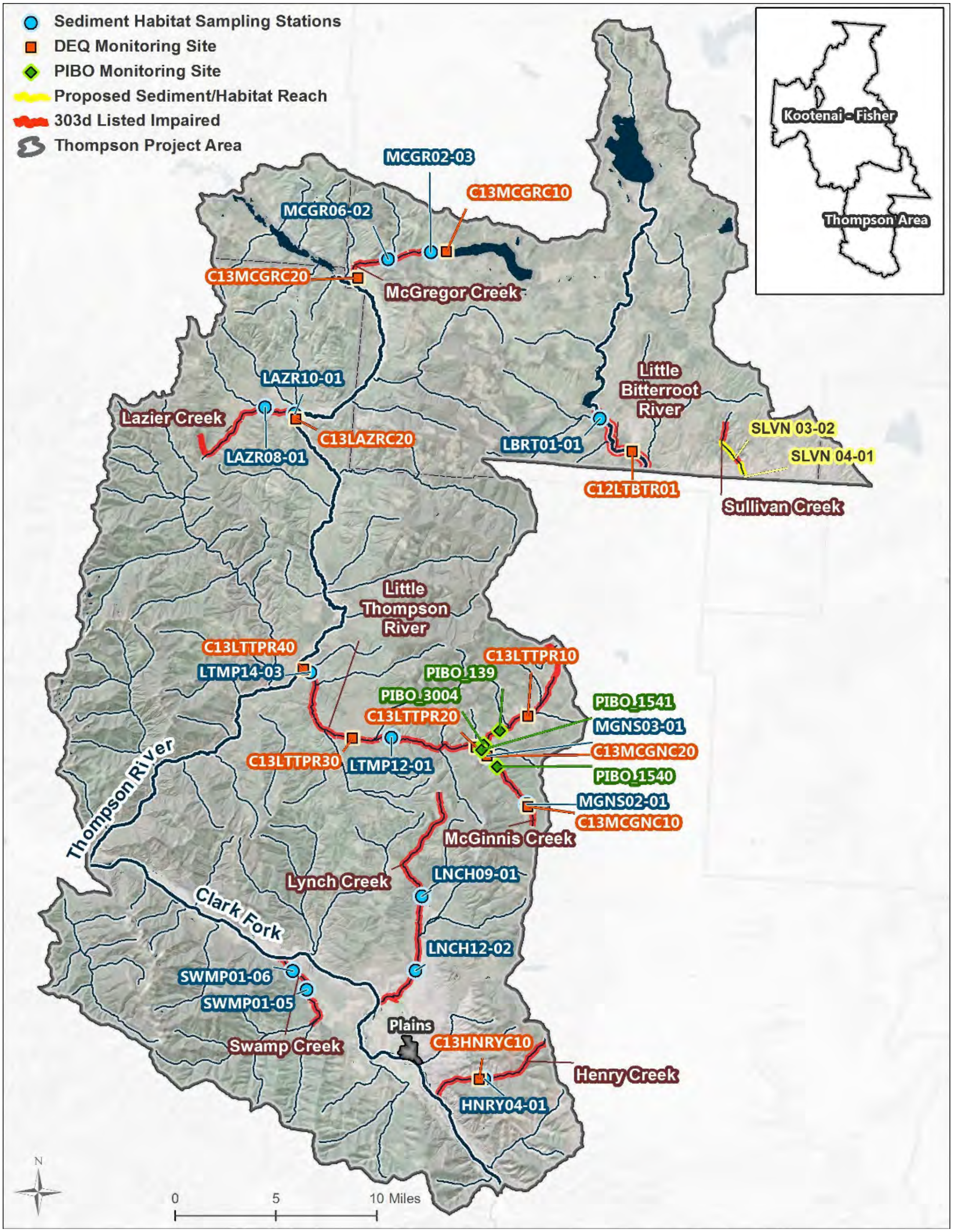


Figure 5-1. Sediment/Habitat Monitoring Sites in the Thompson Project Area

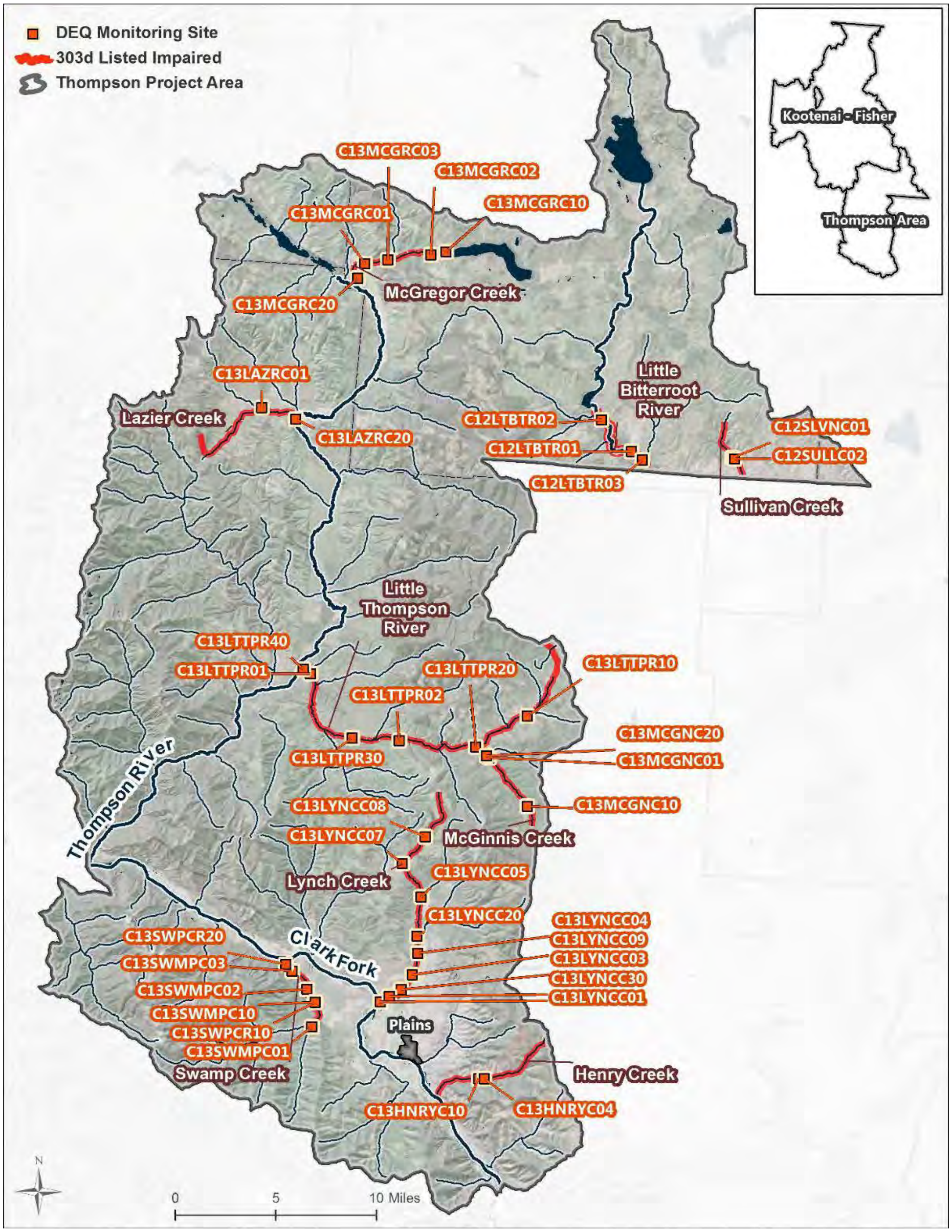


Figure 5-2. Biological Monitoring Sites in the Thompson Project Area

5.3.3 EPA's 2011 Sediment and Habitat Assessments

To aid in TMDL development, field measurements of channel morphology and riparian and instream habitat parameters were collected in September 2011 from 16 reaches (ATKINS, 2013c) (**Figure 5-1**). Reaches were dispersed among the nine segments of concern listed in **Section 5.2**, with two full assessment reaches on most streams and two reaches on Fishtrap Creek to broaden the range of conditions in the sample dataset and serve as a potential reference sites. Two reaches were initially identified on Sullivan Creek (**Figure 5-1**) but during reconnaissance of the reaches, no defined channel was observed, making it unsuitable for sampling following the protocol applied at the other reaches (and described in **Attachment A**). No sediment-related data were collected on Sullivan Creek in 2011.

Initially, all streams were assessed aerially 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. The result was stratifying streams 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 further characterize sediment impairment conditions. Thus, it is not a random sampling design intended to sample stream reaches representing all potential impairment and non-impairment conditions. Instead, it is a targeted sampling design that aims to assess a representative subset of reach types, while ensuring that reaches within each 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 Thompson Project Area

Reach Type	Number of Reaches	Number of Monitoring Sites	Monitoring Sites
NR-0-1-U	6		
NR-0-2-C	1		
NR-0-2-U	2		
NR-0-3-C	2		
NR-0-3-U	26	6	FTRP06-02, LAZR10-01, LTMP12-01, MCGR06-02, SWMP01-05, SWMP01-06
NR-0-4-C	3	1	FTRP 08-01
NR-0-4-U	9	3	LBTR01-01, LNCH12-02, LTMP14-03
NR-10-1-C	2		
NR-10-1-U	4		
NR-10-3-C	1		
NR-2-1-U	10	1	MGNS02-01
NR-2-2-U	4	1	MGNS03-01

Table 5-1. Stratified Reach Types and Sampling Site Representativeness within the Thompson Project Area

Reach Type	Number of Reaches	Number of Monitoring Sites	Monitoring Sites
NR-2-3-C	2		
NR-2-3-U	7	2	LAZR08-01
NR-2-4-C	1		
NR-2-4-U	1		
NR-2-5-U	1		
NR-4-1-C	4		
NR-4-1-U	8	1	LNCH09-01
NR-4-2-C	1		
NR-4-2-U	2	1	HNRY04-01
NR-4-3-C	1		
NR-4-3-U	1		

The field parameters assessed in 2011 include standard measures of stream channel morphology, fine sediment, stream habitat, riparian vegetation, and streambank erosion. Although the sampling areas are frequently referred to as "sites" within this document, to help increase sample sizes and capture variability within assessed streams, sampling reaches were either 500 or 1000 feet (depending on the channel bankfull width) and were broken into five cells. Generally, channel morphology and fine sediment measures were performed in three of the cells, and stream habitat, riparian, and bank erosion measures were performed in all cells. Field parameters are briefly described in **Section 5.4**, and summaries of all field data and sampling protocols are contained in the 2011 Sediment and Habitat Assessment report (**Attachment A**).

5.3.4 Relevant Local and Regional Reference Data

Regional reference data were derived from Kootenai National Forest (KNF) reference sites and the PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO). There is reference data for channel morphology parameters (i.e., width/depth and entrenchment) for 151 sites assessed within all districts of the KNF between 1992 and 1999 and then a more extensive reference dataset (i.e., channel morphology, fine sediment, and habitat measures) for 77 sites within the Libby District collected between 1995 and 2004. The Libby District lies entirely within the Northern Rockies (Level III ecoregion) and Salish Mountains (Level IV ecoregion). The PIBO reference dataset (http://www.fs.fed.us/biology/fishecology/emp/) includes US Forest Service (USFS) and Bureau of Land Management (BLM) sites throughout the Pacific Northwest, but to increase the comparability of the data to conditions in the Thompson Project Area, only data collected within the Northern Rockies ecoregion were evaluated. PIBO reference sites are defined as having catchment road densities less than 0.25km/km^2, no grazing within 30 years, and no known in-channel mining upstream of the site. Between 2001 and 2012, 35 PIBO sites have been established in the Northern Rockies, and most of the sites have been visited more than once (n=109). Eleven of the PIBO reference sites are located in the Kootenai National Forest and three are in the Lolo National Forest. Much of the PIBO sampling protocol (Heitke et al., 2012) is similar to the DEQ protocol used by EPA in 2011; the methodologies are discussed in more detail within this section for any PIBO parameters considered for water quality targets.

5.3.5 Other Data and Reports

The PIBO dataset also includes non-reference, or managed sites, so that effects of management activities on federally-managed land can be compared to reference conditions. Within the Thompson

Project Area, there are four PIBO managed sites: two on the Little Thompson River and two on McGinnis Creek. Data were collected at these sites at varying frequency between 2001 and 2012, and data collected within the past ten years (i.e., since 2004) are included in this section. As mentioned above, the PIBO sampling protocol is documented in Heitke et al. (2012), and methodology differences between that and the DEQ protocol are described in **Section 5.4**.

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: a biological report summarizing macroinvertebrate and periphyton data collected in 2011 in the same reaches as the sediment and habitat sites (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2011b); an assessment of upland sediment sources (ATKINS, 2013b); and an assessment of sediment from roads (ATKINS, 2013a).

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 2011 EPA data. As discussed in **Appendix B**, there are several statistical approaches DEQ uses for target development. They include using percentiles of reference data or of the entire sample dataset, if reference data are limited. For example, if low values are desired (like with fine sediment), and there is a high degree of confidence in the reference data, the 75th percentile of the reference dataset is typically used.

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

In general, stream sediment and habitat conditions within the streams evaluated by EPA in 2011 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., KNF or PIBO) as well as for the entire sample dataset. The preferred approach for setting target values is to use reference data, where preference is given to the most protective reference dataset.

Additionally, the target value for some parameters may apply to all streams in the Thompson 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**. Field data from the reference sites on Fishtrap Creek are not discussed within this section but were compared with target values during the target development process to help evaluate the appropriateness and achievability of target values.

5.4.1 Targets

The sediment water quality targets for the Thompson Project Area are summarized in **Table 5-2** and described in detail in the sections that follow. Listed in order of preference, sediment-related targets are based on a combination of reference data from the KNF, reference data from the Northern Rockies portion of the PIBO dataset, and sample data from the EPA 2011 sampling effort. For target development purposes, sample dataset percentiles within this section are based on the data collected in the Thompson Project Area along with data collected by the same methods from 13 reaches in the adjacent Kootenai-Fisher TMDL Project Area (inset, **Figure 5-1**), which is also in the Northern Rockies. Percentiles specific to just the Thompson Project Area are presented in **Attachment A**. The raw data from the Kootenai-Fisher Project Area is available by request from DEQ and is included in **Attachment A** of the Kootenai-Fisher TMDL document (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, 2014), which is posted on DEQ's website.

KNF reference data were incorporated (along with other sources, such as Lolo National Forest data) into target development for most of the other Montana sediment TMDLs that have been completed within the Northern Rockies to date: Bobtail Creek (Lindgren and Anderson, 2005), Grave Creek (Montana Department of Environmental Quality et al., 2005), Yaak (Montana Department of Environmental Quality, 2008), St Regis (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2008), Prospect Creek (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2009b), Lower Clark Fork (Montana Department of Environmental Quality, 2010), and Tobacco (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2011a). Targets from these TMDLs and others that have been completed in Montana within the Northern Rockies (i.e., Flathead Headwaters and Swan) are referenced within this section to provide context for potential target values and/or to apply as target values.

Consistent with EPA guidance for sediment TMDLs (U.S. Environmental Protection Agency, 1999b), water quality targets for the Thompson 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.

Table 5-2. Sediment Targets for the Thompson TMDL Project Area

Parameter Type	Target Description	Criterion
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%
	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
Channel Form and Stability	Bankfull width/depth ratio (reach median)[1]	B & C stream types with bankfull width < 30ft: ≤ 21 B & C stream types with bankfull width > 30ft: ≤ 32 E stream types: ≤ 8
	Entrenchment ratio[1] (reach median)	B stream types: ≥ 1.4
		C stream types: ≥ 2.7
		E stream types: ≥ 2.3
Instream Habitat	Residual pool depth (reach average)	< 20' bankfull width : ≥ 0.6 (ft)
		20' - 35' bankfull width : ≥ 1.2 (ft)
		> 35' bankfull width : ≥ 1.6 (ft)
	Pools/mile	< 20' bankfull width : ≥ 81
		20' - 35' bankfull width: ≥ 38
		> 35' bankfull width : ≥ 25
	Large Woody Debris/mile	< 20' bankfull width : ≥ 359
		20' - 35' bankfull width : ≥ 242
		> 35' bankfull width : ≥ 148
Riparian Health	Percent of streambank with understory shrub cover (reach average)	≥ 58% understory shrub cover
Sediment Source	Significant and controllable sediment sources	Identification of significant and controllable anthropogenic sediment sources throughout the watershed
Biological Indices	Macroinvertebrate bioassessment metric	O/E ≥ 0.90 for samples collected since 2011 O/E ≥ 0.80 for samples collected prior to 2011
	Periphyton Increaser Taxa	Probability of Impairment <51%

[1] For other channel types, Rosgen delineative criteria apply (Rosgen, 1996)

5.4.1.1 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 Bjornn, 1984; Shepard et al., 1984; Suttle et al., 2004; Weaver and Fraley, 1991). Excess fine sediment can also decrease macroinvertebrate abundance and taxa richness (Mebane, 2001; Zweig and Rabeni, 2001). Because similar concentrations of sediment can cause different degrees of impairment to different species (and even age classes within a species), and because the particle size defined as "fine" is variable (and some assessment methods measure surficial sediment while other measures also include subsurface fine sediment), literature values for harmful fine sediment thresholds are highly variable. Some studies of salmonid and macroinvertebrate survival found an inverse relationship between fine sediment and survival (Suttle et al., 2004) whereas other studies have concluded the most harmful percentage falls within 10% to 40% fine sediment (Bjornn and Reiser, 1991; Mebane, 2001; Relyea et al., 2000). Bryce 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**.

Percent Surface Fine Sediment < 6mm and < 2mm in Riffles via Pebble Count

Surface fine sediment measured in riffles by the modified (Wolman, 1954) pebble count indicates the particle size distribution across the channel width and is an indicator of aquatic habitat condition that can point to excessive sediment loading. Pebble counts in 2011 were performed in four riffles per sampling reach for a total of at least 400 particles. For DEQ data collected in 2004, pebble counts at each reach were performed from bankfull to bankfull in a single representative riffle for a total of at least 100 particles.

Pebble count reference data are available from the Libby District of the KNF and PIBO. Pebble counts for the Libby District were a composite of riffles and pools, which can increase the fine sediment percentage relative to a riffle-only pebble count; in a review of the field forms, pools did not typically increase the overall percentage of fines, indicating results between the Libby District and Thompson sample dataset are comparable. PIBO samples consisted of approximately 100 particles collected at transects, which could include any habitat type, were not stratified by Rosgen stream type, and the sample size is small (n=16). Because the Libby District data are comparable to the DEQ data and the preferable reference dataset, the target for riffle substrate percent fine sediment is based on the 75th percentile of the KNF Libby District reference dataset and is set at less than or equal to 15% < 6mm and 8% < 2mm. PIBO data are not available for <2mm but the 75th percentile for particles <6mm is very close to Libby District value at 16%. The target for sediment < 6mm is the same or similar to that set in other TMDL documents within the Northern Rockies (e.g., Lower Clark Fork: 10%, Tobacco/Grave Creek/Prospect Creek: 15%, Yaak/Flathead Headwaters/St. Regis: 20%), and the target for < 2mm is close to the macroinvertebrate minimum effect level of 10% found by Bryce et al. (2010). Rosgen E channels tend to have a higher percentage of fine sediment than B and C channels (which compose all but one of the 2011 EPA assessment reaches), but the KNF Libby District dataset only contains two E channel sites. The 75th percentile values at the KNF reference E channel sites are 1% and 16% for < 6mm and 0% and 8% < 2mm. By comparison, the E channel target value from 115 reference sites in the Beaverhead Deerlodge National Forest (Bengeyfield, 2004) is 30% fine sediment <6mm and there are no data for particles < 2mm.

For B and C channel types, 15% < 6mm and 8% < 2mm will be applied as fine sediment targets for riffle pebble counts. Because the E channel sample size from the Beaverhead Deerlodge National Forest is much greater than from the KNF, a target of 30% <6mm will be applied to E channels in the Thompson Project Area. Since the fine sediment <2mm target for B and C channels is roughly half of the <6mm target, 15% <2mm will be applied as the target for E channels. The pebble count target values for E channels will carry less weight than for the other channel types because they are based on another ecoregion and have a higher level of uncertainty. Target values should be compared to the reach average value from pebble counts.

Percent Surface Fine Sediment < 6mm in Pool Tails and Riffles via Grid Toss
Grid toss measurements in riffles and pool tails are an alternative measure to pebble counts that assess the level of fine sediment accumulation in macroinvertebrate habitat and potential fish spawning sites. A 49-point grid toss (Kramer et al., 1993) was used to estimate the percent surface fine sediment < 6mm in riffles and pool tails in the Thompson Project Area, and three tosses, or 147 points, were performed and then averaged for each assessed riffle and for the spawning gravel substrate portion of each assessed pool tail. Riffle grid tosses were performed at the same riffle per cell as pebble counts and pool tail grid tosses were performed at all pool tails with potential spawning gravel (i.e., not all sand or cobble).

For grid toss values, PIBO pool tail data are the only reference data currently available. The 75th percentile of the PIBO reference data for pool tails is 20% and the median is 9%. In the 2011 sample dataset, pool tail grid toss values were low with percentiles as follows: 25th= 4%, median = 7%, and 75th = 10%. This information suggests a potential variation in assessment methods between PIBO and the DEQ pool grid toss method. This is further supported by the fact that reference data sets used for target setting for the St Regis, Grave Creek, Prospect Creek, and Tobacco TMDLs resulted in pool tail grid toss targets between 8 and 10%. Therefore, the grid toss target for fine sediment < 6mm in B and C channels is ≤ 9% for pool tails, consistent with the PIBO median values, the sample dataset, and results from other TMDL projects.

In the 2011 sample dataset, riffle grid toss values were less than pool tail values with percentiles as follows: 25th= 1%, median = 3%, and 75th = 7%. The 75th percentile of the sample dataset is less than conservative literature values for harm to aquatic life (i.e., 10%) and similar to the TMDL targets used in the Tobacco and Prospect Creek (i.e., 8 and 10%, respectively), the riffle grid toss target for fine sediment < 6mm in B and C channels is ≤ 7% based on the 75th percentile of the 2011 sample dataset.

A separate target will be applied to E channels because they tend to have a higher percentage of fine sediment than B and C channels. The reference based pebble count target for fine sediment < 6 mm for E channels is double that of B and C channels. That relationship will be used for the grid toss targets for fine sediment < 6 mm; for E channels, the pool grid toss target is ≤ 18% and the riffle grid toss target is ≤ 14%. For each habitat area, the target should be assessed based on the reach average grid toss value.

5.4.1.2 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 Thompson Project Area 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 having energy dissipate to the floodplain. Accelerated bank erosion and an increased sediment supply often accompany an increase in the width/depth ratio and/or a decrease in the entrenchment ratio (Knighton, 1998; Rosgen, 1996; Rowe et al., 2003). Width/depth and entrenchment ratios were calculated for each 2011 assessment reach based on five riffle cross-section measurements.

<u>Width/Depth Ratio Target Development</u>

There is reference riffle width/ratio data for the KNF, KNF Libby District, and PIBO, but because the Libby District data is a subset of the KNF dataset, only the KNF and PIBO reference data were reviewed as potential targets. The 2011 sample dataset primarily comprises B and C channels, and although on average B channels tend to have a smaller width/depth ratio than C channels (Rosgen, 1996) , the ratio can vary quite a bit between small and larger streams. Because the waterbodies in the 2011 Thompson dataset range in bankfull width (BFW) from 8 to 48 feet (median=19 ft, 75^{th}=26 ft), target values are combined for B and C channels and expressed by BFW. Both reference datasets have BFW values that range from approximately 5ft to 60ft, but the PIBO dataset has a much greater number of larger streams (KNF: median=15 ft, 75^{th}=21 ft; PIBO: median=29 ft, 75^{th}=35 ft).

The 75^{th} percentiles of width/depth ratios for both reference datasets (**Table 5-3**) are similar to targets that have been applied in TMDLs for Bobtail Creek, Prospect Creek, the Lower Clark Fork, St Regis, Grave Creek, and the Tobacco. For B and C channels with a bankfull width < 30 ft, the target will be ≤ 21 based on the 75^{th} percentile of the KNF data. For B and C channels with a bankfull width ≥ 30ft, the target will be ≤ 32 based on the 75^{th} percentile of PIBO reference, which has a much greater number of large reference streams than the KNF dataset. The streams in the PIBO dataset are not broken out by Rosgen channel type but based on a review of reference-based width/depth ratio targets ranging from 29-33 for large B/C channels in the St. Regis, Grave Creek, and Prospect Creek TMDLs, 32 is an appropriate target for larger B/C channels within the Thompson Project Area. Although the sample size is smaller than desired, the target for E channels will be ≤ 8 based on the 75^{th} percentile of E channel in the KNF dataset (**Table 5-4**) because the PIBO dataset is not broken out by stream type.

Table 5-3. The 75th Percentiles of Reference Data used for Width/Depth Ratio Target Development

Data Source	Category	Sample Size	75th Percentile W/D
KNF Reference	B/C channels BFW < 30’	94	**21**
KNF Reference	B/C channels BFW > 30’	7	29
KNF Reference	E channels	3	**8**
PIBO Reference	BFW < 30’	61	26
PIBO Reference	BFW > 30’	48	**32**

Entrenchment Ratio Target Development

Because higher values are more desirable for entrenchment ratio, the target value for entrenchment ratio is set at greater than or equal to the 25th percentile of the KNF reference data (**Table 5-4**). When comparing assessment results to target values, more weight will be given to those values that fail to satisfy the identified target and fail to meet the minimum value associated with literature values for Rosgen stream type (i.e., B=1.4-2.2 ± 0.2, C & E 2.2 ± 0.2) (Rosgen, 1996) and reaches with multiple potential channel types will be evaluated using the lowest target value (e.g., Target for B3/C3 = 1.4).

Table 5-4. Entrenchment Targets for the Thompson TPA Based on the 25th Percentile of KNF Reference Data

Rosgen Stream Type	Sample Size	25th Percentile of KNF Reference Data
B	93	1.4
C	8	2.7
E	3	2.3

Channel form targets are expressed specifically for B, C, and E channels because they are either the primary existing or potential channel type in low gradient sections of the streams of concern, which is where the effects of excess sediment from human sources are most likely to be observed. For channel types not specifically mentioned above (i.e., A, F, D, G), the Rosgen delineative criteria for width/depth ratio and entrenchment apply (Rosgen, 1996). Channel types can evolve naturally or as a result of human changes to the landscape, and channel type adjustments should be evaluated in the context of the potential cause(s) and whether human sources are causing channel instability or if the channel is recovering.

5.4.1.3 Instream Habitat Measures

For all instream habitat measures (i.e., residual pool depth, pool frequency, and large woody debris frequency), there is available reference data from the Libby District of the KNF and from PIBO. 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 (Bonneau, 1998; Nielson et al., 1994; Baigun, 2003). Similar to channel morphology measurements, residual pool depth integrates the effects of several stressors; pool depth can be decreased as a result of filling with excess sediment (fine or coarse), a reduction in-channel obstructions (such as large woody debris), and changes in-channel form and stability (Bauer and Ralph, 1999). A reduction in pool depth from channel aggradation may not only alter surface flow during the critical low flow periods, but may also impair fish condition by altering habitat, food availability, and productivity (Sullivan and Watzin, 2010; May and Lee, 2004). Residual pool depth is typically greater in larger systems.

Although the residual pool depth measure is similar between DEQ's method and both reference methods, 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 2011 sample dataset 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). The Libby District dataset defines pools as slack water areas occupying at least one-third of the bankfull channel with a scour feature and hydraulic control.

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 2011 sample dataset 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. In comparison to the Libby dataset, the 2011 sample dataset could have a lower pool frequency but more pools with a deeper residual pool depth since some slack water areas in the Libby District dataset might not meet the head crest to tail crest ratio requirement used by DEQ. However, residual pool depths in the sample dataset are not noticeably less than the PIBO depths or greater than the Libby depths, indicating the slight protocol differences are not an issue and the reference datasets are appropriate to use for setting residual pool depth targets.

The 25th percentile of the Libby reference data will be applied as residual pool depth targets for streams with a bankfull width < 35ft (**bolded** in **Table 5-5**), which is the upper limit of streams in the Libby dataset. Given that the 25th percentile and median of the sample dataset is greater than PIBO reference values for the largest category, a PIBO based target should be achievable. The residual pool depth target for streams with a bankfull width ≥35 will be 1.6 ft based on the PIBO median (**bolded** in **Table 5-5**).

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

Table 5-5. Percentiles of Reference Data and 2011 Sample Data for Residual Pool Depth (ft)

Category	Libby Reference			PIBO Reference			2011 Sample Data			
	n	Median	25th	n	Median	25th	n	Median	25t^{h}	75th
< 20' BFW	57	0.8	**0.6**	33	0.9	0.7	137	0.8	0.6	1.0
20-35' BFW	18	1.4	**1.2**	46	1.1	0.9	107	1.1	0.8	1.7
> 35' BFW	0	--	--	29	**1.6**	1.1	60	1.9	1.3	3.0

Targets are shown in **bold**.

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 Libby and PIBO reference datasets are suitable for setting targets. Therefore, the 25th percentile of the Libby reference data will be applied as pool frequency targets for streams with a bankfull width < 35ft (**bolded** in **Table 5-6**), which is the upper limit of streams in the Libby dataset. Since the PIBO 25th percentile is comparable to all quartiles from the sample dataset, 25 pools per mile will be applied as the pool frequency target for streams with a bankfull width ≥ 35 ft (**Table 5-6).** The pool frequency targets are similar to the INFISH Riparian Management Objectives (U.S. Department of Agriculture, Forest Service, 1995) as well as reference data from the Swan River and Grave Creek watersheds (Montana Department of Environmental Quality et al., 2005) (**Table 5-7**). Pools per mile should be calculated based the number of measured pools per reach and then scaled up to give a frequency per mile.

Table 5-6. Percentiles of Reference Data and 2011 Sample Data for Pool Frequency (pools/mile)

Category	Libby Reference			PIBO Reference			2011 Sample Data			
	n	Median	25th	n	Median	25th	n	Median	25th	75th
< 20' BFW	57	114	**81**	33	82	44	12	84	67	121
20-35' BFW	18	53	**38**	46	38	32	7	63	53	98
>35' BFW	0	--	--	29	34	**25**	10	26	26	28

Targets are shown in **bold**

Table 5-7. INFISH and Reference Pool Frequency Values by Channel Bankfull Width (BFW)

Comparative Data Source	Smaller Stream Values (pools/mile)	Larger Stream Values (pools/mile)
Swan River tributary reference	19-35' BFW: 25th = 70	35-45' BFW: 25th = 29
Grave Creek reference	10-20' BFW: 73-118 20-35' BFW: 47-66	40-60' BFW: 12-24
INFISH	< 20' BFW: 56-96 25' BFW: 47	50' BFW: 26

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 EPA sampling in 2011, 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 both available reference datasets was compiled using a different definition of LWD than the 2011 sample dataset; if measurements were conducted within the same reach, the Libby District LWD count would likely be less than the 2011 LWD count because the protocol only counted wood if it was larger than 6 inches in diameter and longer than the BFW, and the PIBO LWD count would likely be greater because it includes pieces 3 feet long and 4 inches in diameter. Unlike for pool frequency and residual pool depth, the summary statistics indicate the protocol differences did result in lower numbers in the Libby dataset and greater numbers in the PIBO dataset (except for BFW < 20 ft) (**Table 5-8**).

The Libby dataset is the preferred reference dataset for setting target values; however, using the 25th percentile of the Libby dataset as a starting point, it is less than the 25th percentile of the sample dataset, indicating the effect of the protocol difference and that the potential for streams of concern in the project area is greater than the 25th percentile of the Libby dataset. Therefore, LWD target values for streams with a bankfull width <35 ft will be based on the median of the Libby reference data (**bolded** in **Table 5-8**). For streams with a BFW ≥ 35 feet, both the PIBO median and 25th percentile values are too high relative to the sample data and are not appropriate targets. Therefore, the 25th percentile of the sample data, 148 pieces of LWD per mile, will be applied as the target for all streams with a BFW ≥ 35 feet. A range of 104-210 LWD per mile was applied as a target in TMDLs for Grave Creek, Prospect Creek, St Regis, and Tobacco based on the 25th and 75th percentile of reference data from the Swan River watershed for streams with a bankfull width ≥ 35 ft (Land & Water Consulting, Inc. et al., 2004). This range indicates the 25th percentile of the sample data is an appropriate target. Due to the extent of historical timber removal or channel encroachment by the transportation network, it is acknowledged that these targets may not be achievable for all streams.

Table 5-8. Percentiles of Reference Data and 2011 Sample Data for LWD (LWD/mile)

Category	Libby Reference			PIBO Reference			2011 Sample Data			
	n	Median	25th	n	Median	25th	n	Median	25th	75th
< 20' BFW	57	**359**	183	33	244	90	12	359	206	638
20-35' BFW	18	**242**	92	46	412	243	7	285	177	330
> 35' BFW	0	--	--	29	466	298	10	321	**148**	396

Targets are shown in **bold**

5.4.1.4 Riparian Health

Riparian Understory Shrub Cover

Interactions between the stream channel and the riparian vegetation along the streambanks are a vital component in the support of the beneficial uses of coldwater fish and aquatic life. Riparian vegetation provides organic material used as food by aquatic organisms and supplies LWD that influences sediment storage and channel morphology. Riparian vegetation helps filter sediment from upland runoff, stabilize streambanks, and it can provide shading, cover, and habitat for fish. During EPA assessments conducted in 2011, 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 is no available understory shrub cover reference data so the target is based on the sample dataset. At the 2011 assessment sites, there was an average value of 59% understory shrub cover and a median value of 58% understory shrub cover. Based on this median value, a target value of ≥ 58% is established for understory shrub cover in the Thompson Project Area. This target value should be assessed based on the reach average greenline understory shrub cover value. Because not all reaches have the potential for dense shrub cover, for any reaches that do not meet the target value, the greenline assessment results will be more closely examined to evaluate the potential for dense riparian shrub cover and identify if the streambanks in the reach are stabilized instead by rocks, a mature pine forest, and/or wetland vegetation.

5.4.1.5 Sediment Supply and Sources

Anthropogenic Sediment Sources

The presence of anthropogenic sediment sources does not always result in sediment impairment of a beneficial use. When there are no significant identified anthropogenic 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 Geographic Information System (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 anthropogenic 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**, with additional information in **Attachments A** through **C**.

5.4.1.6 Biological Indices

Macroinvertebrates

Siltation exerts a direct influence on benthic macroinvertebrates assemblages by filling in spaces between gravel and by limiting attachment sites. Macroinvertebrate assemblages respond predictably to siltation with a shift in natural or expected taxa to a prevalence of sediment tolerant taxa over those that require clean gravel substrates. Macroinvertebrate bioassessment scores are an assessment of the macroinvertebrate assemblage at a site, and DEQ uses one bioassessment 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 Sample Collection, Sorting, Taxonomic Identification, and Analysis of Benthic Macroinvertebrate Communities Standard Operating Procedure (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2012). 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 western Montana streams is any O/E value < 0.90. Therefore, an O/E score of ≥ 0.90 is established as a sediment target in the Thompson Project Area. Note, the threshold for data collected prior to 2011 is 0.80 because the O/E model has been updated since that time to better reflect DEQ's current sampling protocol (i.e., MAC-R-500). The rationale and methodology for the previous O/E model and 0.80 threshold value is detailed in the previous macroinvertebrate standard operating procedure (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2006).

Unless noted otherwise, macroinvertebrate samples discussed within this document were collected according to DEQ protocols. There were a few PIBO samples collected in both riffles and pools with either a Hess or Surber sampler at the sites on Little Thompson River and McGinnis Creek. However, upon examination of the O/E scores, which were well below 0.80, DEQ determined that it is not appropriate to use the O/E model for those samples because the model is sensitive to the collection procedure.

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.

DEQ collected periphyton from reference streams and from streams known to have excess sediment and used statistical analysis to identify taxa that tend to increase in the presence of excess sediment (Teply, 2010b; Teply, 2010a). Algal community composition and dynamics differs geographically, and DEQ has developed ecoregion-specific periphyton sediment metrics. The rationale and methodology for the periphyton-based metrics is presented in the DEQ Periphyton Standard Operating Procedure (Montana Department of Environmental Quality, 2011c). The metric is reported as a percent probability of impairment. According to the DEQ Standard Operating Procedure (Montana Department of Environmental Quality, 2011c), a probability of impairment > 51% indicates sediment may be impairing aquatic life but should be used in conjunction with other data when assessing stream condition. Therefore, > 51% probability of impairment will be applied as a target for the Thompson Project Area, and it will be interpreted in the context of other indicators of sediment impairment for each stream.

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

5.4.2.1 Henry Creek (MT76N003_170)

Henry Creek (MT76N003_170) flows 7.1 miles from its headwaters to its mouth at the Clark Fork River and is listed for sedimentation/siltation on the 2012 303(d) List. This segment is also listed for alteration in stream-side or littoral vegetative covers, which is a non-pollutant listing commonly linked to sediment impairment. It was originally listed in 1996 due to historical grazing, timber harvest, and roads.

Physical Condition and Sediment Sources

The watershed has a history of extensive management activity including road construction, timber harvest, grazing, and residential development. Timber harvest dates back to the early 1900s and the watershed has continued to be actively managed for timber (Errecart et al., 1999). Management activities on both public and private land have contributed to alteration of drainage patterns, subsurface flow, sediment, water yield, and fisheries habitat (Errecart et al., 1999). The effects of past management activities were exacerbated by natural disasters: a flood in 1980 caused extensive sediment loading and channel erosion in Henry Creek and fires in 1994 (Henry Peak) and 1998 (Boyer) burned quite a bit of the watershed (U.S. Department of Agriculture, Forest Service, 2012) (see **Figure A-12** in **Appendix A**).

There is an active grazing allotment, the Henry Creek Allotment, in the upper half of the watershed that is cooperatively managed by the USFS and the Montana Department of Natural Resources and Conservation (DNRC) because of open access between USFS and State-managed land. The USFS conducted Environmental Assessments (EAs) for the *Boyer Fire Salvage and Rehabilitation* (Errecart et al., 1999) and the *Henry Creek and Swamp Creek Range Allotment Management Plans Revision* (U.S. Department of Agriculture, Forest Service, 2012). Relevant information from both EAs is summarized within this section to help characterize grazing management, allotment conditions, and the history of human and natural disturbances in the watershed.

The Henry Creek Allotment has been grazed under a permit since the 1930s, with a wide variation in intensity but well-documented overuse (U.S. Department of Agriculture, Forest Service, 2012). Due to concerns over riparian condition, the USFS reduced its permit numbers by 72% in 1990 and restricted grazing along the creek to the uppermost half mile within the allotment (U.S. Department of Agriculture, Forest Service, 2012). The change resulted in an allowance of 50 cow/calf pairs from July 1 to September 15 (i.e., 28 USFS, 22 state of Montana) (Errecart et al., 1999). In 1996, the USFS made additional changes to the seasonally permitted numbers that still apply today: 22 cow/calf pairs and 1 bull on USFS lands. Since 1990, all USFS reviews have noted improved vegetative condition and diversity within the allotment, as well as reduced sediment from trampling and overutilization (U.S. Department of Agriculture, Forest Service, 2012). Fisheries habitat has also improved since 1990, but there is still an overall lack of habitat complexity and a low number of shallow pools because of low amounts of LWD and the naturally well-armored channel (Errecart et al., 1999). Historical riparian harvest and the adjacent road have reduced LWD inputs to Henry Creek (Errecart et al., 1999). Within the *Boyer Fire Salvage and Rehabilitation EA* (Errecart et al., 1999)the potential for roads to route sediment to streams and the insufficient Best Management Practices (BMPs) on Henry Creek Road were noted, but all action alternatives proposed to bring the road up to USFS BMP standards.

Although substantial improvements have been made within the grazing allotment and there is a limited amount of stream frontage where grazing is still permitted, the USFS continues to evaluate the effect of the allotment on sediment and habitat conditions and make recommendations for improvement as summarized here from the *Henry Creek and Swamp Creek Range Allotment Management Plans Revision* (U.S. Department of Agriculture, Forest Service, 2012). The document states that the majority of Henry Creek that cattle can access within the allotment is intermittent and the channel is relatively narrow, shallow and well armored with cobble and gravels. However, the channel is slightly overwidened at the cattle crossings, and a few segments of the trails likely deliver fine sediments during runoff. Therefore, selective small tree felling across trails and a seep and removal of a fence that crosses the channel are proposed in the plan to reduce cattle crossings from five to one and prevent trampling of a seep area adjacent to the creek. Overall, the plan concludes that grazing impacts in the allotment appear to have minor effects on stream stability, water quality, and fisheries habitat, and the proposed measures are only anticipated to result in localized improvements.

In 2004, DEQ collected some sediment and habitat data at a site located just downstream of the grazing allotment (C13HNRYC10 in **Figure 5-1**). The Henry Creek Road parallels the stream for all but the last mile and was located just over 30 feet from the left bank at the sample site. The substrate was dominated by cobble and there was not much sediment deposition in pools or along channel margins but the whole stream bottom was lightly covered in silt. The streambanks were stable and armored with large cobble and small boulders. Channel alterations seemed minimal and the stream appeared to be in its natural state. The road and private residences occasionally encroached on the channel but the riparian zone was thick and had dense vegetation. No streambank erosion was observed. DEQ attempted to collect data at a second site closer to the mouth but it was dry; assessment file field notes indicate an adjacent homeowner told the field crew that the lower 3 miles of Henry Creek is ephemeral and generally only flows from March to late June/early July.

In 2011, EPA collected sediment and habitat data at one site on Henry Creek (HNRY04-01) (**Figure 5-1**). The site was located just 0.3 miles upstream of the 2004 site (C13HNRYC10) and was adjacent to Henry Creek Road, which parallels the stream along the narrow valley bottom. Based on the stratification process described in **Section 5.3.3**, all of Henry Creek has a gradient greater than 4%, which means it is more likely to transport than accumulate excess sediment. Reach HNRY04-01 was selected for a sampling site because it covers 55% of the stream, and the site location was selected because it appeared representative of the stream and is close to the 2004 DEQ site and grazing allotment boundary. Evidence of recent timber harvest was observed in the watershed but not adjacent to the reach. The stream channel was a relatively straight riffle-dominated cascade with small pocket pools and coarse substrate. Pools were relatively shallow and the substrate was too large to support spawning, so no pool tail grid toss measurements were performed. Riparian vegetation was dense and dominated by alders. Many of the streambanks were exposed but they contained relatively coarse material, which limited overall sediment loads from streambank erosion. Streambank erosion was attributed primarily to the road and natural sources but also to timber harvest.

Although sediment data were only collected at one site in 2011, three sites were visited twice to collect nutrient data (**Figure 6-1**). Photos from those sites are shown below to help expand characterization of channel and riparian conditions in Henry Creek. **Figure 5-3** shows a site 3 miles upstream of HNRY04-01 near the headwaters (left photo) and substrate at a site approximately 2 miles upstream of HNRY04-01 (right photo). Both the photos in **Figure 5-3** and other photos from those sampling sites show a cobble-dominated stream with dense riparian vegetation. The lowermost site, C13HNRYC10, is approximately 0.25 miles downstream of HNRY04-01 and sites photos indicate the riparian vegetation and substrate are similar to all other sampling sites. However, the entire substrate was covered with a layer of brown particulate matter (**Figure 5-4**), and it is unclear from the photos if it is silt or algae. Field forms from 2011 indicated dense microalgae, but this is the same sampling location where silt was denoted on field forms in 2004.

Figure 5-3. Site photos from Henry Creek upstream of HNRY04-01 at C13HNRYC01 (left) and C13HNRYC02 (right) in 2011.

Figure 5-4. Site photos from C13HNRYC10, 0.25 miles downstream of HNRY04-01, in August 2011.

Comparison with Water Quality Targets

The existing physical data in comparison with the targets for Henry Creek are summarized in **Table 5-9**. The macroinvertebrate bioassessment data are located in **Table 5-10**. All bolded cells are beyond 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 Henry 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			Riparian Health
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	Percent Understory Shrub Cover
C13HNRYC10	2004	13.6	B3	--	**30**	**30**	--	--	9.3	1.7	--	--	--	--
HNRY04-01	2011	10.3	F3a, B3a	B3a	2	1	5	--	9.9	3.8	**0.5**	116	**158**	76

Table 5-10. Bioassessment data for Henry Creek
Values that do not meet the target threshold (≥0.80 for 2004 O/E, ≥0.90 for 2011 O/E, and <51% for periphyton) are in bold.

Station ID	Collection Date	Collection Method	O/E	Periphyton %
C13HNRYC10	9/6/2004	Kick	0.94	25.3
C13HNRYC10	9/4/2006	--	--	33.6
C13HNRYC10	8/9/2007	--	--	27.1
C13HNRYC10	7/28/2011	MAC-R-500	0.96	
C13HNRYC01	7/29/2011	MAC-R-500	**0.80**	
C13HNRYC10	8/24/2011	MAC-R-500	**0.79**	26.0
C13HNRYC10	8/28/2011	--	--	32.2
HNRY04-01	7/12/2012	MAC-R-500	**0.76**	19.4

Summary and TMDL Development Determination
For fine sediment, the riffle pebble count exceeded the target in 2004 at station C13HNRYC10, but easily met that target at station HNRY04-01 (less than 0.5 mile upstream of station C13HNRYC10) in 2011. In 2011, the riffle grid toss target also met the target; as mentioned above, no pool tail grid tosses were performed because of the large substrate present in pools. Pool frequency met the target value, but the residual pool depth and the LWD frequency did not meet their target values of 0.6 and ≥ 359, respectively. Given the large cobbles that dominate the system and predominance of step-pools, the residual pool depths are likely at their potential. Both channel morphology parameters met the target values, and the percent of streambank with understory shrub cover met the target of ≥ 58%. All periphyton samples met the targets but three of the five macroinvertebrate samples did not meet the target. The low O/E scores all occurred at separate sampling sites, but two of the sites are located at or close to the location of the photos in **Figure 5-4**.

The riffle pebble count in Henry Creek has decreased substantially from 2004 to 2011, and with the exception of LWD frequency, the 2011 data from HNRY04-01 indicate Henry Creek has recovered from excess sediment associated with historical management practices and natural disasters. This improvement also corresponds to the improvements noted within the USFS EAs discussed above (Errecart et al., 1999; U.S. Department of Agriculture, Forest Service, 2012). However, based on the field photos indicating fine particulate matter on the stream bottom and failure to meet the macroinvertebrate target at several sites, there may be still chronic sources of sediment to Henry Creek that are limiting its ability to fully support aquatic life. Therefore, a sediment TMDL will be developed for Henry Creek. However, because of the documented improvements to the grazing allotment and Henry Creek Road and because of the limited amount of recent sediment/habitat data, additional data regarding remaining human sediment sources and instream conditions should be collected prior to TMDL implementation to determine if additional restoration measures are necessary.

5.4.2.2 Lazier Creek (MT76N005_060)

Lazier Creek (MT76N005_060) flows 7.8 miles from its headwaters to its mouth at the Thompson River and is listed for sedimentation/siltation on the 2012 303(d) List. In addition, this segment is also listed for alteration in stream-side or littoral vegetative covers, which is a non-pollutant listing commonly linked to sediment impairment. It was originally listed in 1996 because of excess sediment associated with agriculture and rangeland.

Physical Condition and Sediment Sources

The watershed is primarily evergreen forest, with most of it being private timber land owned by Plum Creek Timber Company, Inc. (Plum Creek). Most of the Plum Creek land in the Lazier Creek watershed is leased for grazing. The land is used for grazing from June through September and works on a rest-rotation system where some pastures are grazed while others are rested. The grazing pastures are rotated regularly (Plum Creek, personal communication 2013). Portions of the USFS's Fishtrap Grazing Allotment are located in the headwaters of the Lazier Creek watershed (2,916 acres); however, it was last used in 1993 and officially closed in May 2007 (USFS, personal communication 2013[1]).

Montana Fish, Wildlife, and Parks (FWP) owns a conservation easement on 84,412 acres of land in the Thompson River watershed. Quite a bit of Plum Creek land in the lower portion of the Lazier Creek watershed is included in this easement (**Figure 6-5**). The state of Montana acquired the easement in several phases between 2001 and 2003. It precludes development, but allows traditional uses such as forestry, grazing, hunting, and fishing. Public access is secured through this easement (Plum Creek, personal communication 2013[2]).

In 2004, DEQ collected some sediment and habitat data at two sites: C13LAZRC20, about 100 yards upstream from the confluence with the Thompson River (**Figure 5-1**), and C13LAZRC10, which is near the headwaters. C13LAZRC10 is not shown in **Figure 5-1** because there was no defined channel and no data were collected there. Site notes indicate Lazier Creek is spring-fed and near the headwaters it has marshy habitat with minimal surface flow and only occasional sections with a small definable channel. Although there was surface flow in Lazier Creek near the mouth at C13LAZRC20, the channel was dry from about one mile above the mouth to the headwaters, where flow was minimal. Site visit notes discuss extensive timber harvest in the watershed, including a large clearcut several decades ago near the headwaters, but there were no signs of recent harvest in 2004. Although excessive fine sediment was observed in the riparian zone, along the channel margins, and on point bars, the stream was narrowing, indicating the system was recovering. The substrate was dominated by gravels with lots of sand and cobbles, and there was good riffle-pool spacing. LWD was abundant and influenced pool formation. The riparian zone contained lots of mature trees and woody riparian vegetation was

[1] 2013. Personal communication with Randy Hojem. Plains/Thompson Falls Ranger, Lolo National Forest
[2] September 2013. E-mails from Brian Sugden, Plum Creek Hydrologist to Eugenia Hart, Tetra Tech

becoming established, but there was a lack of older age class woody shrubs. Bank erosion was primarily observed on meander bends.

In 2011, EPA collected sediment and habitat data at two sites on Lazier Creek: LAZR10-01 and LAZR08-01 (**Figure 5-1**). LAZR10-01 is located approximately 0.1 miles upstream of the mouth, where Lazier Creek flows into the Thompson River. As in the watershed in general, historic timber harvest is the primary land use activity along this reach. The channel was predominately comprised of long riffles with a cobble substrate and few pools. Streambank erosion was observed at channel bends, though streambanks were generally stabilized by deep rooted vegetation and armored by cobbles and large woody debris. Streambank erosion was attributed to a combination of timber harvest and natural sources. Alder, hawthorn and red osier dogwood comprised the riparian shrub community, with larger conifers on the hill slopes.

LAZR08-01 was located in a small shallow portion of the stream downstream of the confluence with Whitney Creek and approximately 2 miles from the mouth of Lazier Creek. Timber harvest and riparian grazing are the primary land use activities along this reach. Portions of this reach were completely overgrown with hawthorn, making them inaccessible, and the remainder of the reach was lined with grasses and wetland vegetation. The meandering channel contained a well-defined riffle-pool sequence with a fine gravel substrate that appeared to provide good fisheries habitat. Streambank erosion was occurring at the outsides of meander bends and attributed to timber harvest and riparian grazing.

Comparison with Water Quality Targets

The existing physical data in comparison with the targets for Lazier Creek are summarized in **Table 5-11**. The macroinvertebrate bioassessment data are located in **Table 5-12**. All bolded cells are beyond 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 Lazier 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			Riparian Health
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	Percent Understory Shrub Cover
LAZR08-01	2011	7.7	E4b, B4	E4	12	5	12	11	**15.8**	**2.1**	0.7	137	**169**	75
LAZR10-01	2011	11.9	C4b, E4b, B4	B4	4	1	3	6	13.4	2.8	0.7	**53**	**216**	78
C13LAZR C20	2004	11	E4b	--	**56**	**47**	--	--	**8.8**	6	--	**--**	**--**	--

Table 5-12. Bioassessment data for Lazier Creek
Values that do not meet the target threshold (≥0.80 for 2004 O/E, ≥0.90 for 2011 O/E, and <51% for periphyton) are in bold.

Station ID	Collection Date	Collection Method	O/E	Periphyton %
C13LAZRC20	9/4/2004	Kick	0.96	31.5
C13LAZRC20	8/23/2011	MAC-R-500	0.96	30.2
C13LAZRC01	8/23/2011	MAC-R-500	**0.68**	**60.0**
C13LAZRC20	9/4/2006	--	--	25.0

Summary and TMDL Development Determination
For fine sediment, the riffle pebble count exceeded the target in 2004 at station C13LAZR20, but easily met the target at both sites in 2011. The riffle and pool tail grid toss targets were also met at both sites in 2011. This improvement in the percentage of fine sediment is consistent with the indicators of recovery that were observed in 2004. The channel morphology parameters, width/depth ratio and entrenchment ratio, did not meet their target values at the upper site (LAZR08-01) in 2011 and did not meet the width/depth ratio in 2004. Both targets were met in 2011 at the lower site (LAZR10-01). Both 2011 sites met the residual pool depth target, however, the pool frequency target was not met at the lower site and the LWD frequency target was not met at either site. The percent of streambank with understory shrub cover met the target of ≥ 58% at both sites in 2011. For biological data, one periphyton sample and one macroinvertebrate sample did not meet the target; both failures occurred in 2011 at station C13LAZRC01, just upstream of the confluence with Whitney Creek and about 0.2 mile upstream of station LAZR08-01.

Although the fine sediment measurements indicate fine sediment levels have declined in Lazier Creek, both biological metrics indicate excess sediment is still limiting aquatic life support, particularly near the confluence with Whitney Creek. This information supports the sediment impairment listing and a sediment TMDL will be developed for Lazier Creek.

5.4.2.3 Little Bitterroot River (MT76L002_060)
The impaired portion of the Little Bitterroot River (MT76L002_060) flows 5.2 miles from the mouth of the Hubbart Reservoir to the Flathead Reservation boundary and is listed for sedimentation/siltation on the 2012 303(d) List. The river was originally listed in 1996 because of excess sediment associated with agriculture, irrigated crop production, natural sources, and rangeland. The 1996 listing was based on a 55 mile segment, which included 50 miles of Flathead Reservation land. All of the available data at that time were collected many miles below this segment.

Physical Condition and Sediment Sources
The impaired segment flows from Hubbart Reservoir through a steep, forested canyon with limited access. Based on notes in the DEQ assessment file, the predominant land use in along the segment is timber harvest. Most of the land in the Little Bitterroot River watershed is private timber land (**Appendix A**, **Figure A-15**) owned by Plum Creek and is not leased for grazing. There are no USFS or BLM grazing allotments in the Little Bitterroot River watershed but private lands are used for grazing.

In 2004, DEQ collected some sediment and habitat data in the lower part of the segment at C12LTBTR01, which is approximately 1.4 miles upstream of the reservation boundary. At the time of data collection (August), water was being drawn down from Hubbart Reservoir for dam repair. The river was flowing near bankfull and was turbid, which was attributed to the drawdown of the reservoir. The substrate was dominated by large cobble, but sand was prevalent and heavy deposits of sand were observed behind boulders and large cobbles in riffles. Boulders in the channel were not embedded but those along the water's edge were estimated to be 50-90% embedded. The streambanks were very stable and erosion uncommon because woody debris, boulders, and vegetation armored the bank. Historic riparian harvest had reduced the abundance of large conifers but in general the riparian vegetation was rated as robust and diverse. Numerous logging roads were found above the canyon rim with poor BMPs in place. Briggs Creek, a tributary to the Little Bitterroot River was partially diverted into Hubbart Reservoir; erosion of the diversion appeared to be contributing massive amounts of silt and sand into the reservoir and was indicated as a likely source of fine sediment to the Little Bitterroot River.

In 2011, EPA collected sediment and habitat data at one site on the Little Bitterroot River (LBRT01-01) (**Figure 5-1**). LBRT01-01 is located approximately 0.5 miles downstream of Hubbart Reservoir. There is evidence of timber harvest in the upper watershed, but grazing is the primary land use adjacent to this reach. Pugging and hummocking were noted and the wetland vegetation was heavily browsed, although woody shrubs were well established (**Figure 5-5**). Streamflows were relatively high and appeared to be near bankfull during the site visit in September 2011. The cold water was tannic colored and there was an organic smell coming from the stream. A local rancher indicated that this reservoir is operated for irrigation purposes and the water is shut off in mid-September, leaving only tributary stream inputs to sustain the streamflow. The streambed was composed of fine gravel and sand that easily formed depressions and pools behind LWD and overhanging streamside vegetation. The majority of the channel was a deep run, with a few short riffles. There was a layer of fine material coating the streambed. Extensive hoof shear was observed along the grass-covered streambanks, though streambank erosion was minimal, which is likely associated with the stable streamflows resulting from reservoir operations.

No data were collected at site LBRT01-05, which is on private land approximately one mile from the bottom of the segment, but a site visit was conducted in 2011. This site was similar to LBRT01-01, though the channel was more sinuous and streambank erosion appeared more severe. The channel was a deep run with a streambed comprised of fine gravel and sand, with deep unwadeable pools at the outsides of meander bends. The land around the site is actively used for livestock grazing. Woody vegetation was essentially absent along the stream channel and the wetland vegetation was heavily browsed.

Figure 5-5. Pugging and hummocking observed at station LBRT01-01

Comparison with Water Quality Targets

The existing physical data in comparison with the targets for the Little Bitterroot River are summarized in **Table 5-13**. The macroinvertebrate bioassessment data are located in **Table 5-14**. All bolded cells are beyond 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 the Little Bitterroot River 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			Riparian Health
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	Percent Understory Shrub Cover
LBRT01-01	2011	48.4	B4c, C4	C4	**32**	**25**	**8**	8	32.1	**2.4**	2.0	42	227	78
C12LTBTR 01*	2004	--	--	--	**32**	**26**	**--**	--	**--**	**--**	--	--	--	--

*Data from station C12LTBTR01 were compared to criteria for C streams to be consistent with the 2011 data since stream type was not available for station C12LTBTR01.

Table 5-14. Bioassessment data for the Little Bitterroot River
Values that do not meet the target threshold (≥0.80 for 2004 O/E, ≥0.90 for 2011 O/E, and <51% for periphyton) are in bold.

Station ID	Collection Date	Collection Method	O/E	Periphyton %
C12LTBTR01	8/4/2004	Kick	1.00	**51.6**
C12LTBTR02/ LBRT01-01	8/22/2011	MAC-R-500	**0.83**	--
C12LTBTR03	8/22/2011	MAC-R-500	0.96	--
C12LTBTR02/ LBRT01-01	9/8/2006	--	--	48.5

Summary and TMDL Development Determination

For fine sediment, the riffle pebble count exceeded the targets at both stations with no change from 2004 to 2011. The riffle grid toss value for fine sediment also exceeded the target in 2011 (no data available for 2004). The pool tail grid toss value met the target. The W/D ratio was right at the target and the entrenchment ratio did not meet the target but does meet the Rosgen delineative value of 2.2; given the confinement of the stream channel within the canyon and control that the reservoir exerts on high flows (which tend to shape channel morphology), the channel morphology appears stable and within the expected range. The instream habitat parameters and riparian health parameters all met their targets. Of the two periphyton samples, the one collected in 2004 was slightly over the target of 51% and a 2006 sample was slightly below the target. One of the three macroinvertebrate samples failed to meet the target, and it was collected in 2011 at the sediment/habitat site (LBRT01-01).

Habitat indicators look good but fine sediment measurements indicate fine sediment levels have not improved since 2004. Both the levels of fine sediment and biological data indicate excess fine sediment may be limiting the Little Bitterroot River's ability to fully support aquatic life. This information supports the sediment impairment listing and a sediment TMDL will be developed for the Little Bitterroot River.

5.4.2.4 Little Thompson River (MT76N005_040)

The Little Thompson River (MT76N005_040) flows 19.92 miles from its headwaters to its confluence with the Thompson River and is listed for sedimentation/siltation on the 2012 303(d) List. In addition, this segment is also listed for alteration in stream-side or littoral vegetative covers, which is a non-pollutant listing commonly linked to sediment impairment. The Little Thompson River was originally listed in 1996 because of excess sediment associated with agriculture and rangeland.

Physical Condition and Sediment Sources

The upper watershed is predominantly USFS land, while the lower watershed is a mix of state-owned land and private timber land (**Appendix A**, **Figure A-15**). The USFS, DNRC, and Plum Creek cooperatively manage grazing in the Little Thompson River watershed. The USFS's Little Thompson and McGinnis Grazing Allotments are located in the headwaters of the watershed (U.S. Forest Service, 2009). The Little Thompson Grazing Allotment is used in connection with approximately 1,280 acres of private land. The grazing occurs from June 15 through September 15 with 110 cattle permitted. The allotment is managed as three pastures under a rotation system. Each pasture is grazed two out of every three years: year 1 is grazed early, year 2 is grazed late, and year 3 is rested. The McGinnis Allotment is active from June 1 through September 30 with 52 cattle permitted (USFS, personal communication 2013[3]).

For private timber land, Plum Creek is a major landowner in the Thompson Project Area. A substantial portion of Plum Creek land in the Little Thompson River watershed is included in the conservation

[3] Personal communication with Randy Hojem, Plains/Thompson Falls District Ranger, Lolo National Forest. 2013

easement Fish, Wildlife and Parks (FWP) owns in the Thompson River watershed. The state of Montana acquired the easement in several phases between 2001 and 2003. It precludes development, but allows traditional uses such as forestry, grazing, hunting, and fishing. Public access is secured through this easement (Plum Creek, personal communication 2013[4]). Most of the Plum Creek land in the Little Thompson River watershed is leased for grazing. Plum Creek requires the leaseholder to prepare a Range Management Plan annually that includes animal units and discusses grazing practices and BMPs. Additionally, the leaseholder must monitor conditions twice a year (mid and end of season) and document an improving trend where environmental conditions are unacceptable. In general, the land is used for grazing from June through September and works on a rest-rotation system where some pastures are grazed whiles others are rested. The grazing pastures are rotated regularly (Plum Creek, personal communication 2013[4] and 2014[5]).

In 2004, DEQ collected some sediment and habitat data at four sites dispersed from the upper watershed to the mouth: C13LTTPR10, C13LTTPR20, C13LTTPR30, and C13LTTPR40 (**Figure 5-1**). At the uppermost site (C13LTTPR10), pools were shallow, a high amount of silt was observed in the channel, and gravel, sand, and silt were forming new point bars. Breaks in the riparian vegetation were common, with riparian growth and LWD cited as being below potential. Erosion was common on most outside bends and channel constrictions. Field notes at the upper site indicated logging and livestock use was common and some grazing impacts were observed in the riparian zone.

The next downstream site, C13LTTPR20, was just downstream of the confluence with McGinnis Creek. Some sediment deposition was observed in pools but the streambanks appeared stable with no evidence of erosion and good streambank vegetation. Between this site and C13LTTPR30, which was located downstream of the North Fork, signs of instability were apparent and the river was commonly braided. Directly below the confluence with the North Fork Little Thompson River a section of channel was observed that had downcut about three feet and the streambanks were severely eroding. Large depositional features were common at C13LTTPR30 with abundant cobble and a small amount of sediment present with increasing amounts of silt in the upstream direction. It appeared the channel was starting to narrow and vegetative growth was observed on point bars. There was evidence of large peak flows observed in an overflow channel. Some manmade bed control structures were also observed. Roads, grazing, and logging were indicated on the field form as causing moderate amounts of disturbance in the watershed.

The site nearest the mouth, C13LTTPR40, had no indications of human disturbance and the channel was predominately boulder-dominated pools. The river flowed through a narrow canyon near the mouth with steep slopes and conifers. The stream channel was almost at a 4% gradient and was extremely armored and stable. Vegetation appeared to be near potential and instream habitats were diverse, including abundant woody debris and deep pools. Streambanks were stable with good riparian vegetation and little erosion was observed.

In 2011, EPA collected sediment and habitat data at two sites on the Little Thompson River: LTMP12-01 and LTMP14-03 (**Figure 5-1**). LTMP12-01 is located approximately 1 mile upstream of the confluence with the North Fork Little Thompson River and 2 miles upstream of C13LTTPR30. The Little Thompson River Road is situated on the river hillslope. A dense band of alders line the stream channel along this reach, covering the narrow valley bottom, and conifers are growing on the hillslopes. Evidence of

[4] E-mails from Brian Sugden, Plum Creek Hydrologist to Eugenia Hart, Tetra Tech in September 2013
[5] 4/22/14 E-mail from Brian Sugden, Plum Creek Hydrologist to Lisa Kusnierz, EPA

historic logging was observed but grazing is now the primary land use along this reach. Selective browsing of the wetland vegetation along the channel margin was observed and hoof shear was noted along the streambanks. The streambed was comprised of large gravel and cobble, with a good distribution of riffles and pools. Multiple depositional features suggest aggradation is occurring and the channel was braided in the upper part of the reach. In places, the depositional features constrict the channel, leading to the formation of deep pools, though the large substrate size limits spawning potential. Flow constrictions due to depositional features also lead to localized streambank erosion, though the streambanks were composed of coarse gravel and cobbles, which likely limits the overall erosion rate. A layer of fine silt was noted in slow water areas, potentially from aerial deposition from the adjacent roadbed. Overlapping cobbles on point bars suggest active bedload transport.

LTMP14-03 is located approximately 0.6 miles upstream of the mouth where the Little Thompson River joins the Thompson River and approximately 0.35 miles upstream of site C13LTTPR40. Like the upper site, evidence of historic logging was observed but grazing is now the primary land use along this reach. The stream channel was primarily composed of riffle habitat with a cobble substrate and a few deep pools formed by LWD, which was generally limited throughout the reach. Pool tails are typically identified as potential spawning locations but at this site only a few potential spawning locations were identified at the edge of pools. Streambanks were generally armored with larger cobbles (**Figure 5-6**), which likely limit overall bank retreat, though some channel over-widening was observed. The riparian corridor included alder and conifers. Marten Creek, which is a tributary to the Little Thompson River entering at the downstream end of the LTMP14-03 monitoring site, was slightly turbid during the September 2011 site visit, indicating there may be sediment sources in that drainage.

Figure 5-6. Presence of cobble along streambanks at site LTMP14-03 on the Little Thompson River

Comparison with Water Quality Targets

The existing physical data in comparison with the targets for the Little Thompson River are summarized in **Table 5-15**. The macroinvertebrate bioassessment data are located in **Table 5-16**. All bolded cells are beyond the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-15. Existing sediment-related data for the Little Thompson River 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			Riparian Health
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	Percent Understory Shrub Cover
LTMP14-03	2011	41.1	B3c, B4c,C4	C3	3	2	2	5	31.6	**2.2**	**1.3**	26	**121**	64
LTMP12-01	2011	28.4	F3,C3, B3c	B3	1	0	2	--	**33**	1.8	1.4	48	253	90
PIBO_3004[a]	2010	19.7	--	--	--	--	--	--	18.3	--	0.7	**13**	**--**	--
PIBO_139[a]	2004	19.2	--	--	--	--	--	**18**	**27.0**	--	0.8	**38**	**170**	--
PIBO_139[a]	2004	18.5	--	--	--	--	--	**24**	**26.6**	--	0.7	89	**249**	--
PIBO_139[a]	2006	21.0	--	---	--	--	--	1	**23.7**	--	**0.6**	93	**241**	--
PIBO_139[a]	2007	18.0	--	--	--	--	--	5	**25.0**	--	0.7	**66**	**199**	--
PIBO_139[a]	2008	17.1	--	--	--	--	--	0.4	19.3	--	0.6	**61**	**339**	--
PIBO_139[a]	2009	21.6	--	--	--	--	--	3	19.7	--	**0.5**	122	434	--
PIBO_139[a]	2010	22.8	--	--	--	--	--	0	16.6	--	**1.0**	**27**	380	--
PIBO_139[a]	2011	20.7	--	--	--	--	--	1	16.3	--	0.6	82	435	--
PIBO_139[a]	2012	20.2	--	--	--	--	--	1	15.1	--	0.7	64	684	--
C13LTTPR10[b]	2004	10.3	E4	--	**43**	**42**	--	--	**11.7**	8.6	**--**	--	--	--
C13LTTPR20[b]	2004	34.3	C4	--	**30**	**29**	--	--	24.0	3.2	**--**	--	--	--
C13LTTPR30[b]	2004	23.4	C3	--	**18**	**16**	--	--	14.1	6.41	**--**	--	--	--
C13LTTPR40[b]	2004	42	B3	--	**16**	**15**	--	--	25.2	1.4	**--**	--	--	--

[a]Note that these parameters were compared to the criteria for B/C streams to be consistent with the 2011 data because there was no Potential stream type available for the PIBO stations. These sites are near station C13LTTPR20, which also is a type C stream and the bankfull widths are in the same range as the other B and C streams.
[b]These parameters were compared to the criteria for the existing stream type because there was no potential stream type available for the 2004 sampling stations.

Table 5-16. Bioassessment data for the Little Thompson River
Values that do not meet the target threshold (≥0.80 for 2004 O/E, ≥0.90 for 2011 O/E, and <51% for periphyton) are in bold.

Station ID	Collection Date	Collection Method	O/E	Periphyton %
C13LTTPR10	8/26/2004	Kick	**0.60**	28.2
C13LTTPR20	8/26/2004	Kick	**0.66**	28.2
C13LTTPR30	8/27/2004	Kick	1.14	25.1
C13LTTPR40	8/27/2004	Kick	0.91	24.8
C13LTTPR01 (near C13LTTPR40)	8/24/2011	MAC-R-500	0.94	42.7
C13LTTPR02	8/24/2011	MAC-R-500	**0.87**	45.5
C13LTTPR40	8/10/2007	--	--	**80.1**
C13LTTPR40	9/4/2006	--	--	**80.1**

Summary and TMDL Development Determination
For fine sediment, all four 2004 observations exceeded the targets but both sites easily met the riffle pebble count target in 2011. Most of the PIBO data are from the same site, and both values in 2004 at PIBO_239 exceeded the pool tail grid toss target but all other samples at that site and other sites met the grid toss target. The width/depth ratio target was not met at the upper site in 2011 (LTMP12-01) and just barely met at the lower site (LTMP14-03); site PIBO_139 prior to 2008; and at the uppermost site in 2004 (C13LTTPR10). All of the width/depth ratio target exceedances occurred upstream of the North Fork Little Thompson River. The entrenchment ratio did not meet the target at station LTMP14-03 in 2011 but the value does meet the Rosgen delineative criterion. The instream habitat parameters and riparian health parameters observed in 2011 all met their targets at station LTMP12-01 (upstream station), but neither the residual pool depth nor LWD frequency targets were met at station LTMP14-03 (downstream station). Pool frequency was not met at PIBO_3004 in 2010 and four of the nine samples from PIBO_139 did not meet the target (between 2004 and 2010). The LWD frequency target was also not met at LTMP14-03 in 2011 and five of the nine samples at PIBO_139 (between 2004 and 2008).

Two of the eight periphyton samples exceeded the target of 51% and three of the six macroinvertebrate samples were not meeting the target. Both of the periphyton target exceedances occurred at station C13LTTPR40 in 2006 and 2007, which is located at the mouth of the Little Thompson River. The macroinvertebrate exceedances all occurred upstream of the North Fork, which is where most of the channel instability has been observed.

The fine sediment measurements in 2011 and at PIBO_139 over the past several years indicate fine sediment levels have declined in the Little Thompson River since 2004, and the pattern of decreasing W/D ratios and increasing LWD frequency at PIBO_139 indicate sediment and habitat improvements through the watershed. However, the overwidened channel, residual pool depth failures, observations of aggradation, and biological metrics indicate excess sediment is still limiting aquatic life support in the Little Thompson River. This information supports the sediment impairment listing and a sediment TMDL will be developed for the Little Thompson River.

5.4.2.5 Lynch Creek (MT76N003_010)
Lynch Creek (MT76N003_010) extends 13.3 miles from its headwaters to its mouth at the confluence with the Clark Fork River and is listed for sedimentation/siltation on the 2012 303(d) List. In addition, this segment is also listed for alteration in stream-side or littoral vegetative covers, which is a non-pollutant listing commonly linked to sediment impairment.

Physical Condition and Sediment Sources

There is more development in the Lynch Creek watershed than other sediment-impaired watersheds in the Thompson Project Area. There are 446 acres of pasture/hay in the watershed that appear to be concentrated near the mouth of the creek (Homer et al., 2007). The lower portion of Lynch Creek is just outside the town of Plains, MT, which has a population of 1,074 (United States Census Bureau, 2010).

In 2004, DEQ collected some sediment and habitat data at three sites: C13LYNCC10, C13LYNCC20, and C13LYNCC30 (**Figure 5-1**). Station C13LYNCC10 represented upper Lynch Creek, a forested section extending from the headwaters to Cedar Creek. No data were collected at the site because the stream was intermittent and mostly dry but notes regarding sediment sources and channel conditions were recorded. The only flow was in small spring-fed sections. The channel was generally stable except for a channelized section in the canyon where the road left a buffer no greater than 5 feet and no room for the stream to meander. Vegetation in this stretch was almost non-existent and heavy cattle grazing exasperated these problems. Road fill was entering the channel directly and cutslopes and road crossings were active sediment sources. Silt, sand, and gravel were in the stream channel from the road. Several gravel bars were observed in the channel. The area above the channelized section, which was just upstream of the confluence with Cedar Creek had a much wider riparian zone that averaged about 55 feet. Riparian vegetation throughout the reach was lacking in diversity and very limited.

Station C13LYNCC20, which was in middle Lynch Creek just above the confluence with Hinchwood/Clark Creek, ran through forested and agricultural land that was moderately used for grazing. There appeared to be a minimal amount of irrigation withdrawal. The stream channel was braided, but it appeared to be natural and not due to alterations. Sediment deposition occurred as a light layer of silt over the cobble substrate with a moderate buildup in pools and moderate deposition at constrictions. Pools were present but shallow. Streambank stability and riparian vegetation were in good condition. There was very little erosion present at cattle crossings, and streambank erosion was localized to a few private sections that were more heavily grazed.

Site C13LYNCC30 was located near the mouth of Lynch Creek. Livestock use was minimal in this reach. Land uses causing moderate disturbance in this section of the stream in 2004 were irrigation and cropland. This reach was characterized by a lack of woody species in the riparian area, a historically straightened channel, and a moderate amount of streambank erosion. The stream had been channelized in the past and was incised about 4 feet at the time of the assessment. Reed canary grass was very thick and lined the banks while woody species were lacking. The only riffle section was dominated by fine gravels and the bottom substrate consisted of about 3-4 inches of silt. Irrigation for hay fields was common in this section as well.

In 2011, EPA collected sediment and habitat data at two sites on Lynch Creek: LNCH09-01 and LNCH12-02 (**Figure 5-1**). LNCH09-01 is located just above Cedar Creek in a forested area that was likely logged at one time. Signs of grazing were observed at the monitoring site (**Figure 5-7**). Extensive gravel deposits suggest this reach is aggrading (**Figure 5-7**), which is caused when sediment inputs to a stream exceed its transport capacity. Historic logging along the channel margin may have destabilized the streambanks, leading to channel over-widening and aggradation. Those factors, coupled with a lack of deep pools, limits the amount of quality fish habitat within this reach. Streambank erosion was frequent, often occurring where gravel bars direct the flow toward the bank, with the stream commonly eroding into the surrounding forest floor. Understory shrub cover was lacking due to the dense coniferous overstory.

LNCH12-02 is located downstream of the Lower Lynch Creek Road crossing in an area used for livestock grazing and irrigation water diversion. Hummocking and hoof trampling was noted along the channel margins, resulting in stream channel over-widening and streambank erosion. Streambanks were generally composed of loose cobble and relatively unconsolidated soil. The stream channel fluctuates between single and multiple channels dominated by coarse gravel and small cobble. There were several deep pools with undercut streambanks, which provide good fish habitat. Streambank erosion was common and streamside vegetation was comprised primarily of hawthorn and alder, with a few cottonwood trees.

Figure 5-7. Evidence of grazing along the streambanks (left) and sediment aggradation in the stream channel (right) at LNCH09-01

Comparison with Water Quality Targets

The existing physical data in comparison with the targets for Lynch Creek are summarized in **Table 5-17**. The macroinvertebrate bioassessment data are located in **Table 5-18**. All bolded cells are beyond 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 Lynch 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			Riparian Health
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	Percent Understory Shrub Cover
LNCH09-01	2011	11.3	C4b, F4b	B4	3	3	4	8	19.9	4.2	0.8	95	**259**	**9**
LNCH12-02	2011	18.7	E4,C4,C3	C4	2	2	4	--	18.9	6.3	1.3	**79**	**264**	**35**

Table 5-18. Bioassessment data for Lynch Creek

Values that do not meet the target threshold (≥0.80 for 2004 O/E, ≥0.90 for 2011 O/E, and <51% for periphyton) are in bold.

Station ID	Collection Date	Collection Method	O/E	Periphyton %
C13LYNCC20	9/7/2004	Kick	1.36	43.4
C13LYNCC30	9/7/2004	Kick	1.01	**67.2**
C13LYNCC05/ LNCH09-01	8/25/2011	MAC-R-500	1.01	**52.6**
C13LYNCC09/ LNCH12-02	8/25/2011	MAC-R-500	**0.44**	**55.8**
C13LYNCC01	9/4/2006	DEQ	--	**72.2**
C13LYNCC01	9/3/2011	MAC-R-500	**0.33**	**70.5**
C13LYNCC03	9/3/2011	MAC-R-500	**--**	42.3
C13LYNCC04	9/4/2011	MAC-R-500	**0.46**	41.2
C13LYNCC05	9/4/2011	MAC-R-500	0.96	41.5
C13LYNCC07	9/5/2011	MAC-R-500	**0.63**	**90.4**
C13LYNCC08	9/5/2011	MAC-R-500	--	**57.3**

Summary and TMDL Development Determination

For fine sediment, the riffle pebble count and grid toss values all met their targets. All of the channel morphology parameters and residual pool depth values also met their targets. The LWD frequency did not meet the target at the upper site (LNCH09-01) in 2011 and the pool and LWD frequencies did not meet their respective targets at the lower site (LNCH12-02). The riparian health target for understory shrub cover was not met at either site in 2011, but was at its potential at the upper site because of the dense coniferous overstory. Seven of the 11 periphyton samples exceeded the target of 51%. These exceedances occurred at sites throughout Lynch Creek. Four of the eight macroinvertebrate samples were not meeting the target, and three of the failures are at the same sites not meeting the periphyton target. The sites not meeting the macroinvertebrate target were also located throughout Lynch Creek.

Although indications of excess sediment loading and fine sediment are not apparent in the sediment and habitat data collected in 2011, the field observations of aggradation and channel instability combined with the numerous exceedances of the macroinvertebrate and periphyton targets indicate sediment is limiting full support of aquatic life. This information supports the sediment impairment listing and a sediment TMDL will be developed for Lynch Creek.

5.4.2.6 McGinnis Creek (MT76N005_070)

McGinnis Creek (MT76N005_070) extends for 5.12 miles from its headwaters to its mouth at the confluence with the Little Thompson River and is listed for sedimentation/siltation on the 2012 303(d) List. It was originally listed in 1996 due to excess sediment associated with agriculture and rangeland.

Physical Condition and Sediment Sources

In 2004, DEQ collected some sediment and habitat data at two sites: C13MCGNC10 and C13MCGNC20 (**Figure 5-1**). C13MCGNC10 was located near the headwaters and C13MCGNC20 was located near the mouth but both sites were on USFS land, which owns almost all of the watershed (**Appendix A**, **Figure A-15**). According to the DEQ assessment file, 15% of the watershed had been harvested in the 30 years preceding the 2004 field work, but not many impacts were observed directly in the stream channel. Some evidence of logging was seen at the upper site but a higher degree of historic logging, particularly closer to the stream channel, was noted at the lower site. There was also a grazing allotment near the stream, but it appeared to be managed well with little to no eroding streambanks or hoof shear. Forty-two percent of the stream was within 300 feet of a road and 15% of the stream had a road within 150 feet. The water was slightly turbid, likely because of rain preceding the site visit, but total suspended sediment concentrations were low.

Both sites were noted as having sub-optimal substrate, but more details were provided about the lower site, which had frequent sediment deposits around obstructions, some braiding and enlargement of point bars, and a limited number of shallow pools. The stream was noted as having a heavy bedload. The riparian zone was rated as acceptable at both sites but was more diverse near the mouth. It appeared as if the riparian area had recovered significantly since the original listing. Grazing was noted as a source when the stream was listed, but in 2004 cattle were not heavily using the riparian zone and no habitat alterations were documented. LWD was abundant throughout the stream. Eroding streambanks at the upper site were in the process of healing and the streambanks at the lower site were more stable. Overall, DEQ determined sediment, physical barriers, pool frequency, refugia, and road density were all functioning at unacceptable risk.

In 2011, EPA collected sediment and habitat data at two sites on McGinnis Creek: MGNS02-01 and MGNS03-01 (**Figure 5-1**). MGNS02-01 was located near C13MCGNC10, upstream of the uppermost road crossing in an area that has re-grown following historic timber harvest. The stream character was noted to be a small mountain stream in a forested habitat. Signs of livestock grazing were observed. Frequent LWD led to the formation of small pools. Streambed substrate was composed of cobbles and small boulders and spawning potential was limited, though some small pockets of spawning-sized gravels were observed. Streambank erosion was limited, primarily occurring in areas where LWD directed flow towards the streambank. A dense coniferous overstory limits the development of riparian shrubs, though some alders occur along the channel margin (**Figure 5-8**).

MGNS03-01 was located approximately 0.5 mile upstream of the mouth and the Corona Road crossing, near C13MCGNC20. This site was much wider with more flow than the upper site. Numerous fallen trees spanned the channel, though most remained elevated above the streambed and had relatively little influence on channel morphology. Pools were generally shallow and formed by LWD across the channel. Timber harvest is the primary land use in the watershed and likely occurred along this site at one time, though the reach is now forested, with alders along the channel margin and conifers in the overstory. Streambank erosion was limited by the large angular cobble material that covered the streambanks.

Figure 5-8. Dense coniferous overstory along McGinnis Creek

Comparison with Water Quality Targets

The existing physical data in comparison with the targets for McGinnis Creek are summarized in **Table 5-19**. The macroinvertebrate bioassessment data are located in **Table 5-20**. All bolded cells are beyond the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-19. Existing sediment-related data for McGinnis 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			Riparian Health
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	Percent Understory Shrub Cover
MGNS02-01	2011	8.5	C4b, E4b, E3b,B4	B3	**16**	**12**	**9**	**24**	11.3	3.9	0.7	180	623	**48**
MGNS03-01	2011	18.7	F3b,B3,C3b	B3	4	3	1	--	16.8	1.6	1.0	**37**	681	**53**
PIBO_1540[a]	2005	21.8	--	--	--	--	--	**74**	13.6	--	**1.0**	70	**--**	**--**
PIBO_1540[a]	2010	22.6	--	--	--	--	--	2	15.7	--	1.3	**26**	1,019	**--**
PIBO_1541[a]	2010	31.3	--	--	--	--	--	--	14.0	--	3.3	**26**	**--**	**--**

Table 5-19. Existing sediment-related data for McGinnis 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			Riparian Health
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	Percent Understory Shrub Cover
C13MCGNC10[a]	2004	--	--	--	**43**	**43**	--	--	--	--	--	**--**	**--**	**--**
C13MCGNC20[b]	2004	25.2	C3	--	**29**	**29**	--	--	**22.1**	**2.3**	--	**--**	**--**	**--**

[a]Note that these parameters were compared to the criteria for B streams to be consistent with the 2011 data because there was no Potential Stream Type available for the PIBO sites at C13MCGNC10.
[b]Note that these parameters were compared to the criteria for C streams (existing conditions) because there was no Potential Stream Type available for the 2004 data.

Table 5-20. Bioassessment data for McGinnis Creek
Values that do not meet the target threshold (≥0.80 for 2004 O/E, ≥0.90 for 2011 O/E, and <51% for periphyton) are in bold.

Station ID	Collection Date	Collection Method	O/E	Periphyton %
C13MCGNC10	8/25/2004	Kick	0.84	36.3
C13MCGNC20	8/25/2004	Kick	**0.62**	22.7
C13MCGNC01/ MGNS03-01	8/26/2011	MAC-R-500	**0.64**	25.1
C13MCGNC10/ MGNS02-01	8/26/2011	MAC-R-500	**0.67**	43.6

Summary and TMDL Development Determination

For fine sediment, both sites exceeded the riffle pebble count targets in 2004, and although values were much lower in 2011, both target values were exceeded at the upper site in 2011. Grid toss riffle and pool tail values were also exceeding their targets at the upper site in 2011 (MGNS02-01), but not at the downstream site. The grid toss value for pool tails was also exceeded at site PIBO_1540 (above Foolhen Creek) in 2005, but the 2010 values indicate an improvement since that time. All of the channel morphology parameters met their target values except at site C13MCGNC20 (near the mouth) in 2004, also indicating improvement. All of the instream habitat parameters were meeting the targets in 2011 except for pool frequency near the mouth at site MGNS03-01. Additional instream habitat targets were also exceeded in 2005 and 2010 at sites PIBO_1540 (above Foolhen Creek) and PIBO_1541 (at the mouth) (see **Table 5-19**). The riparian health target for understory shrub cover was not met at either site in 2011, but given the dense coniferous overstory and general observations of the riparian habitat, the riparian vegetation is at its potential. None of the four periphyton samples exceeded the target of 51% but three of the four macroinvertebrate samples did not meet the target, including both samples from 2011. Macroinvertebrate scores can be affected by a variety of stressors other than sediment, but given the failure of fine sediment target at MGNS02-01 and that the periphyton percentage is close to the target at the same site, this indicates the macroinvertebrates at the upper site are likely being affected by excess sediment.

Although McGinnis Creek appeared to be improving in 2004 and has continued to improve, recent data indicate excess sediment is still limiting its ability to fully support aquatic life, particularly in the upper watershed. This information supports the sediment impairment listing and a sediment TMDL will be developed for McGinnis Creek.

5.4.2.7 McGregor Creek (MT76N005_030)

The impaired portion of McGregor Creek (MT76N005_030) extends 6.82 miles from McGregor Lake to the mouth of the creek at the confluence with the Thompson River and is listed for sedimentation/siltation on the 2012 303(d) List. It was originally listed in 1996 because of excess sediment associated with timber harvest.

Physical Condition and Sediment Sources

In 2004, DEQ collected some sediment and habitat data at two sites on McGregor Creek: C13MCGRC10 and C13MCGRC20 (**Figure 5-1**). The predominant land uses in the basin were timber management and recreation, and major water level disturbances were observed due to irrigation. Site C13MCGRC10 was located just below the McGregor Lake outlet in an area owned by the USFS. The major disturbances at this location were flow regulation from McGregor Lake, channelization from Highway 2, and timber harvest. The outlet of McGregor Lake was controlled for irrigation by ranchers on private land near the mouth of McGregor Creek. The only water making it down the channel was whatever spilled over the headgate. It was thought that the stream was not getting purging flows to clean out the channel in the spring. The steam's substrate did not appear natural at this location; it was very angular and did not match the underlying material. The source was identified as possibly road fill or rip-rap from Highway 2, as the creek is channelized by Highway 2 in this section. There were silt fences present but many of them were not being maintained and were not functioning properly. There was also an abundance of sand in the channel at this location embedding particles about 55%. The majority of the pools were shallow.

Site C13MCGRC20 was closer to the mouth of the stream, where agriculture was the dominant land use. The riparian zone was dominated by reed canary grass, making the streambanks very stable, but there was a lack of woody and native vegetation. The channel was very narrow and deep and flowed through a valley bottom that was used for hay production. The extent of the riparian zone was the buffer the rancher left when cutting hay. There was a lot of sediment deposition forming new bars and accumulating on old bars consisting of mostly sand. The flow in this portion of the stream was considerably less than the upstream portion due to irrigation. Bank erosion was occurring on some outside bends. The stream channel was also used to water cattle, but because of the channel dimension, it was difficult for them to access and access was restricted to few locations. Therefore, disturbance from cattle was minimal. The largest problem appeared to be the modified flow regime. Fish habitat was rated as marginal to sparse for the entire stream and was lacking complexity.

In 2011, EPA collected sediment and habitat data at two sites on McGregor Creek: MCGR02-03 and MCGR06-02 (**Figure 5-1**). The MCGR02-03 monitoring site is located approximately 1.2 miles downstream of McGregor Lake and streamflow is regulated for irrigation purposes. Highway 2 crosses the stream on a large fill slope approximately 500 feet upstream of the monitoring site. Timber harvest has occurred along this monitoring site and throughout the McGregor Creek watershed. The small stream channel appeared extremely stable and wetland vegetation was growing into the flowing portion of the channel. The channel contained a cobble substrate and was often spanned by fallen trees, though pool formation was limited. Wetland vegetation lined the entire reach, along with sparse young alders, and the wetland vegetation prevented exposed streambanks and limited erosion. **Figure 5-9** (left photo) shows the upstream portion of McGregor Creek.

MCGR06-02 is located in the middle section of McGregor Creek that runs along Highway 2, which has confined the valley bottom reducing the stream's access to the floodplain. Alders and red osier dogwood line the stream channel, with a forested hillslope on one side of the stream and Highway 2 on the other. Historic timber harvest, channelization by Highway 2, and flow regulation from McGregor Lake appear to be the primary human disturbances along this reach. The stream channel contains a stable riffle-pool sequence with a streambed composed of gravel, cobble, and small boulders. The boulder-formed pools tend to lack spawning-sized substrate. Streambank erosion is limited by the extensive shrub cover and large streambank material, while relatively stable streamflow from McGregor Lake may also play a role.

Site MCGR09-03/04 was visually assessed in 2011 to help better characterize McGregor Creek. MCGR09-03/04 is located upstream of the confluence with the Thompson River and is dramatically different than the upstream reaches. During the site visit a local ranch caretaker indicated that McGregor Creek "ends" upstream of this site and this portion of McGregor Creek is considered to be a ditch. In this reach, McGregor Creek has been channelized to flow through a field used for irrigated agriculture. The stream channel is narrow, deep and somewhat entrenched, with a fine sediment substrate and reed canary grass lining the streambanks (**Figure 5-9**, right photo). Streambank erosion, a lack of riparian shrub cover, and a streambed dominated by fine sediment was also observed along the Thompson River downstream of the confluence with McGregor Creek.

Figure 5-9. Wetland vegetation and fallen trees at upper McGregor Creek (MCGR02-03) (left) and channelized lower portion of McGregor Creek lined by reed canary grass (right)

Comparison with Water Quality Targets

The existing physical data in comparison with the targets for McGregor Creek are summarized in **Table 5-21**. The macroinvertebrate bioassessment data are located in **Table 5-22**. All bolded cells are beyond the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-21. Existing sediment-related data for McGregor 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			Riparian Health
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	Percent Understory Shrub Cover
MCGR02-03	2011	11.9	C3, E3	E3	28	**27**	0	--	**11.9**	17.6	0.6	**74**	792	78
MCGR06-02	2011	19.3	B4c ,C4	B4	3	1	2	8	16.3	2.2	0.8	**69**	**164**	89
C13MCG RC10[a]	2004	--	--	--	**31**	**31**	--	--	--	--	--	**--**	**--**	--
C13MCG RC20[b]	2004	--	--	--	**74**	**70**	--	--	--	--	--	**--**	**--**	--

[a]Note that these parameters were compared to the criteria for E streams to be consistent with the 2011 data because there was no Potential Stream Type available for the 2004 data.
[b]Note that these parameters were compared to the criteria for B streams to be consistent with the 2011 data because there was no Potential Stream Type available for the 2004 data.

Table 5-22. Bioassessment data for McGregor Creek
Values that do not meet the target threshold (≥0.80 for 2004 O/E, ≥0.90 for 2011 O/E, and <51% for periphyton) are in bold.

Station ID	Collection Date	Collection Method	O/E	Periphyton %
C13MCGRC10	9/3/2004	Kick	**0.42**	**71.7**
C13MCGRC20	9/3/2004	Kick	0.93	**92.3**
C13MCGRC01	9/8/2006	--	--	29.0
C13MCGRC02	8/23/2011	MAC-R-500	**0.46**	40.6
C13MCGRC03/ MCGR06-02	8/23/2011	MAC-R-500	**0.73**	**55.2**
C13MCGRC20	8/23/2011	MAC-R-500	**0.27**	**65.6**
C13MCGRC02	7/12/2012	MAC-R-500	**0.64**	41.9
C13MCGRC03/ MCGR06-02	7/11/2012	MAC-R-500	**0.88**	33.1

Summary and TMDL Development Determination

For fine sediment, the riffle pebble count was exceeding both targets at sites C13MCGRC10 (just below McGregor Lake) and C13MCGRC20 (near the mouth) in 2004 and exceeding the 2mm target at MCGR02-03 (downstream of McGregor Lake) in 2011. There were no exceedances of the fine sediment parameters at site MCGR06-02 (middle of the stream) in 2011. There does not appear to be much of a change in fine sediment in the upper portion of the watershed since 2004 and there are no 2011 data available near the mouth of the creek for a comparison to the 2004 data. However, observations at MCGR09-03/04 (described above) indicate fine sediment levels are still high near the mouth. As noted during the 2004 field work, the flow control by the headgate at the lake outlet likely limits the stream's ability to flush fine sediment downstream. The width/depth ratio target was also exceeded at site

MCGR02-03 (downstream of McGregor Lake) in 2011, but does meet the Rosgen criterion for E channels and all other channel morphology parameters met their target values. This combined with the limited streambank erosion indicates that the channel morphology is stable. The residual pool depth target was met at both sites in 2011 and the pool frequency target was not met at both sites but was close. The LWD frequency target was not met at site MCGR06-02 (middle portion of the impaired segment), and is likely not met closer to the mouth given the herbaceous monoculture that dominates the riparian zone in the lower part of the segment. The percent understory shrub cover target for riparian health was met at both sites. Four of the eight periphyton samples exceeded the target of 51%. The exceedances occurred at sites C13MCGRC10 and C13MCGRC20 in 2004 and sites C13MCGRC03 and C13MCGRC20 in 2011. Six of the seven macroinvertebrate samples were below the target, and three of the failures correspond to failures of the periphyton target, which indicates sediment is limiting support of aquatic life. The sites that failed to meet both biological targets are scattered throughout the segment.

Site MCGR06-02 indicates fine sediment levels are low in the middle part of McGregor Creek but data in upper McGregor Creek and observations near the mouth indicate fine sediment values in McGregor Creek have not improved since 2004 and that excess sediment is impairing aquatic life. This information supports the sediment impairment listing and a sediment TMDL will be developed for McGregor Creek.

5.4.2.8 Sullivan Creek (MT76L002_070)

The impaired portion of Sullivan Creek (MT76L002_070) flows for 3.9 miles from the headwaters to the Flathead Reservation boundary and is listed for sedimentation/siltation on the 2012 303(d) List. This segment is also listed for alteration in stream-side or littoral vegetative covers, which is a non-pollutant listing commonly linked to sediment impairment.

Physical Condition and Sediment Sources

Mining, grazing, and timber harvest are the dominant land uses in the Sullivan Creek watershed. Plum Creek owns much of the land in the watershed, all of which is leased for grazing. The land is grazing from June through September and works on a rest-rotation system where some pastures are grazed while others are rested. The grazing pastures are rotated regularly (Plum Creek, personal communication 2013[6]). There are a number of abandoned mines in the upper watershed, and one with a current operating permit that is fairly close to Sullivan Creek: the Hog Heaven mine. The operating permit for the Hog Heaven mine was issued in 1984 and has not been active. The site has changed ownership a few times since 1984 and is currently owned by Pan American Silver Corporation. Almost all mining at the site occurred between 1930 and 1942. The site is 1,300 acres and the permitted disturbance area is 375 acres. The site is permitted for open pit, underground, and vat leaching forms of mining. Pan American Silver has continued to maintain the site including reclamation of some historic mining disturbances, removal of old buildings, closure of hazardous mine openings, filling of caved stopes, and spraying of noxious weeds. The mine currently has no discharge permits, and site visits by DEQ have indicated that there does not appear to be any stormwater flow from the Hog Heaven site to Sullivan Creek, which begins about a mile south of the mine. During a site visit in a wet spring (2011), there was no evidence of stormwater leaving the mine site.

In 2004, DEQ visited two sites to collect sediment and habitat data: C12SLVNC01 and C12SLVNC02; however data were only collected at C12SLVNC01, which was 0.5 miles downstream of Flathead Mine Road (**Figure 5-1**). Streamflow at that site was noted to be a trickle but was barely flowing and mostly stagnant at site C12SLVNC02, which was just downstream of the road. Sullivan Creek is spring-fed and

[6] E-mails from Brian Sugden, Plum Creek Hydrologist to Eugenia Hart, Tetra Tech in September 2013.

intermittent; one section in the upper watershed was flowing, while the lower section was dry. The upper section also contained a swampy area that was disturbed by mining. Cattle impacts were heavy throughout most of the watershed; streambanks were trampled and riparian vegetation was degraded or missing, and the channel morphology had been altered by grazing. Grazing-induced bank erosion was common. Some riparian areas contained vegetation consisting of mature conifers and plant litter with little brush. In other areas the vegetation consisted of closely cropped grass with no overstory due to grazing. The stream’s substrate was mostly silt, with some cobble. The channel was dry or absent in some areas and subsurface flows predominated the segment. Mine tailings were found near the floodplain and some sort of mine reclamation appeared to have taken place in the upper watershed.

DEQ planned to collect sediment and habitat data at two sites in 2011 (shown on **Figure 5-1**), but no data were collected because there was no defined stream channel in either reach. The 2011 site visit supports the 2006 assessment in that the upper reach was a marshy, intermittent stream with no well-defined channel that goes subsurface. The lower proposed monitoring reach was a dry grassy swale when visited. **Figure 5-10** shows the marshy, grassy nature of Sullivan Creek and evidence of silt in the stream channel during EPA metals sampling in 2012.

Figure 5-10. Upper portion of Sullivan Creek (left) and sediment in the stream channel of the upper portion of Sullivan Creek (right) (both near site C12SULLC02)

Comparison with Water Quality Targets

There are no existing physical data available for Sullivan Creek for comparison with the targets. The macroinvertebrate bioassessment data are located in **Table 5-23**. All bolded cells are beyond the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-23. Bioassessment data for Sullivan Creek

Values that do not meet the target threshold (≥0.80 for O/E and <51% for periphyton) are in bold.

Station ID	Collection Date	Collection Method	O/E	Periphyton %
C12SLVNC01	8/4/2004	Kick	**0.62**	18.1
C12SLVNC01	9/16/2008	--	**--**	30.8
C12SULLC02	7/4/2012	MAC-R-500	**0.32**	--

Summary and TMDL Development Determination
Sediment-related data such as riffle pebble count, grid toss, channel morphology, instream habitat, and riparian habitat were not available for Sullivan Creek. Both periphyton samples met the target of 51% but neither macroinvertebrate sample met the target.

Although there are no sediment-related data available for Sullivan Creek, based on the exceedances of the macroinvertebrate target, the current 303(d) listing status, the history of human sediment sources, and the visual assessment of siltation in the creek during the 2011 assessment, a sediment TMDL will be developed for Sullivan Creek.

5.4.2.9 Swamp Creek (MT76N003_160)
The impaired portion of Swamp Creek (MT76N003_160) is 4.76 miles from the confluence with West Fork Swamp Creek to the mouth of Swamp Creek at the Clark Fork River and is listed for sedimentation/siltation on the 2012 303(d) List.

Physical Condition and Sediment Sources
In the mid to late 1990s, Natural Resources Conservation Service (NRCS) documented substantial sediment problems associated with timber harvest, grazing, and roads in the Swamp Creek watershed and that information is part of the DEQ assessment file (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2014). At the time, channelization and installation of dikes and gravel plugs in the upper watershed had closed off overflow/flood channels, which constricted high flows and caused channel downcutting and incisement. This also caused extensive bank erosion and scouring. Downstream of these areas there were heavy deposits of sediment with some associated headcuts that were migrating upstream. An assessment by Watershed Consulting in 1995 for NRCS noted the watershed contained an upper, high gradient gravel-bedded system and a lower meadow system (Buckley 1995[7]). In the upper system, severe degradation was attributed to a combination of higher peak flows and reduced base flows resulting from forest management activities and flood control activities in the reach. The lower meadow system had become over-widened and lost its capacity to transport sediment resulting in the loss of fish habitat. The cause of the over-widening was caused by the loss of stabilizing riparian vegetation due to grazing. Evidence of an old reservoir in the lower watershed was observed with an old skid trail that had a large slump, about 15 feet, that was contributing sediment directly to the stream channel. Riparian vegetation was essentially gone where this reservoir used to be and the stream channel was downcut about 4 feet. Heavy grazing occurred here and was worsening the stability problems. Overall, the stream channel was significantly over-widened with large silt deposits. No formal restoration work occurred at the time, but NRCS did remove constrictions in the overflow channel (D. Feist, personal comm., 2014[8]). Additionally, 471 acres of land along the upper part of the impaired stream segment (**Figure 6-19**) were placed into conservation easements between 1997 and 2000. Two of the easements (236 acres) are held by the NRCS under the Wetland Reserve Program and grazing and forestry is not allowed unless a benefit to wildlife habitat can be demonstrated (D. Feist, personal comm., 2014[9]). The other easement, which is 235 acres, is held by the Montana Land Reliance and limits development (D. Feist, personal comm., 2014[8]).

[7] Personal communication on behalf of Watershed Consulting to Tim Julander, NRCS. Letter regarding field visit to Swamp Creek and restoration approaches. 1995.
[8] Phone call between Don Fiest, NRCS, District Conservationist, Plains Field Office and Lisa Kusnierz, EPA on 5/5/14
[9] E-mail from Don Fiest, NRCS, District Conservationist, Plains Field Office to Lisa Kusnierz, EPA on 5/5/14

In 2004, DEQ collected sediment and habitat data at two sites: C13SWPCR10, which was located in the upper watershed downstream of the West and East Fork confluence, and C13SWPCR20, which was located at the mouth of Swamp Creek (**Figure 5-1**). Substantial clearcutting had occurred in the headwaters of the West Fork and had changed peak flows and affected streambank stability. Also, agricultural activities were occurring up to the streambank. At the lower site, there was abundant beaver activity above this site and evidence that a beaver dam upstream of the site had blown out. This portion of the stream was in a rock wall canyon. There were beaver dams above and below this canyon section. Large cobble and boulders were common in riffles, but pools were heavily filled with silt, likely due to beaver activity and the backfilling of dams. The heavy silt contribution could also have been from the timber harvest in the headwaters where there had been some recent clearcuts. There was little bank erosion observed because much of the banks were rock walls.

In 2011, EPA collected sediment and habitat data at two sites on Swamp Creek: SWMP01-05 and SWMP01-06 (**Figure 5-1**). SWMP01-05 was located approximately 0.8 miles downstream of the confluence of the East and West Forks of Swamp Creek in a meadow area that may have been logged and was likely grazed historically, though no signs of recent grazing were observed. Historic logging in the upper watershed may have increased water yields, sediment loads, and affected stream morphology. The stream channel was primarily composed of slow moving runs with deep pools at meander bends and infrequent short riffles. Channel substrate was primarily fine gravel and clay, which limited spawning potential. The stream channel appeared slightly entrenched, with tall eroding streambanks comprised primarily of clay located at meander bends (**Figure 5-11**). The channel margin was lined with reed canary grass, sparse alders, and wetland vegetation at the lower end of point bars.

SWMP01-06 was located near the mouth of the creek in an area historically used for crop production and grazing that has been allowed to recover over the past 25 years. The stream is over-widened from past use. Historic timber harvest in the upper watershed may have increased water yields, sediment loads, and affected stream morphology along Swamp Creek. The stream channel contained a well-developed riffle-pool sequence, with gravel and small cobble substrate creating good potential spawning habitat. Transverse and mid-channel bar depositional features suggest elevated sediment loads from higher in the watershed. The adjacent landowner reported recent beaver activity, though high flows in 2011 removed the beaver dams. Streambank erosion was limited to meadow areas that lacked stabilizing woody streamside vegetation (**Figure 5-11**), while areas lined with alders were relatively stable.

Figure 5-11. Eroding streambanks in the upper (left) and lower (right) portions of Swamp Creek

The USFS has a grazing allotment in the headwaters of the Swamp Creek watershed. The *Environmental Assessment for Henry Creek and Swamp Creek Range Allotment Management Plans Revision* (U.S. Department of Agriculture, Forest Service, 2012) provides a summary of past and current conditions in the Swamp Creek watershed. The purpose of the EA is to propose revisions to the grazing allotment management plan to address resource concerns related to environmental impacts from cattle grazing. The measures included in the proposed actions are in response to impacts in localized areas in the grazing allotment that have the potential to impact soil and water resources. The following discussion of the conditions in Swamp Creek are summarized from the EA (U.S. Department of Agriculture, Forest Service, 2012).

The Swamp Creek watershed has been grazed by livestock since at least 1947. The numbers of animals permitted to graze has varied over the years from 104 head of cattle and some horses in 1957 (May 15 to October 15) to the current use of 45 cow/calf pairs (June 1 to September 1). Grazing areas were divided into the East and West Forks of Swamp Creek, with most grazing occurring on State land and Champion Timber Company lands (where were later sold to Plum Creek). In 2006, Plum Creek no longer authorized grazing on its lands in the Swamp Creek watershed and numbers on the allotment were reduced to the current management system of 45 cow/calf pairs.

Within the Swamp Creek Grazing Allotment boundary, there is very little open range because much of the landscape is heavily forested (U.S. Department of Agriculture, Forest Service, 2012). The main forage areas are located in the lower portion of the allotment, adjacent to private, State, and Plum Creek lands. The primary grazing activity in the allotment occurs along less than 1 mile of the lower West Fork Swamp Creek and along less than 0.5 miles of the lower East Fork of Swamp Creek, which is less than 2% of the stream miles in the watershed.

For the most part, current grazing activity on USFS lands in wetland areas on the Swamp Creek allotment is within acceptable use levels. However, excessive grazing use of a wetland along an unnamed intermittent tributary to Swamp Creek (below the confluence of the East and West Forks) was documented (approximately 2-3 acres). Cattle tend to stay in this area because it is shaded, wet, and close to the property where the cows move to at the end of the season. Wetland functions at this site are impacted by hoof shear and heavy browsing of riparian vegetation.

Aside from the use observed at the wetland site, the Swamp Creek Grazing Allotment streams and riparian areas are relatively undisturbed in the higher elevation areas. Slight grazing disturbances were noted in the stream riparian/floodplain area near the confluence of the West Fork Swamp Creek with the East Fork Swamp Creek. Hoof shear and pockmarks were observed in some wetter areas, along riparian corridors, and in large open pasture areas. Vegetation was abundant in this area, which reduced the erosion often associated with overgrazing. Overall, historic grazing, timber management, and road construction have resulted in the soil and site conditions currently observed. To address the site-specific concerns discussed in the plan, the USFS proposes to provide off-site watering, add riparian fencing, and use woody materials to control cattle trailing. These improvements are anticipated to result in site-specific improvements but no measurable changes to Swamp Creek.

Comparison with Water Quality Targets

The existing physical data in comparison with the targets for Swamp Creek are summarized in **Table 5-24**. The macroinvertebrate bioassessment data are located in **Table 5-25**. All bolded cells are beyond the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-24. Existing sediment-related data for Swamp 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			Riparian Health
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	Percent Understory Shrub Cover
SWMP01-05	2011	20.7	B4c	C4	**23**	**17**	**22**	**20**	16.1	**1.7**	2.1	**32**	**100**	**31**
SWMP01-06	2011	25.8	C4	C4	7	5	7	4	**22.5**	11.2	2.0	74	317	**38**

Table 5-25. Bioassessment data for Swamp Creek

Values that do not meet the target are in bold.

Station ID	Collection Date	Collection Method	O/E	Periphyton %
C13SWPCR20	9/8/2004	Kick	0.89	**72.1**
C13SWMPC02/ SWMP01-05	8/25/2011	MAC-R-500	**0.44**	29.1
C13SWMPC03/ SWMP01-06	9/12/2011	MAC-R-500	**0.64**	32.8
C13SWPCR20	8/9/2007	--	--	**77.9**
C13SWPCR20	9/4/2006	--	--	**81.7**
C13SWMPC02/ SWMP01-05	8/27/2011	MAC-R-500	**0.72**	**94.5**
C13SWPCR10	8/27/2011	MAC-R-500	0.96	**65.0**

Summary and TMDL Development Determination

The only sediment-related data for Swamp Creek were collected in 2011 (**Table 5-25**). For fine sediment, the riffle pebble count and grid toss values were exceeding the targets at site SWMP01-05 (below the grazing allotment and the confluence of the East and West Forks of Swamp Creek). The riffle pebble count and grid toss values at station SWMP01-06 (near the mouth of Swamp Creek) were meeting all targets. The width/depth ratio target was just barely exceeded at station SWMP01-06 (lower station) and the entrenchment ratio was exceeded at SWMP01-05 (upper station). Some instream habitat parameters (pool and LWD frequency) exceeded their targets at station SWMP01-05 (upper station below grazing allotment). The percent understory shrub cover target for riparian health was not met at either station. Five of the seven periphyton samples exceeded the target of 51%. These exceedances occurred throughout the entire impaired segment from the mouth (C13SWPCR20) to just below the confluence of the East and West Forks (C13SWPCR10). Three of the five macroinvertebrate samples did not meet the target and those exceedances also occurred throughout the entire segment, although only one failure corresponded to a failure to meet the periphyton target. The sample that failed to meet both biological targets was collected in 2011 at site C13SWMPC02, which is about 2 miles upstream of the mouth at the same location as SWMP01-05, which failed to meet all fine sediment targets.

Observations at the 2011 field sites and those documented in the *Environmental Assessment for Henry Creek and Swamp Creek Range Allotment Management Plans Revision* (U.S. Department of Agriculture, Forest Service, 2012) indicate that improvements in land management practices and adjustments in land use to allow Swamp Creek to recover have had a positive effect on sediment and habitat in Swamp Creek. However, there are still some riparian and streambank stability issues and lasting effects to the stream from historical grazing, timber harvest, and roads. Based on the exceedance of the fine sediment and biological targets, particularly at the same location in the middle of the segment, excess sediment is limiting Swamp Creek's ability to fully support aquatic life. This information supports the sediment impairment listing and a sediment TMDL will be developed for Swamp Creek.

5.5 Source Assessment and Quantification

This section summarizes the assessment approach, current sediment load estimates, and the determination of the allowable load for each source category. DEQ determines the allowable load by estimating the obtainable load reduction once all reasonable land, soil, and water conservation practices have been implemented. The reduction forms the basis of the allocations and TMDLs provided in **Section 5.8**. This section focuses on four potentially significant sediment source categories and associated controllable human loading for each of these sediment source categories:

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

EPA's guidance for developing sediment TMDLs states that the basic procedure for assessing sources includes compiling an inventory of all sediment sources to the waterbody. In addition, the guidance suggests using one or more methods to determine the relative magnitude of loading, focusing on the primary and controllable sources (U.S. Environmental Protection Agency, 1999b). Federal regulations allow that loadings "may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading" (Water quality planning and management, 40 CFR 130.2(G)).

For each impaired waterbody segment, sediment loads from each source category were estimated based on field surveys, watershed modeling, and load extrapolation techniques (described below). In the Thompson Project Area, sand/silt generally comprised the greatest portion of the streambank sediment load, composing greater than 50% of the sediment load in all of the assessed streams except for Henry Creek, Little Thompson River, and Lynch Creek. Eroding streambanks on these three streams is more of a mix of fine and coarse sediment. The complete methods and results for source assessments for streambank erosion, upland erosion, and roads are found in **Attachments A, B,** and **C**, respectively**.**

5.5.1 Eroding Streambank Sediment Assessment

Data collected during the 2011 Thompson Project Area sediment and habitat field work were used to estimate the total sediment load associated with bank erosion for each watershed. Streambank erosion was assessed in 2011 at the 16 assessment reaches discussed in **Section 5.3**. Each reach was walked and measurements were collected on both streambanks where bank erosion was observed. For each eroding streambank, channel cross section measurements were collected to indicate the erosive force (i.e., Near Bank Stress) (Rosgen, 1996; 2004), and measurements of the bank height, bankfull height, root depth, root density, bank angle, and surface protection were collected as indicators each streambank's susceptibility to erosion (i.e., bank erosion hazard index). This information was used to calculate an annual sediment load for each monitoring site.

Because identifying the contribution from human sources is an important part of the source assessment and TMDL allocations, 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
- natural sources
- irrigation-shifts in stream energy
- other (e.g., past sources)

Whether using field observations, aerial photography, or GIS methodology, it is difficult to discern between bank erosion influenced from current or past human practices and bank erosion as a result of natural processes. However, a simple break down of the apparent erosion sources provides a general indicator of the activities that may be affecting bank erosion, which in turn could help land managers prioritize areas for improvement. The erosion sources identified for each reach, and summarized at the watershed scale, are provided in **Attachment A**.

Streambank erosion data from each 2011 monitoring site were used to calculate an annual load for that reach (as identified during the aerial assessment and stratification process described in **Section 5.3**). Because reaches were classified by ecoregion, stream order, and valley gradient/confinement, which may affect the background streambank erosion rate, the annual load from similar reach types was averaged and extrapolated to like reach types to estimate the annual load for each stream segment of concern. To increase the sample size, the annual load from similar streams with the same reach types in the nearby Kootenai-Fisher Project Area, which is the same ecoregion, was also included in the analysis. A more detailed description of the bank erosion assessment can be found in **Attachment A**.

5.5.1.1 Establishing the Total Allowable Load

Streambank erosion is a natural process but human disturbances to riparian vegetation and health and/or stream hydrology can accelerate the natural erosion rate. This commonly occurs when streambanks shift from being well vegetated and/or armored (and commonly undercut) to being largely, or entirely, unvegetated with vertical banks. As discussed above, bank erosion was attributed to human and natural sources during the field work and aerial assessment processes. Based on field observations and best professional judgment, the percent streambank erosion attributed to human sources was reduced to 30% for the field sites to approximate streambank erosion levels when all reasonable land, soil, and water conservation practices are applied. After this reduction was made, the reach type loads were re-averaged to represent the total allowable load for each reach type. The average load associated with implementing all reasonable BMPs for each reach type was applied to all like reaches dominated by human sources of streambank erosion. No reductions were applied to reaches dominated by natural sources of streambank erosion.

The most appropriate BMPs will vary by site, and active restoration may be necessary to address some eroding banks, but streambank stability and erosion rates are largely a factor of the health of vegetation near the stream. Therefore, the load reductions are largely anticipated to be achieved by applying riparian BMPs. DEQ acknowledges that some streams may have a higher or lower background rate of eroding streambanks; thus, although the reduction may not be achievable in all areas, greater reductions will likely be achievable in some areas.

Assessment Summary

Based on the source assessment, streambank erosion loads range from 41 tons per year in the Sullivan Creek watershed to 845 tons per year in the Little Thompson River watershed (**Table 5-26**). Significant human-caused sources of streambank erosion include transportation (i.e., roads), timber harvest, and grazing. Depending on the watershed, DEQ estimated that implementing riparian BMPs could decrease the human-caused level of streambank erosion by 16% to 36%. **Attachment A** contains additional information about the streambank erosion source assessment and associated load estimates for the 303(d) listed streams in the Thompson Project Area, including a breakdown by particle size class (i.e., coarse gravel, fine gravel, and sand/silt).

Table 5-26. Existing and Reduced Sediment Load from Eroding Streambanks in the Thompson Project Area

Subbasin	Existing Sediment Load (tons/year)	Existing Sediment Load (tons/mile/year)	Allowable Sediment Load with Riparian BMPs (tons/year)	Percent Reduction Needed
Henry Creek	149	22	112	25%
Lazier Creek	340	30	229	33%
Little Bitterroot River	453	19	289	36%
Little Thompson River (excluding McGinnis Creek)	845	20	579	31%
Lynch Creek	451	21	300	33%
McGinnis Creek	71	14	60	16%
McGregor Creek	279	26	187	33%
Sullivan Creek	41	13	34	19%
Swamp Creek	430	25	304	29%

5.5.1.2 Streambank Assessment Assumptions

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

- The average annual rate of bank erosion at sites with predominantly natural sources is an appropriate and achievable rate in reaches where all reasonable land, soil, and water conservation practices are applied.
- The streambank erosion data collected during 2011 represent conditions within the watershed.
- The average annual load per reach type is applicable to other reaches within the same category.
- The assignment of influence to eroding streambanks and the distinction between natural and human-caused erosion is based on best professional judgment by qualified and experienced field personnel.
- Sources of bank erosion at the assessed stream segment scale are representative of sources for that watershed.
- The annual streambank erosion rates used to develop the sediment loading numbers were based on Rosgen bank erosion hazard index (BEHI) studies in Colorado for sedimentary and metamorphic geologies (Rosgen, 2006). The Thompson Project Area primarily has sedimentary geology (see **Appendix A**, **Figure A-5**); therefore, the erosion rates applied to help estimate the current loading from streambank erosion and the reductions achievable by implementing riparian BMPs are applicable to the project area.

5.5.2 Upland Erosion and Riparian Buffering Capacity Assessment

Upland sediment originates beyond the stream channel. The erosion rate of sediment from upland sources is influenced by land use and/or vegetative cover. Sediment loading from upland erosion was modeled using a GIS application of the Universal Soil Loss Equation (USLE).

USLE uses five main factors to estimate soil erosion: R * K * LS * C * P, where
R = rainfall/intensity
K = erodibility
LS = length/slope
C = vegetation cover
P = field practices

All factors except for vegetation cover (C-factor) and field practices (P-factor) are environmental variables unaffected by management practices. Because the P-Factor generally relates to practices occurring at a finer scale than is practical for establishing TMDLs in the project area, it was set at 1 for all scenarios. To estimate the existing upland load associated with each land-use category, adjustments were made to the C-Factor, which integrates a number of variables that influence erosion, including vegetative cover, plant litter, soil surface, and land management.

The existing sediment load delivered to each 303(d) listed stream was estimated by combining the USLE model results with a sediment delivery ratio that accounts for downslope travel distance to surface water, along with a riparian buffer factor that reflects ability of buffers to filter sediment from runoff. The ability of existing riparian vegetation to reduce upland sediment loads was based on a riparian health classification performed for the left and right streambank of each 303(d) listed waterbody during the stratification process described in **Section 5.3**. Buffer health was classified into five categories, which ranged from good (i.e., a dense riparian buffer) to poor (i.e., a mix of bare ground and no woody shrubs, in areas with potential for shrub cover). Based on studies that have found that a well-vegetated riparian buffer filters 75% to 90% of incoming sediment from reaching the stream channel (Wegner, 1999; Knutson and Naef, 1997), a 75% removal efficiency was applied to good buffers; this was scaled down to 50% and 30% for fair and poor buffers, respectively.

5.5.2.1 Establishing the Total Allowable Load

The allowable load from upland erosion, which is associated with implementing BMPs, was determined by a two-fold approach: (1) C-factors for human-influenced land-use categories were modified to reflect the improvement in ground cover that is expected by implementing upland BMPs and (2) riparian health was improved to represent the additional decrease in upland sediment loading that will occur by implementing riparian BMPs.

The land-use categories with modified C-factors were grasslands/herbaceous and pasture/hay. The C-factor change equated to an approximate 10% improvement in ground cover per category. Timber harvest and fires also have the potential to contribute upland sediment, but the C-factor was kept the same for both scenarios because upland loading from timber harvest is mitigated by conditions specified in Montana's Streamside Management Zone law and within the Plum Creek and DNRC Habitat Conservation Plans (Plum Creek Timber Co., 2000; Montana Department of Natural Resources and Conservation, 2010) and because disturbance is expected from periodic forest fires. Upland erosion following fire tends to be greater than erosion following timber harvest, but the same C-factor was applied to both disturbance types because of the unpredictable nature of wildfire and the difficulty of estimating the long term average sediment inputs from it. The C-factor values for both scenarios (i.e., existing and improved conditions) were based on literature values, stakeholder input, and field observations. DEQ acknowledges that C-factor values are variable within land-use categories throughout the watershed and over time; however, because of the model's scale, DEQ assumed that values for ground cover were consistent throughout each land-use category and throughout the year.

The potential for improvements in riparian health was based on the existing riparian health classification, a review of aerial imagery, and on-the-ground verification. It is important to note that under the improved-conditions scenario, a significant portion of the remaining sediment load, after BMPs are implemented in human-influenced land-use categories, is also a component of the natural background load. Additionally, the allocation to human 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 historic land uses. A more detailed description of the assessment can be found in **Attachment B**.

Assessment Summary

Sediment loads from upland erosion range from 75 tons/year in the Sullivan Creek watershed to 1,071 tons/year in the Little Thompson River watershed (**Table 5-27**). Since this assessment was conducted at the watershed scale, DEQ expects larger watersheds to have greater sediment loads. A significant portion of the sediment load from upland erosion is contributed by natural sources, but the estimated contribution by all land-use categories is provided in **Attachment B**. By implementing upland and riparian BMPs, annual loading reductions are expected to range from 31% to 64%. Improvement in riparian health comprises greater than 97% of the estimated reduction in annual loading from upland sources.

Table 5-27. Existing and Reduced Sediment Loads from Upland Erosion in the Thompson Project Area

Subbasin	Existing Delivered Sediment Load (tons/year)	Improved Upland and Riparian Conditions Sediment Load (tons/year)	Percent Reduction
Henry Creek	192	69	64%
Lazier Creek	113	73	36%
Little Bitterroot River	730	501	31%
Little Thompson River (excluding McGinnis Creek)	1,071	647	40%
Lynch Creek	306	208	32%
McGinnis Creek	78	51	35%
McGregor Creek	196	114	42%
Sullivan Creek	75	37	51%
Swamp Creek	423	284	33%

5.5.2.2 Upland Assessment Assumptions

As with any modeling effort, and especially when modeling at a watershed scale, a number of assumptions are made. The following is a summary of the significant assumptions used during the assessment of upland erosion:

- The USLE model is sufficiently accurate for the level of detail needed for sediment TMDLs in this project area. This empirical model was selected for this source assessment because it is well suited for large watersheds and incorporates local climate and landscape data, but it is not overly data-intensive.
- The data sources used are reasonable and appropriate to characterize the watershed and build the model.
- The input variables used in the USLE calculations represent their respective land-use conditions.
- The land management practices that define the vegetative cover throughout the year are relatively consistent and represent practices throughout the watershed.
- The riparian condition as estimated through the aerial assessment and verified in the field represents on-the-ground conditions. Riparian buffer health was included to emphasize its importance in reducing upland sediment loading; however, DEQ acknowledges the classification and improvement potential was conducted at a coarse scale.
- The improvement scenarios to riparian condition and land management are reasonable and achievable.
- The USLE model provides an appropriate level of detail and is sufficiently accurate for developing upland sediment loads for TMDL purposes.

5.5.3 Unpaved Road Sediment Assessment

Roads located near stream channels can reduce stream function by degrading riparian vegetation, encroaching on the channel, and adding sediment. The degree of harm is determined by a number of factors, including road type, construction specifications, drainage, soil type, topography, and precipitation, as well as the usage and maintenance of BMPs. Unpaved roads were identified as a potentially significant sediment source for this project area and were the primary focus of the roads source assessment. However, culverts can pose a substantial risk for sediment loading and fish passage, and were also evaluated as part of the roads source assessment.

5.5.3.1 Erosion from Unpaved Road Crossings

Sediment loading from the unpaved road network in the Thompson Project Area was assessed using GIS, field data, and modeling. Prior to field data collection, GIS tools were used to identify each road crossing and near-stream parallel road segment and assign attributes for road name, surface type (i.e., native, gravel, paved), road ownership, stream name, and subwatershed. In 2011, 52 unpaved crossings were field assessed. Of the 52 sites visited, 13 sites had no defined stream crossing or the road had been closed; therefore, no measurements were taken at these sites. Measurements were taken at one alternate crossing site resulting in data from 40 sites.

Ultimately, a suite of measurements related to road composition, traffic level, and contributing distance for eroding sediment were collected at 40 sites. Additionally, the location and type of existing BMPs and potential locations for additional BMPs (if necessary) were recorded (see Attachment B within **Attachment C**). Since no field data were collected along parallel road segments in the Thompson Project Area, field data collected at 14 unpaved road crossings in which there was at least 5 feet of buffer on both the left and right sides of the crossing were used as a surrogate for parallel road segments. Fourteen of the 40 crossings met the buffer criterion, and buffer distances ranged from 5 to 200 feet.

Data from the 40 sites were used as input to the Water Erosion Prediction Project (WEPP): Road soil erosion model to calculate an annual sediment load per crossing. Because precipitation is a key driver of erosion and it varies largely across the project area (**Appendix A**, **Figure A-10**), the project area was divided into six precipitation zones, and crossing loads were modeled in WEPP using climate data from three stations to reflect those zones. Because of differences observed in the field and in WEPP-generated loads between Federally-managed and private/county/state managed crossings in all watersheds except those in the Lower Flathead (i.e., Sullivan Creek and the Little Bitterroot River), modeled loads were grouped by ownership in addition to climate zone before being averaged. This resulted in an average annual load per Federal and non-Federal crossing in each of the precipitation zones that was then extrapolated to all road crossings in each sediment impaired stream's watershed based on ownership and precipitation zone. For Sullivan Creek and the Little Bitterroot River, the two precipitation zones for that area were used to break out the results but all crossings were grouped together because there was no discernible difference in loading between ownership categories.

5.5.3.2 Establishing the Total Allowable Load

For unpaved road crossings, the allowable load was determined by re-entering the 2011 field data into the WEPP: Road model and reducing the contributing distance for each crossing to the length identified in the field where a BMP could potentially be added. This process was used to provide a more customized approach than using a set reduction or contributing length per crossing, however, the distances used are not intended to be prescriptive measures. The optimal location for additional BMPs is ultimately up to the road owner. The overarching goal is to ensure that all road crossings have the appropriate BMPs in place to protect water quality via reduced sediment loading. BMPs that may be used to either reduce the contributing length, or achieve the allowable load, include installing full structural BMPs at existing road crossings (drive through dips, culvert drains, settling basins, silt fence, etc.), improving the road surface, and reducing traffic levels (seasonal or permanent road closures). Although the estimated reductions may not be possible at all locations because of site-specific conditions or existing BMPs, additional loading reductions will likely be achievable at other locations.

Assessment Summary

Based on the source assessment, the sediment load from unpaved roads ranges from 0.06 ton/year in the Sullivan Creek watershed to 38.1 tons/year in the Little Thompson River watershed (**Table 5-28**). In general, private/county roads had a higher proportion of crossings with adequate BMPs than federal roads (i.e., 13/21 vs. 7/19, respectively). This trend is also apparent in the contributing lengths when broken down by jurisdiction: the average contributing length at all private/county crossings was 117 feet and the average contributing length at all federal crossings was 220 feet. However, conditions for unpaved roads within the project area are generally good for all ownership categories. Most loading is coming from a limited number of crossings with inadequate or improperly maintained BMPs.

At 20 of the crossings, sufficient BMPs are already in place. The average contributing length at those sites was 70 feet, whereas the average contributing length at the sites needing additional BMPs was 319 feet. The most common BMPs observed were rolling dips and water bars. Both of these BMPs interrupt the flow of water, reducing the amount of road surface that water can erode as it moves towards the stream channel (i.e., the contributing length). Numerous crossings do not need additional BMPs because of good road maintenance, which is also a BMP. A more detailed description of this assessment, including loading estimates by ownership category, can be found in the Road Sediment Assessment report (**Attachment C**).

Table 5-28. Annual Sediment Load (tons/year) from Roads in the Thompson Project Area

Watershed	Total Load (tons/year)*	Percent Load Reduction After BMP Application	Total Sediment Load After BMP Application*
Henry Creek	6.4	63%	2.4
Lazier Creek	8.5	51%	4.2
Little Bitterroot River	0.21	28%	0.15
Little Thompson River (excluding McGinnis Creek)	31.2	53%	14.6
Lynch Creek	6.4	47%	3.4
McGinnis Creek	6.9	73%	1.9
McGregor Creek	3.5	54%	1.6
Sullivan Creek	0.06	33%	0.04
Swamp Creek	15.3	67%	5.0

*Because of rounding, differences in loads presented in this table may not correspond to the percent reduction.

5.5.3.3 Culvert Failure and Fish Passage

Undersized or improperly installed culverts may be a chronic source of sediment to streams, or a large acute source during failure. They may also be passage barriers to fish. Therefore, during the roads assessment, the flow capacity and potential to be a fish passage barrier was evaluated for each culvert. Out of the 40 field assessed sites in the Thompson Project Area, 39 had culverts, while one site was at a bridge crossing. While only 20 of the culverts had flowing water at the time that field data were collected, all 39 culverts assessed in the field were evaluated for conveyance capacity to provide a conservative estimate of sediment loading associated with failure for those culverts not sized to pass at least a 25-year storm event. The assessment 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), as well as measurements to estimate the capacity and amount of fill material of each culvert.

A common BMP for culverts is designing them to accommodate 25-year storm events; this capacity is specified as a minimum in Water Quality BMPs for Montana Forests (Montana State University Extension Service, 2001), and it is typically the minimum used by the USFS. Therefore, fill was only assumed to be at-risk in culverts that cannot convey a 25-year event. However, other considerations, such as fish passage, the potential for large debris loads, and the level of development and road density upstream of the culvert, should also be considered during culvert installation and replacement. When these are factored in, larger culverts may be necessary. For instance, USFS typically designs culverts to pass the 100-year event, while also accommodating fish and aquatic organism passage on fish bearing streams (U.S. Department of Agriculture, Forest Service, 1995). Therefore, the BMP scenario for culverts is no loading from culverts as a result of being undersized, improperly installed, or inadequately maintained. At a minimum, culverts should meet the 25-year event. For fish-bearing streams, or those with a high level of road development upstream, meeting the 100-year event is recommended.

Fish passage assessments were performed on 20 culverts with flowing water. 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 culvert's ability to pass fish (**Attachment C**, **Figure 3-2**). Sites where all measurements could not be collected, as well as sites lacking perennial flow, were excluded. 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, 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 barriers and those that need a more in-depth analysis. The culvert assessment in **Attachment C** contains information that may help land managers focus restoration efforts on those culverts that were deemed fish barriers and/or undersized per this analysis.

Assessment Summary

Out of the 39 culverts assessed for failure risk, 27 (69%) were estimated to pass a 25-year event, and 19 (49%) were estimated to pass the 100-year event. Seventy five percent of the culverts not passing the 25-year event and 60% not passing the 100-year event were on road crossings administered by private/county/state entities. Although this may mean that additional education is needed in the project area on the importance of installing properly sized culverts and replacing inadequate ones, especially for non-federal landowners, approximately half of assessed crossings had no surface flow and the risk of failure from those crossings may be less than for perennial stream crossings.

If the 12 culverts that are predicted to pass less than a 25-year recurrence interval flood were to fail, up to 1,299 tons of sediment are at risk of being contributed to the road-related sediment load. Particularly since this is just a sampling of crossings from the project area, the potential amount of sediment at-risk for eroding into impaired streams is likely even greater. However, because of the sporadic natural and uncertainty regarding timing of culvert failures, the estimated load at-risk is not included in the existing loads estimates for each impaired stream.

For the fish passage assessment, none of the 20 culverts assessed at crossings with flowing water had a high probability of allowing fish passage. Eighteen culverts (90%) were classified as fish passage barriers. Steep culvert gradient was cited as the predominant barrier to fish passage in the Thompson Project Area. Recent research suggests fish can pass steeper culverts than indicated by the screening tool used for this assessment (Burford et al., 2009; Peterson et al., 2013), particularly if there is no outlet drop (Peterson et al., 2013). When gradients up to 8% are considered at culverts with no outlet perch, seven additional culverts may pass some fish. As this is a very coarse assessment, additional evaluations should be conducted at any culvert that may be replaced to facilitate fish passage.

The USFS (2012) provides some information on the culvert on Henry Creek under the freeway near the Clark Fork River. The culvert is currently a barrier to fish passage, but based on genetic testing conducted by Montana Fish, Wildlife and Parks in 2002, the westslope cutthroat trout in Henry Creek are genetically pure (U.S. Department of Agriculture, Forest Service, 2012). In situations such as this, it may be preferable to maintain the fish barrier, which is why it is important to consult with a fish biologist when conducting additional culvert evaluations and prioritizing culverts for replacement.

5.5.3.4 Road Assessment Assumptions

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

- The road crossings assessed in the field represent conditions throughout the watershed.
- The WEPP: Road model reasonably characterizes the existing sediment loads and potential for load reductions for the road and climate conditions observed in the Thompson Project Area.
- Using modeling scenarios that focus on reducing the contributing length near road crossings will effectively reduce the majority of the sediment load from roads. This is an effective way to represent loading reductions associated with implementing all reasonable, land, soil, and water conservation practices.
- BMPs may have already have been implemented on many roads, and therefore the reductions necessary in some locations may be less than described in this document.

5.5.4 Permitted Point Sources

The only sediment-related permit in the Thompson Project Area is an Industrial Stormwater facility in the McGregor Creek watershed: Montana Rockworks Inc – McGregor Lake Quarry (MTR000517). The permit is part of the Multi-sector General Permit for Stormwater Discharges Associated with Industrial Activity (MTR000000), which requires a Stormwater Pollution Prevention Plan (SWPPP) to document the erosion and stormwater control measures at the site. Prior to its permit renewal in 2013, the facility was permitted to discharge stormwater to an ephemeral drainage to McGregor Lake. However, it no longer has permitted outfalls because it can retain stormwater on-site. Therefore, there is anticipated to be no load from this facility to McGregor Lake, which McGregor Creek flows out of, and a wasteload allocation (WLA) of 0 is being provided to Montana Rockworks Inc – McGregor Lake Quarry (MTR000517). Based on the conditions in the general permit and site-specific information in the permit file, this WLA should be met by adhering to the permit requirements and is not intended to add a load limit to the permit.

5.5.5 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). Results for each source assessment category provide an adequate tool to focus water quality restoration activities in the Thompson Project Area; they indicate the relative contribution of different subwatersheds 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**).

5.6 TMDLs and Allocations

The sediment TMDLs for the Thompson 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. Each impaired segment's TMDL consists of any upstream allocations. An implicit margin of safety will be applied, further discussed in **Section 5.9**.

5.6.1 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 C**.

5.6.2 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 5.7** and associated 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.

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

5.6.2.1 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, timber harvest, 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 for attributing 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.

5.6.2.2 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.

5.6.2.3 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. The allocation to roads also includes no loading from undersized, improperly installed, or inadequately maintained culverts. At a minimum, culverts should meet the 25-year event; however, for fish-bearing streams and streams with a high level of road and impervious surface development upstream, or for culvert sites with a large amount of fill, meeting the 100-year event is recommended.

5.6.2.4 Permitted Point Sources

The only sediment-related permit in the Thompson Project Area is an Industrial Stormwater facility in the McGregor Creek watershed: Montana Rockworks Inc – McGregor Lake Quarry (MTR000517). This facility does not have permitted outfalls because it can retain stormwater on-site and is not expected to contribute sediment to McGregor Lake, which McGregor Creek flows out of. Therefore, a WLA of 0 is being provided to Montana Rockworks Inc – McGregor Lake Quarry (MTR000517). See **Section 5.5.4** for greater detail.

5.6.3 Allocations and TMDL for Each Stream

The following subsections present the existing quantified sediment loads, allocations, and TMDL for each waterbody (**Tables 5-29** through **5-37**). Note, sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.

5.6.3.1 Henry Creek (MT76N003_170)

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

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	6.41	2.36	63%
Streambank Erosion	149	112	25%
Upland Sediment Sources	192	69	64%
Total Sediment Load	**347**	**183**	**47%**

5.6.3.1 Lazier Creek (MT76N005_060)

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

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	8.45	4.17	51%
Streambank Erosion	340	229	33%
Upland Sediment Sources	113	73	36%
Total Sediment Load	**461**	**306**	**34%**

5.6.3.2 Little Bitterroot River (MT76L002_060)

Table 5-31. Sediment Source Assessment, Allocations and TMDL for the Little Bitterroot River

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	0.21	0.15	28%
Streambank Erosion	453	289	36%
Upland Sediment Sources	730	501	31%
Total Sediment Load	**1,183**	**790**	**33%**

5.6.3.3 Little Thompson River (MT76N005_040)

Table 5-32. Sediment Source Assessment, Allocations and TMDL for the Little Thompson River (excluding McGinnis Creek)

Sediment Sources	Current Estimated Load (Tons/Year)[1]	Total Allowable Load (Tons/Year)[1]	Load Allocations (% reduction)
Roads	38.06	16.43	57%
Streambank Erosion	916	639	30%
Upland Sediment Sources	1,149	698	39%
Total Sediment Load	**2,103**	**1,353**	**36%**

[1]Loads are expressed for the entire Little Thompson watershed, including McGinnis Creek

5.6.3.4 Lynch Creek (MT76N003_010)

Table 5-33. Sediment Source Assessment, Allocations and TMDL for Lynch Creek

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	6.43	3.39	47%
Streambank Erosion	451	300	33%
Upland Sediment Sources	306	208	32%
Total Sediment Load	**763**	**511**	**33%**

5.6.3.5 McGinnis Creek (MT76N005_070)

Table 5-34. Sediment Source Assessment, Allocations and TMDL for McGinnis Creek

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	6.88	1.85	73%
Streambank Erosion	71	60	16%
Upland Sediment Sources	78	51	35%
Total Sediment Load	**156**	**113**	**28%**

5.6.3.6 McGregor Creek (MT76N005_030)

Table 5-35. Sediment Source Assessment, Allocations and TMDL for McGregor Creek

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	3.54	1.63	54%
Streambank Erosion	279	187	33%
Upland Sediment Sources	196	114	42%
McGregor Lake Quarry (MTR000517)	0	0	0%
Total Sediment Load	**479**	**303**	**37%**

5.6.3.7 Sullivan Creek (MT76L002_070)

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

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	0.06	0.04	33%
Streambank Erosion	41	34	19%
Upland Sediment Sources	75	37	51%
Total Sediment Load	**116**	**71**	**39%**

5.6.3.8 Swamp Creek (MT76N003_160)

Table 5-37. Sediment Source Assessment, Allocations and TMDL for Swamp Creek

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	15.28	5.03	67%
Streambank Erosion	430	304	29%
Upland Sediment Sources	423	284	33%
Total Sediment Load	**868**	**593**	**32%**

5.7 Seasonality and Margin of Safety

Seasonality and margin of safety are both required elements of TMDL development. This section describes how seasonality and margin of safety were applied during development of the Thompson Project Area sediment TMDLs.

5.7.1 Seasonality

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

- The applicable narrative water quality standards (**Appendix B**) are not seasonally dependent, although low-flow conditions provide the best ability to measure harm-to-use based on the selected target parameters. The low-flow or base-flow condition represents the most practical time period for assessing substrate and habitat conditions, and also represents a time period when high fine sediment in riffles or pool tails will likely influence fish and aquatic life. Therefore, meeting targets during this time frame represents an adequate approach for determining standards attainment.
- The substrate and habitat target parameters within each stream are measured during summer or autumn low-flow conditions consistent with the time of year when reference stream measurements are conducted. This time period also represents an opportunity to assess effects of the annual snow runoff and early spring rains, which is the typical time frame for sediment loading to occur.
- The DEQ sampling protocol for macroinvertebrates identifies a specific time period for collecting samples based on macroinvertebrate life cycles. This time period coincides with the low-flow or base-flow condition.
- All assessment modeling approaches are standard approaches that specifically incorporate the yearly hydrologic cycle specific to the 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.

5.7.2 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 margin of safety (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, 1999b; Rosgen, 2006). This plan incorporates an implicit MOS in a variety of ways.

- Multiple targets were used to assess a broad range of physical and biological parameters known to illustrate the effects of sediment in streams and rivers. These targets serve as indicators of potential impairment from sediment and also help signal recovery, and eventual standards attainment, after TMDL implementation. Conservative assumptions were used during development of these targets; as discussed for each target parameter in **Section 5.4.1**, an effort was made to select achievable water quality targets, but in all cases, the most protective statistical approach was used. **Appendix B** contains additional details about statistical approaches used by DEQ.
- The C-factor and Sediment Reduction Efficiency values used to estimate sediment loading from upland sources were based on conservative literature values (i.e., allowing for more sediment erosion and delivery).
- TMDLs were developed for streams that were close to meeting all target values. 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.
- Seasonality was incorporated into target development, source assessments, and TMDL allocations (details provided in **Section 5.9.1**).
- An adaptive management approach was used to evaluate target attainment and allow for refinement of load allocation, targets, modeling assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development (discussed in **Sections 5.10**, **9.0**, and **10.0**).
- Naturally occurring sediment loads were used as described in ARM 17.30.602(17) (see **Appendix B**) to establish the TMDLs and allocations based on reasonably achievable load reductions for each source category. Specifically, each major source category must meet percent reductions to satisfy the TMDL because of the relative loading uncertainties between assessment methodologies.
- TMDLs were developed 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.

5.8 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 Thompson 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 gauge progress toward meeting water quality standards and to satisfy 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.

5.8.1 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, 2011b). This procedure defines specific methods for each parameter, including sampling location and frequency, to ensure proper representation and applicability of results. Before any sampling, a sampling and analysis plan (SAP) was developed to ensure that all activity was consistent with applicable quality control and quality assurance requirements. Site selection was a major component of the SAP and was based on a stratification process described in **Attachment A**. The stratification work ensured that each stream included one or more sample sites representing a location where excess sediment loading or altered stream habitat could affect fish or aquatic life.

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

Target Development

Several data sets were evaluated 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 recent sample data for the project area. These differences were acknowledged within the target development discussion and taken into consideration during target setting. For each target parameter, the Thompson sample results and target data were stratified 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.

5.8.2 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 nonpoint source categories: bank erosion, upland erosion, and unpaved road crossings. Additional details about uncertainties associated with the source assessments are contained in the associated attachments/appendices.

Bank Erosion

Bank erosion loads were initially quantified using the DEQ protocols (Montana Department of Environmental Quality, 2011b) and the standard BEHI methodology, defined in **Attachment A**. Before any sampling, a SAP was developed to ensure that all activity was consistent with applicable quality control and quality assurance requirements. Site selection was a major component of the SAP and was based on a stratification process described in **Attachment A**. The results were then extrapolated across the project area to provide an estimate of bank erosion loading to the stream segments of concern. Based on this process, the relative contribution from human versus natural sources, as well as the potential for reduction with the implementation of riparian BMPs, was estimated and used for TMDL allocations. Because of the small sample size for each unique reach type, and even for the reach types groupings that were used for the extrapolation, there is a high degree of uncertainty in the average annual load estimates that were extrapolated to the stream segment and watershed scale. For this reason, the loads are intended to provide a relative sense of the loading associated with bank erosion from human and natural sources for each watershed.

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

Upland Erosion

A professional modeler determined upland erosion loads by applying a landscape soil loss equation (USLE), defined in **Attachment B**. As with any model, there will be uncertainty in the model input parameters, including land use, land cover, and assumptions regarding existing levels of BMP application. For example, only one vegetative condition was assigned per land cover type. In other words, the model cannot reflect land management practices that change vegetative cover from one season to another, so an average condition is used for each scenario in the model. The potential to reduce sediment loading was based on modest land cover improvements, along with riparian improvements, to reduce the generation of eroded sediment particles. Thus, there is uncertainty regarding existing erosion prevention BMPs and the ability to reduce erosion with additional BMPs.

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

The riparian health analysis was not performed with the expectation that it would identify specific locations for implementation of additional BMPs. Instead it was performed to simulate the buffering capacity of riparian vegetation and emphasize the importance of a healthy riparian buffer. Even with these uncertainties, the ability to reduce upland sediment erosion and delivery to nearby waterbodies is well documented in literature, and the estimated reductions are consistent with literature values for riparian buffers.

Roads

As described in **Attachment C**, the road crossings sediment load was estimated via a standardized simple yearly model developed by USFS. This model relies on a few basic input parameters that are easily measured in the field, as well as inclusion of precipitation data from local weather stations. A total of 54 sites were visited in the field, representing about 5% of the total population of roads. The results from these sites were extrapolated to the whole population of roads stratified by ownership and precipitation class. Random selection of the stratified sites was intended to capture a representative subset of the road crossings for existing conditions and level of BMP implementation. However, some uncertainty is introduced because of the small sample size relative to the total number of road crossings.

Although the culvert assessment is a coarse level assessment, there is uncertainty in the peak flow capacity that was calculated for each culvert because it is based on regional regression equations, which may substantially overestimate or underestimate peak flow. The fish passage assessment indicated most culverts are problematic for fish passage. In addition to the assessment being a quick screening tool, there is uncertainty associated with the fish passage conclusion because the assessment uses criteria that differ from that found by some recent research, which means fish passage rates may be higher than indicated by this analysis. The conclusions of the analysis were not used for the TMDL and are not intended to be used for decision-making but instead to raise awareness about the importance of proper culvert installation and maintenance, and to be a general indicator of potential fish passage issues at the watershed scale.

6.0 Nutrient TMDL Components

This section focuses on nutrients (total nitrogen (TN) and total phosphorus (TP) forms; nitrate (NO_3) and nitrite (NO_2) forms (referred to as nitrate throughout the remainder of this section); and chlorophyll-*a*) as a cause of water quality impairment in the Thompson TMDL Project Area (AKA Thompson Project Area). It includes 1) nutrient impairment of beneficial uses; 2) specific stream segments of concern; 3) currently available data on nutrient impairment assessment in the watershed; 4) target development and a comparison of existing water quality targets; 5) description of nutrient sources; and 6) identification and justification for nutrient TMDLs and TMDL allocations.

6.1 Effects of Excess Nutrients on Beneficial Uses

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

Excess nitrogen in the form of dissolved ammonia (which is typically associated with human sources) can be toxic to aquatic life. Elevated nitrates in drinking water can inhibit normal hemoglobin function in infants. Besides the direct effects of excess nitrogen, elevated inputs of nitrogen and phosphorus from human sources can accelerate aquatic algal growth to nuisance levels. Respiration and decomposition of excessive algal biomass depletes dissolved oxygen, which can kill fish and other forms of aquatic life. Nutrient concentrations in surface water can lead to blue-green algae blooms (Priscu, 1987), which can produce toxins lethal to aquatic life, wildlife, livestock, and humans.

Aside from toxicity, nuisance algae can shift the macroinvertebrate community structure, which also may affect fish that feed on macroinvertebrates (U.S. Environmental Protection Agency, 2010). Additionally, changes in water clarity, fish community structure, and aesthetics can harm recreational uses, such as fishing, swimming, and boating (Suplee et al., 2009). Nuisance algae can increase treatment costs of drinking water or pose health risks if ingested in drinking water (World Health Organization, 2003).

6.2 Stream Segments of Concern

There are nine waterbody segments in the Thompson Project Area that are present on the 2012 303(d) List for phosphorus and/or nitrogen impairments (**Table A-1**): Henry Creek, Lazier Creek, Little Bitterroot River, Little Thompson River, Lynch Creek, McGinnis Creek, McGregor Creek, Sullivan Creek, and Swamp Creek (**Figure 6-1**). Based on data collected as part of this project, Department of Environmental Quality (DEQ) has concluded Henry Creek, McGinnis Creek, and McGregor Creek are no longer impaired for nutrients. These changes in impairment status are the result of the assessment process and will be updated on the 2014 303(d) List.

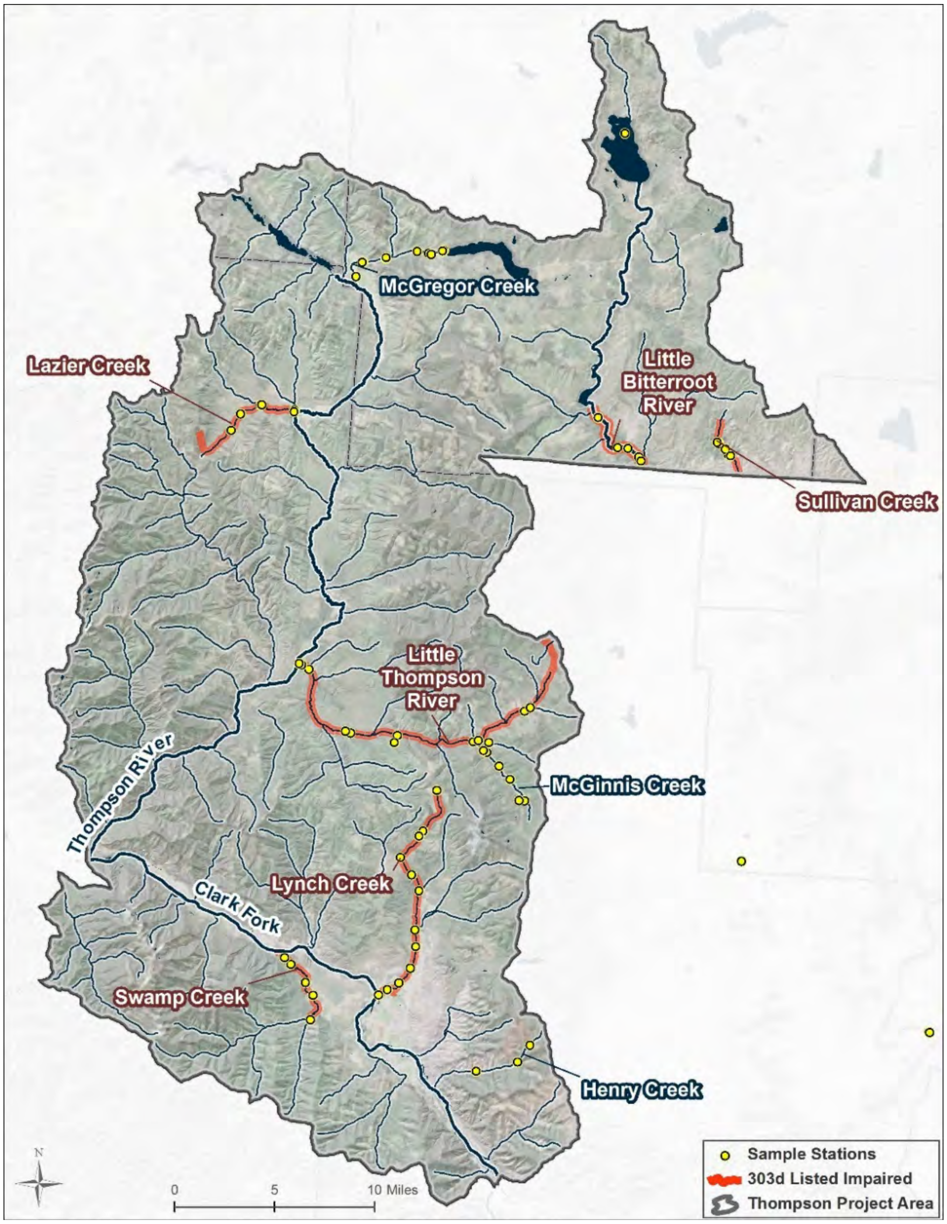


Figure 6-1. Nutrient impaired streams in the Thompson TMDL Project Area for which TMDLs will be written and associated sampling locations.

6.3 Information Sources and Assessment Methods

The following information sources were searched and/or used to describe water quality and nutrient loading conditions in the project area:

- Monitoring and assessment data were compiled by DEQ for the impaired waterbodies in the Thompson Project Area (2004-2012). Most data were collected between 2009 and 2012 to help support TMDL development.
    - o Because sediment and nutrient sources are commonly linked, site visit notes from sediment and habitat sampling conducted in September 2011 to support sediment TMDL

development (**Section 5.0**) were also used to describe channel conditions and potential nutrient sources (ATKINS, 2013c)

- United States Geological Survey (USGS), National Water Information System (NWIS) database of surface water chemistry and discharge
- United States Environmental Protection Agency (EPA) STORET database of surface water chemistry and stream discharge
- Federal and state government agency geographical information system (GIS) data for geology, topography, land cover, and land-use layers
- Montana DEQ Clean Water Act Information Center - Water Quality Standards Attainment Records (Montana Department of Environmental Quality, 2012b)

Sample locations were generally such that they provided a comprehensive upstream to downstream view of nutrient levels (**Figure 6-1**). The location of sample collection also allowed for analysis of potential source impacts (e.g., changes in land use or septic influence). All data used in TMDL development were collected during the growing season for the Northern Rockies Level III Ecoregion (July 1 – September 30). Benthic algae samples were collected from 2007 through 2012. These samples were analyzed for Chlorophyll-*a* concentration and ash free dry mass (AFDM). AFDM is a measurement that captures both living and dead algal biomass and is particularly helpful for streams where some or all of the algae are dead (because chlorophyll-*a* measures only living algae). Macroinvertebrate samples were collected from 2004 through 2012.

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

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

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 Thompson Project Area following DEQ's draft assessment methodology (Suplee and Sada de Suplee, 2011). To be consistent with DEQ's draft assessment methodology, and because of improvements in analytical methods, only data from the past 10 years are included in the review of existing data.

6.4.1 Nutrient Water Quality Standards

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

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 the harmful growth and proliferation of excess algae. Since 2002, DEQ has conducted a number of studies in order to develop numeric criteria for nutrients (N and P forms). DEQ is developing draft numeric nutrient standards for total nitrogen (TN), total phosphorus (TP), chlorophyll-*a*, and AFDM based on 1) public surveys defining what level of algae was perceived as “undesirable” and 2) the outcome of nutrient stressor-response studies that determine nutrient concentrations that will maintain algal growth below undesirable and harmful levels (Suplee et al., 2008). Although dissolved fractions of phosphorus and nitrogen do not have draft numeric nutrient criteria because uptake by aquatic organisms can make their concentrations highly variable, DEQ has determined that nitrate is an important constituent to evaluate in conjunction with TN and TP (Suplee and Watson, 2013).

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 6-1**. The nitrate target is based on research by Suplee (11/14/2013) and can also be found in **Table 6-1**. DEQ has determined that the values for nitrate, TN, and TP provide an appropriate numeric translation of the applicable narrative nutrient water quality standards based on existing water quality data in the Thompson Project Area. The target values are based on the most sensitive uses; therefore, the nutrient TMDLs are protective of all designated uses. When the draft criteria for TN and TP become numeric standards they will be in DEQ’s DEQ-12 circular.

The nutrient target suite for streams in the Northern Rockies Level III Ecoregion also includes two biometric indicators: macroinvertebrates and diatoms. For macroinvertebrates, the Hilsenhoff Biotic Index (HBI) score) is used. The HBI value increases as the amount of pollution tolerant macroinvertebrates in a sample increases; the macroinvertebrate target is an HBI score equal to or less than 4.0 (Suplee and Sada de Suplee, 2011) (**Table 6-1**). Benthic diatoms, or periphyton, are a type of algae that grow on the stream bottom, and there are certain taxa that tend to increase as nutrient concentrations increase. The diatom target is a periphyton sample with a ≤51% probability of impairment by nutrients (Suplee and Sada de Suplee, 2011) (**Table 6-1**).

Because numeric nutrient chemistry is established to maintain algal levels below target chlorophyll-*a* concentrations and AFDM, target attainment applies and is evaluated during the summer growing season (July 1–September 30 for the Northern Rockies Level III Ecoregion) when algal growth will most likely affect beneficial uses. Targets listed here have been established specifically for nutrient TMDL development in the Thompson Project Area and may or may not be applicable to streams in other TMDL project areas. The target values for total nitrogen and total phosphorus will be used to develop TMDLs. TMDLs will not be written specifically for nitrate or chlorophyll-*a*. Nitrate impairments are addressed by TN TMDLs and chlorophyll-*a* impairment is addressed by TN and TP TMDLs. See **Section 9.1** for the adaptive management strategy as it relates to nutrient water quality targets.

Table 6-1. Nutrient Targets for the Thompson TMDL Project Area

Parameter	Northern Rockies Level III Ecoregion Target Value
Nitrate[(1)]	<0.1 mg/L
Total Nitrogen[(2)]	≤ 0.275 mg/L
Total Phosphorus[(2)]	≤ 0.025 mg/L
Chlorophyll-*a*[(2)]	≤ 125 mg/m2

Table 6-1. Nutrient Targets for the Thompson TMDL Project Area

Parameter	Northern Rockies Level III Ecoregion Target Value
Ash Free Dry Mass[(2)]	≤ 35 g /m2
Hilsenhoff's Biotic Index[(3)]	< 4.0
Periphyton[(3)]	< 51%

[(1)] Value is from Suplee (11/14/2013).
[(2)] Value is from Suplee and Watson (2013).
[(3)] Value is from Suplee and Sada de Suplee (2011).

6.4.3 Existing Conditions and Comparison to Targets

For each waterbody segment included on Montana's 2012 303(d) List for nutrients (**Table A-1**), DEQ evaluates recent water quality data relative to the water quality targets to make a TMDL development determination. DEQ has recently completed several years of water sampling in the Thompson TMDL Project Area for the purpose of assessing the nutrient impairment determinations. These data provide the basis for the nutrient target evaluations below.

Evaluation of nutrient target attainment is conducted by comparing existing water quality conditions to the water quality targets in **Table 6-1** following the methodology in the DEQ guidance document, *Assessment Methodology for Determining Wadeable Stream Impairment Due to Excess Nitrogen and Phosphorus Levels* (Suplee and Sada de Suplee, 2011). This approach provides DEQ with updated impairment determinations used for TMDL development. Because the original impairment listings are based on old data or were listed before developing the numeric criteria, each stream segment will be evaluated for impairment from nitrate, TN, and TP using data collected within the past 10 years. Additionally, nutrient samples collected prior to 2005 were analyzed for Total Kjeldahl Nitrogen (TKN), which has since been replaced by DEQ with Total Persulfate Nitrogen as the preferred analytical method for total nitrogen; DEQ determined that samples analyzed for TKN may have a high bias relative to identical samples analyzed for Total Persulfate Nitrogen and are excluded from the data review. As mentioned in **Section 6.2**, Henry Creek, McGinnis Creek, and McGregor Creek showed no nutrient impairment, and therefore TMDLs are not being developed for them and assessment information is not included in this document.

The assessment methodology uses two statistical tests (Exact Binomial Test and the One-Sample Student's T-test for the Mean) to evaluate water quality data for compliance with established target values. In general, compliance with water quality targets is not attained when nutrient chemistry data shows a target exceedance rate of >20% (Exact Binomial Test), when mean water quality nutrient chemistry exceeds target values (Student T-test), or when a single chlorophyll-*a* exceeds benthic algal target concentrations (125 mg/m^2 or 35 g AFDM/m^2). Where water chemistry and algae data do not provide a clear determination of impairment, or where other limitations exist, macroinvertebrate and periphyton biometrics are considered in further evaluating compliance with nutrient targets. Lastly, inherent to any impairment determination is the existence of human sources of pollutant loading. Human-caused sources of nutrients must be present for a stream to be considered impaired.

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

When applying the T-test for assessment and sample values were below detection limits, one-half the detection limit was used.

6.4.3.1 Lazier Creek (MT76N005_060)

Lazier Creek is on the 2012 303(d) List as impaired by TN, TP, nitrate/nitrite. The impaired segment of Lazier Creek begins at the headwaters and flows 7.8 miles until its termination at the confluence with the Thompson River (**Figure 6-1**).

Summary nutrient data statistics and assessment method evaluation results for Lazier Creek are provided in **Tables 6-2 and 6-3**, respectively. Nutrient samples for Lazier Creek were collected between 2004 and 2012. Fourteen nitrate samples were collected and values ranged from < 0.01 to 0.08 mg/L with none of the samples exceeding the nitrate target of 0.1 mg/L. Note that one of the values was excluded because it exceeded the TN concentration of that sample (which indicates a potential data quality issue). Thirteen TN samples were collected and values ranged from < 0.04 to 0.1 mg/L with none of the samples exceeding the TN target of 0.275 mg/L. Values ranged from <0.005 to 0.024 mg/L for the 14 TP samples with no samples exceeding the TP target of 0.025 mg/L.

There were eight chlorophyll-*a* samples, three AFDM samples, four periphyton samples, and three macroinvertebrate samples collected from Lazier Creek. Chlorophyll-*a* values ranged from 22 to 69 mg/m^2 and none of the samples exceed the target of 125 mg/m^2. AFDM ranged from 18 to 54 g/m^2 with two exceedances of the 35 g/m^2 target. Two periphyton samples exceeded the 51% target. HBI values ranged from 2.67 to 5.37 with two exceedances of the 4.0 target. The exceedance of the targets for AFDM, periphyton, and HBI indicate nutrient impairment. According to DEQ’s assessment methodology, failure of biological targets while meeting the nutrient targets indicates algae may be consuming excess nutrients in the water column and/or that water quality sampling missed the pulse of nutrients that is causing the biological response.

Based on the existing nutrient impairment listings and failure of multiple biological targets (**Table 6-3**), all nutrient listings (i.e., nitrate, TN and TP) will be retained. Therefore, TMDLs will be written for TN and TP. The TN TMDL will address the nitrate listing. However, because none of the water samples exceeded target values, additional water column and biological sampling is recommended to help refine the impairment cause(s) and sources.

Table 6-2. Nutrient Data Summary for Lazier Creek

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1]	Max	Mean
Nitrate, mg/L	2004-2012	14	< 0.01	0.08	0.015
TN, mg/L	2011-2012	13	< 0.04	0.1	0.059
TP, mg/L	2004-2012	14	< 0.005	0.024	0.011
Chlorophyll-*a*, mg/m2	2011-2012	8	22	69	36
AFDM, g/m2	2012	3	18	54	36
Periphyton, %	2004-2011	4	25	68	47
Macroinvertebrate HBI	2004-2011	3	2.67	5.37	4.19

[1] Values preceded by a “<” symbol are detection limits for that parameter. The actual sample value was below the detection limit.

Table 6-3. Assessment Method Evaluation Results for Lazier Creek

Nutrient	Sample Size	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	Periphyton Test	Macro Test Result	TMDL Required
Nitrate	14	0.1	0	PASS	PASS	PASS	FAIL	FAIL	FAIL	YES
TN	13	0.275	0	PASS	PASS					YES
TP	14	0.025	0	PASS	PASS					YES

6.4.3.2 Little Bitterroot River (MT76L002_060)

The Little Bitterroot River is on the 2012 303(d) List as impaired by TN, TP, nitrate/nitrite, and chlorophyll-*a*. The impaired segment of the Little Bitterroot River begins at Hubbart Reservoir and flows 5.2 miles to the Flathead Reservation boundary (**Figure 6-1**).

Summary nutrient data statistics and assessment method evaluation results for the Little Bitterroot River are provided in **Tables 6-4 and 6-5**, respectively. Nutrient samples for the Little Bitterroot River were collected from 2004 through 2012. Nine nitrate samples were collected with values that ranged from < 0.01 to 0.13 mg/L. One of the samples exceeded the nitrate target of 0.1 mg/L. The values of the eight TN samples ranged from 0.33 to 0.63 mg/L with all samples exceeding the TN target of 0.275 mg/L. Nine TP samples ranged from 0.027 to 0.078 mg/L with all samples exceeding the TP target of 0.025 mg/L.

Two chlorophyll-*a* samples, one AFDM sample, four periphyton samples, and three macroinvertebrate samples were collected from the Little Bitterroot River. Chlorophyll-*a* values ranged from 32 to 124 mg/m² and did not exceed the target of 125 mg/m². The AFDM sample was 20 g/m² and did not exceed the target of 35 g/m². There was one exceedance of the 51% periphyton target. HBI values ranged from 4.72 to 5.61 with all three samples exceeding the target of 4.0.

The short length of Little Bitterroot River between Hubbart Reservoir and the Flathead Reservation resulted in a slightly smaller sample size than desired, but the data strongly support the existing nutrient impairment listings for nitrate, TN, and TP (**Table 6-5**). Although the chlorophyll-*a* target was not exceeded, the minimum sample size needed to evaluate if chlorophyll-*a* is still causing impairment was not met. TMDLs will be written for TN and TP. DEQ will address the nitrate listing with the TN TMDL and the chlorophyll-*a* listing with the TN and TP TMDLs.

Table 6-4. Nutrient Data Summary for the Little Bitterroot River

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1]	Max	Mean
Nitrate, mg/L	2004-2012	9	< 0.01	0.13	0.048
TN, mg/L	2011-2012	8	0.33	0.63	0.421
TP, mg/L	2004-2012	9	0.027	0.078	0.051
Chlorophyll-*a*, mg/m²	2004, 2011	2	32	124	78
AFDM, g/m²	2011	1	20	20	20
Periphyton, %	2004-2012	4	38	53	45
Macroinvertebrate HBI	2011	3	4.72	5.61	5.17

[1] 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 the Little Bitterroot River

Nutrient	Sample Size	Target Value (mg/l)	Target Exceed ances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	Peri-phyton Test	Macro Test Result	TMDL Required
Nitrate	9	0.1	1	FAIL	n/a*	PASS	PASS	FAIL	FAIL	YES
TN	8	0.275	8	FAIL	FAIL					YES
TP	9	0.025	9	FAIL	FAIL					YES

*Minimum sample sizes were not met, but impairment is apparent and there were enough exceedances to fully assess and keep listed.

6.4.3.3 Little Thompson River (MT76N005_040)

The Little Thompson River is on the 2012 303(d) List as impaired by TP. The impaired segment of the Little Thompson River begins at the headwaters and flows 19.92 miles until its termination at the confluence with the Thompson River (**Figure 6-1**).

Summary nutrient data statistics and assessment method evaluation results for the Little Thompson River are provided in **Tables 6-6 and 6-7**, respectively. Nutrient samples were collected for the Little Thompson River from 2003 through 2012. Twenty nitrate samples were collected and values ranged from < 0.005 to 0.02 mg/L with none of the samples exceeding the target of 0.1 mg/L. Sixteen TN samples were collected and values ranged from < 0.01 to 0.26 mg/L with none of the samples exceeding the target of 0.275 mg/L. Twenty TP samples were collected and values ranged from 0.006 to 0.022 mg/L with no samples exceeding the target of 0.025 mg/L.

Eight chlorophyll-*a* samples, 6 AFDM samples, 8 periphyton samples, and 12 macroinvertebrate samples were collected from the Little Thompson River. Chlorophyll-*a* values ranged from 5 to 25 mg/m² and did not exceed the target of 125 mg/m². The AFDM samples ranged from 5 to 45 g/m² with one of the observations exceeding the target of 35 g/m². There were two exceedances of the 51% periphyton target. HBI values ranged from 1.63 to 4.23 with three of the samples exceeding the target of 4.0. The exceedance of the targets for AFDM, periphyton, and HBI indicate nutrient impairment. According to DEQ's assessment methodology, failure of biological targets while meeting the nutrient targets indicates algae may be consuming excess nutrients in the water column and/or that water quality sampling missed the pulse of nutrients that is causing the biological response.

Based on the existing nutrient listing and failure of multiple biological targets (**Table 6-7**), the TP impairment listing will be retained. Because nutrient concentrations in the water column were below target values, it is unclear whether excess phosphorus and/or nitrogen is causing the impairment. Therefore, TN will be added to the 2014 303(d) as an impairment cause and TMDLs will be written for TN and TP. However, because none of the water samples exceeded target values, additional water column and biological sampling is recommended to help refine the impairment cause(s) and sources.

Table 6-6. Nutrient Data Summary for the Little Thompson River

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1]	Max	Mean
Nitrate, mg/L	2004-2012	20	< 0.005	0.02	0.0056
TN, mg/L	2007-2012	16	< 0.01	0.26	0.089
TP, mg/L	2004-2012	20	0.006	0.022	0.013
Chlorophyll-*a*, mg/m^2	2007-2012	8	5	25	15
AFDM, g/m^2	2011-2012	6	5	45	17
Periphyton, %	2004-2011	8	25	95	46
Macroinvertebrate HBI	2003-2011	12	1.63	4.23	3.38

[1] 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 the Little Thompson River

<table>
<tr><th>Nutrient</th><th>Sample Size</th><th>Target Value (mg/l)</th><th>Target Exceedances</th><th>Binomial Test Result</th><th>T-test Result</th><th>Chl-a Test Result</th><th>AFDM Test Result</th><th>Peri-phyton Test</th><th>Macro Test Result</th><th>TMDL Required</th></tr>
<tr><td>Nitrate</td><td>20</td><td>0.1</td><td>0</td><td>PASS</td><td>PASS</td><td rowspan="3">PASS</td><td rowspan="3">FAIL</td><td rowspan="3">FAIL</td><td rowspan="3">FAIL</td><td>NO</td></tr>
<tr><td>TN</td><td>16</td><td>0.275</td><td>0</td><td>PASS</td><td>PASS</td><td>YES</td></tr>
<tr><td>TP</td><td>20</td><td>0.025</td><td>0</td><td>PASS</td><td>PASS</td><td>YES</td></tr>
</table>

6.4.3.4 Lynch Creek (MT76N003_010)

Lynch Creek is on the 2012 303(d) List as impaired by TN and TP. The impaired segment of Lynch Creek begins at the headwaters and flows 13.33 miles until its termination at the confluence with the Clark Fork River (**Figure 6-1**).

Summary nutrient data statistics and assessment method evaluation results for Lynch Creek are provided in **Tables 6-8 and 6-9**, respectively. Nutrient samples for Lynch Creek were collected from 2004 through 2012. Twenty-six nitrate samples were collected with values ranging from < 0.01 to 0.32 mg/L. One of the samples exceeded the target of 0.1 mg/L. Twenty-four TN samples were collected and values ranged from < 0.05 to 0.91 mg/L with six of the samples exceeding the target of 0.275 mg/L. Twenty-six TP samples were collected and values ranged from 0.013 to 0.038 mg/L with eight samples exceeding the TP target of 0.025 mg/L.

Twelve chlorophyll-*a* samples were collected from Lynch Creek between 2009 and 2011 and six AFDM samples were collected from Lynch Creek in 2011. Chlorophyll-*a* values ranged from 1 to 53 mg/m^2 and did not exceed the target of 125 mg/m^2. The AFDM samples ranged from 4 to 37 g/m^2 with one of the observations exceeding the target of 35 g/m^2. There were 10 periphyton samples collected from Lynch Creek between 2004 and 2011 with 4 exceedances of the 51% target. There were seven macroinvertebrate samples collected from Lynch Creek between 2004 and 2011. HBI values ranged from 2.03 to 7.17. Two of these samples exceeded the target of 4.0.

Assessment results (**Table 6-9**) support the existing Lynch Creek impairment listings for TN and TP. As a result TMDLs will be written for TN and TP.

Table 6-8. Nutrient Data Summary for Lynch Creek

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1]	Max	Mean
Nitrate, mg/L	2004-2012	26	< 0.01	0.32	0.03
TN, mg/L	2009-2012	24	< 0.05	0.91	0.198
TP, mg/L	2004-2012	26	0.013	0.038	0.022
Chlorophyll-*a*, mg/m^2	2009-2011	12	1	53	12
AFDM, g/m^2	2011	6	4	37	10
Periphyton, %	2004-2011	10	28	95	55
Macroinvertebrate HBI	2004-2011	7	2.03	7.17	3.7

[1] 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 Lynch Creek

Nutrient	Sample Size	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	Periphyton Test	Macro Test Result	TMDL Required
Nitrate	26	0.1	1	PASS	PASS	PASS	FAIL	FAIL	FAIL	NO
TN	24	0.275	6	FAIL	PASS					YES
TP	26	0.025	8	FAIL	PASS					YES

6.4.3.5 Sullivan Creek MT76L002_070

Sullivan Creek is on the 2012 303(d) List as impaired by TP. The impaired segment of Sullivan Creek begins at the headwaters and flows 3.9 miles to the Flathead Reservation (**Figure 6-1**).

Summary nutrient data statistics and assessment method evaluation results for Sullivan Creek are provided in **Tables 6-10 and 6-11**, respectively. The sample dataset is very small because of the short length of the waterbody segment and limited surface flow, and it precluded the use of the statistical tools during assessment. Nutrients were sampled in Sullivan Creek from 2004 through 2012. Five nitrate samples were collected and all observations were < 0.01 mg/L with none of the samples exceeding the target of 0.1 mg/L. Three TN samples were collected and values ranged from 0.11 to 1.28 mg/L with one sample exceeding the target of 0.275 mg/L. Five TP samples were collected and values ranged from 0.014 to 0.061 mg/L with two samples exceeding the TP target of 0.025 mg/L.

One chlorophyll-*a* sample, one AFDM sample, two periphyton samples, and two macroinvertebrate samples were collected from Sullivan Creek. The chlorophyll-*a* value was 19 mg/m^2 and did not exceed the target of 125 mg/m^2. The AFDM sample was 6 g/m^2 and did not exceed the target of 35 g/m^2. Neither periphyton sample was exceeding the 51% target. The HBI values were 6.5 and 2.1 with one of these samples exceeded the target of 4.0.

Although the small sample size precluded a formal assessment, the exceedance of the HBI, TN, and TP targets indicate nutrient impairment. Since Sullivan Creek is currently listed for impairment by TP, that cause will be retained. There are insufficient data to determine if TN is also causing impairment in Sullivan Creek, but based on the magnitude of the exceedance (i.e., more than four times the target), a protective TMDL will be written for TN. Water quality samples have been collected by the Confederated Salish and Kootenai Tribes downstream of this segment within the Flathead Reservation. Although that data cannot be used to determine impairment for this segment of Sullivan Creek, TN concentrations close to the reservation boundary were reviewed and support the development of a protective TMDL for TN. Therefore, TMDLs will be written for TN and TP (**Table 6-11**).

Table 6-10. Nutrient Data Summary for Sullivan Creek

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1]	Max	Mean
Nitrate, mg/L	2004-2012	5	< 0.01	< 0.01	< 0.01
TN, mg/L	2012	3	0.11	1.28	0.52
TP, mg/L	2004-2012	5	0.014	0.061	0.03
Chlorophyll-*a*, mg/m^2	2012	1	19	19	19
AFDM, g/m^2	2012	1	6	6	6
Periphyton, %	2004-2008	2	18	21	19
Macroinvertebrate HBI	2004, 2011	2	2.1	6.5	4.27

[1] 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 Sullivan Creek

<table>
<tr><th>Nutrient</th><th>Sample Size</th><th>Target Value (mg/l)</th><th>Target Exceedances</th><th>Binomial Test Result</th><th>T-test Result</th><th>Chl-a Test Result</th><th>AFDM Test Result</th><th>Peri-phyton Test</th><th>Macro Test Result</th><th>TMDL Required</th></tr>
<tr><td>Nitrate</td><td>5</td><td>0.1</td><td>0</td><td>n/a[2]</td><td>n/a[2]</td><td rowspan="3">PASS[3]</td><td rowspan="3">PASS[3]</td><td rowspan="3">PASS[3]</td><td rowspan="3">FAIL[3]</td><td>NO</td></tr>
<tr><td>TN[1]</td><td>3</td><td>0.275</td><td>1</td><td>n/a[2]</td><td>n/a[2]</td><td>YES</td></tr>
<tr><td>TP</td><td>5</td><td>0.025</td><td>2</td><td>n/a[2]</td><td>n/a[2]</td><td>YES</td></tr>
</table>

[1]There are insufficient data to include Sullivan Creek on the 303(d) list for TN, but based on the magnitude of exceedances, a TMDL was developed for TN.
[2]Not enough data to complete binomial test or T-test
[3]Minimum sample size not met

6.4.3.6 Swamp Creek (MT76N003_160)

Swamp Creek is on the 2012 303(d) List as impaired by TN, TP, and nitrate/nitrite. The impaired segment of Swamp Creek begins at West Fork Swamp Creek and flows 4.76 miles until its termination at the confluence with the Clark Fork River (**Figure 6-1**).

Summary nutrient data statistics and assessment method evaluation results for Swamp Creek are provided in **Tables 6-12 and 6-13**, respectively. Nutrient samples for Swamp Creek were collected from 2004 through 2011. Fourteen nitrate samples were collected and values ranged from < 0.01 to 0.01 mg/L with none of the samples exceeding the target of 0.1 mg/L. Thirteen TN samples were collected with values ranging from < 0.01 to 0.11 mg/L with none of the samples exceeding the target of 0.275 mg/L. Fourteen TP samples were collected and values ranged from <0.005 to 0.027 mg/L with one sample exceeding the target of 0.025 mg/L.

Twelve chlorophyll-*a* samples, three AFDM samples, six periphyton samples, and four macroinvertebrate samples were collected from Swamp Creek. Chlorophyll-*a* values ranged from 2 to 71 mg/m^2 and did not exceed the target of 125 mg/m^2. The AFDM samples ranged from 5 to 47 g/m^2 with one of the observations exceeding the target of 35 g/m^2. Two periphyton samples exceeded the 51% target. HBI values ranged from 3.39 to 6.05 with three exceedances of the 4.0 target. The exceedance of the targets for AFDM, periphyton, and HBI indicate nutrient impairment. According to DEQ's assessment methodology, failure of biological targets while meeting the nutrient targets indicates algae may be taking up excess nutrients in the water column and/or that water quality sampling missed the pulse of nutrients that is causing the biological response.

Based on the existing nutrient impairment listings and failure of multiple biological targets (**Table 6-13**), all nutrient listings (i.e., nitrate, TN and TP) will be retained. Therefore, TMDLs will be written for TN and TP. The TN TMDL will address the nitrate listing. However, because none of the water samples exceeded target values, additional water column and biological sampling is recommended to help refine the impairment cause(s) and sources.

Table 6-12. Nutrient Data Summary for Swamp Creek

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1]	Max	Mean
Nitrate, mg/L	2004-2011	14	< 0.01	0.01	0.006
TN, mg/L	2007-2011	13	< 0.01	0.11	0.074
TP, mg/L	2004-2011	14	< 0.005	0.027	0.010
Chlorophyll-*a*, mg/m^2	2007-2011	12	2	71	18
AFDM, g/m^2	2011	3	5	47	23
Periphyton, %	2004-2011	6	30	61	43
Macroinvertebrate HBI	2004, 2011	4	3.39	6.05	5.18

[1] 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 Swamp Creek

Nutrient	Sample Size	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	Periphyton Test	Macro Test Result	TMDL Required
Nitrate	14	0.1	0	PASS	PASS					YES
TN	13	0.275	0	PASS	PASS	PASS	FAIL	FAIL	FAIL	YES
TP	14	0.025	1	PASS	PASS					YES

6.5 Source Assessment

This section summarizes the source assessment approach and findings for each of the six stream segments of concern for nutrients.

6.5.1 Source Assessment Approach

Based on the review of water quality data, geographic information, and project reports and narratives, potential human caused sources of nutrient loading to the impaired waterbodies in the Thompson TMDL Project Area include agriculture, development, timber harvest, and failing septic systems. These are all nonpoint sources, meaning they are dispersed across the landscape and do not originate from a discrete source, such as a pipe (i.e., point source). The Thompson Project Area does not have any permitted point sources of nutrients. Nutrient sources therefore consist primarily of 1) natural sources derived from airborne deposition, vegetation, soils, and geologic weathering; and 2) human-caused nonpoint sources (i.e., grazing, septic, residential development, and timber harvest).

Because there are no point sources and nonpoint source categories are intermixed within each watershed, the source assessment approach focuses on using monitoring data collected between 2004 and 2012 to evaluate spatial patterns and identify the most probable nutrient sources. Since all water quality data were collected during the growing season (i.e., July 1 – September 30), the source characterizations are focused mainly on sources and mechanisms that influence nutrient contributions during this period. To display this information, box plots are used. In descriptive statistics, box plots are a convenient way of graphically depicting groups of numerical data through their five number summaries. Box plots depict the smallest observation (sample minimum), 25th percentile, median, 75th percentile, and the largest observation (sample maximum). Box plots display differences between the data without making any assumptions of the underlying statistical distribution of the data. The spacing between the different parts of the box indicates the degree of dispersion and skewness in data and identifies outliers. When sample data used in boxplots were below detection limits, one half of the detection limit was used.

Synoptic sampling data (from multiple sites on the same day) as well as other sources such as DEQ assessment files, GIS land use data, and personal communication with land managers were also used for the source assessment. For streams where low nutrient concentrations limited the use of instream data for assessing source category contributions, these other data sources were the basis of the source assessment.

6.5.2 Source Categories

There are no permitted point sources of nutrients in the impaired waterbody segments; cattle grazing and timber harvest are the primary human source categories in the Thompson Project Area, but developed areas and septic systems are other potential human sources that were evaluated. **Section 6.5.2.1** through **Section 6.5.2.6** presents individual source assessment summaries for each impaired watershed in the Thompson Project Area. A brief summary of each potential source category is described below.

6.5.2.1 Agriculture

Although the majority of cattle are typically not grazing along the valley bottoms during the growing season, there are several possible mechanisms for the transport of nutrients from agricultural land to surface water during the growing season. The potential pathways include: the effect of grazing on vegetative health and its ability to uptake nutrients and minimize erosion in upland and riparian areas, breakdown of excrement and loading via surface and subsurface pathways, delivery from grazed forest and rangeland during the growing season, transport of fertilizer applied in late spring via overland flow and groundwater, and the increased mobility of phosphorus caused by irrigation-related saturation of soils in pastures (Green and Kauffman, 1989). Cattle grazing occurs in several of the impaired watersheds in the Thompson Project Area.

6.5.2.1.1 Pasture

Pasture is managed for hay production during the summer, and for grazing feed during the fall and spring. Hay pastures are fairly thickly vegetated in the summer, and less so in the fall through spring. During the winter grazing period (October – May), trampling and consumption reduces biomass at a time of the year when it is already low.

6.5.2.1.2 Rangeland

Rangeland has much less biomass than other land uses, and therefore contributes fewer nutrients from biomass decay. However, grazing impacts (manure deposition) do factor in. Rangeland is grazed during the summer months in the watershed. The rangeland grazing typically occurs from June through September in the Thompson Project Area.

6.5.2.2 Development

Developed areas can contribute nutrients to the watershed by runoff from impervious surfaces, deposition by machines/automobiles, application of fertilizers, and increased irrigation on lawns.

Although developed areas often have the highest nutrient loading rates, in the Thompson Project Area developed areas make up a very small percentage of the overall area (0.23%). The only town in the Thompson Project Area is Plains, which is located in the Lynch Creek subwatershed. The total population in Plains is 1,048 according to the 2010 U.S. Census.

6.5.2.3 Septics

Septic systems, even when operating as designed can contribute nutrients to surface water through subsurface pathways. The amount of nutrients that a given septic system contributes to a waterbody is dependent upon its discharge, soils, and distance from the waterbody. The number and location of septic systems in the watershed was estimated based on cadastral data.

6.5.2.4 Timber Harvest

The forested areas in the Thompson Project Area are heavily timbered. Timber harvest inevitably causes some measure of downstream effects that may or may not be significant over time. Changes in land cover will change the rate at which water evapotranspires and thus the water balance, in that the distribution of water between base flow and runoff will change. Disturbances of the ground surface will also disrupt the hydrological cycle. The combination of these changes can alter water yield, peak flows and water quality (Jacobson, 2004). Changes in biomass uptake and soil conditions will affect the nutrient cycle. Nutrient uptake by biomass is greatly reduced after timber harvest, leaving more nutrients available for runoff. Elevated nitrate concentrations also result from increased leaching from the soil as mineralization is enhanced. This increase generally only lasts up to two or three years before returning to pre-harvest levels (Feller and Kimmins, 1984; Likens et al., 1978; Martin and Harr, 1989).

Therefore, the source assessment of timber harvest focuses on relatively recent harvest data. As part of the *Assessment of Upland Sediment Sources for TMDL Development* (**Attachment B**), timber harvest that occurred between 2006 and 2011 was identified by adjusting the 2006 NLCD layer. Adjustments on U.S. Forest Service lands were performed based on timber harvest polygons provided by the U.S. Forest Service.

6.5.2.5 Natural Background

The natural background component of nutrient loading was not explicitly evaluated, but a significant component of the forest category and portions of all other categories are associated with background loading.

The effect of wildlife grazing and waste on nutrient loading is considered part of the natural background load. The contribution of wildlife was not evaluated during this project and may be greater in more heavily used areas of the watershed, however, wildlife were assumed to contribute a minimal nutrient load relative to livestock. Forest fires are also considered part of natural background. Fires occurring between 2006 and 2011 were quantified for private and public land using the process described above for timber harvest (and in **Appendix A**). Recently burned areas are indicated on the watershed map for each stream segment of concern within this section for informational purposes. The only recent fires occurred in the Little Bitterroot and Little Thompson drainages in 2007.

6.5.3 Lazier Creek (MT76N005_060)

The source assessment for Lazier Creek consists of an evaluation of nitrate, TN, and TP concentrations in the impaired segment of Lazier Creek. This is followed by a description of the potential human caused sources of nutrients as indicated by the source assessment for the Thompson Project Area.

Data Analysis

DEQ collected water quality samples from Lazier Creek during the growing season over the time period of 2004-2012 (**Section 6.4.3.1**, **Table 6-2**). **Figures 6-2, 6-3, and 6-4** present summary statistics for TN, nitrate, and TP concentrations, respectively, at sampling sites in Lazier Creek. The stations are listed from upstream to downstream (left to right). All TN, nitrate, and TP values in this segment were below their respective targets of 0.275, 0.1, and 0.025 mg/L. The segment was listed for nutrient impairment due to exceedances of the HBI, periphyton, and AFDM targets. There does not appear to be a strong pattern for nutrient concentrations in the segment. Although all nutrient samples were below their targets, the highest observations occurred in the most downstream portion of the creek, below Whitney Creek. However, exceedances of the AFDM, HBI, and periphyton targets occurred both above and below Whitney Creek, indicating nutrient sources are likely dispersed throughout the watershed.

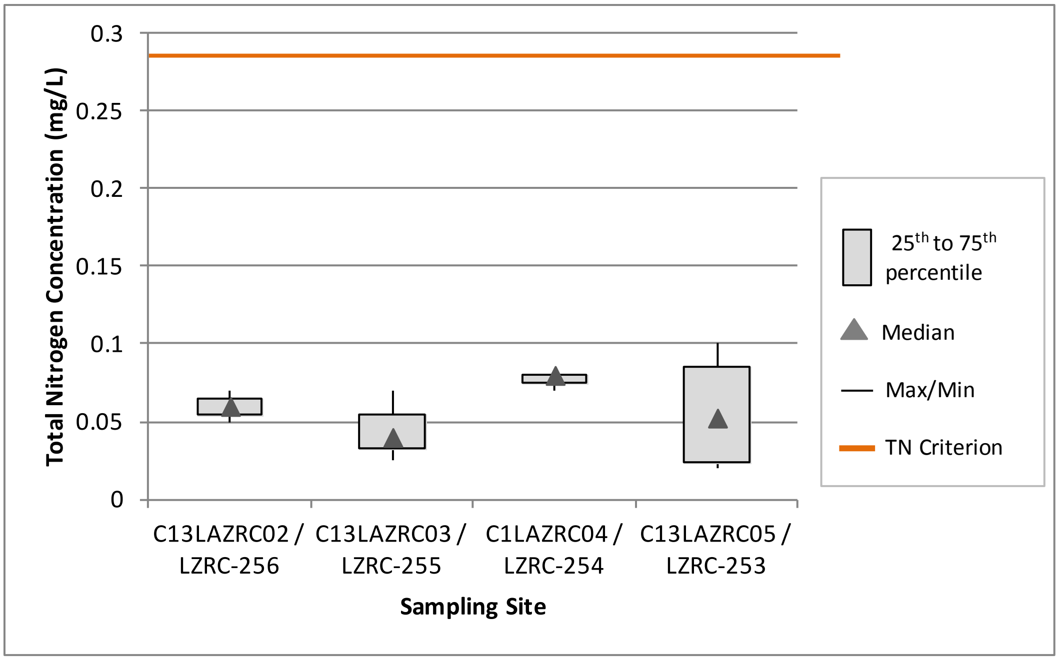


Figure 6-2. TN Box Plots for Lazier Creek.

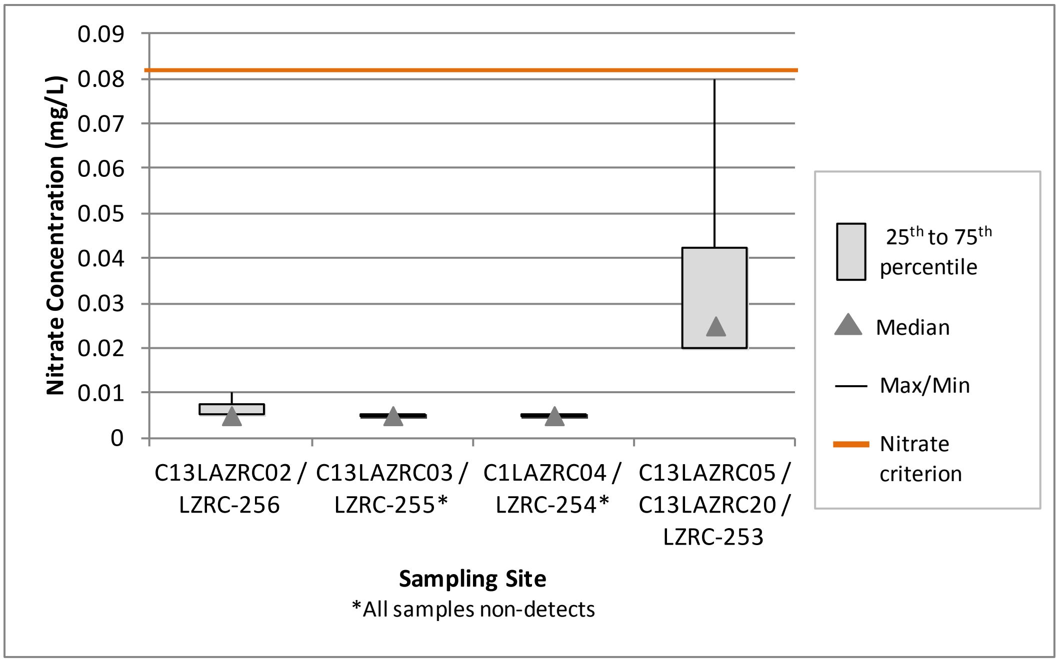


Figure 6-3. Nitrate Box Plots for Lazier Creek.

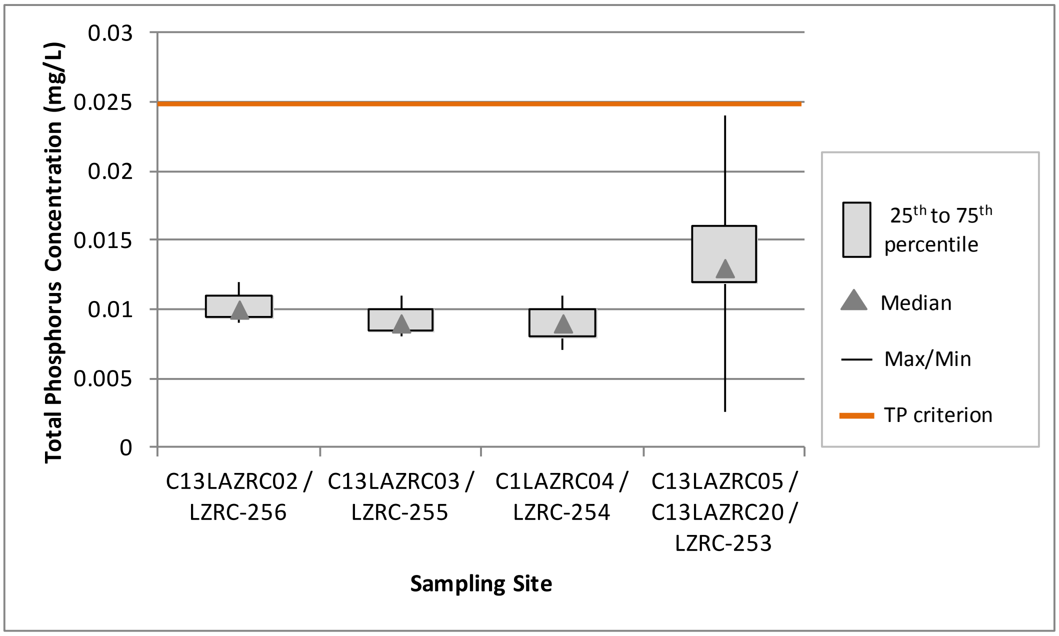


Figure 6-4. TP Box Plots for Lazier Creek.

Land Cover and Land Use

The dominant land cover in the Lazier Creek watershed is evergreen forest (81%) (Homer et al., 2007). Most of the evergreen forest (83%) is private timberland (Montana Cadastral, 2013). DEQ's 2011 field notes (ATKINS, 2013c) indicate timber harvest as the primary land use along Lazier Creek below the confluence with Whitney Creek. Above the confluence with Whitney Creek, timber harvest and grazing are the primary land uses. The field notes also indicate that extensive timber harvest has occurred throughout the watershed.

Plum Creek Timber Co., Inc. is a major landowner in the Thompson Project Area, including much of the Lazier Creek watershed. Most of the Plum Creek land in the Lazier Creek watershed is leased for grazing. The land is used for grazing from June through September and works on a rest-rotation system where some pastures are grazed while others are rested. These grazing pastures are rotated regularly. Portions of the U.S. Forest Service's (USFS's) Fishtrap grazing allotment are located in the headwaters of the Lazier Creek watershed (2,916 acres); however, the Fishtrap allotment is currently inactive (U.S. Forest Service, 2009). The Fishtrap allotment was last used in 1993 and officially closed in May 2007 (USFS, personal communication 2013[10]).

Montana Fish, Wildlife, and Parks (FWP) owns a conservation easement on 84,412 acres of land in the Thompson River watershed. Quite a bit of Plum Creek land in the lower portion of the Lazier Creek watershed is included in this easement. The state of Montana acquired the easement in several phases between 2001 and 2003. It precludes development, but allows traditional uses such as forestry, grazing, hunting, and fishing. Public access is secured through this easement (Plum Creek, personal communication 2013[11]).

According to the Montana cadastral, there are no septic systems in the Lazier Creek watershed (Montana Department of Administration, 2010).

Summary and Conclusions

Timber harvest and grazing appear to be the most probable sources of nutrients to Lazier Creek. The water quality data indicate some higher nutrient loading in the downstream portion of Lazier Creek; however, the biological data indicate sources throughout the impaired segment. Field observations also indicate timber harvest throughout the watershed and grazing upstream of Whitney Creek as potential sources. Development and septic systems are not expected to be nutrient sources in the watershed due to their absence. **Figure 6-5** shows the locations of all potential nutrient sources in the Lazier Creek watershed.

[10] Personal communication with Randy Hojem, Plains/Thompson Falls District Ranger, Lolo National Forest. 2013.
[11] E-mails from Brian Sugden, Plum Creek Hydrologist to Eugenia Hart, Tetra Tech in September 2013.

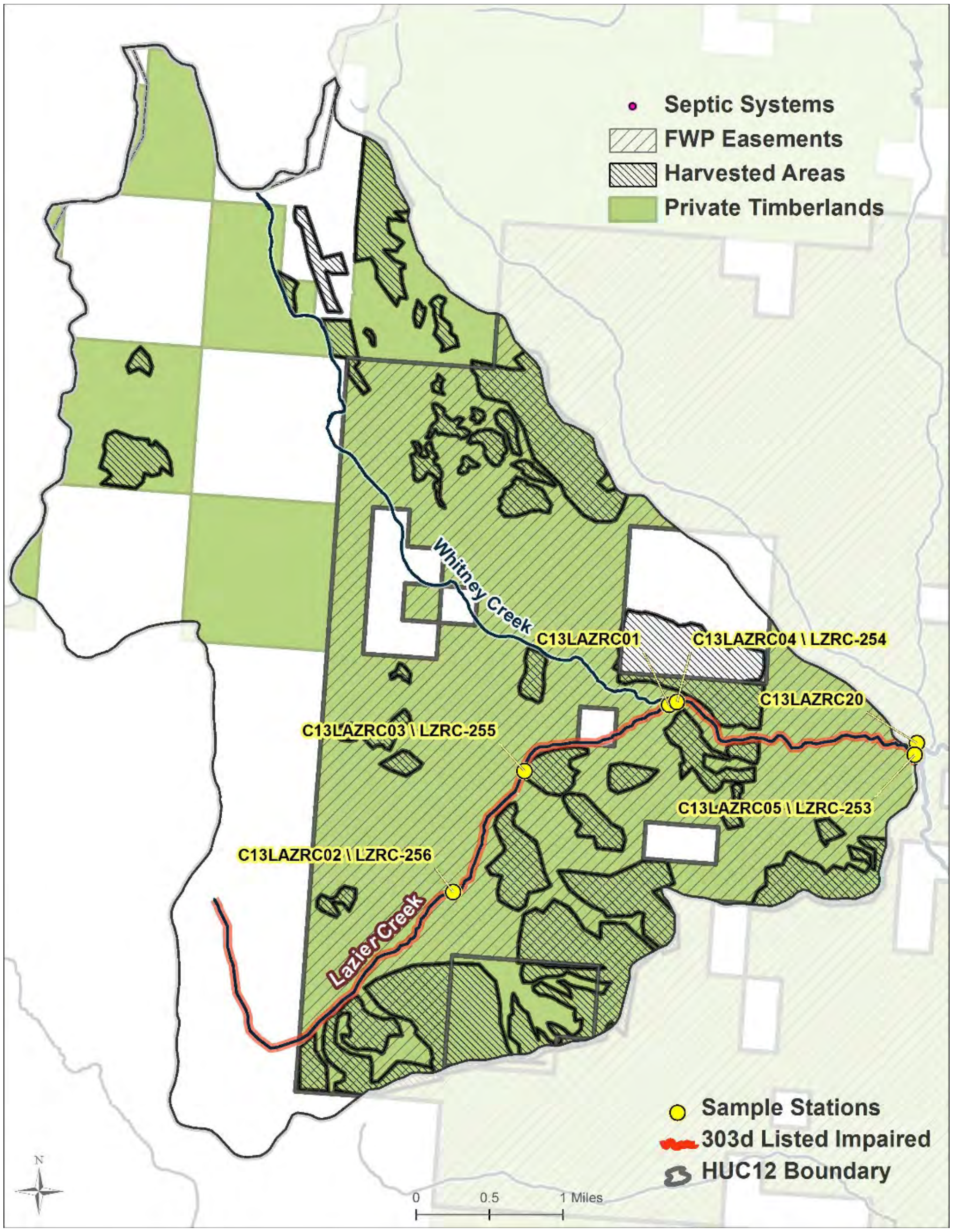


Figure 6-5. Location of potential nutrient sources in the Lazier Creek watershed.

6.5.4 Little Bitterroot River (MT76L002_060)

The source assessment for the Little Bitterroot River consists of an evaluation of nitrate, TN, and TP concentrations in the impaired segment of the Little Bitterroot River. This is followed by a description of potential human caused sources of nutrients as indicated by the source assessment for the Thompson Project Area.

Data Analysis

DEQ collected water quality samples from the Little Bitterroot River during the growing season over the time period of 2004-2012 (**Section 6.4.3.2**, **Table 6-4**). **Figures 6-6** through **6-8** present summary statistics for TN, nitrate, and TP concentrations at sampling sites in the Little Bitterroot River. There are exceedances of the TN target of 0.275 mg/L at all 3 stations. The highest observation was at station

LBRR-299 below Clear Creek; however, there is no strong pattern of TN concentrations upstream to downstream (left to right). Nitrate values in this segment were typically below the target of 0.1 mg/L, except for one exceedance at the most upstream station (C12LTBTR02) just below Briggs Creek. There is no strong nitrate pattern along the stream gradient. TP values in this segment were often greater than the target of 0.025 mg/L at all sites, with the highest observation occurring in the upper part of the segment at station C12LTBTR02/LBRR-289 just below Briggs Creek, but there is no consistent spatial pattern.

Chlorophyll-*a* and AFDM observations were below their respective targets and HBI scores were exceeding their target throughout the entire reach. The periphyton target was exceeded in the upstream portion of the impaired segment just below Briggs Creek.

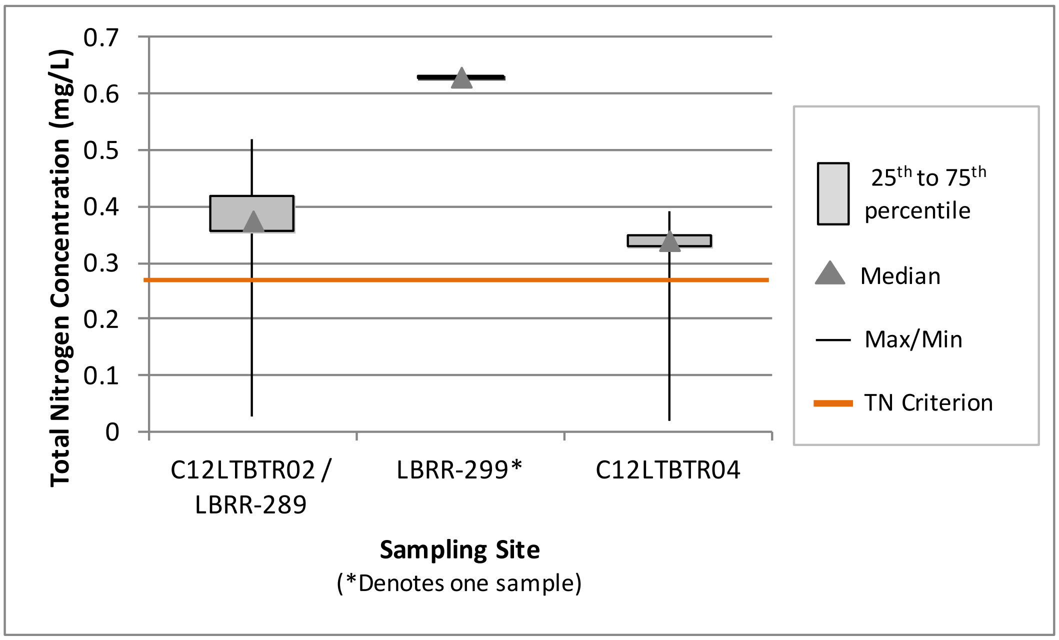


Figure 6-6. TN Box Plots for the Little Bitterroot River.

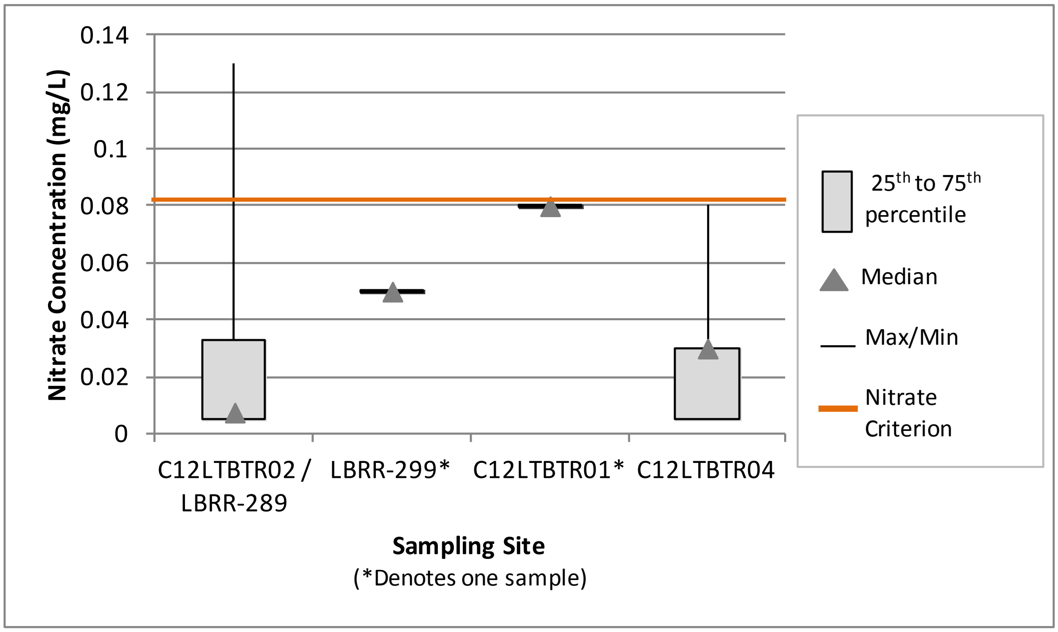


Figure 6-7. Nitrate Box Plots for the Little Bitterroot River.

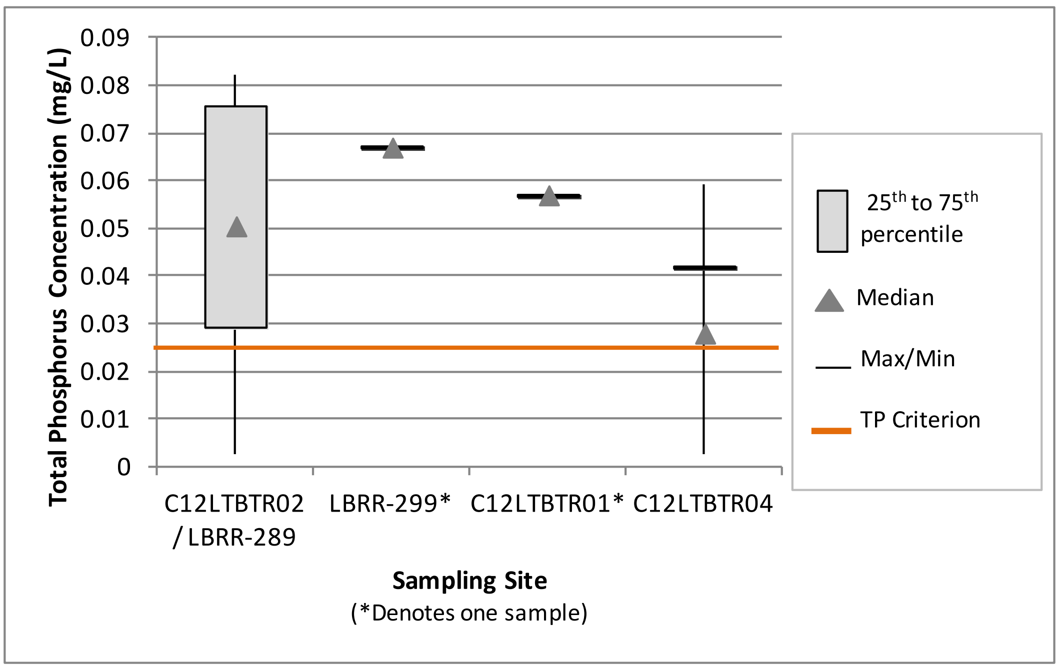


Figure 6-8. TP Box Plots for the Little Bitterroot River.

Land Use and Land Cover

The dominant land cover in the Little Bitterroot River watershed is evergreen forest (64%) and the predominant land use in this area is timber harvest (Montana Department of Environmental Quality, 2012e). Most of the land in the Little Bitterroot River watershed is owned by the Plum Creek Timber Company (Montana Cadastral, 2013). There are no USFS or Bureau of Land Management (BLM) grazing allotments and no land is leased from Plum Creek for grazing in the Little Bitterroot River watershed, however, private lands are used for grazing.

There are 140 septic systems in the watershed (Montana Base Map Service Center, 2010), but they are concentrated around Little Bitterroot Lake, well upstream of the impaired portion of the river. There are two septic systems located along unnamed tributaries to the impaired portion of the Little Bitterroot River and there is one septic system located adjacent to the lower portion of the Little Bitterroot River. However, the water quality samples do not indicate that nutrient loading from septic systems is a particular issue in the Little Bitterroot River.

DEQ's 2011 field notes (ATKINS, 2013c) indicate that the area near stations C12LTBR02/LBRR-289, just downstream of the confluence with Briggs Creek, is primarily used for grazing and timber harvest. Signs of heavy grazing were noticed near the mouth of Briggs Creek as well as extensive aquatic vegetation on the streambed. The field notes also noted severe streambank erosion near the lower end of the Little Bitterroot River, which is also used for cattle grazing. Woody vegetation was lacking along the streambanks and the wetland vegetation was heavily browsed.

Summary and Conclusions

In summary, grazing and timber harvests appear to be the most probable sources of nutrients to the Little Bitterroot River. The water quality data are exceeding the nutrient targets throughout the entire impaired portion of the Little Bitterroot River, indicating sources are located throughout the entire watershed. Recent site visits (2011) indicate grazing throughout the entire watershed and timber harvest in the upper watershed as potential sources. Timber harvests have occurred throughout the entire stream segment. The impaired portion of the Little Bitterroot River drains an area from the mouth of Little Bitterroot Lake (about 14 miles upstream of the northern portion of the impaired segment) and includes Hubbart Reservoir directly above the impaired segment; however, there are no data available for Hubbart Reservoir upstream of the impaired segment to analyze potential upstream sources. Data collection at the reservoir outlet and upstream of the impaired reach would be useful in determining additional potential sources. It is currently unknown if the development and septic systems located in the headwaters of the river near Little Bitterroot Lake could be contributing to the high nutrients in the lower portion of the waterbody. One observation in Little Bitterroot Lake in 2011 shows no exceedances of the TN or TP targets. No other data are available. Development and septic systems are not expected sources in the lower reach because nutrient concentrations below the unnamed tributaries, where septics are located, are no higher than any other area of the impaired reach. **Figure 6-9** shows the locations of all potential nutrient sources to the Little Bitterroot River.

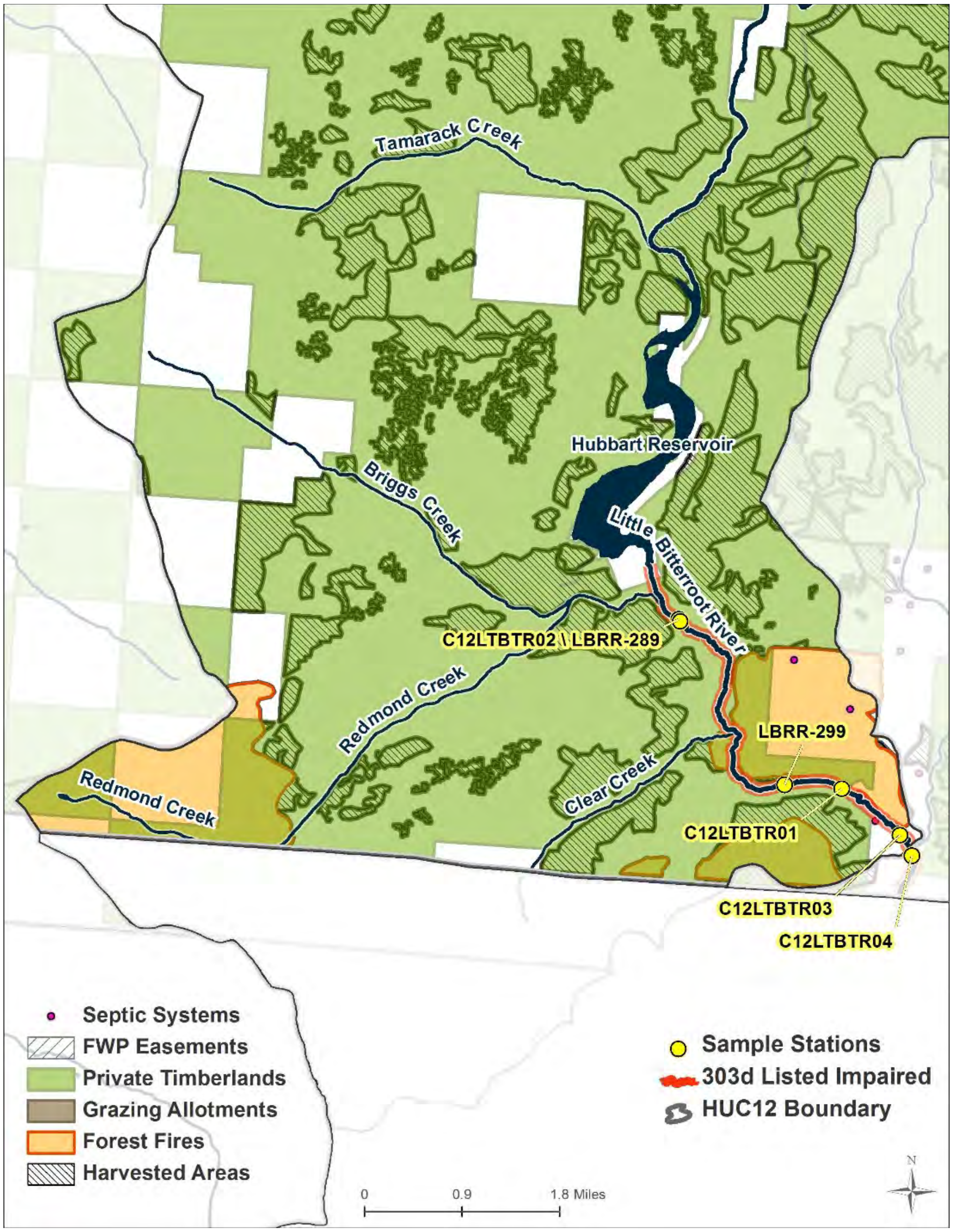


Figure 6-9. Location of potential nutrient sources in the Little Bitterroot River watershed.

6.5.5 Little Thompson River (MT76N005_040)

The source assessment for the Little Thompson River consists of an evaluation of TN and TP concentrations within the impaired segment of the Little Thompson River. This is followed by a description of potential human caused sources of nutrients as indicated by the source assessment for the Thompson Project Area.

Data Analysis

DEQ collected water quality samples from the Little Thompson River during the growing season over the time period of 2004-2012 (**Section 6.4.3.3**, **Table 6-6**). **Figures 6-10** and **6-11** present summary statistics for TN and TP concentrations, respectively, at sampling sites in the Little Thompson River. All TN and TP values in this segment were below their respective targets of 0.275 and 0.025 mg/L. The segment was listed for nutrient impairment due to exceedances of the HBI, periphyton, and AFDM targets.

Although none of the TN or TP observations exceed the criteria, the highest TN and TP concentrations were consistently observed in the upstream portion of the river below Alder Creek. During the four synoptic sampling events between 2004 and 2012, TN and TP concentrations were greatest at the upper most sample site and declined until downstream of the North Fork Little Thompson River (L13LTTPR03/LTLTR-244), where concentrations increased slightly until the mouth. Most exceedances of the biological data were observed in the upper portion of the watershed, above the confluence with McGinnis Creek, except for periphyton. Periphyton exceedances were observed at the mouth of the Little Thompson River. All three exceedances of the HBI target occurred just below the confluence with Tepee Creek and the AFDM exceedance was observed just above the confluence with McGinnis Creek.

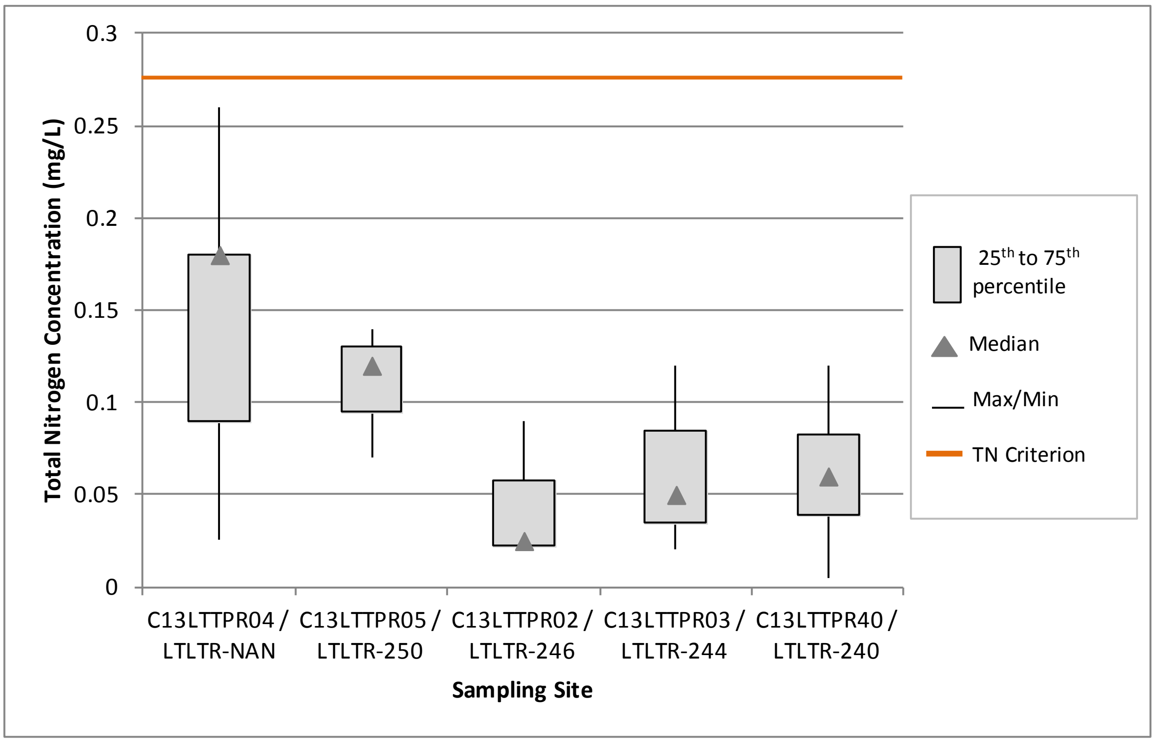


Figure 6-10. TN Box Plots for the Little Thompson River.

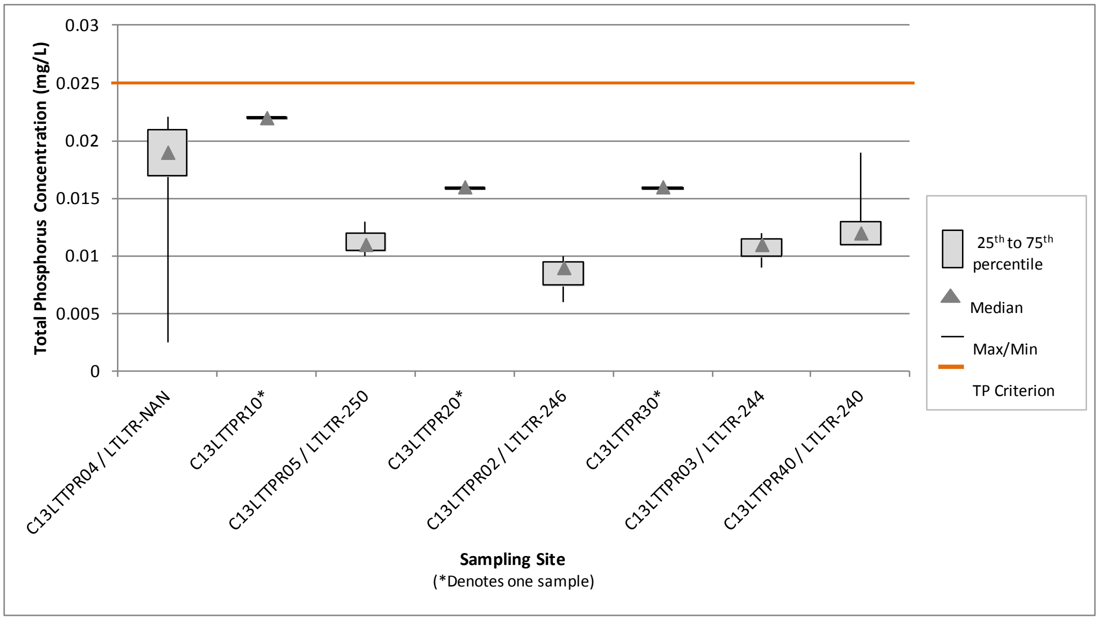


Figure 6-11. TP Box Plots for the Little Thompson River

Land Cover and Land Use

The dominant land cover in the Little Thompson River watershed is evergreen forest (87%) and 35% of that land is private timberland. DEQ's assessment record from 2004 (Montana Department of Environmental Quality, 2012f) states that livestock use in the headwaters of the river is common. The USFS's Little Thompson and McGinnis grazing allotments are located in the headwaters of the watershed (U.S. Forest Service, 2009). The Little Thompson grazing allotment is used in connection with approximately 1,280 acres of private land. The grazing occurs from June 15 through September 15 with 110 cattle permitted. The allotment is managed as three pastures under a rotation system. Each pasture is grazed two out of every three years: year 1 is grazed early, year 2 is grazed late, and year 3 is rested. The McGinnis allotment is active from June 1 through September 30 with 52 cattle permitted (USFS, personal communication 2013[12]).

DEQ's 2011 field notes (ATKINS, 2013c) indicate that the portion of the Little Thompson River above the confluence with the North Fork Little Thompson River is dominated by historic logging and grazing. Selective browsing of the wetland vegetation along the channel and hoof shear were observed along this area of the river (approximately 1 mile above the confluence with the North Fork Little Thompson River). Historic logging and ongoing grazing are also the primary land-use activities near the mouth of the Little Thompson River. Extensive logging occurs throughout the watershed.

Plum Creek Timber Co., Inc. is a major landowner in the Thompson Project Area. Montana Fish, Wildlife, and Parks (FWP) owns a conservation easement on 84,412 acres of land in the Thompson River watershed. Quite a bit of Plum Creek land in the Little Thompson River watershed is included in this easement. The state of Montana acquired the easement in several phases between 2001 and 2003. It precludes development, but allows traditional uses such as forestry, grazing, hunting, and fishing. Public access is secured through this easement (Plum Creek, personal communication 2013[13]).

[12] Personal communication with Randy Hojem, Plains/Thompson Falls District Ranger, Lolo National Forest. 2013.
[13] E-mails from Brian Sugden, Plum Creek Hydrologist, to Eugenia Hart, Tetra Tech in September 2013.

Most of the Plum Creek land in the Little Thompson River watershed is leased for grazing. The land is used for grazing from June through September and works on a rest-rotation system where some pastures are grazed whiles others are rested. These grazing pastures are rotated regularly (Plum Creek, personal communication 2013[14]). Timber harvest is also common in the watershed and roads, pasture, and logging all cause a moderate amount of disturbance (Montana Department of Environmental Quality, 2012f).

The only septic system in the Little Thompson River watershed is located along Marten Creek, a tributary to the mouth of the river (Montana Base Map Service Center, 2010).

Summary and Conclusions

- Grazing and timber harvest appear to be the most probable nutrient sources in the Little Thompson River. The water quality and biological data indicate some higher nutrient loading in the upper portion of watershed; however, exceedances were observed near the mouth of the watershed as well. This suggests that there is not a particular area of the watershed that has increased nutrient loading. Development and septic systems are not expected to be nutrient sources in the watershed due to their absence. **Figure 6-12** shows the locations of all potential nutrient sources in the Little Thompson River watershed.

[14] E-mails from Brian Sugden, Plum Creek Hydrologist, to Eugenia Hart, Tetra Tech in September 2013.

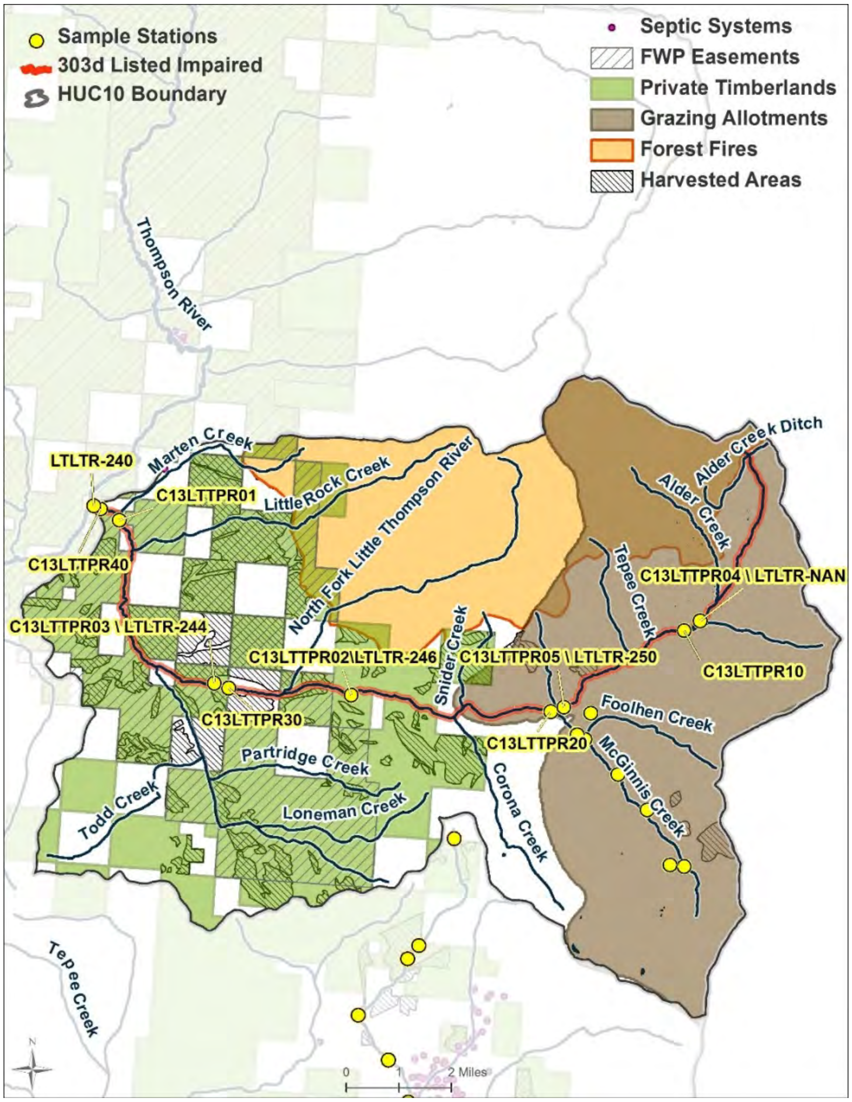


Figure 6-12. Location of potential nutrient sources in the Little Thompson River watershed.

6.5.6 Lynch Creek (MT76N003_010)

The source assessment for Lynch Creek consists of an evaluation of TN and TP concentrations in the impaired segment of Lynch Creek. This is followed by a description of potential human caused sources of nutrients as indicated by the source assessment for the Thompson Project Area.

Data Analysis

DEQ collected water quality samples from Lynch Creek during the growing season over the time period of 2004-2012 (**Section 6.4.3.4**, **Table 6-8**). **Figures 6-13 and 6-14** present summary statistics for TN and TP concentrations, respectively, at sampling sites in Lynch Creek. TN values in this segment were below the target of 0.275 mg/L at all stations except for the most upstream site and the two most downstream sites (**Figure 6-13**). **Figure 6-14** shows an increase in TP values in the downstream direction (left to right), with most exceedances of the 0.025 mg/L target occurring at the three most downstream sites. In addition to the TN and TP exceedances, one exceedance of the AFDM target occurred at the mouth of Lynch Creek as did the two HBI exceedances and one periphyton exceedance. The other three periphyton exceedances occurred in the upper portion of Lynch Creek above the confluence with Cedar Creek.

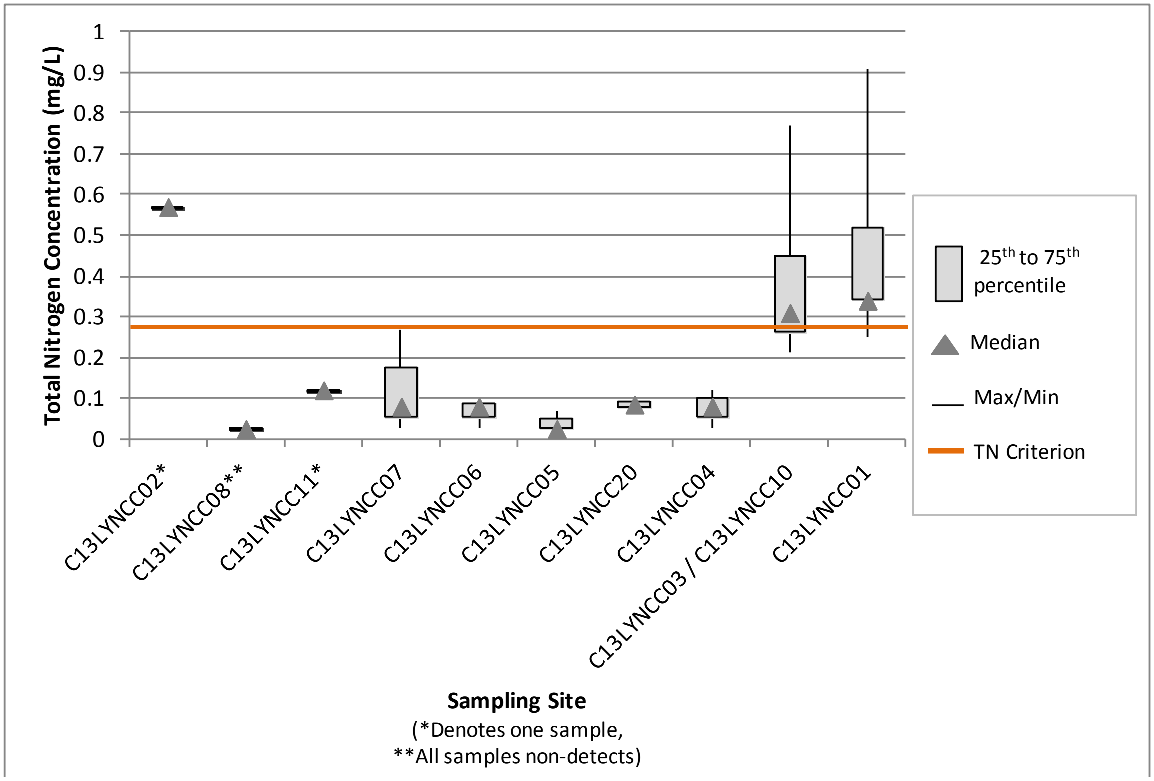


Figure 6-13. TN Box Plots for Lynch Creek.

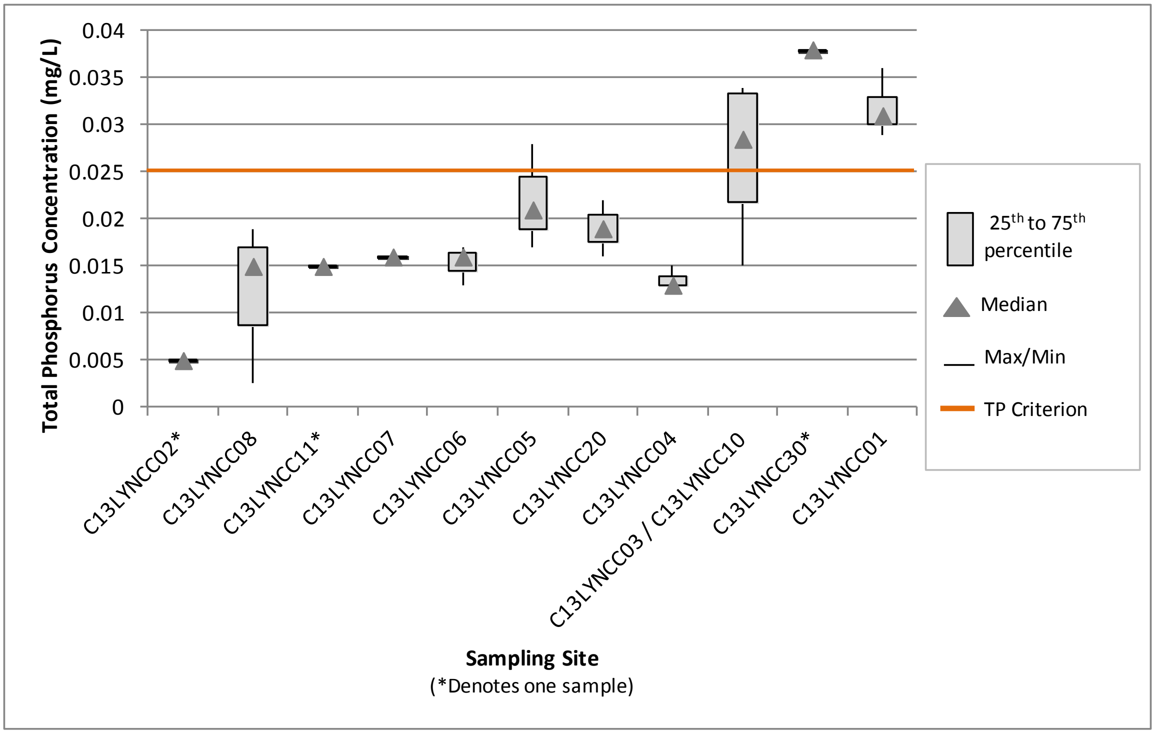


Figure 6-14. TP Box Plots for Lynch Creek.

Land Cover and Land Use

The dominant land cover in the Lynch Creek watershed is evergreen forest (66%) and 30% of the entire watershed is private timberland. Lynch Creek below Clark Creek is characterized by a lack of woody riparian vegetation and a straightened channel with a moderate amount of bank erosion. The dominant land uses in this lower portion of the creek are hay production and cattle grazing (Montana Department of Environmental Quality, 2012g). Hummocking, hoof trampling, and streambank erosion from cattle was noted during the 2011 site visit (ATKINS, 2013c). There are 446 acres of pasture/hay in the watershed that appear to be concentrated near the mouth of the creek (Homer et al., 2007). Within that area, the Montana Land Reliance has a 145-acre conservation easement (**Figure 6-15**) it has held since 1994. The headwaters of Lynch Creek to the confluence with Clark Creek is mostly forest with some cattle grazing but less than below the confluence with Clark Creek (Montana Department of Environmental Quality, 2012g). DEQ's 2011 field notes (ATKINS, 2013c) indicate that the area of the watershed above Cedar Creek is forested and was harvested for timber at one time. Timber harvest has occurred throughout the Lynch Creek watershed and signs of grazing were observed in the upper watershed including hoof trampling resulting in streambank erosion.

There is more development in the Lynch Creek watershed than other nutrient impaired watersheds in the Thompson Project Area. The lower portion of Lynch Creek is just outside the town of Plains, MT, which has a population of 1,074 (United States Census Bureau, 2010). There are 201 septic systems in the Lynch Creek watershed (Montana Base Map Service Center, 2010). Most are located on Cedar Creek, Hinchwood Creek, Clark Creek and along Lynch Creek downstream from Cedar Creek (**Figure 6-15**).

Summary and Conclusions

In summary, the water quality and biological data indicate some high TN concentrations and periphyton scores in the upper Lynch Creek watershed above Cedar Creek. The most probable sources of nutrients to this portion of the watershed appear to be timber harvest and cattle grazing. All TP, AFDM, and HBI exceedances occurred between Cedar Creek and the mouth of Lynch Creek. The most probable sources of nutrient loading to Lynch Creek below Cedar Creek appear to be development and timber harvest along Clark and Hinchwood Creeks as well as cattle grazing, hay production, and development along the mainstem of Lynch Creek below Cedar Creek. **Figure 6-15** shows the location of potential nutrient sources in the Lynch Creek watershed.

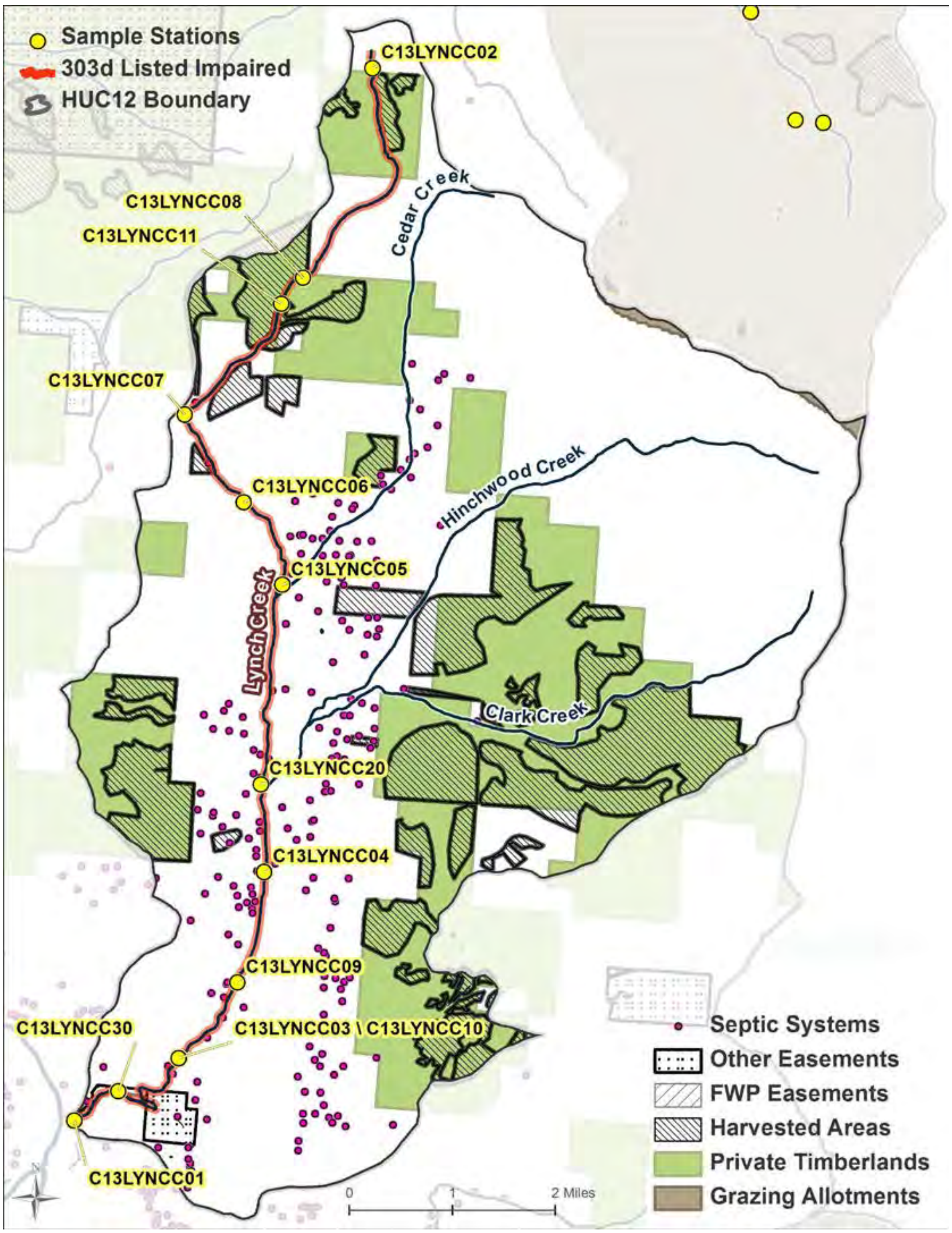


Figure 6-15. Locations of potential nutrient sources in the Lynch Creek watershed.

6.5.7 Sullivan Creek (MT76L002_070)

Data Analysis

Given the intermittent nature of Sullivan Creek, the water quality data are of limited use in assessing nutrient sources and loading. There are not enough stations with nutrient data on Sullivan Creek to make box plots meaningful. There are only two stations with a total of three TN observations and three stations with a total of six TP observations. There was one TN and one TP exceedance of their respective water quality targets. Both of the exceedances occurred at upstream station C12SLVNC02 (**Figure 6-16**) with the TN exceedance occurring in 2012 and the TP exceedance occurring in 2004. There was also one HBI score exceedance in 2012 at the most downstream station (C12SUllC02). There are not enough data to determine any seasonal or temporal trends or trends along the stream gradient.

Land Cover and Land Use

A site visit was performed at Sullivan Creek in 2011; however, no notes were included in the site assessment. The most recent site visit notes for Sullivan Creek are from the 2004 assessment. The upper section of the stream contains a swampy area that was disturbed by mining and the lower section is dry. Sub-surface flows predominate the segment. Cattle impacts are heavy throughout most of the watershed. Streambanks are trampled, riparian vegetation is degraded or missing, and the channel morphology has been altered by grazing (Montana Department of Environmental Quality, 2012i).

The dominant land covers in the Sullivan Creek watershed are evergreen forest (41%), shrub (25%), and grassland (34%) (Homer et al., 2007). Grazing and timber harvest appear to be the dominant land uses. There are a number of abandoned mines in the watershed, and one mine (Hog Heaven) that has an operating permit, but is not currently producing. These include both surface and underground mining (Montana Department of Environmental Quality, 2012i). These mines are not expected to be sources of nutrients to Sullivan Creek because they are currently inactive and they were not cyanide mines; therefore, there were no nitrates in the mining residuals. There are no other permitted point sources in the watershed, so any nutrient inputs are from nonpoint sources.

Plum Creek Timber Co., Inc. owns much of the land in the Sullivan Creek watershed. All of the Plum Creek land in the watershed is leased for grazing. The land is used for grazing from June through September and works on a rest-rotation system where some pastures are grazed whiles others are rested. These grazing pastures are rotated regularly.

Summary and Conclusions

There are only two septic systems in the watershed, both of which are located near the mouth of the stream (Montana Base Map Service Center, 2010) and are not expected to be a major source of nutrients to Sullivan Creek.

Water quality and biological data in Sullivan Creek indicate nutrient loading throughout the entire sampled portion of the creek. The most probable sources of nutrients to Sullivan Creek are timber harvesting and grazing in the upper portion of the watershed. Septic systems are not expected to be nutrient sources in the watershed due to their small numbers. **Figure 6-16** shows the locations of potential nutrient sources in the Sullivan Creek watershed.

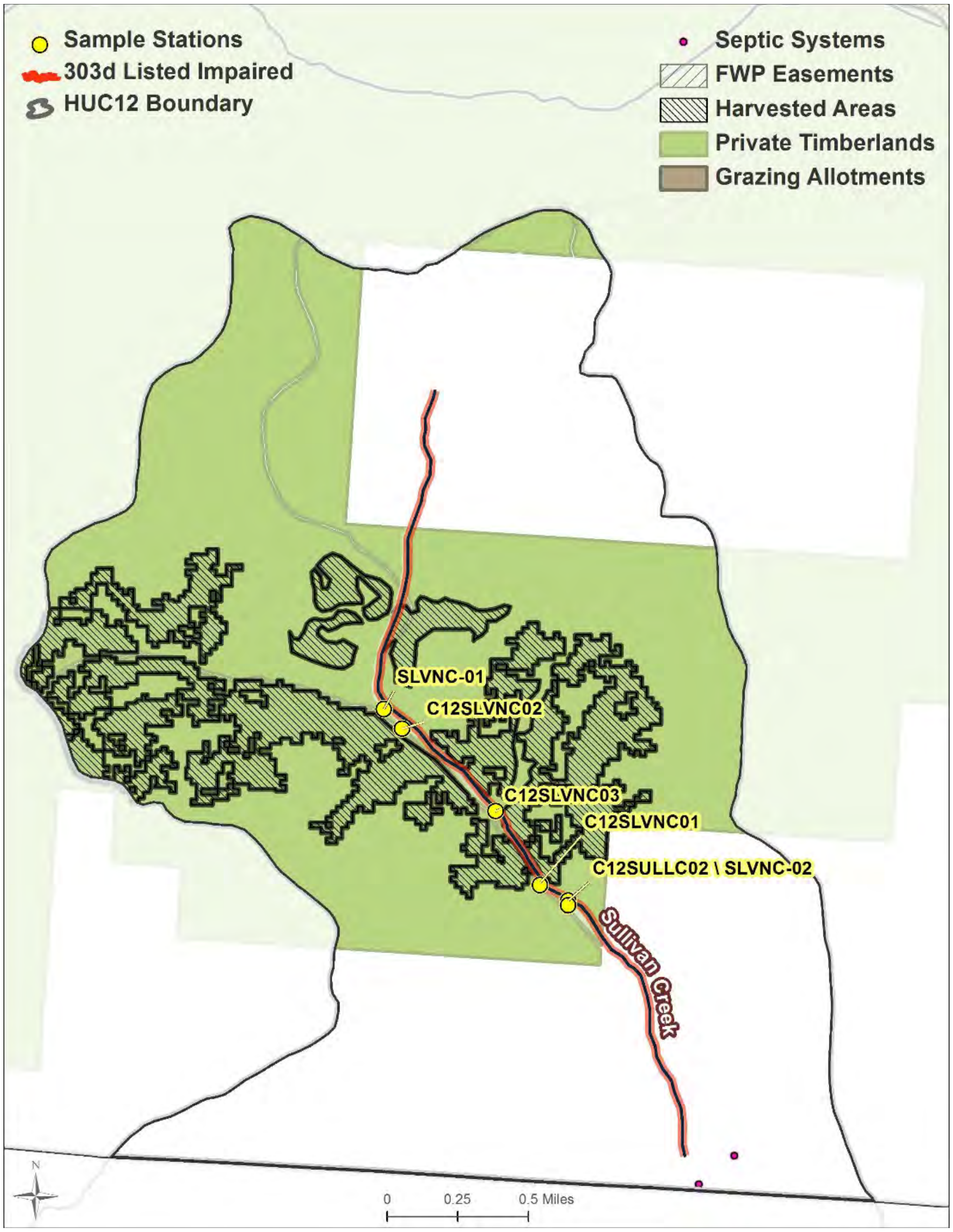


Figure 6-16. Location of potential nutrient sources in the Sullivan Creek watershed.

6.5.8 Swamp Creek (MT76N003_160)

The source assessment for Swamp Creek consists of an evaluation of nitrate, TN and TP concentrations in the impaired segment of Swamp Creek. This is followed by a description of potential human caused sources of nutrients as indicated by the source assessment for the Thompson Project Area.

Data Analysis

DEQ collected water quality samples from Swamp Creek during the growing season over the time period of 2004-2012 (**Section 6.4.3.6**, **Table 6-10**). **Figure 6-17** presents summary statistics for TN concentrations at sampling sites in Swamp Creek. TN values in this segment were always below the target of 0.275 mg/L and did not show any strong trends along the stream gradient.

Box plots for nitrate in Swamp Creek were not developed because almost all nitrate observations are non-detects or at the detection limit, therefore, box plots are of limited use in showing data trends. None of the observations were exceeding the 0.1 mg/L target. **Figure 6-18** presents summary statistics for TP concentrations at sampling sites in Swamp Creek. TP values in this segment were below the target of 0.025 mg/L at all sites except for one exceedance at the most downstream station (C13SWPCR20). Swamp Creek was listed for nutrients because of high AFDM, periphyton, and HBI scores rather than exceedances of the nitrate, TN, and TP targets. All exceedances of the AFDM, periphyton, and HBI targets occurred at the two most downstream stations: C13SWMPC02 (about 2.2 miles upstream of the mouth of Swamp Creek) and C13SWPCR20 (mouth of Swamp Creek).

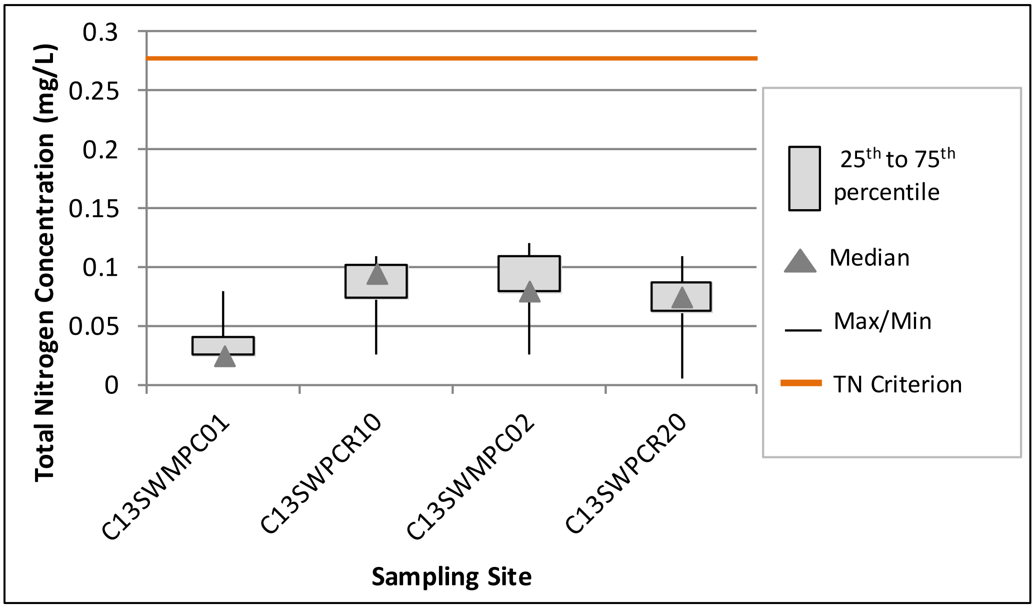


Figure 6-17. TN Box Plots for Swamp Creek.

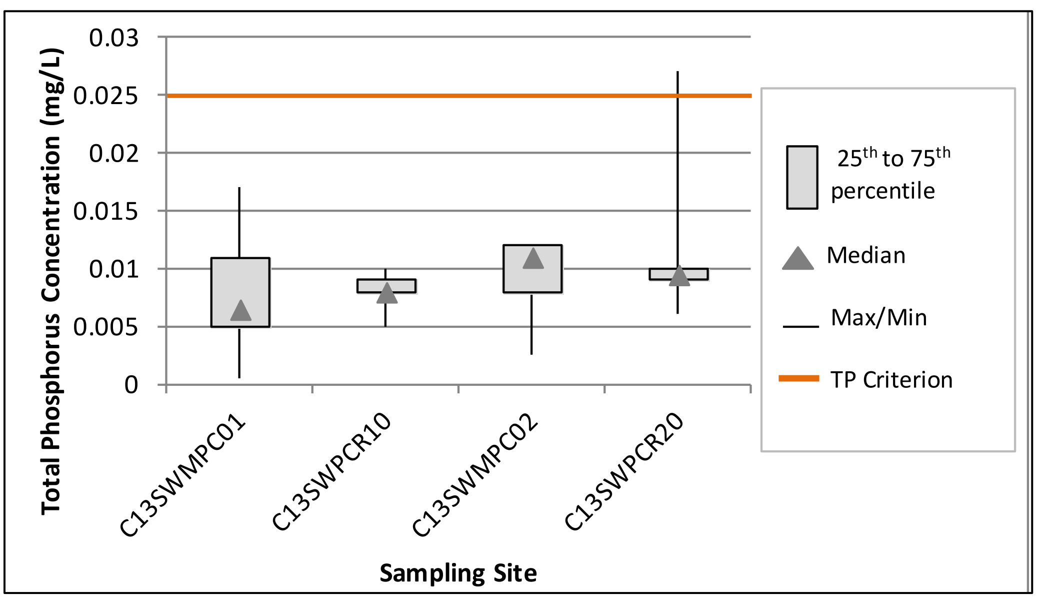


Figure 6-18. TP Box Plots for Swamp Creek.

Land Cover and Land Use

The dominant land cover in the Swamp Creek watershed is evergreen forest (86%) and 17 percent of the watershed is private timberland. Information in the DEQ assessment file indicates that the upper and lower portions of Swamp Creek are very different: the lower portion is a meadow stream system, while the upper portion is a higher gradient gravel-bedded system (Montana Department of Environmental Quality, 2012j).

DEQ's 2011 field notes (ATKINS, 2013c) confirm that the lower portion of Swamp Creek, below the confluence of the East and West Forks of Swamp Creek, are part of the meadow stream system, which may have been logged in the past and was likely grazed historically; however, there are no signs of recent grazing. The lower portion of the watershed, below station C13SWMPC02 was historically used for crop production and grazing but has been allowed to recover over the past 25 years (**Figure 6-19**). There are 45 septic systems located along the lower portion of the creek, mostly below station C13SWMPC10 (Montana Base Map Service Center, 2010).

The USFS has a grazing allotment in the headwaters of the Swamp Creek watershed. The Swamp Creek grazing allotment is active from June 1 through September 1 with 40 cattle permitted (USFS, personal communication 2013[15]). Plum Creek Timber Co., Inc. also owns land in the watershed and timber harvest occurs in the headwaters. All of the Plum Creek land in the watershed is leased for grazing. The land is used for grazing from June through September and works on a rest-rotation system where some pastures are grazed whiles others are rested. These grazing pastures are rotated regularly.

Approximately 471 acres of land along the upper part of the impaired stream segment (**Figure 6-19**) were placed into conservation easements between 1997 and 2000. Two of the easements (236 acres) are held by the Natural Resources Conservation Service (NRCS) under the Wetland Reserve Program and grazing and forestry is not allowed unless a benefit to wildlife habitat can be demonstrated (D. Feist, personal comm., 2014[16]). The other easement, which is 235 acres, is held by the Montana Land Reliance and limits development (D. Feist, personal comm., 2014[16)].

Summary and Conclusions

All monitoring stations in Swamp Creek are located below areas of grazing and timber harvest; however, no water quality or biological exceedances occurred at the upper two monitoring stations indicating that the nutrient sources may be downstream of station C13SWPCR10. Therefore, the most probable nutrient sources in Swamp Creek appear to be the ongoing grazing and timber harvesting occurring below station C13SWPCR10. Most of the septic systems in the watershed are located upstream of site C13SWPCR10, but there are no nutrient or biological exceedances seen until station C13SWMPC02, indicating that septic systems are not a significant source of nutrients to Swamp Creek. **Figure 6-19** shows the locations of all potential nutrient sources in the Swamp Creek watershed.

[15] Personal communication with Randy Hojem. Plains/Thompson Falls District Ranger, Lolo National Forest. 2013.
[16] Personal e-mail communication between Don Feist, District Conservationist, Natural Resources Conservation Service, Plains Field Office and Lisa Kusnierz, EPA, Region 8.

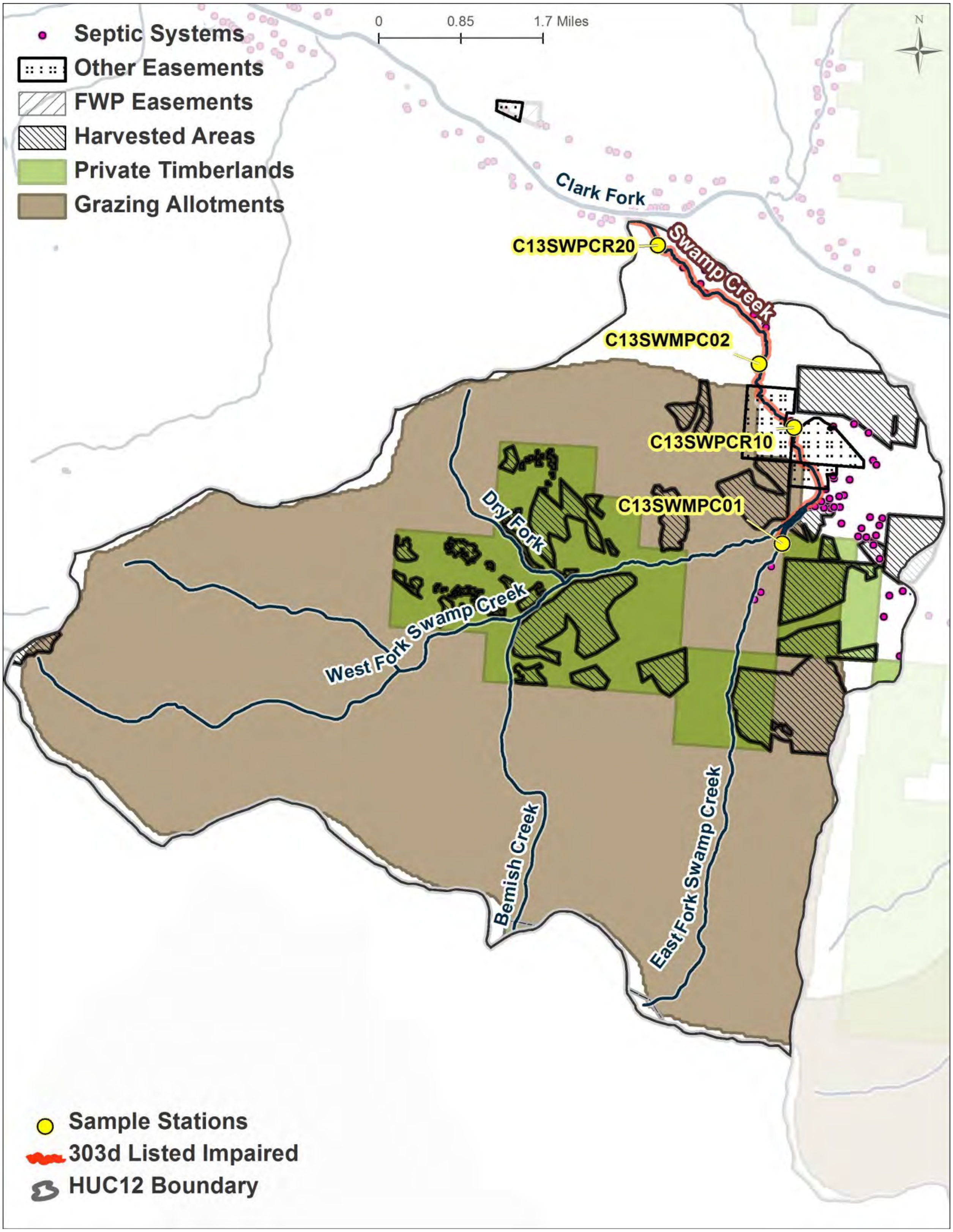


Figure 6-19. Locations of potential nutrient sources in the Swamp Creek watershed.

6.6 TMDL AND ALLOCATIONS FOR EACH STREAM

6.6.1 Nutrient TMDLs

DEQ presents nutrient TMDLs for impaired waterbodies in the Thompson TMDL Project Area, summarized in **Section 6.2**. The TMDL is based on the most stringent water quality criteria, or the water quality target, and the streamflow. All nutrient TMDLs are calculated using the most stringent target value, which ensures that the TMDLs are protective of all designated beneficial uses. A detailed discussion of target development is included in **Section 6.4.2**.

Because streamflow varies seasonally, the TMDL is not expressed as a static value, but as an equation of the appropriate target multiplied by flow. As flow increases, the allowable load (TMDL) increases as shown by the total phosphorus example in **Figure 6-20.** The TMDL calculations for TN and TP under a specific flow condition are calculated using the following formula:

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

TMDL= Total Maximum Daily Load in lbs/day
X = water quality target in mg/L (TN = 0.275 mg/L or TP = 0.025 mg/L)
Y = streamflow in cubic feet per second (cfs)
k = conversion factor of 5.4

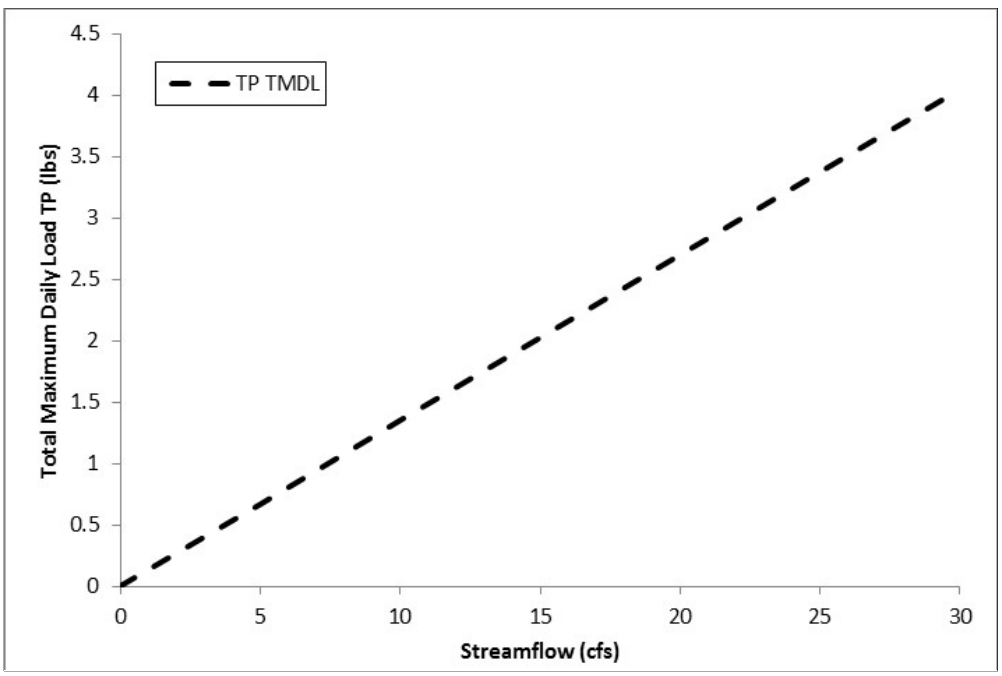


Figure 6-20. Example TMDL for total phosphorus from 0 to 30 cfs.

6.6.2 Approach to TMDL Allocations and Reductions

As discussed in **Section 4.0**, a TMDL equals the sum of all the wasteload allocations (WLAs), load allocations (LAs), and a margin of safety (MOS). WLAs are allowable pollutant loads that are assigned to permitted and non-permitted point sources. LAs are allowable pollutant loads assigned to nonpoint sources and may include the pollutant load from naturally occurring sources, as well as human-caused nonpoint loading. Where practical, LAs to human sources are provided separately from naturally occurring sources. In addition to nutrient load allocations, the TMDL must also take into account the seasonal variability of nutrient loads and adaptive management strategies in order to address uncertainties inherent in environmental analyses.

These elements are combined in the following equation:

TMDL = ∑WLA + ∑LA + MOS

WLA *= Wasteload Allocation or the portion of the TMDL allocated to nutrient point sources.*

LA *= Load Allocation or the portion of the TMDL allocated to nonpoint nutrient sources and naturally occurring background*

MOS *= Margin of Safety or an accounting of uncertainty about the relationship between nutrient loads and receiving water quality.*

Because grazing and timber harvest are the most probable source categories and all sources are nonpoint, the TMDL allocations are composited into a single load allocation to all nonpoint sources, including natural background sources. Because there are no point sources, the wasteload allocation is zero. All nutrient TMDLs include an implicit margin of safety, which is based on conservative assumptions as described in **Section 6.7.2**. In the absence of point sources and an explicit MOS, the equation for all nutrient TMDLs is as follows:

Equation 2: TMDL = LA

LA = Load Allocation to all sources including natural background

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

Equation 3: Total Existing Load = (X) (Y) (5.4)

X = measured concentration in mg/L (associated with the median reduction for measured loads that exceed the TMDL or with the median measured load if none exceed the TMDL)

Y = streamflow in cubic feet per second (associated with the median reduction for measured loads that exceed the TMDL or with the median measured load if none exceed the TMDL)

5.4 = conversion factor

6.6.3 TMDLs and Allocations by Waterbody Segment

The following sections establish TMDLs, provide current nutrient loading estimates, and estimate reductions necessary to meet water quality targets for the following streams:

- Lazier Creek
- Little Bitterroot River
- Little Thompson River
- Lynch Creek
- Sullivan Creek
- Swamp Creek

The TMDL equations are shown for Lazier Creek as an example of how the TMDLs were calculated (**Section 6.6.3.1**). The calculations are not shown for the remaining impaired waterbodies, only the results.

The existing loads are used to estimate load reductions by comparing them to the allowable (TMDL) load and computing a required percent reduction to meet the TMDL. The actual reductions needed may be greater than the load reductions provided in this section because the reduction estimates are based on measured loads, which may differ from loading inputs because algae and other primary producers in streams regularly consume nutrients and alter instream concentrations.

6.6.3.1 Lazier Creek (MT76N005_060)

Total Nitrogen TMDL

The composite load allocation to all sources equals the TMDL, which is calculated from **Equation 1**. The value of the TN TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The flow used in the example below is associated with the median measured load from all sites during the 2011-2012 sampling (0.21 cfs):

TMDL = LA = (0.275 mg/L) (0.21 cfs) (5.4) = 0.3119 lbs/day

An example total existing load is calculated as follows using **Equation 3** and the flow and concentration associated with the median measured load for TN in Lazier Creek from 2011-2012:

Total Existing Load = (0.07 mg/L) (0.21 cfs) (5.4) = 0.0794 lb/day

The example TN TMDL and composite load allocation and current loading are summarized in **Table 6-14**. Because the measured existing load is less than the example TMDL, no reduction is provided to meet the water quality target. As discussed above, nutrient uptake by algae and other primary producers may decrease nutrient loads, which can make it appear as though there is not a nutrient problem when there actually is. The target exceedances of AFDM, which is a measure of excessive algal growth, along with periphyton and HBI scores all indicate excess nutrient loading to the stream. Determining the precise cause(s) of these target exceedances and the role of nitrogen warrants further study, but reducing nutrient loading to address excessive algal growth is still considered necessary to address the nutrient impairment. Reductions may be achieved through a variety of water quality planning and implementation actions as discussed in **Section 10.0.**

Table 6-14. Lazier Creek TN Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Load Allocation (lbs/day)[1]	Existing Load (lbs/day)[1]
All Sources	0.3119	0.0794

[1] Based on a flow of 0.21 cfs

Nitrate 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 Lazier Creek. None of the nitrate values measured in Lazier Creek were above the target of 0.1 mg/L (**Tables 6-2 and 6-3**), potentially due to nutrient uptake as discussed above.

Total Phosphorus TMDL

The composite load allocation to all sources equals the TMDL, which is calculated from **Equation 1**. 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 Lazier Creek uses **Equation 1** and the flow associated with the median measured TP load from all sites during the 2011-2012 sampling (0.32 cfs):

TMDL = LA = (0.025 mg/L) (0.32 cfs) (5.4) = 0.0432 lb/day

An example total existing load is calculated as follows using **Equation 3** and the flow and concentration associated with the median measured TP load in Lazier Creek from 2004-2012:

Total Existing Load = (0.009 mg/L) (0.32 cfs) (5.4) = 0.0156 lbs/day

The example TP TMDL, load allocations, and current loading are summarized in **Table 6-15**. Because the measured existing load is less than the example TMDL, no reduction is provided to meet the water quality target. As discussed above, nutrient uptake by algae and other primary producers may decrease nutrient loads, which can make it appear as though there is not a nutrient problem when there actually is. The target exceedances of AFDM, which is a measure of excessive algal growth, along with periphyton and HBI scores all indicate excess nutrient loading to the stream. Determining the precise cause(s) of these target exceedances and the role of phosphorus warrants further study, but reducing nutrient loading to address excessive algal growth is still considered necessary to address the nutrient impairment. Reductions may be achieved through a variety of water quality planning and implementation actions as discussed in **Section 10.0.**

Table 6-15. Lazier Creek TP Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Allocation (lb/day)[1]	Existing Load (lbs/day)[1]
All Sources	0.0432	0.0156

[1] *Based on a flow of 0.32 cfs*

6.6.3.2 Little Bitterroot River (MT76L002_060)

Total Nitrogen TMDL

The example TN TMDL and composite load allocation and current loading are summarized in **Table 6-16**. Because the existing load is greater than the TMDL, a reduction is necessary to meet the water quality target for TN. The source assessment for the Little Bitterroot River watershed indicates that timber harvest and grazing are the most likely sources of TN; load reductions should focus on limiting and controlling TN loading from these sources. Meeting load allocations for the Little Bitterroot River may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 9.0**.

Table 6-16. Little Bitterroot River TN Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Allocation (lb/day)[1]	Existing Load (lbs/day)[1]
All Sources	79.34	106.75

[1] *Based on a flow of 53.43 cfs*

Figure 6-21 shows the percent reductions for TN loads measured in the Little Bitterroot River from 2011-2012. TN reductions are required from the smallest to the largest measured flows. There were no measured loads less than or equal to the TMDL. Reductions ranged from 17% to 56% to meet the TMDL.

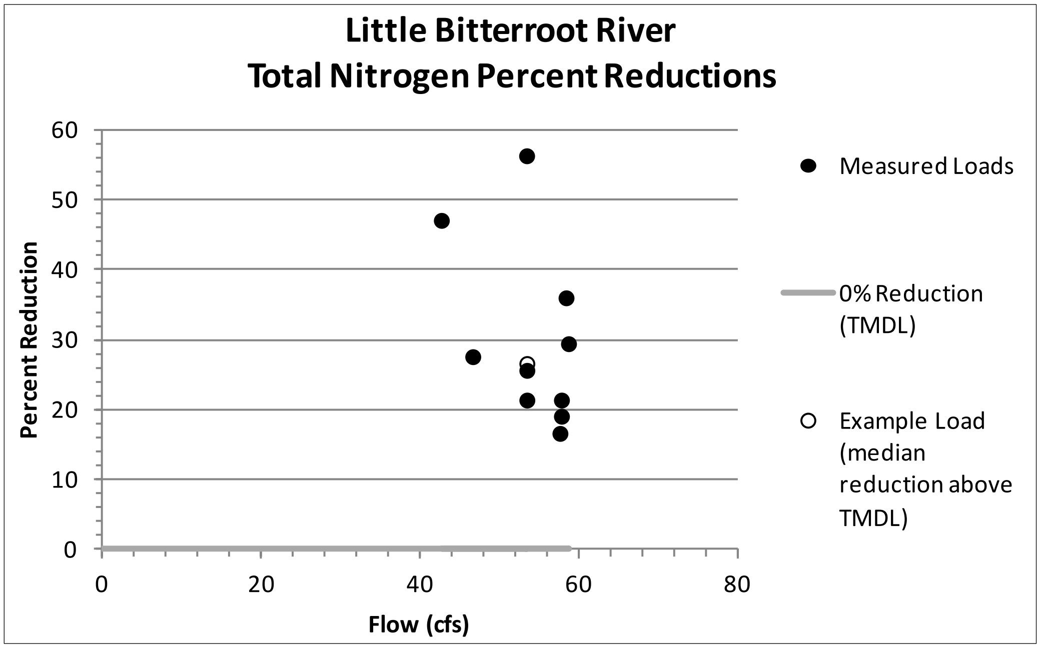


Figure 6-21. TN percent reductions for the Little Bitterroot River.
(All points on or below the gray line are meeting the TMDL. The example existing load from **Table 6-16** is represented by the hollow circle.)

Nitrate 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 the Little Bitterroot River. One of the nine nitrate values measured in the Little Bitterroot River was above the target of 0.1 mg/L (**Tables 6-4 and 6-5**). As a result, existing nitrate loading requires reductions consistent with the TN TMDL and the composite allocation for nitrate would apply to the same source categories as the TN composite allocation.

Total Phosphorus TMDL

The example TP TMDL, load allocations, and current loading are summarized in **Table 6-17**. Because the existing load is greater than the TMDL, a reduction is necessary to meet the water quality target for TP. The source assessment for the Little Bitterroot River watershed indicates that timber harvest and grazing are the most likely sources of TP; load reductions should focus on limiting and controlling TP loading from these sources. Meeting load allocations for the Little Bitterroot River may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 10.0**.

Table 6-17. Little Bitterroot River TP Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Allocation (lb/day)[1]	Existing Load (lbs/day)[1]
All Sources	7.78	18.35

[1] *Based on a flow of 57.6 cfs*

Figure 6-22 shows the percent reductions for TP loads measured in the Little Bitterroot River from 2004-2012. TP reductions are required from the smallest to the largest measured flows. There were no measured loads less than or equal to the TMDL. Reductions ranged from 7% to 70%.

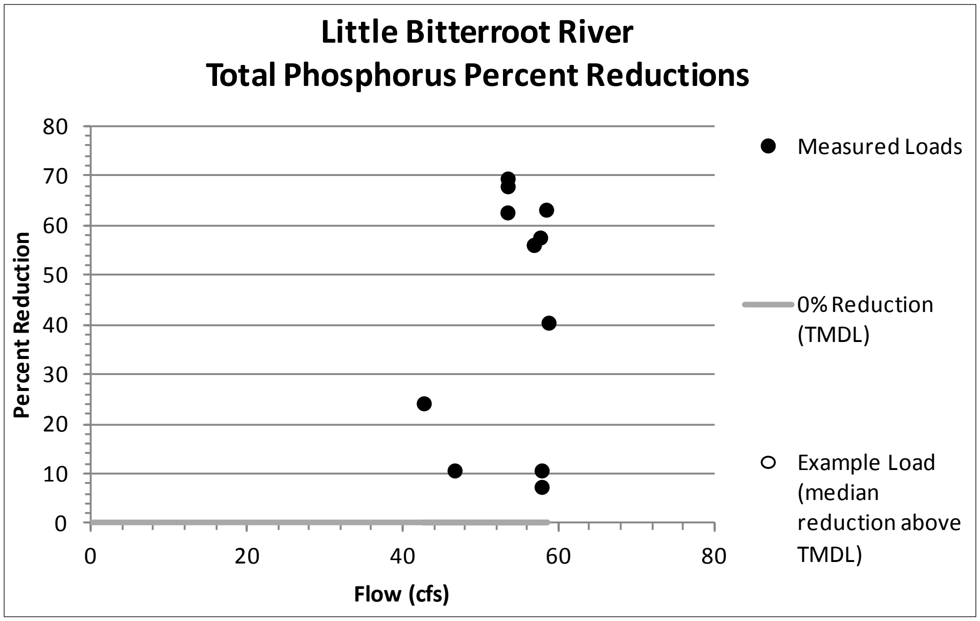


Figure 6-22. TP percent reductions for the Little Bitterroot River.
(All points on or below the gray line are meeting the TMDL. The example existing load from **Table 6-17** is represented by the hollow circle.)

6.6.3.3 Little Thompson River (MT76N005_040)

Total Nitrogen TMDL

The example TN TMDL, composite load allocation, and current loading for the Little Thompson River are summarized in **Table 6-18**. Because the measured existing load is less than the example TMDL, no reduction is provided to meet the water quality target. As discussed above, nutrient uptake by algae and other primary producers may decrease nutrient loads, which can make it appear as though there is not a nutrient problem when there actually is. The target exceedances of AFDM, which is a measure of excessive algal growth, along with periphyton and HBI scores all indicate excess nutrient loading to the stream. Determining the precise cause(s) of these target exceedances and the role of nitrogen warrants further study, but reducing nutrient loading to address excessive algal growth is still considered necessary to address the nutrient impairment. Reductions may be achieved through a variety of water quality planning and implementation actions as discussed in **Section 10.0.**

Table 6-18. Little Thompson River TN Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Load Allocation (lbs/day)[1]	Existing Load (lbs/day)[1]
All Sources	12.1	1.1

[1] *Based on a flow of 8.15 cfs*

Total Phosphorus TMDL

The example TP TMDL, load allocations, and current loading are summarized in **Table 6-19**. Because the measured existing load is less than the example TMDL, no reduction is provided to meet the water quality target. As discussed above, nutrient uptake by algae and other primary producers may decrease nutrient loads, which can make it appear as though there is not a nutrient problem when there actually is. The target exceedances of AFDM, which is a measure of excessive algal growth, along with periphyton and HBI scores all indicate excess nutrient loading to the stream. Determining the precise cause(s) of these target exceedances and the role of phosphorus warrants further study, but reducing nutrient loading to address excessive algal growth is still considered necessary to address the nutrient impairment. Reductions may be achieved through a variety of water quality planning and implementation actions as discussed in **Section 10.0.**

Table 6-19. Little Thompson River TP Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Allocation (lb/day)[1]	Existing Load (lbs/day)[1]
All Sources	1.06	0.4675

[1] Based on a flow of 7.87 cfs

6.6.3.4 Lynch Creek (MT76N003_010)

Total Nitrogen TMDL

The example TN TMDL and composite load allocation and current loading are summarized in **Table 6-20**. Because the existing load is greater than the TMDL, a reduction is necessary to meet the water quality target for TN. The source assessment for the Lynch Creek watershed indicates that livestock grazing, timber harvest, and development are the most likely sources of TN; load reductions should focus on limiting and controlling TN loading from these sources. Meeting load allocations for Lynch Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 10.0**.

Table 6-20. Lynch Creek TN Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Load Allocation (lbs/day)[1]	Existing Load (lbs/day)[1]
All Sources	7.63	9.44

[1] Based on a flow of 5.14 cfs

Figure 6-23 shows the percent reductions for TN loads measured in Lynch Creek from 2011-2012. TN reductions are required from the smallest to the largest measured flows. Most of the measured loads were meeting the TMDL. The remaining loads required reductions ranging from 19% to 47%.

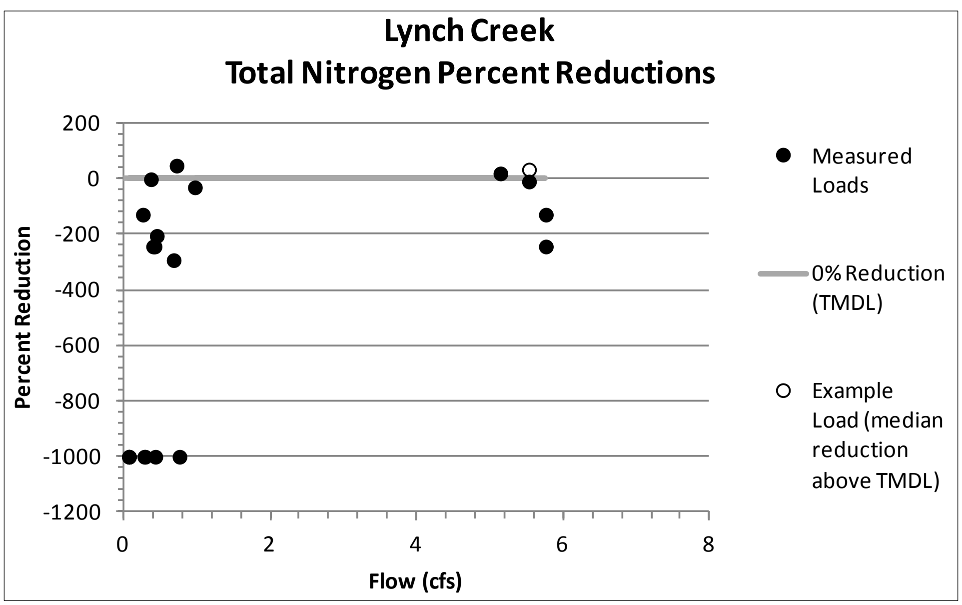


Figure 6-23. TN percent reductions for Lynch Creek.
(All points on or below the gray line are meeting the TMDL. The example existing load from **Table 6-20** is represented by the hollow circle.)

Total Phosphorus TMDL

The example TP TMDL, load allocations, and current loading are summarized in **Table 6-21**. Because the existing load is greater than the TMDL, a reduction is necessary to meet the water quality target for TP. The source assessment for the Lynch Creek watershed indicates that livestock grazing, timber harvest, and development are the most likely sources of TP; load reductions should focus on limiting and controlling TP loading from these sources. Meeting load allocations for Lynch Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 10.0**.

Table 6-21. Lynch Creek TP Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Allocation (lb/day)[1]	Existing Load (lbs/day)[1]
All Sources	0.0972	0.1205

[1] *Based on a flow of 0.72 cfs*

Figure 6-24 shows the percent reductions for TP loads measured in Lynch Creek from 2004-2012. TP reductions are required from the smallest to the largest measured flows. The reductions ranged from 11% to 34% to meet the TMDL.

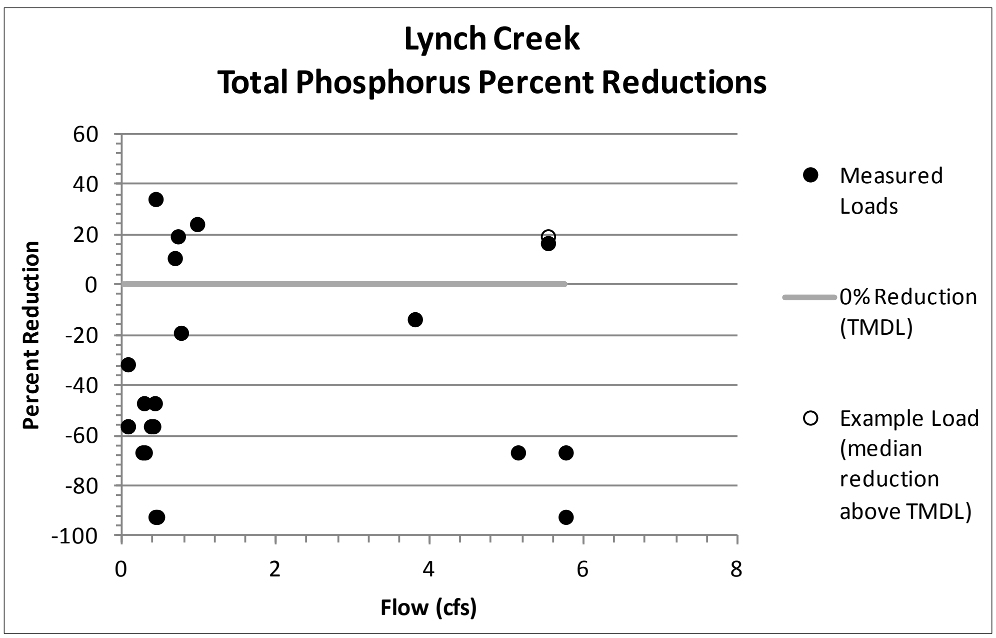


Figure 6-24. TP percent reductions for Lynch Creek.

(All points on or below the gray line are meeting the TMDL. The example existing load from **Table 6-21** is represented by the hollow circle.)

6.6.3.5 Sullivan Creek (MT76L002_070)

Total Nitrogen TMDL

The example TN TMDL and composite load allocation and current loading are summarized in **Table 6-22**. Because the existing load is greater than the TMDL, a reduction is necessary to meet the water quality target for TN. The source assessment for the Sullivan Creek watershed indicates that livestock grazing and timber harvest are the most likely sources of TN; load reductions should focus on limiting and controlling TN loading from these sources. Meeting load allocations for Sullivan Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 10.0**.

Table 6-22. Sullivan Creek TN Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Load Allocation (lbs/day)[1]	Existing Load (lbs/day)[1]
All Sources	0.0446	0.2074

[1] *Based on a flow of 0.03 cfs*

Figure 6-25 shows the percent reductions for TN loads measured in Sullivan Creek from 2012. TN reductions are required from the smallest to the largest measured flows. Only one of the measured loads was exceeding the TMDL. This load required a reduction of 79% to meet the TMDL.

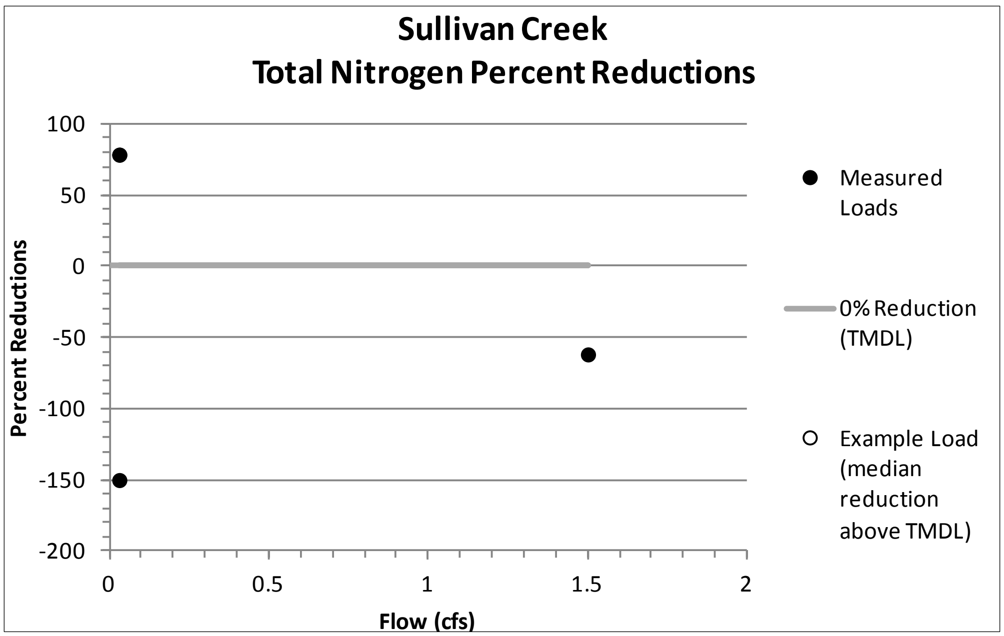


Figure 6-25. TN percent reductions for Sullivan Creek.
(All points on or below the gray line are meeting the TMDL. The example existing load from **Table 6-22** is represented by the hollow circle.)

Total Phosphorus TMDL
The example TP TMDL, load allocations, and current loading are summarized in **Table 6-23**. Because the existing load is greater than the TMDL, a reduction is necessary to meet the water quality target for TP. The source assessment for the Sullivan Creek watershed indicates that livestock grazing and timber harvest are the most likely sources of TP; load reductions should focus on limiting and controlling TP loading from these sources. Meeting load allocations for Sullivan Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 10.0**.

Table 6-23. Sullivan Creek TP Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Allocation (lb/day)[1]	Existing Load (lbs/day)[1]
All Sources	0.0135	0.0329

[1] *Based on a flow of 0.1 cfs*

Figure 6-26 shows the percent reductions for TP loads measured in Sullivan Creek from 2004-2012. TP reductions are required from the smallest to the largest measured flows. Two of the measured loads were exceeding the TMDL. These loads required reductions of 42% and 59% to meet the TMDL.

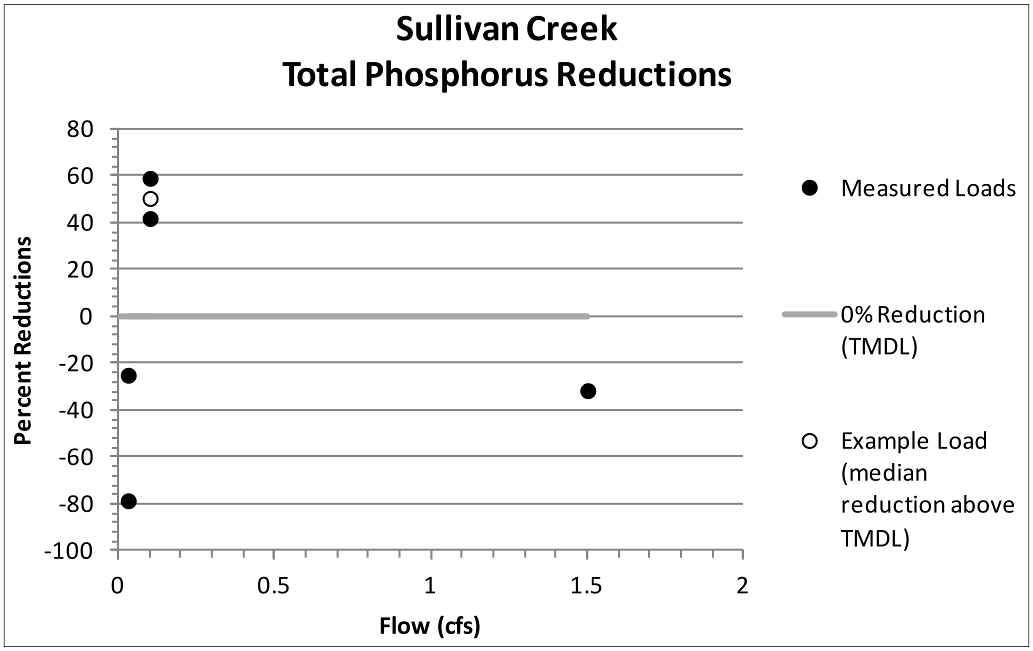


Figure 6-26. TP percent reductions for Sullivan Creek.
(All points on or below the gray line are meeting the TMDL. The example existing load from **Table 6-23** is represented by the hollow circle.)

6.6.3.6 Swamp Creek (MT76N003_160)

Total Nitrogen TMDL

The example TN TMDL and composite load allocation and current loading for Swamp Creek are summarized in **Table 6-24**. Because the measured existing load is less than the example TMDL, no reduction is provided to meet the water quality target. As discussed above, nutrient uptake by algae and other primary producers may decrease nutrient loads, which can make it appear as though there is not a nutrient problem when there actually is. The target exceedances of AFDM, which is a measure of excessive algal growth, along with periphyton and HBI scores all indicate excess nutrient loading to the stream. Determining the precise cause(s) of these target exceedances and the role of nitrogen warrants further study, but reducing nutrient loading to address excessive algal growth is still considered necessary to address the nutrient impairment. Reductions may be achieved through a variety of water quality planning and implementation actions as discussed in **Section 10.0.**

Table 6-24. Swamp Creek TN Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Allocation (lb/day)[1]	Existing Load (lbs/day)[1]
All Sources	22.19	2.02

[1] Based on a flow of 14.94 cfs

Nitrate 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 Swamp Creek. None of the nitrate values measured in Swamp Creek were above the target of 0.1 mg/L (**Tables 6-12 and 6-13**), potentially due to nutrient uptake as discussed above.

Total Phosphorus TMDL

The example TP TMDL, load allocations, and current loading are summarized in **Table 6-25**. Because the existing load is greater than the TMDL, a reduction is necessary to meet the water quality target for TP. The source assessment for the Swamp Creek watershed indicates that livestock grazing and timber harvest are the most likely sources of TP; load reductions should focus on limiting and controlling TP loading from these sources. Meeting load allocations for Swamp Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 10.0**.

Table 6-25. Swamp Creek TP Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Allocation (lb/day)[1]	Existing Load (lbs/day)[1]
All Sources	2.2	2.38

[1] Based on a flow of 16.3 cfs

Figure 6-27 shows the percent reductions for TP loads measured in Swamp Creek from 2004-2011. TP reductions are required from the smallest to the largest measured flows. There was one measured load greater than the TMDL with a required reduction of 7%.

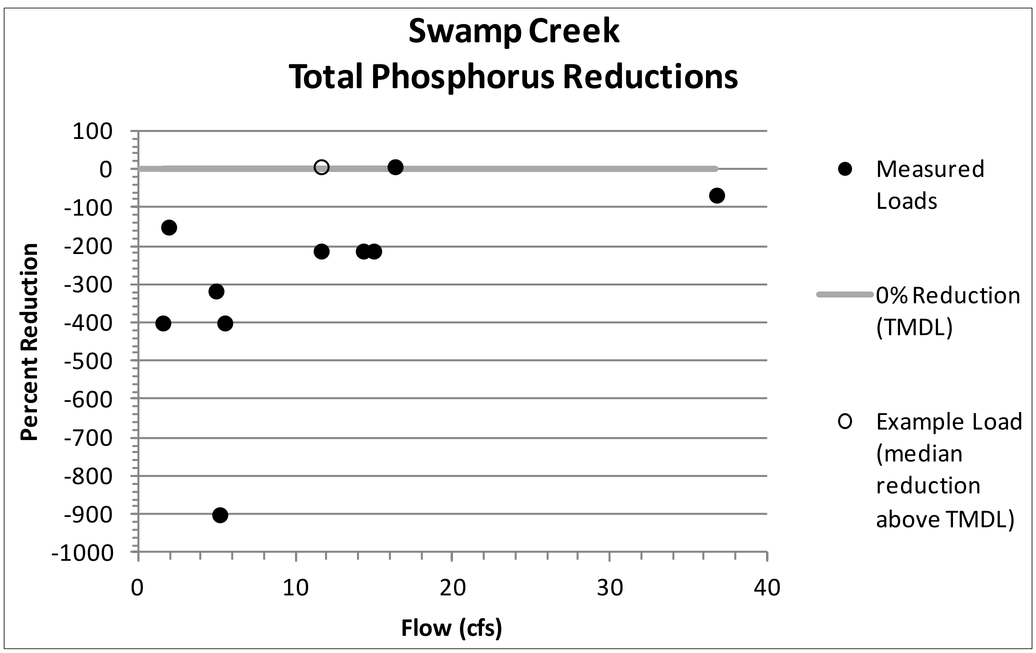


Figure 6-27. TP percent reductions for Swamp Creek.
(All points on or below the gray line are meeting the TMDL. The example existing load from **Table 6-25** is represented by the hollow circle.)

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. TMDL development must also incorporate a margin of safety to account for uncertainties between pollutant sources and the quality of the receiving waterbody, and to ensure (to the degree practicable) that the

TMDL components and requirements are sufficiently protective of water quality and beneficial uses. This section describes seasonality and margin of safety in the Thompson 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-time growing season (July 1st – Sept 30th), to coincide with seasonal algal growth targets.
- Nutrient data used to determine compliance with targets and to establish allowable loads were collected during the summer-time period to coincide with applicable nutrient targets.

6.7.2 Margin of Safety

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

- Static nutrient target values (e.g., 0.275 mg/L TN and 0.025 mg/L TP) were used to calculate allowable loads (TMDLs). Allowable exceedances of nutrient targets were not incorporated into the calculation of allowable loads, thereby adding a MOS to established allocations.
- Target values were developed to err on the conservative side of protecting beneficial uses.
- Seasonality (discussed above) and variability in nutrient loading were considered.
- An adaptive management approach is used to evaluate target attainment and allow for refinement of load allocation, assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development.

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. Four of the segments have more than the desired 12 samples but 2 have fewer samples for at least 1 nutrient form. Additionally, there were situations where data for a specific nutrient indicated that values were below targets, but because of previous impairment determinations, exceedances of the chlorophyll-*a*, periphyton, or HBI targets, and the uncertainty in nutrient limitation and uptake within the streams the impairment determinations were retained. As a result, data for some waterbody segments with a nutrient TMDL indicate that targets are being attained. Future monitoring as discussed in **Section 11.0** should help reduce the uncertainty regarding data representativeness, clarify whether or not nutrient forms that have a TMDL but are meeting targets have a role in causing excess algal growth, improve the understanding of the effectiveness of Best Management Practices (BMPs) implementation, and increase the understanding of the loading reductions needed to meet the TMDLs.

It was assumed that background concentrations are less than the target values. However, it is possible that target values are naturally exceeded during certain times or at certain locations in the watershed. Future monitoring should help reduce uncertainty regarding background nutrients concentrations.

Based on the age of some septic systems within the watershed, there are probably some failing systems, and depending on their proximity or connectivity to surface water, they could be point sources of nutrient loading. However, a completely failing system has obvious symptoms and will be addressed quickly, and a partially failing system will likely result in similar loading as a functioning system, unless it is in close proximity to surface water. This source could be investigated further, particularly in segments with nearby septic systems and elevated nutrient concentrations that cannot be explained by other sources.

Despite the uncertainty associated with the loading contributions from the various nonpoint sources in the watershed, based on the literature and field observations there is a fairly high level of certainty that improvements in land management practices discussed in this document will reduce nutrient loading sufficiently to meet the TMDLs.

7.0 Temperature TMDL Components

This portion of the document focuses on temperature as an identified cause of water quality impairment in the Thompson Project Area. It describes: (1) the mechanisms by which temperature affects beneficial uses of streams; (2) the stream segments of concern; (3) information sources used for temperature TMDL development; (4) temperature target development; (5) assessment of sources contributing to excess thermal loading; (6) the temperature TMDL and allocations; (7) seasonality and margin of safety; and (8) 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 also 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 (Jakober et al., 1998; Brown, 1999), 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

Two waterbody segments in the Thompson Project Area are identified as impaired by temperature in Montana's 2012 Integrated Report (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012a): Lynch Creek and McGregor Creek (**Appendix A**, **Figure A-8**).To help put sampling data into perspective and understand how elevated stream temperatures may affect aquatic life, information on fish presence in these water bodies and temperature preferences for the most sensitive species are described below.

7.2.1 Fish Presence in Lynch Creek

Based on a query of the Montana Fisheries Information System (MFISH), Lynch Creek is inhabited by brook trout, brown trout, longnose dace, northern pike, rainbow trout, and westslope cutthroat trout (Montana Department of Fish, Wildlife and Parks, 2013). Lynch Creek is not within a Core or Nodal bull trout area (Montana Department of Fish, Wildlife and Parks, 2013). According to the Montana Fish, Wildlife, and Parks fisheries resource value ratings, Lynch Creek is considered "Moderate" (rating score 4) (Montana Department of Fish, Wildlife and Parks, 2013).

7.2.2 Fish Presence in McGregor Creek

Based on a query of the MFISH, brook trout (unknown abundance), rainbow trout (rare), and westslope cutthroat trout (rare) are present in McGregor Creek (Montana Department of Fish, Wildlife and Parks, 2013). Although McGregor Creek is a tributary to the Thompson River, which is inhabited by bull trout, McGregor Creek is not within a Core or Nodal bull trout area (Montana Department of Fish, Wildlife and Parks, 2013). According to the Montana Fish, Wildlife, and Parks fisheries resource value ratings, McGregor Creek is considered "Substantial" (rating score 3) (Montana Department of Fish, Wildlife and Parks, 2013).

7.2.3 Temperature Levels of Concern

Special temperature considerations are warranted for the westslope cutthroat trout, which are identified in Montana as species of concern and occur in both Lynch and McGregor Creeks. 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 (Liknes and Graham, 1988).

7.3 Information Sources and Data Collection

As discussed in **Appendix B** and **Section 7.4.1**, Montana defines temperature impairment as occurring when human sources cause a certain degree of change over the water temperature that occurs as a result of natural sources and human sources that 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, QUAL2K water quality models were needed to determine if human sources are causing the allowable temperature change to be exceeded in Lynch and McGregor Creeks. Model details for Lynch and McGregor Creeks are presented in **Attachments D and E,** respectively, but the model summary and outcome is provided in **Section 7.5**, **Source Assessment**.

The following information sources were searched and/or used to set up the QUAL2K models and assist with temperature TMDL development.

7.3.1 Department of Environmental Quality (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 Temperature Related Data Collection

In summer 2011 (McGregor Creek) and 2012 (Lynch Creek) DEQ and U.S. Environmental Protection Agency (EPA) collected temperature data, along with measurements of streamflow, riparian shade, and channel geometry. This information is collectively used within the QUAL2K models to evaluate impairment and the potential for improvement associated with the implementation of all reasonable land, soil, and water conservation practices. These data are presented and described in detail in **Attachment D** for Lynch Creek and **Attachment E** for McGregor Creek. Monitoring locations for Lynch and McGregor Creeks are shown in **Figure 7-1** and **Figure 7-2**, respectively.

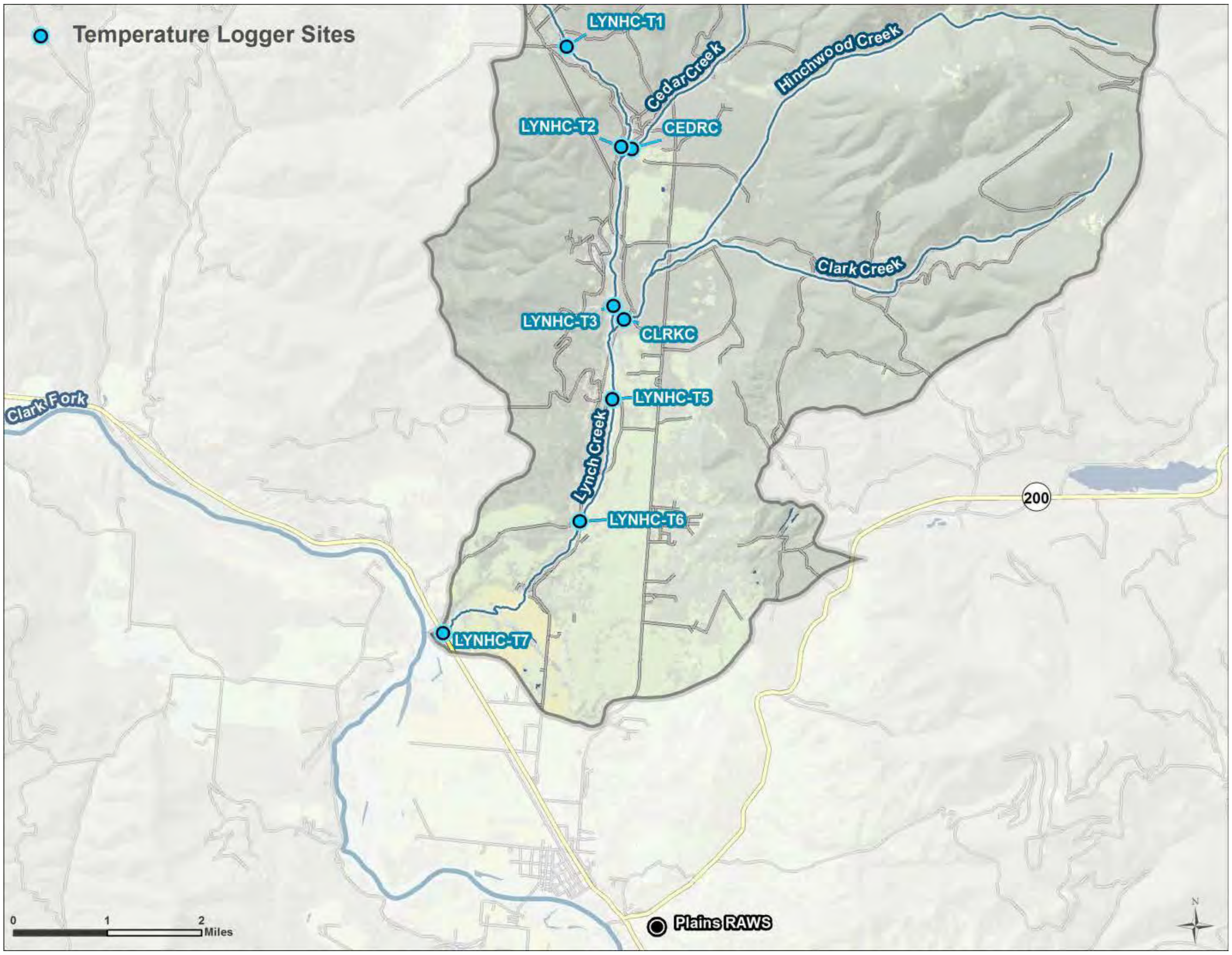


Figure 7-1. Temperature data logger sampling sites on Lynch Creek and nearby weather station.

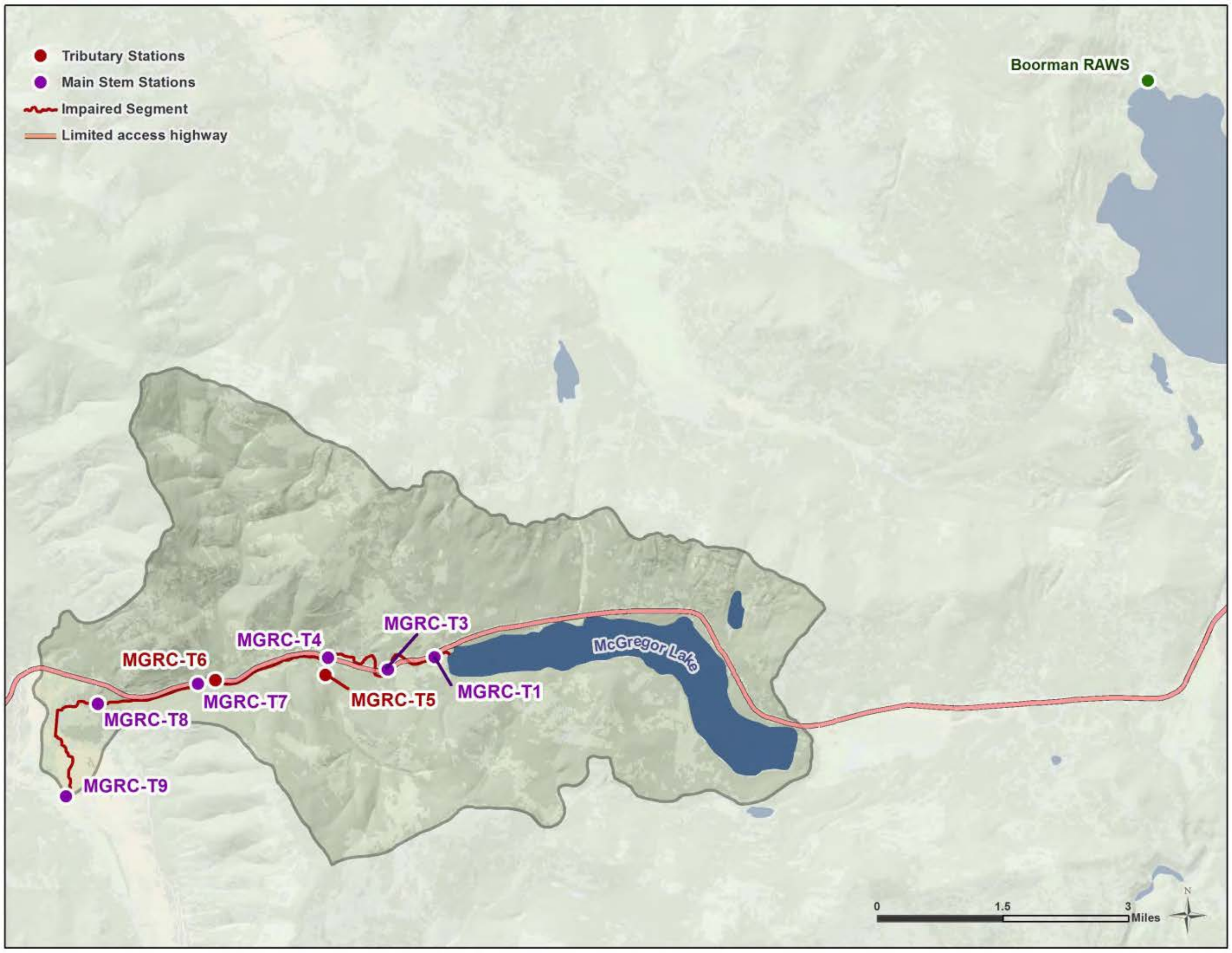


Figure 7-2. Temperature data logger sampling sites on McGregor Creek and nearby weather station.

7.3.3 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 Remote Automatic Weather Stations (RAWS) (**Figure 7-1** and **Figure 7-2**).

7.3.4 DNRC Water Usage Data

Spatial DNRC water usage data that include identification of active points of diversion and places of use were obtained from the Natural Resources Information System (Natural Resource Information System, 2012). This information was necessary because streamflow is an important input for the QUAL2K model and irrigation withdrawals have the potential to influence stream temperatures.

7.4 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 Lynch and McGregor 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 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.

QUAL2K models were used for Lynch and McGregor Creeks 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), this verifies the existing temperature impairment. This section discusses whether the model outcome supports the existing impairment listing, and model scenario details are presented in **Section 7.5**, **Source Assessment,** and **Attachments D and E,** for Lynch and McGregor Creeks, respectively.

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 are riparian shade, channel geometry, and improved streamflow conditions. All targets are described in more detail below.

7.4.2.1 Allowable Human-Caused Temperature Change

The target for allowable human-caused temperature change links directly to the 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 over-widened channel.

To help minimize the influence of upland activities on stream temperature, a riparian buffer close to 100 feet is commonly recommended (Knutson and Naef, 1997; Ellis, 2008; Ledwith, 1996). 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 (Castelle and Johnson, 2000; CH2M, 2000; Christensen, 2000). The Natural Resources Conservation Service (NRCS) conservation practice standard for riparian buffers, 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 (CH2M, 2000; Castelle and Johnson, 2000; Christensen, 2000; Natural Resources Conservation Service, 2011b; Natural Resources Conservation Service, 2011a). 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 (Montana Department of Natural Resources and Conservation, 2006), the target is a buffer width of 50 feet. Based on NRCS recommendations for buffers with medium to high shade value, this 50 foot buffer should consist of medium density trees 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).

Although the target is 50 feet, the US Forest Service (USFS) abides by Inland Native Fish Strategy standards in both the Lynch and McGregor Creek watersheds 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 (U.S. Department of Agriculture, Forest Service, 1995).

DEQ realizes most healthy riparian buffers are comprised of more than a single category of vegetation, but a buffer of medium density trees was used as a 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 was determined to be a reasonable target. Considering the variability in potential vegetation and shade, medium density trees was used as a surrogate 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 structural bank armoring that may not feasibly be modified or relocated. The target is provided as a quantitative guide for meeting the standard but since it is intended to represent all reasonable land, soil, and water conservation practices, if those are being implemented, then Lynch and McGregor Creeks will be meeting the riparian shade target. The rationale for target selection is further described in **Section 7.4.4.1** in the discussion of existing conditions as compared with the target.

7.4.2.3 Width/Depth Ratio

A narrower channel with a lower width-to-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. A target for width/depth ratio was developed for the sediment TMDLs using reference data (**Section 5.4.1**) and will also apply for temperature. The width/depth ratio target for Rosgen stream types B and C is ≤ 21 for sections with a bankfull width less than 30 feet. The width/depth ratio target for Rosgen stream type E is ≤ 8 regardless of bankfull width. 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 to improve riparian shade are also anticipated to lower width/depth ratios.

7.4.2.4 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 proposed target for instream flow (water use) is the increased instream flow that can be achieved via a 15% reduction in flow diverted for irrigation purposes based on improvements in irrigation water management and irrigation system and delivery efficiencies during the summer (June through September). Per Montana’s water quality law, TMDL development cannot be construed to divest, impair, or diminish any water right recognized pursuant to Title 85 (MCA §75-5-705). Therefore, any voluntary water savings and subsequent instream flow augmentation must be done in a way that protects water rights. The 15% water savings could be achieved through best management practices including delivery system upgrades, irrigation scheduling, and application management (Waskom, 1994).

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 three temperature-influencing targets (i.e., riparian shade, width/depth ratio, and instream flows). In this approach, if all reasonable land, soil, and water conservation practices are installed or practiced, water quality standards will be met. **Table 7-1** summarizes the temperatures targets for Lynch and McGregor Creeks.

Table 7-1. Temperature Targets for Lynch and McGregor Creeks

Target Parameter	Target Value
Primary Target	
Allowable Human-Caused Temperature Change	If 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.
Temperature-Influencing Targets: Meeting both will meet the primary target	
Riparian Health - Shade	50 foot buffer with medium density trees, or appropriate native vegetation providing equivalent effective shade where achievable (with the exception of areas dominated by hydrophytic shrubs, roads, and road right-of-ways).
Width/Depth Ratio	B & C stream types with bankfull width < 30ft: ≤ 21
Instream Flows (Water Use)	15% reduction of irrigation withdrawals due to improvements in irrigation efficiency during the summer (June through September)

7.4.4 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 Lynch Creek and McGregor Creek. QUAL2K model results will be 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**.

7.4.4.1 Lynch Creek (MT76N003_010)

Lynch Creek (MT76N003_010) was initially listed for temperature impairment in 2006. The assessment file noted that temperatures were elevated for salmonids and one of the major limitations of Lynch Creek was the lack of water (Montana Department of Environmental Quality, 2012d). It was considered chronically dewatered by Fish, Wildlife and Parks (FWP) fisheries biologists from 1992-2005. It was also noted that stream shading was rated as poor, and recruitment of woody vegetation was reduced due to the presence of thick, monotypical stands of reed canary grass in the lower reach of Lynch Creek where it flows through largely agricultural lands (Montana Department of Environmental Quality, 2012d).

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. Observed temperatures were commonly outside the optimal growth range for westslope cutthroat trout and maximum daily temperatures exceeded 73°F at LYNHC-T1, LYNHC-T3, LYNHC-T6, and LYNHC_T7 (**Figure 7-3**). Measured temperatures were warmest for the longest period of time near the mouth at LYNHC-T7. However, temperatures within the lethal range discussed in **Section 7.2.3** were not sustained for more than a few hours on a daily basis **(Figure 7-4).**

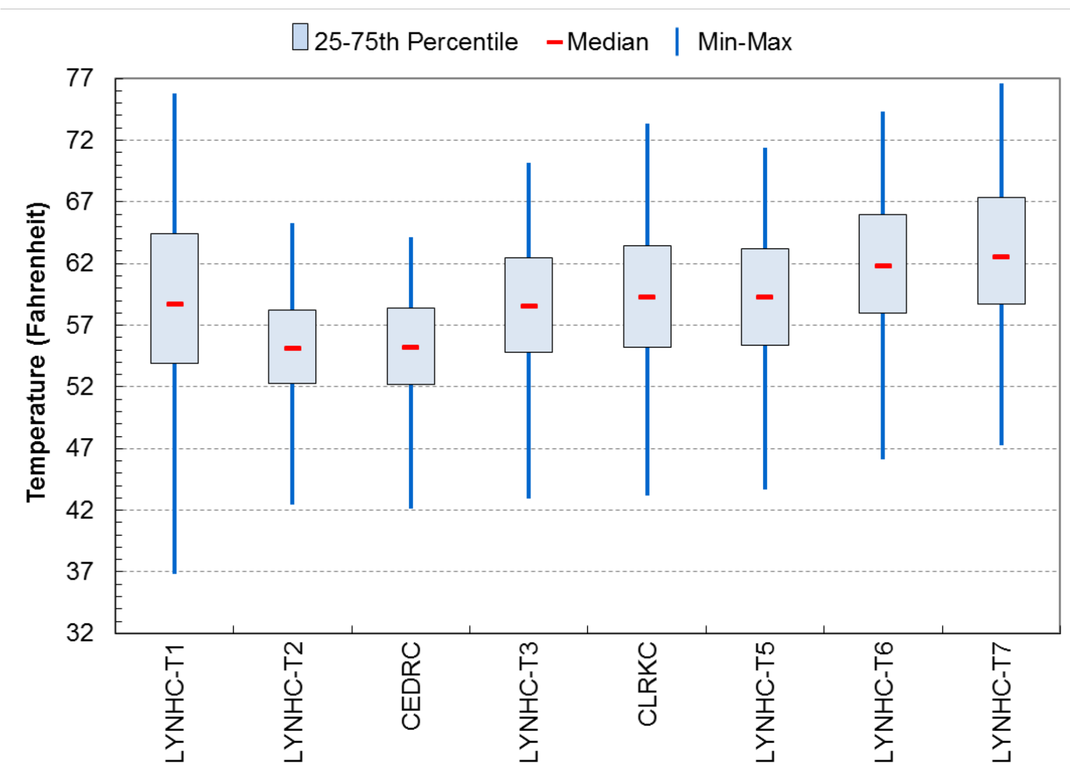


Figure 7-3. 2012 temperature logger monitoring data for Lynch Creek and tributaries.

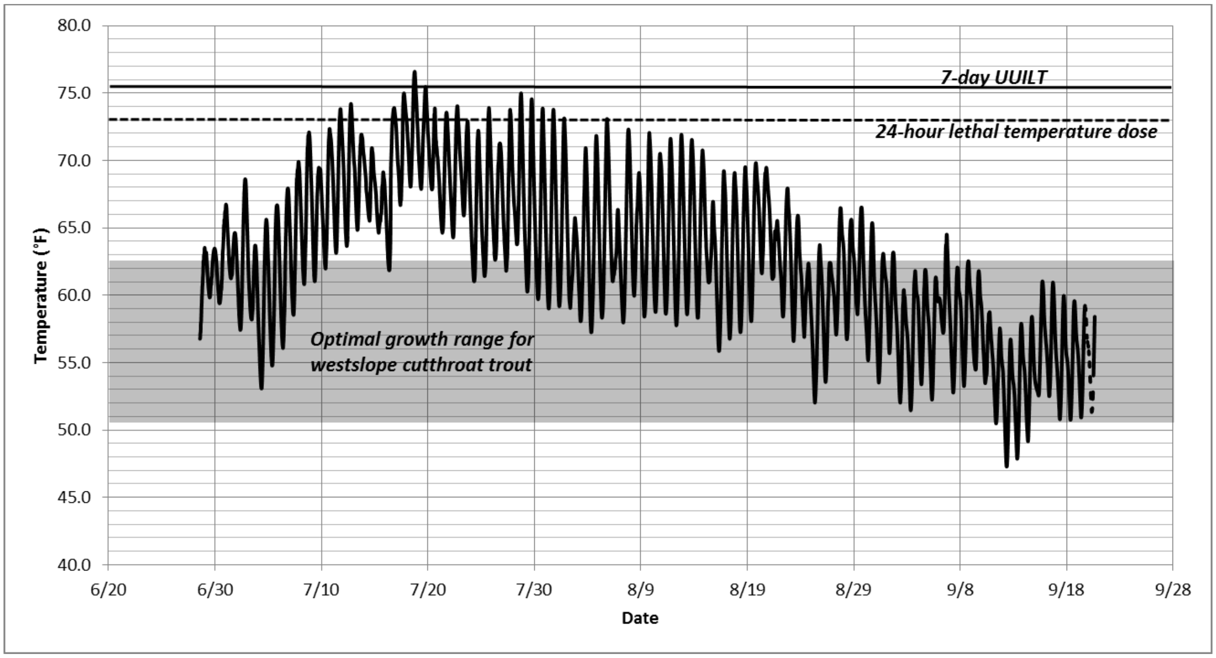


Figure 7-4. Observed diurnal temperatures at LYNHC-T7.

The QUAL2K model results (see **Attachment D**) indicate that the maximum naturally occurring summer temperatures in Lynch Creek are less than 66.0 degrees over most of its length, with the exception of a very short reach near river mile 8.3. This means that human sources cannot cause the temperature to be exceeded by more than 1.0°F in Lynch Creek, with the exception of the short reach in the headwaters where temperatures cannot be exceeded by more than 0.5°F. Based on the model and temperature data, human sources have caused the allowable change target to be exceeded throughout all but a very short segment of Lynch Creek. Excluding the short segment, the anthropogenic temperature increase ranged from 0.10°F to 13.45°F, with an average of 2.58°F. There is only a 1 mile section of stream from roughly river mile 7.0 to 8.0 where human sources are causing less than a 1.0°F increase.

Herbaceous vegetation (grass) and shrubs are the most common cover types along Lynch Creek, followed by high and medium density trees (**Table 7-2**). Sparse trees, roads, and bare ground compose only a small percentage of the riparian area. **Figure 7-5** shows the percent difference between the existing effective shade and the target effective shade (based on the Shade Model results provided in **Attachment D**). The greatest shade deficit is in the lower three miles where Lynch Creek flows through predominantly agricultural lands and the riparian vegetation is dominated by shrubs and grasses.

Table 7-2. Composition of the existing riparian buffer 50 feet on both sides of Lynch Creek

Land cover type	Area (acres)	Relative area (percent)
Bare ground	1.3	0.3%
Herbaceous	130.5	25.5%
Roads	9.3	1.8%
Shrub	117.1	22.9%
Sparse trees	19.0	3.7%
Low density trees	47.0	9.2%
Medium density trees	96.5	18.9%
High density trees	90.5	17.7%

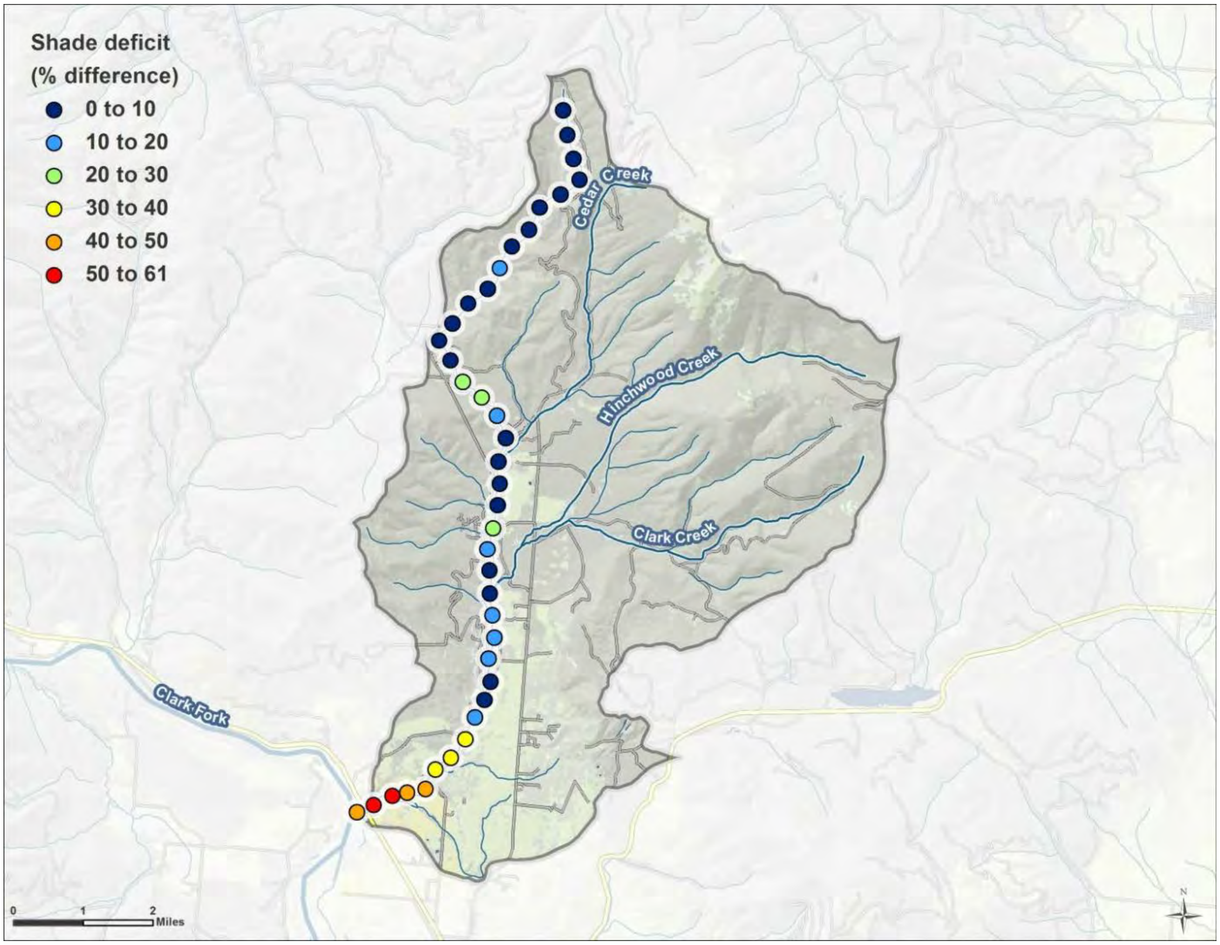


Figure 7-5. The percent of additional effective shade needed to meet the target along Lynch Creek.

The width/depth ratios measured at two sites in Lynch Creek in 2011 to support sediment TMDL development (**Section 5.5.5**) indicated that both observations met the target value.

7.4.4.2 McGregor Creek (MT76N005_030)

McGregor Creek (MT76N005_030) was initially listed for temperature impairment in 2006 (Montana Department of Environmental Quality, 2012d). The assessment file noted that, just downstream of the McGregor lake outflow, the stream supported a macroinvertebrate assemblage strongly suggestive of warm water temperatures, and the possibility that the reach is periodically dewatered or suffers severe thermal stress. Additionally, in 2004, observed water temperatures below the lake were elevated above the peak growth rate for the most sensitive species present, westslope cutthroat trout (Montana Department of Environmental Quality, 2012d).

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. Observed temperatures were commonly outside the optimal growth range for westslope cutthroat trout in the upper reaches of McGregor Creek below the outlet from McGregor Lake (MGRC-T1, MGRC-T3, and MGRC-T4) (**Figure 7-6**). Measured temperatures were warmest for the longest period of time immediately below McGregor Lake at MGRC-T1, but, were only briefly with the lethal range discussed in **Section 7.2.3** and were not sustained for more than a few hours on a daily basis**.** Nevertheless, in evaluating the information provided by **Figure**

7-6, it is important to remember that impairment is defined by human caused increases in temperature above naturally occurring values. Because water is naturally warmer at a lake outlet, the data for the site immediately below the lake does not represent temperature impairment. It is further downstream where there is concern about human caused temperature increases resulting in impairment conditions because the stream has not cooled to the extent it should have due to a lack of shade and/or flow diversions. **(Figure 7-7)**

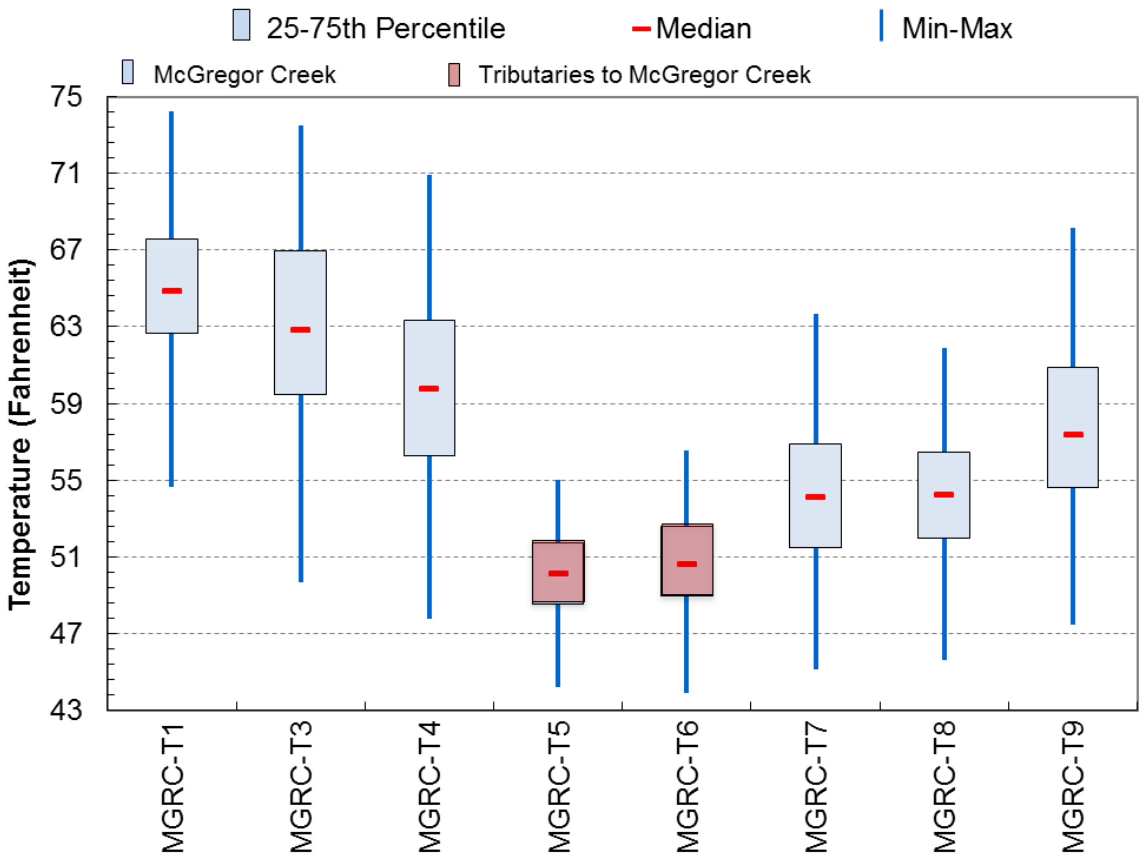


Figure 7-6. 2012 temperature logger monitoring data for McGregor Creek and tributaries.

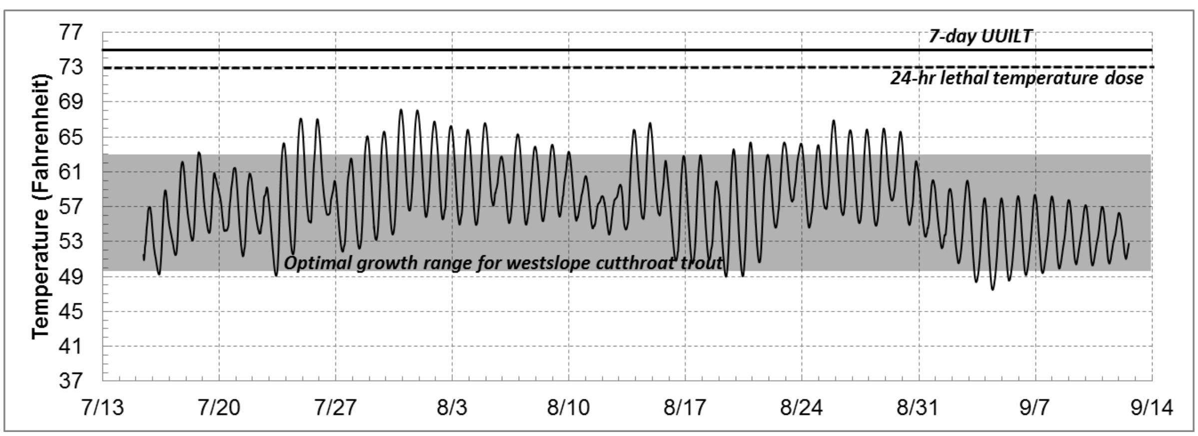


Figure 7-7. Observed diurnal temperatures at MGRC-T9.

The QUAL2K model results indicate that the maximum naturally occurring summer temperatures in McGregor Creek are less than 66.0 degrees most of the time over most of its length, with the exception of a short reach (approximately 0.4 miles) immediately below the outlet from McGregor Lake where temperatures routinely exceed 66.5°F, and at location MGRC-T9 where temperatures sometimes exceed 66.0 degrees. This means that human sources cannot cause the temperature to be exceeded by more than 1.0°F in the majority McGregor Creek, with the exception of the short reach in the headwaters and occasionally at the furthest downstream reach where temperatures cannot be exceeded by more than 0.5°F. Based on the model and temperature data, human sources have caused the allowable change target to be exceeded throughout McGregor Creek, with the increase ranging from 1.57°F to 7.30°F, with an average of 4.92°F.

Herbaceous vegetation (grass) and sparse trees are the most common cover types along McGregor Creek (**Table 7-3**). The remaining cover types comprise roughly equal percentages of the riparian area. **Figure 7-8** shows the percent difference between the existing effective shade and the target effective shade (based on the Shade Model results provided in **Attachment E**). The greatest shade deficit is in the lower two miles where McGregor Creek flows through predominantly agricultural lands and the riparian vegetation is currently dominated by grasses.

Table 7-3. Composition of the existing riparian buffer 50 feet on both sides of McGregor Creek

Land cover type	Area (acres)	Relative area (percent)
Bare ground	1.0	0.4%
Herbaceous	115.2	44.3%
Roads	17.3	6.6%
Shrub	22.2	8.5%
Sparse trees	46.3	17.8%
Low density trees	17.8	6.9%
Medium density trees	16.0	6.1%
High density trees	18.3	7.0%

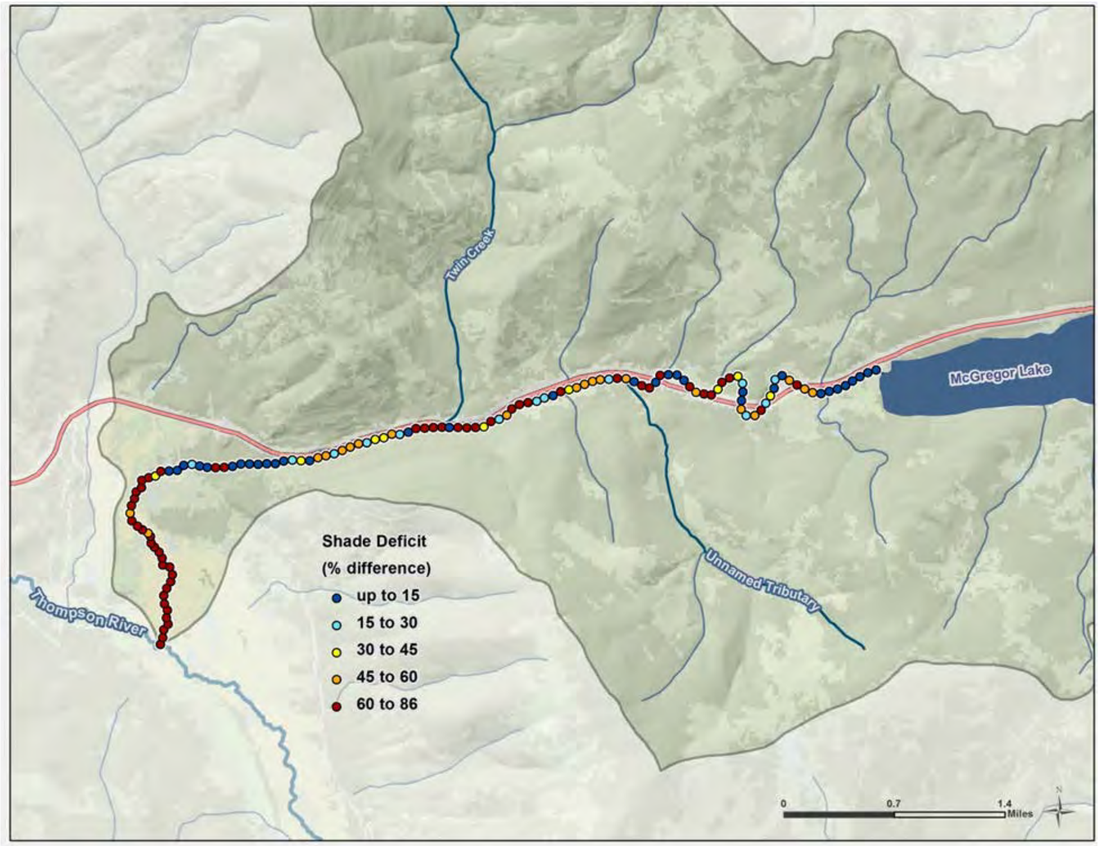


Figure 7-8. The percent of additional effective shade needed to meet the target along McGregor Creek.

The width/depth ratios were measured at two sites in McGregor Creek in 2011 to support sediment TMDL development (**Section 5.4.3.7**; these sites are shown in **Figure 5-1**). The observation at station MCGR02-03 (below McGregor Lake) met the target value, indicating McGregor Creek is meeting the target for width/depth ratio at this location. The observation at station MCGR06-02 (below the confluence with Twin Creek) did not meet the target value, indicating McGregor Creek is not meeting the target for width/depth ratio at this location.

7.4.5 Summary and TMDL Development Determination

7.4.5.1 Lynch Creek

The human-influenced allowable temperature change target is being exceeded along all but one mile of Lynch Creek. Additionally, although width/depth ratios are meeting the target, the riparian vegetation is generally well under the shade target. As described above, stream shading was considered poor, and recruitment of woody vegetation was reduced due to the presence of thick, monotypical stands of reed canary grass in the lower reach of Lynch Creek where the stream flows through largely agricultural lands (Montana Department of Environmental Quality, 2012d). This information supports the existing impairment listing and a temperature TMDL will be developed for Lynch Creek.

7.4.5.2 McGregor Creek

The human-influenced allowable temperature change target is being exceeded along the majority of McGreogor Creek. Additionally, the width/depth ratio is exceeding the target at station MCGR02-03 and the riparian vegetation is generally well under the shade target. This information supports the existing impairment listing and a temperature TMDL will be developed for McGregor Creek.

7.6 Source Assessment

As discussed above, the source assessment largely involved QUAL2K temperature modeling. There are no permitted point sources in either watershed. The watersheds have been affected by the road networks, present and historic agricultural activities, and instream flows. Instead of focusing on the potential contribution of these sources, 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 morphology plays a role in determining effective shade and is an important target, it was not incorporated into the QUAL2K model for either stream. The limited number of data points indicate both streams are at or close to the target for width/depth ratio. Based on the available data and the fact that the target applies to the average condition, changing channel morphology was determined to be an unnecessary management scenario.

A QUAL2K model was used to determine the extent that human-caused disturbances within the Lynch Creek and McGregor Creek watersheds have increased the water temperatures above the naturally occurring level. The evaluation of model results focuses on the maximum daily water temperatures in Lynch Creek and McGregor 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 and channel and shade characteristics are uniform throughout each reach. Segmentation is largely based on the location of field data, tributaries, irrigation withdrawal/returns, channel slope, and changes in channel conditions or shading.

7.6.1 Lynch Creek Source Assessment Using QUAL2K

Within the model, Lynch Creek was segmented into reach lengths of 0.37 miles. The water temperature and flow data collected from Lynch Creek and two tributaries in 2012, along with channel measurements, irrigation data, and climate data (**Section 7.3** and **Attachment D**), were used to calibrate and validate the model. The relative error for the daily maximum stream temperatures (at the loggers, modeled versus observed) for the calibration and validation were 3.6% and 4.3%, respectively, indicating the model provides a reasonable approximation of maximum daily temperatures in Lynch Creek. While the influence of Lynch Creek tributaries was evaluated, the Lynch Creek tributaries were not explicitly modeled; only the main stem of Lynch Creek was modeled. Data collected at the mouths of the tributaries were used to simulate the tributaries as unique inputs to the main stem of Lynch Creek, similar to point sources. Human influences on tributary water temperatures (e.g., irrigation withdrawals or shading along the tributaries) were not evaluated.

Flow data at the United States Geological Survey (USGS) gage at Prospect Creek at Thompson Falls, MT (12390700) were evaluated to determine how August streamflow in 2012 (when data were collected) compared to the average August streamflow; flows were at the 65th percentile, indicating they were higher than average.

A baseline scenario and three additional scenarios were modeled to investigate the potential influences of human activities on temperatures in Lynch Creek. The following sections describe those modeling scenarios. Although channel width and depth can influence stream temperatures, the existing channel dimensions were not changed for any of the scenarios because Lynch Creek is meeting the channel width/depth target. A more detailed summary of the development and results of the QUAL2K model are included in **Attachment D**.

7.6.1.1 Lynch Creek Baseline Scenario (Existing Conditions)

The baseline scenario represents stream temperatures under existing measured flows, and meteorological, shade, and channel conditions on August 11, 2012. This is the scenario that all other scenarios are compared against to evaluate the influence of human sources. Based on long-term flow data at the nearby Prospect Creek USGS gage, flows in August 2012 were at the 65th percentile of flows recorded between 1958 and 2012. Under the baseline scenario, maximum daily temperatures range from approximately 61°F near the headwaters to 78°F at the mouth (**Figure 7-9**). Temperatures generally increase in a downstream direction.

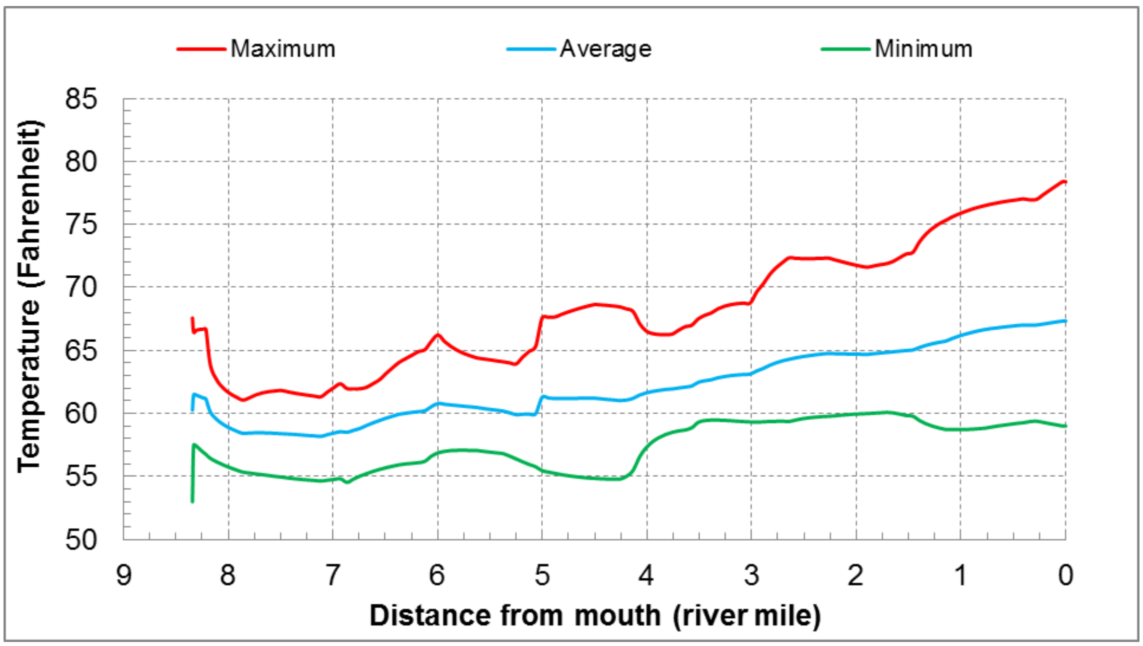


Figure 7-9. Modeled temperatures for the Lynch Creek baseline scenario.

7.6.1.2 Lynch Creek Water Use Scenario

A water use scenario was modeled to evaluate the effect that water conservation measures resulting in more instream flow would have on temperatures. In this scenario, withdrawals from Lynch Creek (which were estimated at 6.50 cfs daily, see **Attachment D**) are reduced by 15% within the model and that savings of 0.98 cfs (6.50 * 0.15 = 0.98) is allowed to remain in the stream. It is estimated that a 15% water savings can be achieved through improvements in irrigation water management, irrigation system structural upgrades, and irrigation water delivery system efficiencies. The Irrigation Guide in the National Engineering Handbook from the NRCS states typical irrigation system efficiencies for several different types of irrigation systems. This data can be used to determine the effectiveness of irrigation system improvements on water savings. For example, if a field is currently under flood irrigation with an average irrigation efficiency of 35%, by converting to center pivot irrigation, which has an average irrigation efficiency of 85%, the upgraded irrigation system is now 50% more efficient at using the same volume of irrigation water. This allows the irrigator to manage water more efficiently, and reduce runoff or deep percolation (Natural Resources Conservation Service, 1997). These improvements in irrigation efficiency can be used to produce higher crop yields, or ultimately divert 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.

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); thus, any voluntary water savings and subsequent in-stream flow augmentation must be done in a way that protects water rights. In the water use scenario, a 15% reduction in withdrawal volume was used to simulate the outcome of leaving some of the water saved by implementing improvements to the irrigation network in the stream. 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 and Stewart, 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 the Lynch Creek watershed, this scenario is not a formal efficiency improvement goal; it is an example intended to represent the application of water conservation practices for water withdrawals.

There are seven points of diversion on Lynch Creek distributed from a point midway between LYNHC-T1 and LYNHC-T2 and the mouth (**Figure 7-1**). A maximum change in the maximum daily water temperature of 2.95° F from the existing condition was observed in the segment immediately upstream from the mouth of the creek. The temperature difference only becomes significant for the final 1.5 miles of the stream (**Figure 7-10**).

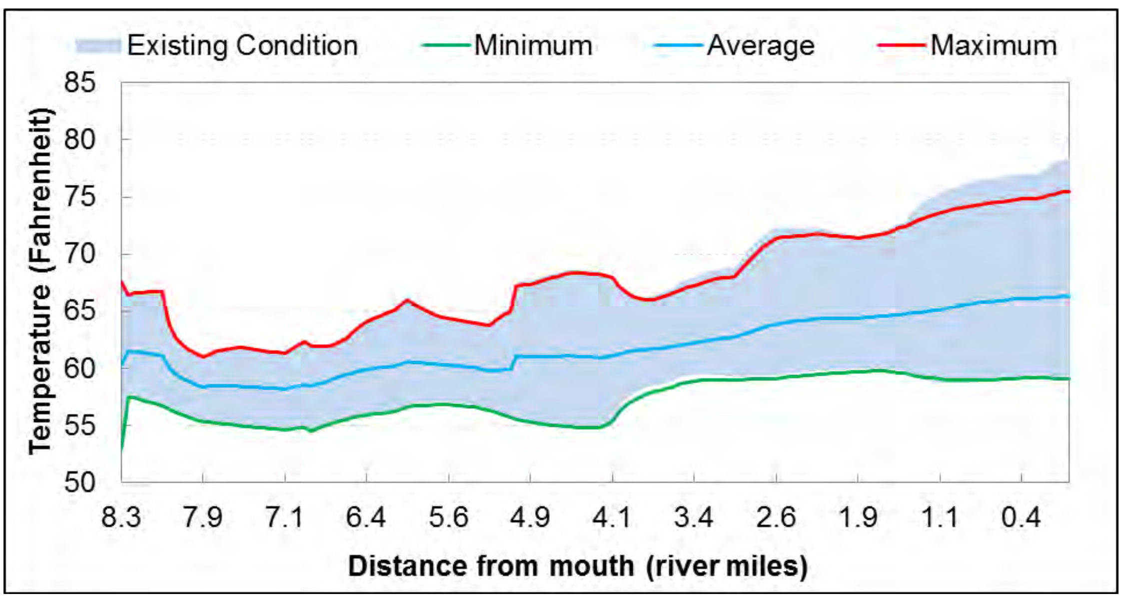


Figure 7-10. Comparison of modeled temperatures in Lynch Creek between the water use and baseline scenarios.

7.6.1.3 Lynch Creek Shade Scenario

For the shade scenario, the effective shade inputs to the model were set to represent the target shade condition (**Attachment D**). Since the target is a 50 foot buffer of medium density trees or any vegetation providing equivalent effective shade, the effective shade generated by a 50 foot buffer of medium density trees along Lynch Creek was calculated using the Shade Model (discussed in **Attachment D**) and averaged for each model segment (0.37 miles). Based on this scenario, the maximum daily stream temperature is very sensitive to improvements in riparian shade. This scenario resulted in maximum daily temperatures ranging from 61°F to 66°F, which is decrease from the baseline scenario of up to 12.2°F (**Figure 7-11**). Meeting the shade target caused an average (i.e., a distance-weighted average of the QUAL2K results along the entire stream) decrease in the maximum daily temperature of 2.41°F from the baseline scenario. The water temperatures for Lynch Creek in this scenario decrease throughout the system. The upper reach of the system showed the least impact due to shade. The change in shade was minimal because this area is well vegetated. A maximum change in the maximum daily water temperature of 12.2° F from the existing condition was observed at river mile 0.1 to the mouth. The difference in the daily maximum water temperature between the existing condition and maximum potential shade scenario was almost always greater than 0.5° F.

The shade scenario indicates that human changes to the riparian vegetation are the primary source of temperature impairment. To illustrate how this scenario relates to current conditions, the average daily effective shade (which is averaged across all daylight hours) is presented in **Table 7-4** for the baseline scenario and shade scenario.

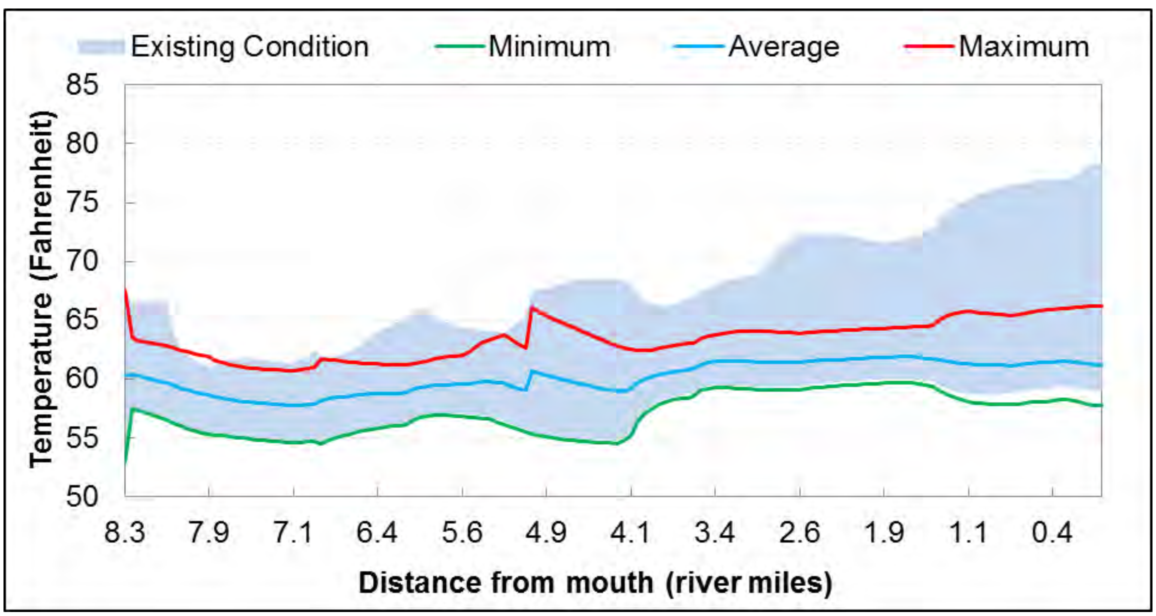


Figure 7-11. Comparison of modeled temperatures in Lynch Creek between the shade and baseline scenarios.

Table 7-4. Comparison of effective shade between the existing condition and shade scenario in Lynch Creek.

Segment	Existing condition (scenario 1)	50-foot buffer (scenario 3)
8.3 - 7.1	95%	97%
7.1 - 5.6	87%	96%
5.6 - 4.5	87%	96%

Table 7-4. Comparison of effective shade between the existing condition and shade scenario in Lynch Creek.

Segment	Existing condition (scenario 1)	50-foot buffer (scenario 3)
4.5 - 3.0	84%	96%
3.0 - 1.5	61%	95%
1.5 - 0.0	44%	91%

7.6.1.4 Lynch Creek Naturally Occurring Scenario (Full Application of Best Management Practices with Current Land Use)

The naturally occurring scenario represents Lynch 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. 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 Lynch Creek watershed are encouraged to work with the United States Department of Agriculture (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 (Natural Resources Conservation Service, 1997; Negri and Brooks, 1990). If warranted and practical, users may consider changes that increase in-stream flows, and/or reduce warm water return flows in Lynch Creek.

The naturally occurring scenario maximum daily temperatures ranged from approximately 60.69 °F to 67.58°F, with an average of 63.01°F. Based on these results, the naturally occurring temperature is less than 66.0°F for majority of Lynch Creek, with the exception of a very short reach at river mile 8.3. An increase of 1°F is allowed from human sources in all areas but river mile 8.3 where human sources are not allowed to increase stream temperatures by more than 0.5°F (**Figure 7-12**).

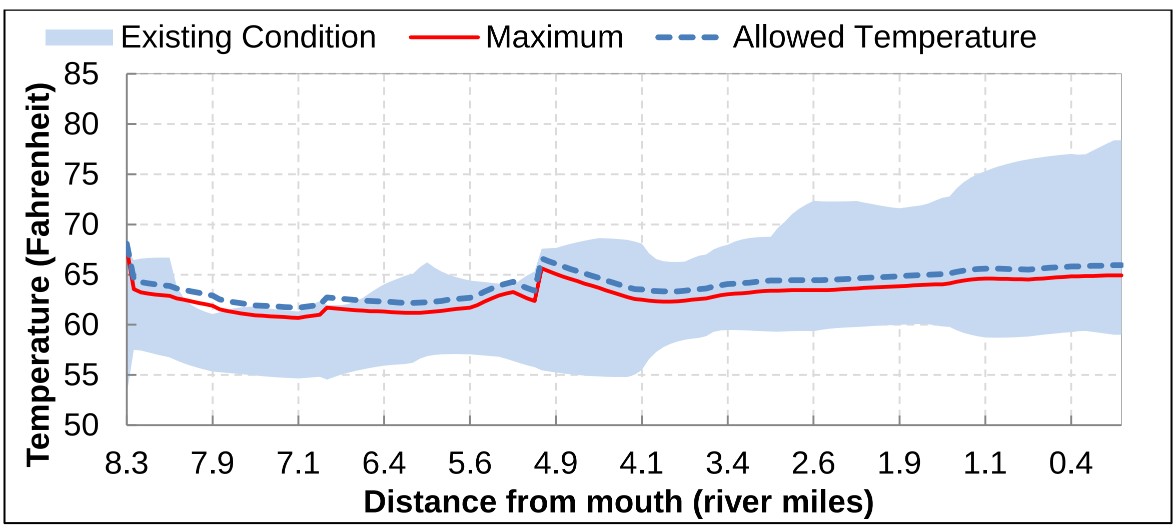
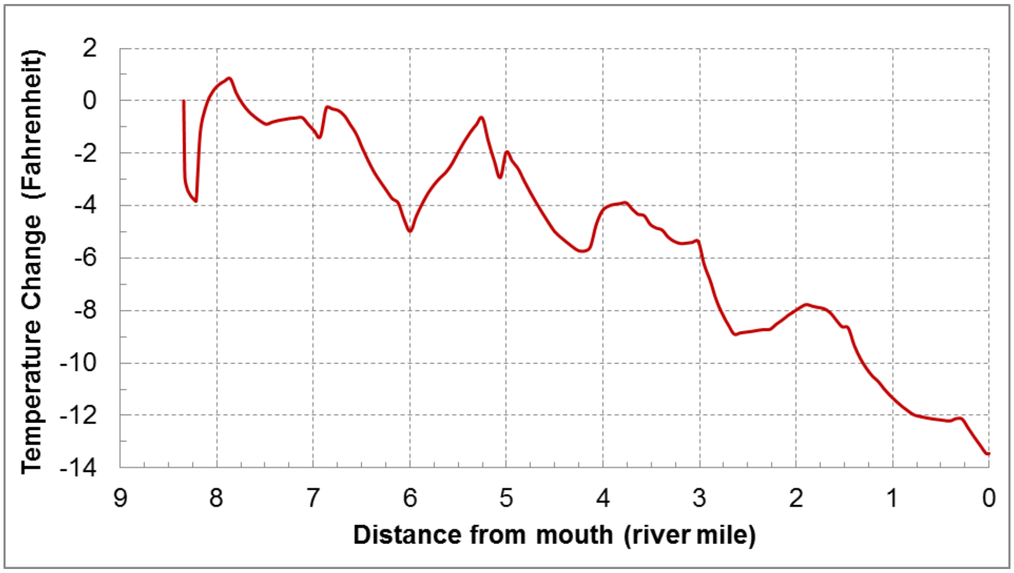


Figure 7-12. The maximum naturally occurring temperature in Lynch Creek relative to the existing condition (baseline scenario) and the allowed temperature.

The naturally occurring scenario results indicate 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 0.10°F to 13.45°F (except for one small segment), with an average decrease of 2.58°F (**Figure 7-13**). Like the shade scenario, the maximum decrease was in the lower watershed, from approximately river mile 5.0 to the mouth. The smallest change was in the reach between river miles 5.0 and 8.0 in the upper portion of the watershed where existing vegetation is currently at or near potential (**Figure 7-14**).



Note: A negative temperature change indicates potential decreases in temperatures from the baseline existing conditions to the naturally occurring conditions.

Figure 7-13. Potential temperature changes in Lynch Creek between the baseline (existing conditions) and naturally occurring scenario.

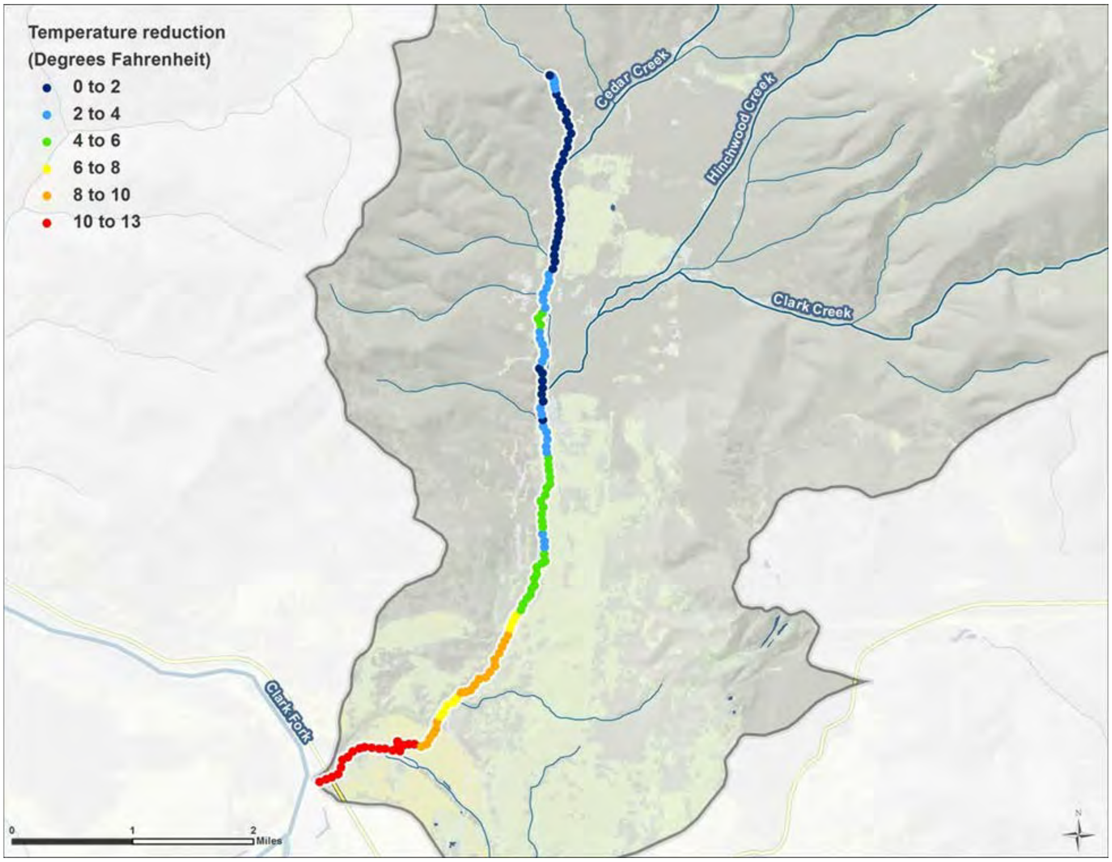


Figure 7-14. Temperature reductions in Lynch Creek that can be obtained under naturally occurring conditions (relative to the baseline scenario).

7.6.1.5 Lynch Creek QUAL2K Model Assumptions

The following is a summary of the significant assumptions used during the QUAL2K model development:

- Lynch Creek 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 of Lynch Creek.
- 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 Plains RAWS are representative of local weather conditions along Lynch Creek.
- Shade Model results are representative of riparian shading along segments of Lynch Creek.
- 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.
- The effective shade provided by a 50 foot buffer of medium density trees, or appropriate native vegetation providing equivalent effective shade where achievable (with the exception of areas dominated by hydrophytic shrubs, roads, and road right-of-ways) is consistent with the definition of the naturally occurring condition.

7.6.2 McGregor Creek Source Assessment Using QUAL2K

A QUAL2K model was used to determine the extent that human-caused disturbances within the McGregor 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 McGregor 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, McGregor Creek was segmented into nine reaches with lengths ranging from 0.22 miles to 1.25 miles (**Attachment E**). The water temperature and flow data collected from McGregor Creek and two 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 1.73% and 0.93%, respectively, indicating the model provides a reasonable approximation of maximum daily temperatures in McGregor Creek.

A baseline scenario and three additional scenarios were modeled to investigate the potential influences of human activities on temperatures in McGregor Creek. The following sections describe those modeling scenarios. Although channel width and depth can influence stream temperatures and the width/depth ratio target was not met at one site in McGregor Creek, the existing channel dimensions were not changed for any of the scenarios. It was assumed that the influence of a slightly over widened channel in one portion of McGregor Creek is not having a significant impact on stream temperature. This issues will be addressed through the sediment TMDL (see **Section 5.0**). A more detailed report of the development and results of the QUAL2K model are included in **Attachment E**.

7.6.2 .1 McGregor Creek Baseline Scenario (Critical Existing Conditions)

The baseline scenario represents stream temperatures under existing shade and channel conditions and is the scenario that all others are compared against to evaluate the influence of human sources. The baseline scenario was run using the observed discharge in McGregor Creek (on the calibration date) and modified to represent critical meteorological conditions (**Attachment E**). Based on an analysis of a discharge records from a nearby USGS gage, flows in McGregor Creek during the calibration timeframe were likely above average (**Attachment E**). However, given that discharge in McGregor Creek is controlled by releases from the Palm Dam and is not necessarily representative of natural streamflows, using the measured flows in August 2012 for the baseline scenario was deemed appropriate.

Under the baseline scenario, maximum daily temperatures range from 69.79°F near the McGregor Lake outlet to less than 60°F from roughly river mile 4.7 downstream to the mouth (**Figure 7-15**).

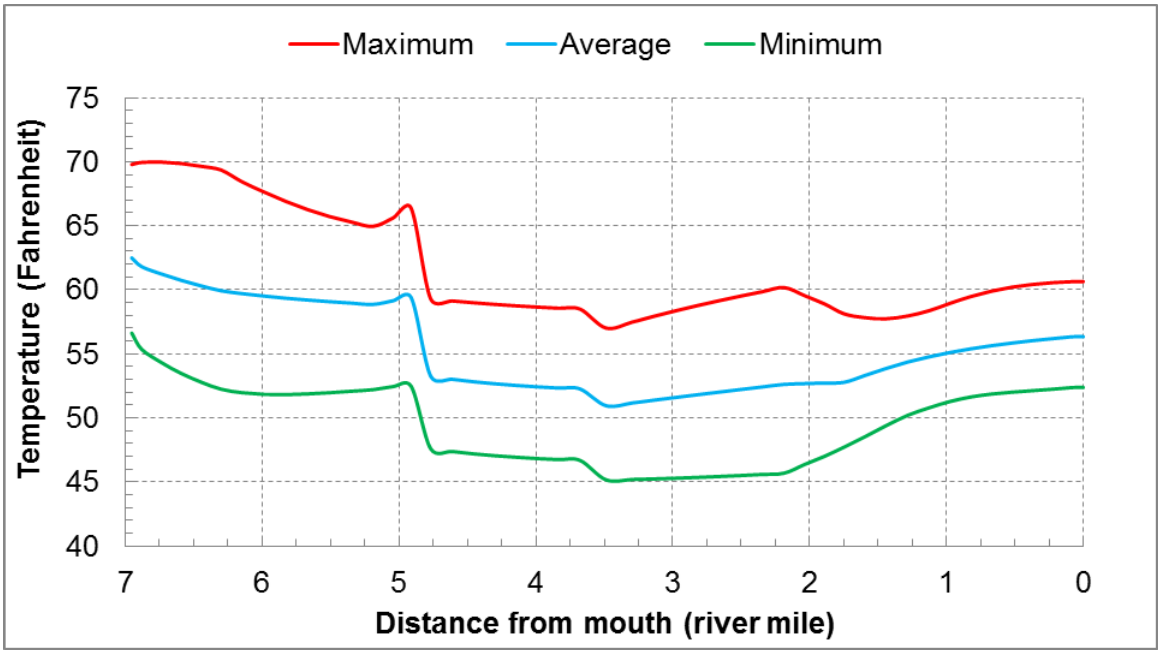


Figure 7-15. Modeled temperatures for the McGregor Creek baseline scenario.

7.6.2.2 Water Use Scenario

A water use scenario was modeled to evaluate the effect that water conservation measures resulting in more instream flow would have on temperatures. In this scenario, withdrawals from McGregor Creek (which were estimated at 13.66 cfs daily, see **Attachment E**) are reduced by 15% within the model and that savings of 2.05 cfs (13.66 * 0.15 = 2.05) is allowed to remain in the stream. It is estimated that a 15% water savings can be achieved through improvements in irrigation water management, irrigation system structural upgrades, and irrigation water delivery system efficiencies. The Irrigation Guide in the National Engineering Handbook from the NRCS states typical irrigation system efficiencies for several different types of irrigation systems. This data can be used to determine the effectiveness of irrigation system improvements on water savings. For example, if a field is currently under flood irrigation with an average irrigation efficiency of 35%, by converting to center pivot irrigation, which has an average irrigation efficiency of 85%, the upgraded irrigation system is now 50% more efficient at using the same volume of irrigation water. This allows the irrigator to manage water more efficiently, and reduce runoff or deep percolation (Natural Resources Conservation Service, 1997). These improvements in irrigation efficiency can be used to produce higher crop yields, or ultimately divert 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. In the water use scenario, a 15% reduction in withdrawal volume was used to simulate the outcome of leaving some of the water saved by implementing improvements to the irrigation network in the stream. 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; Osteen et al., 2012; Howell and Stewart, 2003) 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 the McGregor Creek watershed, this scenario is not a formal efficiency improvement goal; it is an example intended to represent the application of water conservation practices for water withdrawals.

Water temperatures in McGregor Creek for this scenario generally decreased slightly in the lower reaches (**Figure 7-16**). A maximum change in the maximum daily water temperature of 0.4° F from the existing condition was observed at river mile 0.52, which can just barely be seen in **Figure 7-16**. The difference in water temperature was always less than 0.5° F, demonstrating minimal impact in comparison to the baseline condition.

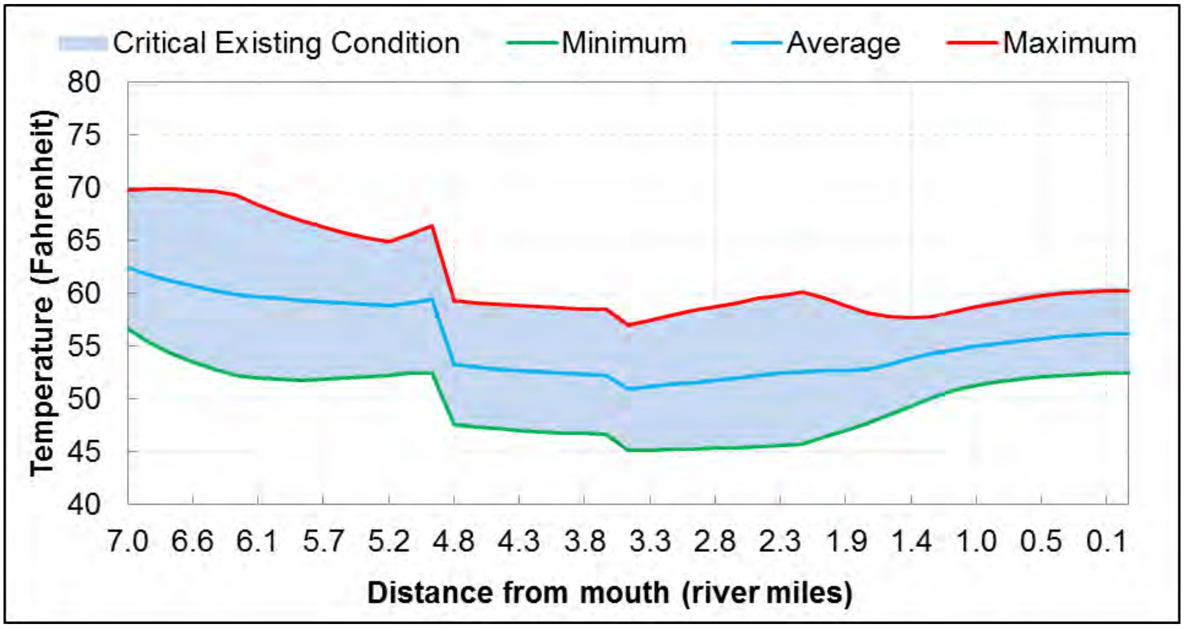


Figure 7-16. Comparison of modeled temperatures in McGregor Creek between the water use and baseline scenarios.

7.6.2.3 Shade Scenario

For the shade scenario, the effective shade inputs to the model were set to represent the target shade condition. Since the target is a 50 foot buffer of medium density trees or any vegetation providing equivalent effective shade, the effective shade generated by a 50 foot buffer of medium density trees along McGregor Creek was calculated using the Shade Model (discussed in **Attachment E**). Based on this scenario, the maximum daily stream temperature is very sensitive to improvements in riparian shade. This scenario resulted in maximum daily temperatures ranging from 52.6°F to 69.8°F, which is decrease from the baseline scenario of up to 7.3°F (**Figure 7-17**). Meeting the shade target caused an average decrease in the maximum daily temperature of 4.88°F from the baseline scenario.

The shade scenario indicates that human changes to the riparian vegetation are the primary source of temperature impairment. To illustrate how this scenario relates to current conditions, the average daily effective shade is presented in **Figure 7-18** for the baseline scenario and shade scenario.

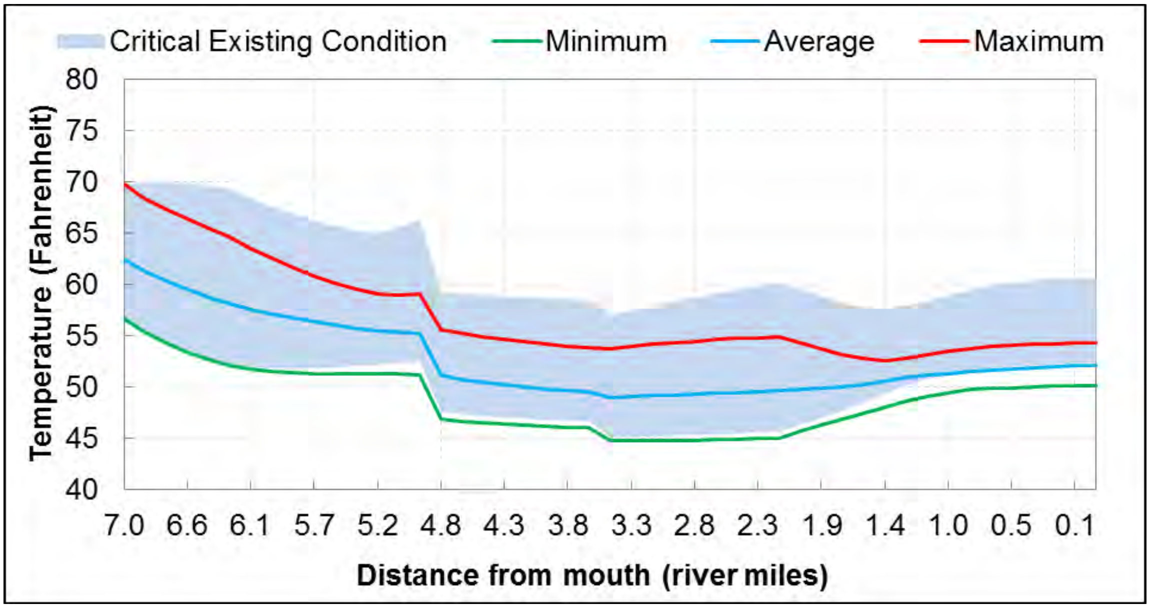


Figure 7-17. Comparison of modeled temperatures in McGregor Creek between the shade and baseline scenarios.

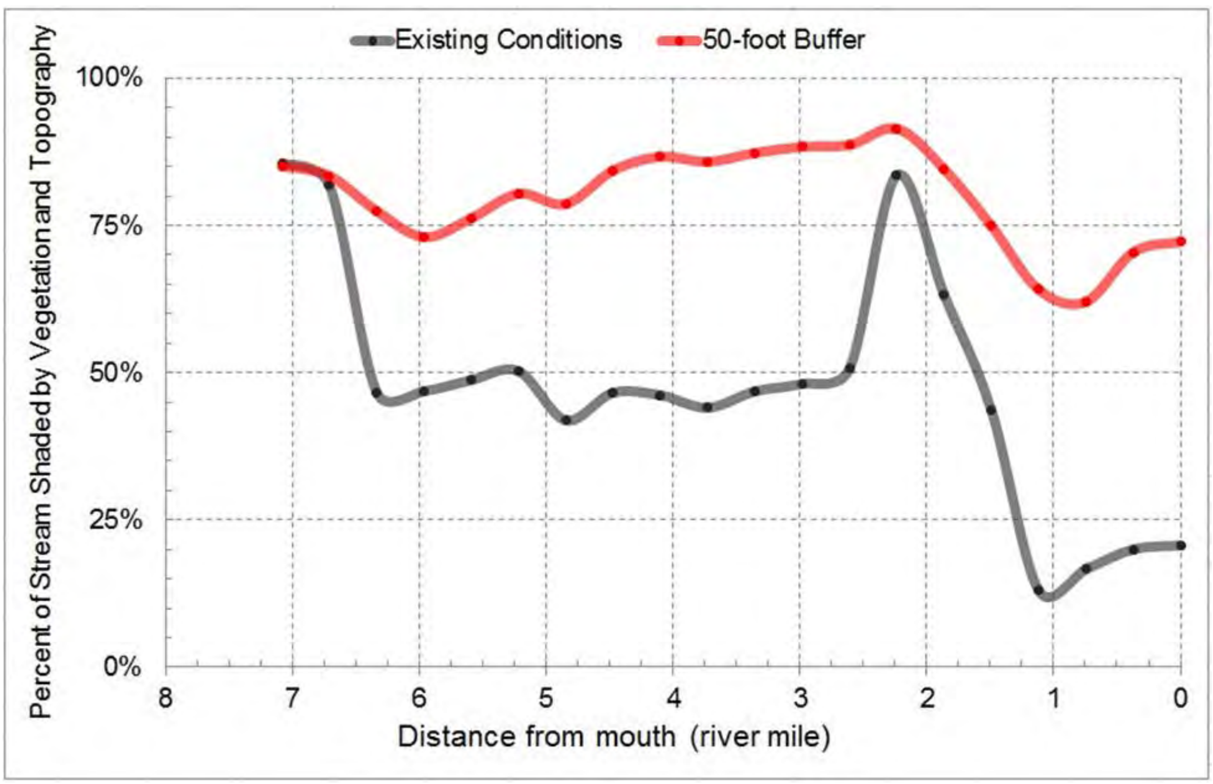


Figure 7-18. Comparison of effective shade in McGregor Creek between the existing condition and shade scenario

7.6.2.4 Naturally Occurring Scenario (Full Application of Best Management Practices with Current Land Use)

The naturally occurring scenario represents McGregor 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. Temperature model scenarios addressing the width/depth ratio were not modeled. It is assumed that this issue will be addressed through the sediment TMDL (**Section 5.0**). 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 McGregor 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 (Natural Resources Conservation Service, 1997; Negri and Brooks, 1990), increase instream flows, and/or reduce warm water return flows in McGregor Creek.

The naturally occurring scenario maximum daily temperatures ranged from approximately 52.6°F to 69.8°F, with an average of 56.9°F. Based on these results, the naturally occurring temperature is less than 66.0°F for all of McGregor Creek, with the exception of a short reach near the McGregor Lake outlet (i.e., the upper 0.4 miles). An increase of 1°F is allowed from human sources in all areas but the upper reach where human sources are not allowed to increase stream temperatures by more than 0.5°F (**Figure 7-19**).

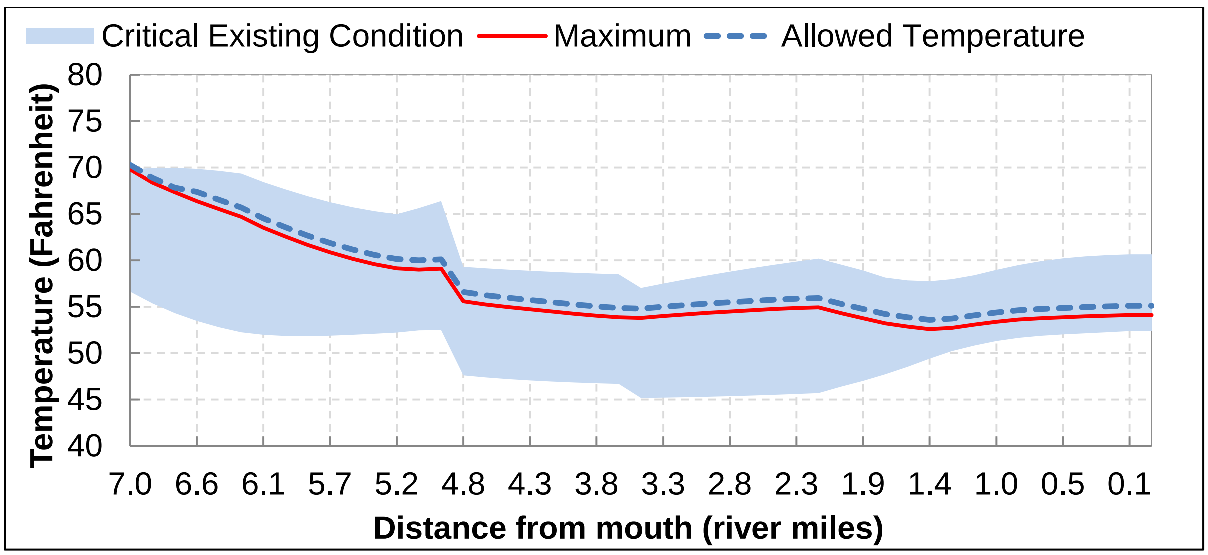
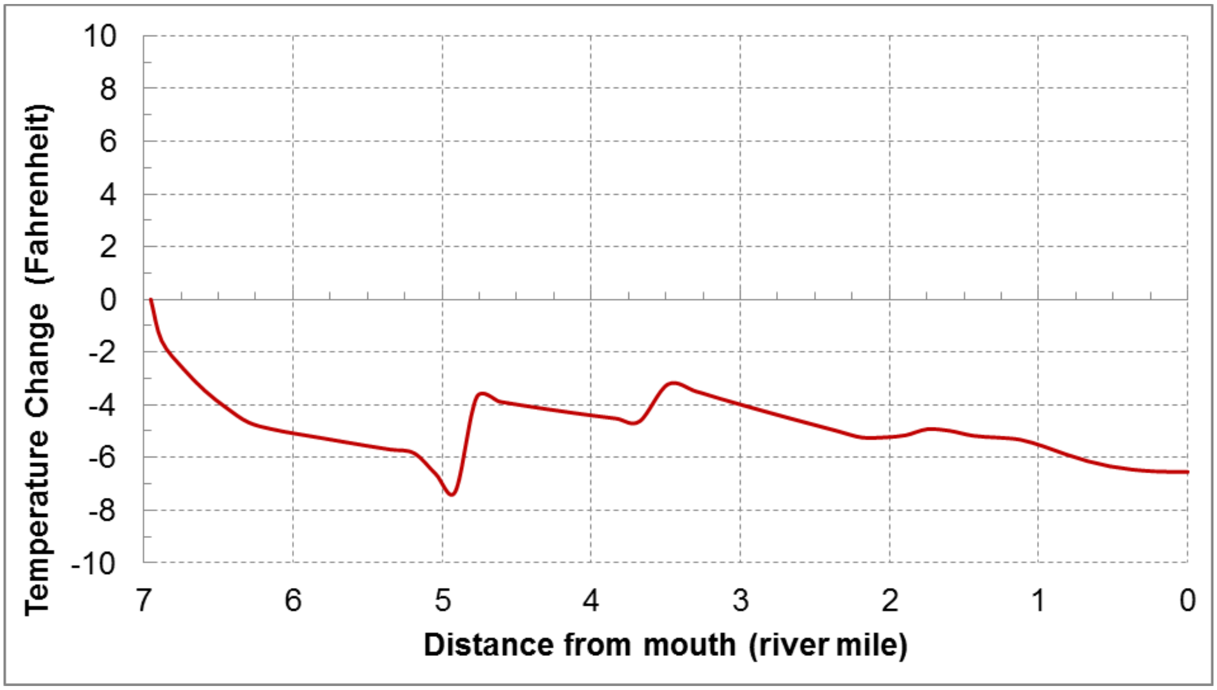


Figure 7-19. The maximum naturally occurring temperature in McGregor Creek relative to the existing condition (baseline scenario) and the allowed temperature.

The naturally occurring scenario results indicate 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 1.6°F to 7.3°F, with an average decrease of 4.9°F (**Figure 7-20** and **Figure 7-21**).



Note: A negative temperature change indicates potential decreases in temperatures from the baseline conditions (existing conditions with critical weather) to the naturally occurring conditions.

Figure 7-20. Potential temperature changes in McGregor Creek between the baseline (critical existing condition) and naturally occurring scenario.

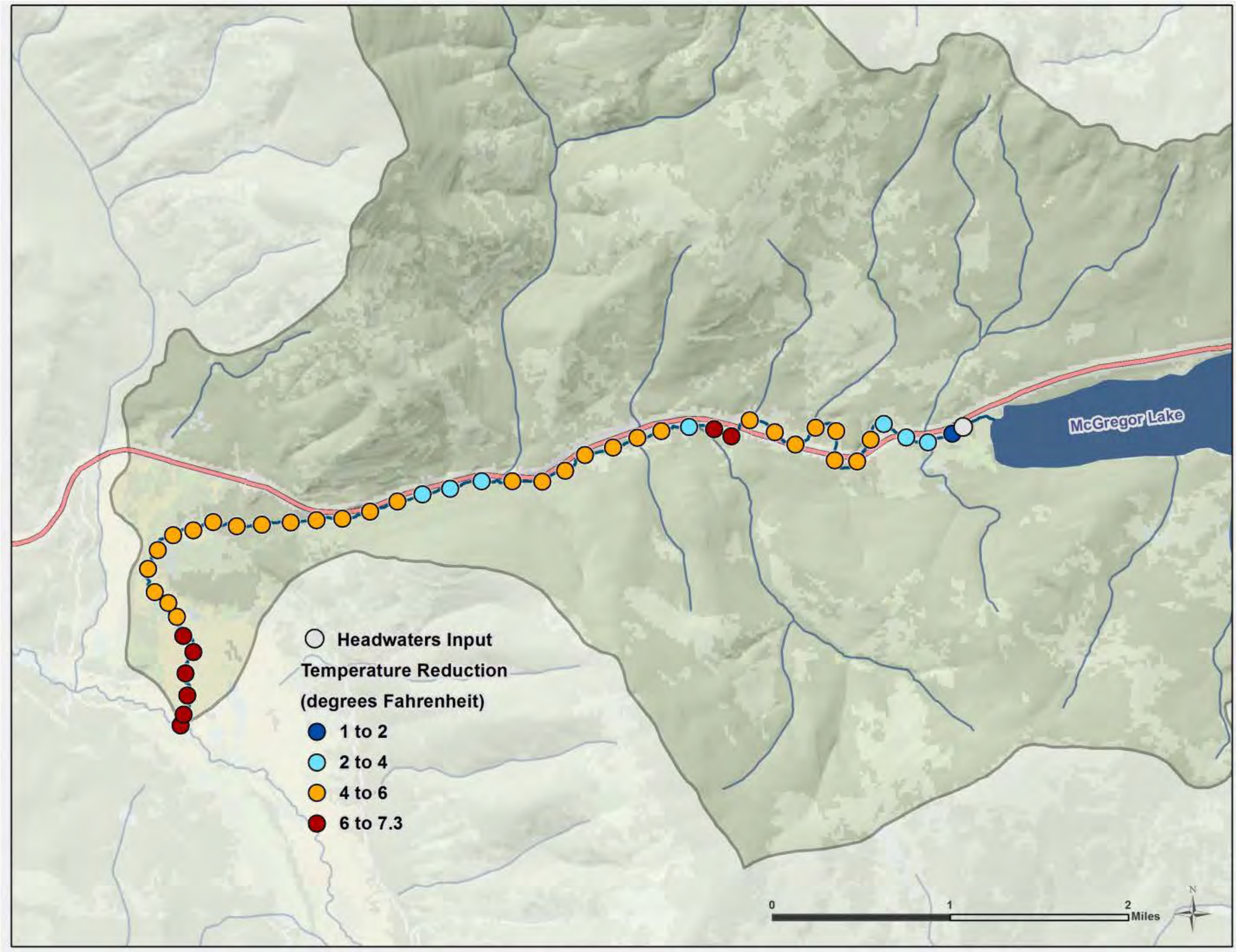


Figure 7-21. Temperature reductions in McGregor Creek that can be obtained under naturally occurring conditions (relative to the baseline scenario).

7.6.2.5 McGregor Creek Model Assumptions

The following is a summary of the significant assumptions used during the QUAL2K model development:

- McGregor Creek 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 of McGregor Creek.
- 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 Boorman RAWS, which were elevation-corrected, are representative of local weather conditions along McGregor Creek. Measured streamflow in August 2011 and climate adjustments for the baseline scenario adequately represent existing conditions on a hot, dry summer.
- Shade Model results are representative of riparian shading along segments of McGregor Creek.
- 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.

- The effective shade provided by a 50 foot buffer of medium density trees, or appropriate native vegetation providing equivalent effective shade where achievable (with the exception of areas dominated by hydrophytic shrubs, roads, and road right-of-ways) is consistent with the definition of the naturally occurring condition.

7.7 Temperature TMDLs and Allocations

Total maximum daily loads (TMDLs) are a measure of the maximum load of a pollutant that 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 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 Lynch Creek relative to naturally occurring temperatures is depicted in **Figure 7-22**.

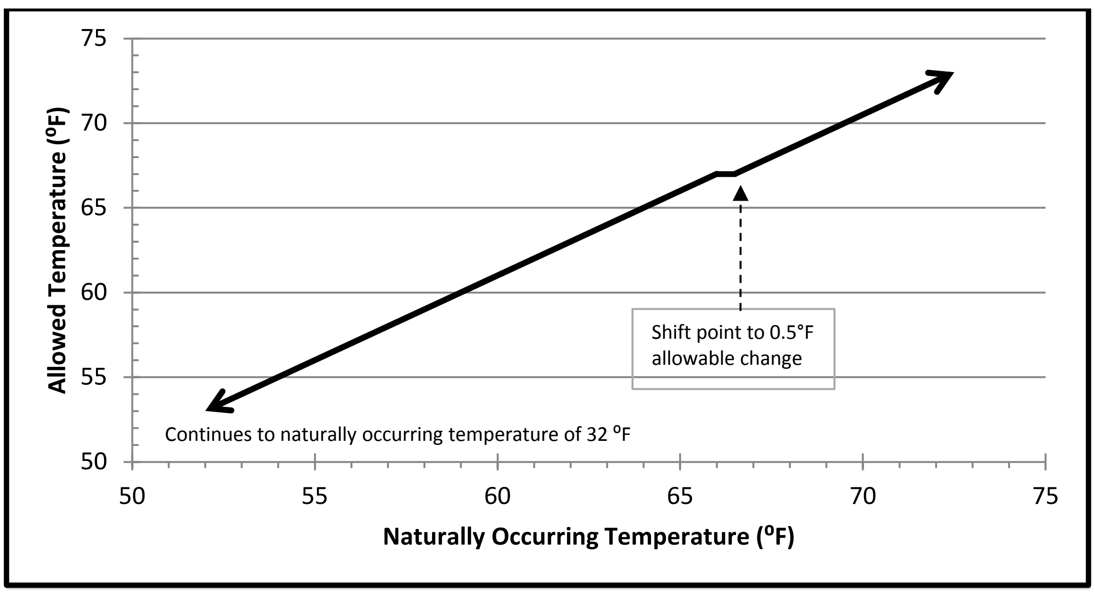


Figure 7-22. Line graph of the temperature standard that applies to Lynch Creek

For any naturally occurring temperature over 32°F (i.e., water's freezing point), the allowable instantaneous thermal total maximum load (kilocalories per second [kcal/s]) can be calculated using the standard to identify the allowable human-caused increase (stated above and shown in **Figure 7-22**) 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)

5/9 = conversion factor from degrees Fahrenheit to Celsius

28.3 = conversion factor from degrees Celsius to kcal/s

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 (i.e., 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, width/depth, and instream flow 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, 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

Example TMDLs for both Lynch and McGregor Creeks, expressed as instantaneous loads, are presented in **Table 7-5** and the surrogate TMDL and allocations are presented in **Table 7-6**. The example TMDLs are a direct translation of the water quality standard into a thermal load. There are no point sources and the entire allowable loads are allocated to natural and human sources that influence temperature.

The example TMDL for Lynch Creek is based on the modeled naturally occurring maximum daily temperature at the mouth during August 2012 flows (0.76 cfs). The naturally occurring temperature used in the example is 64.94°F, which means there is an allowable increase of 1.0°F and the allowable temperature would be 65.94°F. The calculation for the example TMDL following **Equation 7-1** is shown below:

TMDL = ((64.94 + 1.0) – 32) * 5/9) * 0.76 * 28.3 = 405.5 kcal/second

The example TMDL for McGregor Creek is based on the modeled naturally occurring maximum daily temperature at the mouth with a simulated flow of 10.72 cfs. The naturally occurring temperature used in the example is 54.09°F, which means there is an allowable increase of 1.0°F and the allowable temperature would be 55.09°F. The maximum daily temperature at the mouth under the baseline scenario representing critical existing conditions was 60.64°F. The calculation for the example TMDL following **Equation 7-1** is shown below:

TMDL = ((54.09 + 1.0) – 32) * 5/9) * 10.72 * 28.3 = 3,890 kcal/second

The surrogate TMDLs for both Lynch and McGregor Creeks contain allocations to temperature-influencing factors that will result in standards attainment when met. Because there are no point sources, there are 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 described in **Section 7.7**.

Table 7-5. Example Instantaneous Temperature TMDL and Allocation for Lynch and McGregor Creeks (at the mouth).

Waterbody	Modeled Existing Load (kcal/sec)	TMDL/Load Allocation (kcal/sec)	Percent Reduction Needed
Lynch Creek	554.3	405.5	27%
McGregor Creek	4,822	3,890	19%

Table 7-6. Surrogate Temperature TMDL and Allocations for Lynch and McGregor Creeks

Source Type	Surrogate Allocation
Land uses and practices that reduce riparian health and shade provided by near-stream vegetation along Lynch Creek and McGregor Creek.	• Improve to and maintain a 50 foot buffer with medium density trees, or appropriate native vegetation providing equivalent effective shade where achievable (with the exception of areas dominated by hydrophytic shrubs, roads, and road right-of-ways).
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
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 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.

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 margin of safety (MOS) were applied during development of the Lynch and McGregor 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 the focus of 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 the sources causing elevated summer stream temperatures will also address sources that could lower the minimum temperature at other times of the year.
- Temperature targets, the TMDL, and load 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 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 Lynch and McGregor Creeks investigated stream temperatures during summer when effects of increased water temperatures are most likely to have a detrimental effect on aquatic life.
- Compliance with targets and refinement of load allocations are all based on an adaptive management approach (**Section 7.8**) 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 that 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 (Montana Department of Environmental Quality, 2005b; Montana Department of Environmental Quality, 2005a). A QAPP was also completed for the QUAL2K model (Tetra Tech, Inc., 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 7.5.2** but are further detailed within the model reports in **Attachments D** and **E**.

The largest source of uncertainty is regarding the targets and conditions used to represent the naturally occurring condition. The target for width/depth ratio was developed as part of the sediment TMDL process (**Section 5**) and is 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, and best professional judgment. There is some uncertainty as to whether the target is achievable along the entire length of the stream, and as part of the adaptive management process, TMDL targets may be re-evaluated at a later date. DEQ recognizes that a 50 foot buffer of medium density trees may not be achievable in all areas along the stream and as discussed in the target and source assessment sections (**Section 7.4** and **7.5**), the ultimate goal and measure of success is implementation of all reasonable land, soil, and water conservation practices. Since no information 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 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 watershed but a comparison between the field measured effective shade values and values simulated via the Shade Model indicate the model reasonably approximated existing shade conditions within the watershed. Although this uncertainty within the model 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 Lynch and McGregor Creeks. Additional details regarding uncertainty associated with the model are contained in **Attachments D** and **E**.

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 TMDL 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 if necessary.

8.0 METALS TMDL COMPONENTS

This portion of the document focuses on metals [aluminum (Al), cadmium (Cd), copper (Cu), zinc (Zn)] and pH as a cause of water quality impairment in the Thompson TMDL Project Area. It describes: (1) the effects of metals on beneficial uses, (2) the stream segments of concern, (3) currently available data on metals impairment assessment in the watershed, including target development and a comparison of existing water quality targets; (4) metals source assessments; and (5) identification and justification for metals TMDLs and TMDL allocations.

8.1 EFFECTS OF METALS ON BENEFICIAL USES

Elevated concentrations of metals can impair the support of numerous beneficial uses including: aquatic life, primary contact recreation, drinking water, and agriculture. Within aquatic ecosystems, metals can have a toxic, carcinogenic, or bioconcentrating effect on biota. Likewise, humans and wildlife can suffer acute and chronic effects from consuming water or fish with elevated metals concentrations. Because elevated metals concentrations can be toxic to plants and animals, high metals concentrations in irrigation or stock water may also affect agricultural uses. Although arsenic is technically a metalloid, it is treated as a metal for TMDL development due to the similarity in sources, environmental effects, and restoration strategies.

8.2 STREAM SEGMENTS OF CONCERN

One waterbody segment in the Thompson TMDL Project Area is listed as impaired due to metals on the 2012 Montana 303(d) List (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012a) (**Figure 8-1**). The metals impairments for Sullivan Creek are included in **Table 1-1** and the designated use support status of the impaired segment is presented in **Table 3-1**. As noted in **Table 1-1** Sullivan Creek is listed as impaired for pH. The criteria for pH are narrative, therefore, there is no specific numeric target for pH. Instead of developing a pH TMDL, the metals TMDLs were used as a surrogate (see **Section 8.4.2**).

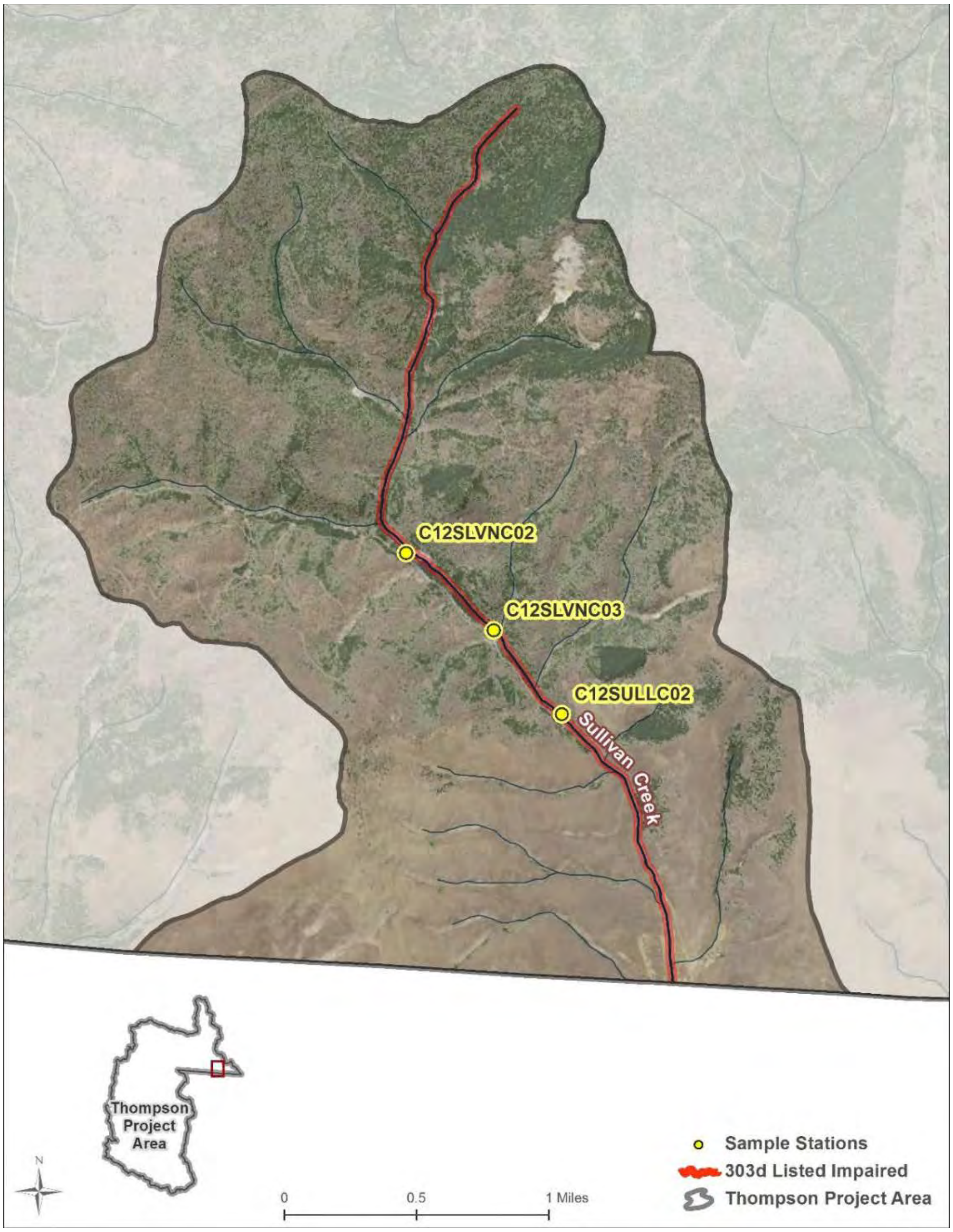


Figure 8-1. Streams impaired by metals in the Thompson TMDL Project Area for which TMDLs will be written and associated sampling locations used in impairment determination.

8.3 Information Sources and Assessment Methods

The following information sources were used to describe water quality and metals loading conditions in the project area:

- The monitoring and assessment data compiled by Department of Environmental Quality for the impaired waterbodies in the Thompson Project Area (2004-2012) (**Figure 8-1**).
- State agency databases and Geographic Information System (GIS) layers of inventoried mining properties and mining disturbances (Montana Bureau of Mines and Geology, 2006).

- Federal and state government agency geographical information system (GIS) data for geology, topography, land cover, and land-use layers
- DEQ historical narratives of mining activities
- DEQ's Water Quality Standards Attainment Record for Sullivan Creek (Montana Department of Environmental Quality, 2012i)
- Pan American Silver Corporation's water quality data for the Hog Heaven mine (2002-2013). Note that these data were not used in impairment determinations, or to calculate the metals TMDLs for Sullivan Creek because they were received after the TMDLs were completed. However, the data were used to assist with the source assessment (see **Section 8.5**).

The DEQ data (2004-2012) are the only data suitable to provide the basis for the existing condition analyses, TMDLs and allocations in this document. The Pan American Silver Corporation's water quality data for the Hog Heaven mine were only used to support the source assessment. Additional sources were searched for water quality and sediment data, including the United States Environmental Protection Agency's (EPA's) STORET database and the United States Geological Survey's (USGS's) National Water Information System (NWIS); however, DEQ is the only agency with available water quality data for Sullivan Creek and no sediment quality data. The water quality data used for analysis in this report are attached in **Appendix D**. Summaries of these data that are relevant to water quality parameters for the impaired segment of Sullivan Creek are provided in **Section 8.5**.

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

8.4 Water Quality Targets

DEQ compiled the water quality data described in **Section 8.3** for comparison to water quality targets. These targets are established using the most stringent water quality standard, in order to protect all designated uses. **Section 8.4** presents the evaluation framework, the metals water quality targets used in the evaluation, and the results of these evaluations for Sullivan Creek. Note that no sediment data are available for Sullivan Creek, and no corresponding sediment analysis will be discussed.

8.4.1 Metals Evaluation Framework

The metals evaluation process includes:

1. Evaluation of metals sources – Metals sources may be both naturally occurring and anthropogenic (i.e., human-caused). TMDLs are developed for waterbodies that do not meet standards, at least in part, due to anthropogenic sources.

2. Development of numeric water quality targets that represent unimpaired water quality (**Section 4.1**) – TMDL plans must include numeric water quality criteria or *targets* that represent a condition that meets Montana's ambient water quality standards. Numeric targets are measurable water quality indicators. They may be used separately or in combination with other targets to represent water quality conditions that comply with Montana's water quality standards (both narrative and numeric). Metals water quality targets are presented in **Section 8.4.2**.

3. Comparison of water quality with water quality targets to determine whether a TMDL is necessary – DEQ determines whether a TMDL is required by comparing recent water quality data to metals water quality targets. In cases where one or more targets are not met, a TMDL is developed. If data demonstrates no impairment, the waterbody – cause combination is recommended for removal from the 303(d) list.

8.4.2 Metals Water Quality Targets

The water chemistry targets are based on numeric human health standards and both chronic and acute aquatic life standards as defined in DEQ Circular DEQ-7 (Montana Department of Environmental Quality, 2012a). For any given pollutant, the most stringent of these criteria is adopted as the water quality target. This approach ensures that the TMDL is protective of all designated beneficial uses.

Montana's numeric aluminum criteria only apply within a pH range of 6.5-9 standard units. Many aluminum samples used in this TMDL analysis were collected from acidic waters below pH 6.5. While this precludes use of the numeric criteria, general prohibitions within Montana's narrative standards still apply. Specifically, ARM 17.30.637 states that "…waters must be free from substances…that will: create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life…" Since the pH criteria are narrative, there is no specific target for pH; however, the cadmium TMDL will be applied as a surrogate to address the narrative criteria.

Published literature confirms that aluminum is lethal to fish when pH is less than 6.5 (Baker and Schofield, 1982; Buckler et al., 1987; Cleveland et al., 1986; Hunn et al., 1987). Many studies have also shown increased aluminum toxicity as acidity increases (Baker and Schofield, 1982; Buckler et al., 1987). Increased toxicity at low pH is common for all metals, not just aluminum. However, with aluminum pH is particularly important due to the increase in bioavailability that results from pH-induced changes in aluminum speciation (Buckler et al., 1987). Often the end result is a coagulation of aluminum hydroxides on gill surfaces leading to death of the individual (Cleveland et al., 1986).

Given the documented toxic effects in low pH situations, the chronic aquatic life criterion (87µg/L) will be applied as the aluminum threshold for impairment determinations. EPA has approved aluminum TMDLs in the past that have followed a similar rationale (Montana Department of Environmental Quality, 2011d). Due to the extent of historic mining in the study area, it is likely that the low pH values and high aluminum concentrations are attributed to acid mine drainage and land disturbances associated with historical mining activity. Thus these aluminum issues are human-caused impairments that must be addressed through TMDL development opposed to a natural phenomenon.

The aquatic life criteria for cadmium, copper, and zinc are dependent upon water hardness values: usually increasing as the hardness increases. Water quality criteria (acute and chronic aquatic life, human health) for each parameter of concern at water hardness values of 200 mg/L and 300 mg/L are shown in **Table 8-1**. Metals criteria are based on site specific hardness values; however, 200 and 300 mg/L hardness values were chosen to calculate example targets since the five hardness observations in Sullivan Creek ranged from 193 to 305 mg/L. Note that the targets used to calculate the metals TMDLs are based on site-specific hardness observations (see **Section 8.6**). The targets are expressed in micrograms per liter (µg/L), equivalent to parts per billion. Acute and chronic toxicity aquatic life criteria are intended to protect aquatic life uses, while the human health standard is intended to protect drinking water uses. Note that there is no numeric human health standard for aluminum and the chronic and acute aquatic life standards for zinc are identical.

The evaluation process summarized below is derived from DEQ's Monitoring and Assessment program guidance for metals assessment methods (Drygas, 2012).

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

Table 8-1. Metals numeric water chemistry targets applicable to the Thompson TMDL Project Area

Metal of Concern	Aquatic Life Criteria (µg/L) at 200 mg/L Hardness		Aquatic Life Criteria (µg/L) at 300 mg/L Hardness		Human Health Criteria (µg/L)***
	Acute	Chronic	Acute	Chronic	
Aluminum, D*	750	87	750	87	N/A
Cadmium, TR**	4.32	0.45	6.52	0.61	5
Copper, TR	26.90	16.87	39.41	23.85	1,300
Zinc, TR	215.57	215.57	303.94	303.94	2,000

*D = dissolved
**TR = total recoverable
***Human Health Criteria are not hardness dependent

Where in-stream water quality data exceed water quality targets, sediment quality data often provide supporting information, but are not necessary to verify impairment. Sediment chemistry targets are included when sediment data are available; however, no sediment data are available for Sullivan Creek. Water quality targets for metals-related impairments in the Thompson TMDL Project Area include only water chemistry targets.

8.4.3 Existing Conditions and Comparison to Targets

For each waterbody segment included on the 2012 303(d) List for metals (**Table A-1**), DEQ evaluates recent water quality and sediment data relative to the water quality targets to make a TMDL development determination. DEQ has recently (2004-2012) completed several years of water quality sampling in the Thompson TMDL Project Area for the purpose of assessing the metals impairment determinations. These data provide the basis for the metals target evaluations below for Sullivan Creek (MT76L002_070). As stated above, there are no sediment quality data available for Sullivan Creek; therefore, metals concentrations in stream sediment were not evaluated.

Sullivan Creek is included on the 2012 303(d) List as impaired by metals: aluminum, cadmium, and zinc, as well as low pH. Data compilation and analysis demonstrate the need for TMDLs for all metals and impairments. A cadmium TMDL will serve as a surrogate TMDL for pH (see further discussion in **Section 8.4.2**. Copper was not originally listed on the 2012 303(d) List as being impaired. Recent (2004-2012) water quality data indicate that copper is a cause for impairment on Sullivan Creek. These updated impairment determinations are all captured in the recent 2014 Integrated Report and associated 2014 303(d) List.

Available Water Quality Data
DEQ used recent metals water quality data (2004-2012) to evaluate current conditions relative to water quality targets. Data were low flow sampling data collected by DEQ for subsequent TMDL development support. Typically high flow data is collected as well, however due to low flow volumes in Sullivan Creek only low flow data was collected. The water sample results are compared to water chemistry standards and targets in **Table 8-2**. None of the sample sets for metals meet the minimum sample size of 8 observations required for comparison to the exceedance rate of 10% identified in **Section 8.4.1**. However, aluminum, cadmium and zinc all exceed the chronic exceedance rate by 100%, and copper exceeded it by 40%. If Sullivan Creek had the minimum 8 samples, these pollutants would still exceed the %10 exceedance rate. Sullivan Creek is also considered to be impaired by cadmium and zinc because at least one sample exceeds the human health criterion. Sullivan Creek is also considered to be impaired by aluminum and copper because at least one sample exceeds the acute aquatic life standard by more than a factor of two.

Table 8-2. Sullivan Creek metals water quality data summary and target exceedances

Parameter*	Aluminum	Cadmium	Copper	Zinc
# Samples	5	5	5	5
Min	800	6.02	5	6,960
Max	10,600	26.5	40	16,800
# Acute Exceedances	5	4	1	5
Acute Exceedance Rate	100%	80%	20%	100%
# Chronic Exceedances	5	5	2	5
Chronic Exceedance Rate	100%	100%	40%	100%
# Human Health Exceedances	N/A	5	0	5
Human Health Standard Exceedance Rate	N/A	100%	0%	100%

*all units in µg/L; total recoverable fraction, except for aluminum (dissolved)

Comparison of Metals Concentrations to Water Quality Targets and TMDL Determination
Each pollutant is discussed individually. The discussions are summarized in **Table 8-3**.

Aluminum
Sullivan Creek is listed as impaired by aluminum in the 2012 303(d) List. The existing aluminum dataset contains five samples collected at two monitoring sites (C12SULLC02 and C12SLVNC02) on Sullivan Creek from 2004-2012 (see **Figure 8-1**). All five samples exceeded both the acute and chronic aquatic life criteria aluminum targets and had pH concentrations less than 6.5. As discussed previously in the metals target section (**Section 8.4.2**), based on an interpretation of the narrative standard the assessment concludes aluminum is impairing the aquatic life beneficial use. Therefore, aluminum remains a cause of impairment and a TMDL has been developed.

Cadmium
Sullivan Creek is listed as impaired by cadmium in the 2012 303(d) List. Recent data collected from 2004-2012 at stations C12SULLC02 and C12SLVNC02 established an acute aquatic life standard exceedance rate of 80%. This same data set established a chronic exceedance rate and the human health

exceedance rate of 100%. Therefore, cadmium remains a cause of impairment and a TMDL has been developed.

Copper
Sullivan Creek is not listed as impaired by copper in the 2012 303(d) List. Recent data from sampling conducted from 2004-2012 at stations C12SULLC02 and C12SLVNC02 show 2 chronic exceedances of the aquatic life target. This equates to a 40% exceedance rate for the chronic aquatic life target. Therefore, copper is a cause of impairment and a TMDL has been developed.

Zinc
Sullivan Creek is listed as impaired by zinc in the 2012 303(d) List. Water quality data from recent sampling (2004-2012) at stations C12SULLC02 and C12SLVNC02 demonstrates the zinc impairment in Sullivan Creek. Zinc concentrations in Sullivan Creek exceeded the acute and chronic aquatic life criteria in 100% of samples. All samples also exceed the human health standard. Therefore, a zinc TMDL has been developed for Sullivan Creek.

pH
Sullivan Creek is also listed as impaired by pH in the 2012 303(d) List. Recent data from sampling conducted from 2004-2012 at stations C12SULLC02, C12SLVNC02 and C12SLVNC03 shows that the pH is often below the range of 6.5-8.5 where natural pH outside this range must be maintained without change per the pH standard ARM 17.30.623(2)(c). The cadmium TMDLs for Sullivan Creek will be used as a surrogate for the pH TMDL because providing a pH TMDL is not practical, and addressing sources of the cadmium impairment related to acid mine drainage will also address sources of pH impairment. Cadmium was chosen as the surrogate because it has the lowest acute and chronic standards, making cadmium the most conservative choice as a surrogate.

Table 8-3. Sullivan Creek metals TMDL decision factors

Parameter	Aluminum	Cadmium	Copper	Zinc	pH
Number of Samples	5	5	5	5	19
Chronic Aquatic Life exceedance rate >10%?	Yes	Yes	Yes	Yes	N/A
Greater than 2x acute Aquatic Life exceeded?	Yes	Yes	No	Yes	N/A
Human Health Criterion exceeded?	N/A	Yes	No	Yes	N/A
Human-caused sources present?	Yes	Yes	Yes	Yes	Yes
2012 303(d) Listed?	Yes	Yes	No	Yes	Yes
TMDL developed?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes***

* The cadmium TMDL will be written as a surrogate to address the pH impairment. See above paragraph for more detail.

8.4.4 Metals Target Comparison and TMDL Development Summary

Sullivan Creek in the Thompson TMDL Project Area is identified on the 2012 303(d) List with metals impairment causes. DEQ recently reassessed Sullivan Creek in order to better reflect current conditions in the 2014 303(d) List. Reassessment of metals chemistry in Sullivan Creek confirmed all of the metals impairments (aluminum, cadmium, and zinc) identified in the 2012 303(d) List. Additionally, a copper impairment was identified for Sullivan Creek, and has been added to the 2014 303(d) List. Sullivan Creek requires TMDLs for a total of 4 metals as well as pH. TMDLs and allocations for these metals are provided in the following section.

8.5 Source Assessment

Based on the review of water quality data, geographic information, and project reports and narratives, potential sources of metals loading to Sullivan Creek include historical mining and natural background sources from mineralized bedrock surface erosion. Both of these sources are described below.

8.5.1 Loading from Point Sources

There are no non-mining point sources in the Sullivan Creek watershed. There is one permitted mine in the watershed, Hog Heaven, which is described in **Section 8.5.2**. Hog Heaven has a DEQ operating permit, not a Montana Pollutant Discharge Elimination System (MPDES) discharge permit.

8.5.2 Loading from Mining Sources

The metals sources in the Sullivan Creek watershed include historical mining and natural background. Historical mining likely contributes the majority of metals loading. Both sources of metals loading are discussed in the following sections. The only mine with an operating permit in the watershed is the Hog Heaven site; all other mines in the watershed are abandoned. **Figure 8-2** shows the location of the Hog Heaven Mine and the abandoned mines. The mining related metals sources include adits and seeps, metals-laden floodplain deposits, waste rock and tailings, or other features associated with abandoned and inactive mining operations.

The operating permit for the Hog Heaven mine was issued in 1984. The site has changed ownership a few times since 1984, but is currently owned by Pan American Silver Corporation Pan American Silver Corporation is not actively mining this site at this time. Almost all mining to date at the site occurred between 1930 and 1942. The site is 1,300 acres and the permitted disturbance area is 375 acres. The site is permitted for open pit, underground, and vat leaching forms of mining. Pan American Silver has continued to maintain the site including reclamation of some historic mining disturbances, removal of old buildings, closure of hazardous mine openings, filling of caved stopes, and spraying of noxious weeds. Based on its operating permit, there should be no surface water discharges from the mine; therefore, it does not have an MPDES discharge permit. Contact with DEQ's Hard Rock Mining section has confirmed that there are no direct discharges to surface water from the Hog Heaven mine (personal communication with Wayne Jepson, 2013[17]). Site visits by DEQ have indicated that there does not appear to be any stormwater flow from the Hog Heaven site to Sullivan Creek, which begins about a mile north of the mine. During a site visit in a wet spring (2011), there was no evidence of stormwater leaving the mine. However, there is potential for the site to contribute metals to the creek via groundwater loading.

Water quality data from three surface water monitoring sites (HSW-1, HSW-2 and HSW-15) and two monitoring wells (West Flathead Well (WFW) and office Well) on the Hog Heaven site were provided by Pan American Silver Corporation. It is important to note that HSW-15 is a groundwater seep that is routinely inundated by livestock and generally does not have any measurable surface water flow. Data from HSW-15 were used as there was limited onsite data that were available to represent background water quality. HSW-15 was the only onsite sample location that was up gradient of any obvious legacy mining in the watershed. HSW-1, HSW-2 and HSW-15 are in the Sullivan Creek watershed; however they do not originate from surface water on the Hog Heaven property. The sampling locations are shown in

[17] Personal communication with Wayne Jepson, Montana Department of Environmental Quality, Hard Rock Mining, Helena, MT. 2013

Figure 8-2. These data were submitted after the updated impairment assessments were completed, although the data appears to support the existing metals and pH impairment determinations. However, the data were used to support the source assessment. The data were compared to the pH and metals targets for Sullivan Creek to characterize any potential metals sources from the Hog Heaven mine. Although the groundwater on the Hog Heaven mine property is not subject to the state surface water quality criteria, the data were compared to the water quality criteria to show the magnitude of the concentrations. This comparison helps to support the fact that Hog Heaven, as well as other inactive mines in the watershed, might be a significant source of metals to Sullivan Creek. Continued monitoring and additional analysis of the elevated metals concentrations in Sullivan Creek and wells on the site are recommended in order to assist with TMDL implementation. The mining data are summarized below and presented in **Appendix D**.

There are 71 Cd observations with exceedances of the 4.32 µg/L acute aquatic life water quality target (based on a hardness of 200 mg/L) at 4 of the five monitoring sites. The only station without any Cd exceedances is the WFW ground water monitoring site. Cd ranges from 0.01 to 327 µg/L, with the highest observations at station HSW-15, which is upgradient of the West Flathead and Hog Heaven mines. Comparison of upgradient surface water samples results (HSW-15) to down gradient surface water sample results (HSW-1) taken on the same date; the data show a decrease in Cd concentrations on four days and an increase on two days.

There are exceedances of the acute aquatic life Cu water quality target of 26.9 µg/L (based on a hardness of 200 mg/L) at 3 of the 5 monitoring sites. There are no exceedances at stations WFW and HSW-2. Cu observations range from 1 to 320 µg/L, with the highest observations at stations Office Shop Well and HSW-1, located both upgradient and downgradient of the West Flathead and Hog Heaven mines, respectively. In comparing upgradient surface water sample results (HSW-15) to downgradient surface water sample results (HSW-1) taken on the same date; the data show an increase in Cu concentration on all 6 days.

There are 86 Zn observations at the Hog Heaven mine and all are exceeding the acute aquatic life Zn water quality target of 215.57 µg/L (based on a hardness of 200 mg/L). Observations range from 2,930 to 180,000 µg/L, with an average concentration of 13,515 µg/L. The highest observations were observed at station HSW-15, upgradient of the West Flathead and Hog Heaven mines closed mine. In comparing upgradient surface water sample results (HSW-15) to downgradient surface water sample results (HSW-1) taken on the same date; the data show a decrease in Zn concentration on three days and an increase on three days.

There are 86 pH samples from the mine and all samples but one are below 6.5. There are 82 Al observations and all but three are exceeding the acute aquatic life water quality target of 750 µg/L. The three observations that are not exceeding were all sampled at station HSW-2, which is downgradient of the West Flathead and Hog Heaven mines. In comparing upgradient surface water sample results (HSW-15) to downgradient surface water sample results (HSW-1) taken on the same date; the data show a decrease in pH on all 6 days, suggesting increased acid drainage.

The Al observations range from 600 to 187,000 µg/L, with the highest observations at station WFW (West Flathead Well), which is also below both mines. In comparing upgradient surface water sample results (HSW-15) to downgradient surface water sample results (HSW-1) taken on the same date; the data show a decrease in Al concentration on three days and an increase on three days

In addition to the permitted Hog Heaven mine, there are several abandoned mines in the watershed (Montana State Library, 2006). The abandoned mines are all located within the Hog Heaven mining district, which is located in Flathead County west of Flathead Lake. The area is in the Flathead Mountain range and is drained by the Little Bitterroot River and its principal tributary, Sullivan Creek. The ore deposits of the region are silver-lead deposits. Historical descriptions for each of the abandoned mines are summarized below from DEQ's abandoned mines website (Montana State Library, 2006).

The data provided by the Pan American Silver Corporation also suggests elevated metals concentrations and relatively low pH concentrations also exist within surface water at locations above major mine sites identified within **Figure 8-2**.

Flathead Mine/Hog Heaven Mine

The Flathead Mine was the principal mine in the district and was located in the headwaters of the Sullivan Creek watershed at the same location as the current Hog Heaven Mine. During the late 1930s and 1940s it was one of the largest silver producers in the Pacific Northwest, producing more than 90% of the ore in the Hog Heaven district. The Flathead mine reported production of ore in the years 1914, 1928-1931 and 1935-40. There was also some production between 1964 and 1976.

The Flathead Mine Complex was on Montana's list of priority abandoned mine cleanup sites (Pioneer Technical Services, Inc., 1995). Waste rock and tailings, by-products of mining and milling processes, were present at the Flathead Mine site during site investigations in the 1990s. These site investigations discovered high levels of metals in the waste rock and tailings, including: arsenic, barium, cadmium, copper, iron, lead, mercury, antimony, and zinc. Discharging adits were observed on the site, but none directly entered surface water. One pipe at the West Flathead Mine did discharge to Sullivan Creek and exceedances of the aquatic life criteria for zinc, iron, and lead were observed in the pipe discharge. No flowing surface water was observed on the site; however, there were observed releases of barium, cadmium, mercury, antimony, and zinc in downstream sediments (Pioneer Technical Services, Inc., 1995). DEQ's 2006 assessment record also indicates that mine tailings from abandoned mines can be found near the floodplain (Montana Department of Environmental Quality, 2012h). According to Montana's Priority Mine List, no further reclamation action has been contemplated for the Flathead Mine Complex (Montana DEQ, http://deq.mt.gov/AbandonedMines/priority.mcpx, accessed July 2013). The Flathead Mine has become the Hog Heaven Mine and currently has an operating permit although no mining activity has occurred on the site since the permit was granted.

Battle Butte Mine

The Battle Butte Mine, also known as the Margarita, was located about 1 mile south of the West Flathead mine. Prospects were started in the late 1930s and operated intermittently until at least 1970. The ore was mainly copper, zinc, and lead, but contained some silver.

O.F. Martin Mine

The Martin Mine was located near the Battle Butte Mine. It was started in the late 1930s and operated intermittently until at least 1970. The ore was mainly zinc, copper, and lead, but includes some silver.

Ole Mine

The Ole Mine was located approximately one mile west of the Flathead Mine. Adits on Ole Hill are adjacent to Sullivan Creek. The mine was active in 1931 with the Ole Mining Company reporting assays of 1,400 ounces of silver to the ton. The mine operated under lease from the Northern Pacific Railroad Company in the 1960s, and in 1963-64 more than 150 tons of silver ore were shipped from the site.

West Flathead Mine

The West Flathead Mine was located approximately 1/2 mile southwest of the Flathead Mine on Sullivan Creek. It was operated between 1938 and 1941 by the Anaconda Mining Company and was operated intermittently until 1946. After 1946 lessees intermittently operated the West Flathead Mine. The mine reportedly had some of the richest ore in the Hog Heaven district.

Other Mines

Information on the additional abandoned mines included in **Figure 8-2** (Mary Ann Mine, Reser, Grant Mine, and the Bergman and Murphy Property) were not included in DEQ's description of the Hog Heaven Mining District (Montana Department of Environmental Quality, 2013), but information found at us-mining.com (US-Mining, http://www.us-mining.com/montana/flathead-county, accessed July 2013) indicates that the Grant Mine ore was barium, copper, gold, lead, and silver; the Reser Mine ore was manganese; the Mary Anne Mine ore included lead, silver, and copper; and the Bergman and Murphy Property ore included lead, silver, gold, and copper.

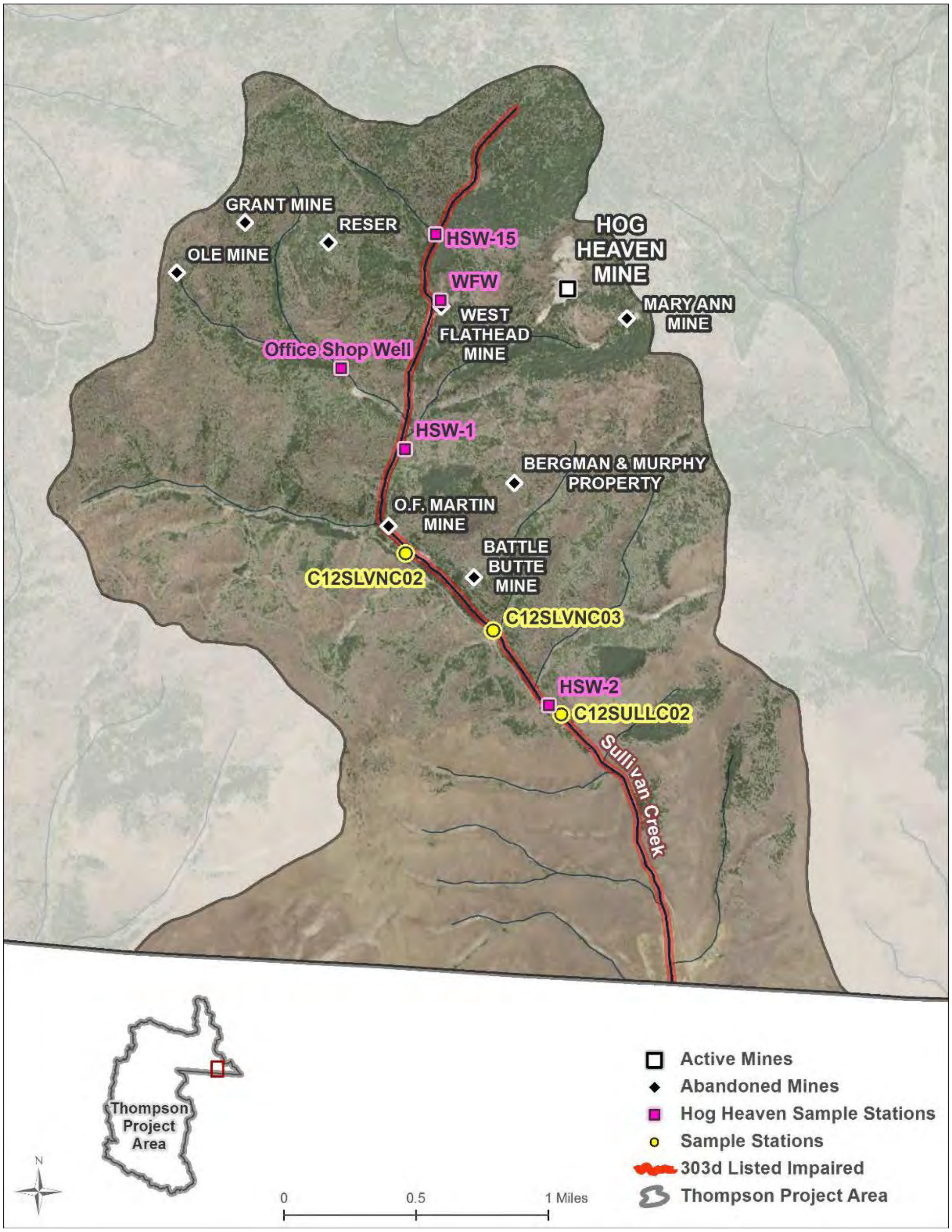


Figure 8-2. Location of Hog Heaven Mine and abandoned mines in the Sullivan Creek watershed.

DEQ completed stream sampling from 2004-2012 to use for an updated stream assessment and to support subsequent TMDL development (**Appendix A**). **Figure 8-2** shows the location of the Flathead Mine Complex, Hog Heaven Mine, DEQ's sample locations, and Pan American Silver's Hog Heaven sample locations.

While there are three DEQ sampling stations on Sullivan Creek, only two of those stations have metals data (C12SLVNC02 and C12SULLC02) and all three have pH data. Station C12SLVNC02 is located just below the Martin Mine, but above the Battle Butte Mine (**Figure 8-2**). There are flow data at this site, but the flow data do not correspond with the metals data. Sullivan Creek is an intermittent stream (with flows often going subsurface), flow data range from 0 to 0.1 cfs. The highest aluminum and cadmium observations were at this site (10,600 µg/L and 26.5 µg/L, respectively) on July 4, 2012; however, aluminum and cadmium exceeded water quality criteria at both locations. The highest copper observations were also at this site on May 31, 2012. The copper observations at the downstream site (C12SULLC02) did not exceed water quality criteria. The highest zinc observations were seen at station C12SULLC02 below Battle Butte Mine; however, zinc was also exceeding criteria at station C12SLVNC02. The water quality data do not provide much insight on whether a specific mine is causing the metals impairment because only two stations have metals data and both stations are located downstream from most of the mines. Therefore, all abandoned and active mines in the watershed are considered to be potential sources of metals loading to Sullivan Creek.

8.5.3 Natural Background Loading

Natural background loading is assumed to be a result of local geology, with minimal influence from human-caused sources. Metal loading to surface water is strongly influenced by geology and streamflow rate. Bedrock composition commonly affects sediment mineralogy and surface water concentrations of many elements, including metals. Higher suspended sediment concentrations usually increase the water column solids concentration of metals and other constituents during seasonal high flows.

The sampling and analysis plans developed for stream assessments in the Thompson Project Area (U.S. Environmental Protection Agency, 2012; Montana Department of Environmental Quality, 2012e) did not identify any sampling sites to determine natural background conditions (e.g., sites removed from mining and other human-caused sources). Intermittent and seasonal flow conditions within the Sullivan Creek drainage make it difficult to use headwater sample site for determining natural background conditions. It was therefore necessary to find sampling sites outside of the Sullivan Creek watershed that could represent similar conditions in Sullivan Creek.

The Sullivan Creek watershed has distinct volcanic geology that is different from the other watersheds in the Thompson Project Area. This unique geology makes it difficult to find a watershed with similar geology to use as a reference site for background metals conditions. Due to the lack of reference watersheds with similar geology, metals data in the non-impaired watersheds of the Thompson Project Area were used to estimate background. The median values for aluminum, cadmium, copper, and zinc concentrations for low flows at 24 stations in the project area were used for the purpose of estimation. **Figure 8-3** shows the locations of the stations. April through June is assumed to represent high flow conditions in the project area, while the remainder of the year is assumed to represent low flow conditions. Only observations during low flow conditions (July- March) were used because Sullivan Creek has intermittent flow and low flows are typical for the waterbody.

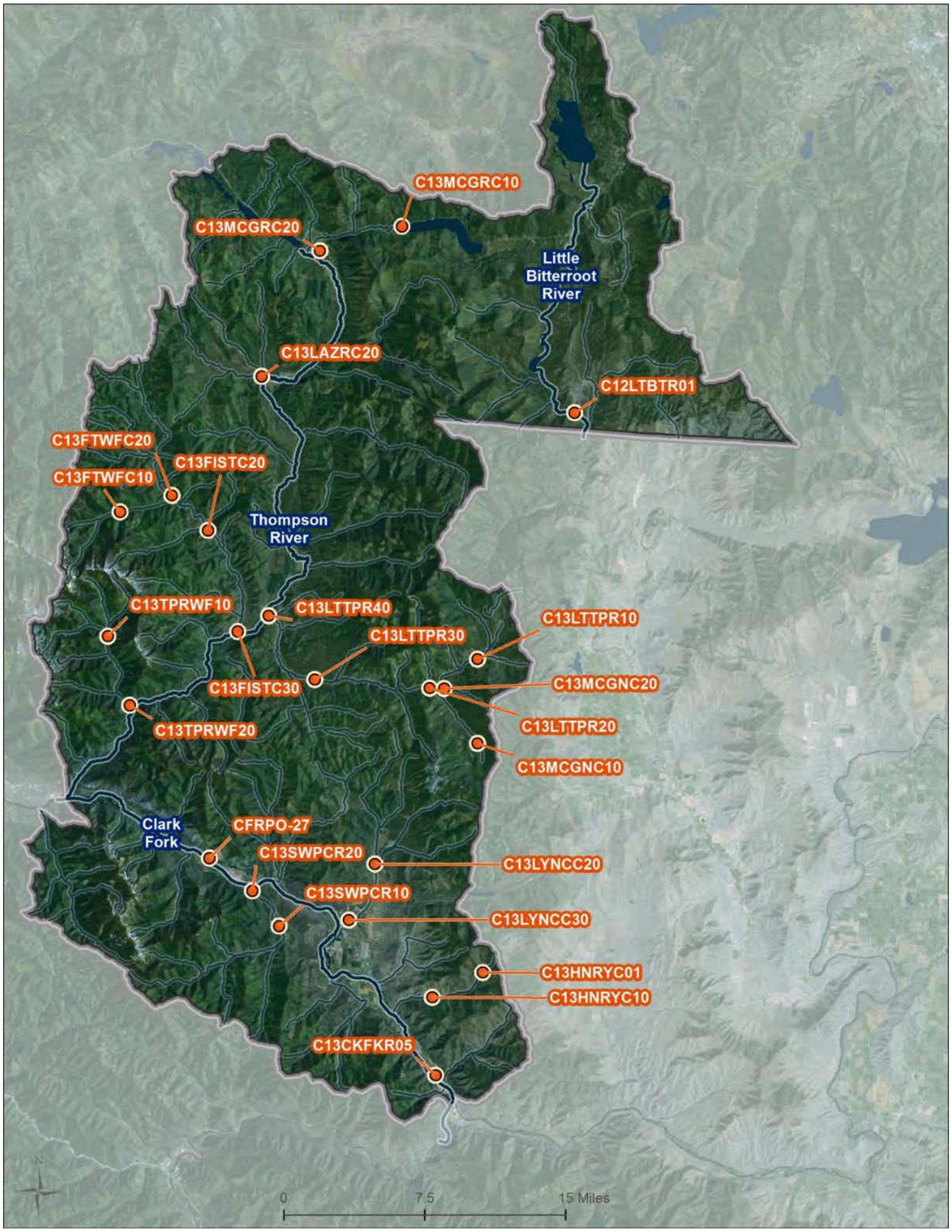


Figure 8-3. Water quality sampling sites representing natural background conditions in the Thompson TMDL Project Area.

To support the use of the median values at non-impaired streams as background metals concentrations, the median values in the Thompson Project Area were compared to the values used in the Boulder-Elkhorn TMDL Planning Area (TPA). The Boulder-Elkhorn TPA is located in western Montana, approximately 125 miles southeast of the Thompson Project Area, and is dominated by volcanic geology similar to Sullivan Creek. The comparison of background data from the Thompson TMDL Project Area to the data from the volcanic Boulder-Elkhorn TPA indicate that the data from the Thompson streams are similar to the Boulder-Elkhorn values and are, therefore, assumed to be representative of background conditions in the Sullivan Creek watershed.

Table 8-4 contains the low-flow median values for metal pollutant parameters representing natural background conditions in both the Sullivan Creek watershed and Boulder-Elkhorn area. Where measured concentrations are less than the analytical method detection limit, one half of the detection limit is used to calculate loading from background sources. The median values for the Thompson TMDL Project Area in **Table 8-4** are used to calculate the load allocations to natural background sources of metals loading in the Sullivan Creek watershed (see **Section 8.6.2**).

Table 8-4. Median metal concentrations for sites representing natural background conditions in the Sullivan Creek watershed and Boulder-Elkhorn TPA.

Parameter	Low Flow Median Concentration – Thompson Project Area[1] (µg/L)	Low Flow Median Concentration - Boulder-Elkhorn Planning Area[2] (µg/L)
Aluminum	50	30
Cadmium	0.05	0.04
Copper	0.5	1
Zinc	5	5

[1]Representing the Sullivan Creek watershed
[2]Source: (Montana Department of Environmental Quality, 2012i)

The Thompson TMDL Project Area data set contains 24 low flow aluminum observations. All of the aluminum observations are below the detection limit except for two observations of 100 and 200µg/L. There are 33 low flow cadmium observations. All of the cadmium observations are non-detects except for one detected value of 0.09 µg/L. There are 33 low flow copper observations. Most are non-detects and the detected values range from 1 to 5 µg/L. There are also 33 low flow zinc observations. Most of the zinc observations are non-detects, while the seven detected values range from 0.9 to 70 µg/L.

Metal concentrations in samples from natural background sites are either less than the method detection limits or within the applicable standards for all metal parameters except dissolved aluminum. The most restrictive aluminum criterion is the chronic aquatic life target of 87 µg/L. The target was exceeded twice in the Thompson Project Area. These exceedances occurred at the Little Bitterroot River 150 yards upstream of Lower Falls (C12LTBTR01) on August 4, 2004 and McGinnis Creek Upper 75 yards upstream from Forest Service Road 16077 (C13MCGNC10) on August 25, 2004. Despite the aluminum exceedances, the median aluminum concentration in the Thompson Project Area remains less than the aquatic life target. Complete water column chemistry results for the selected natural background sites in the Thompson Project Area used to represent Sullivan Creek are contained in **Appendix D**.

When possible, background loading is accounted for separately from human-caused sources. However, the effects of past metal mining are localized within the project area and load allocations to natural background sources cannot always be expressed separately from human-caused sources. Additional surface water monitoring in the Sullivan Creek watershed upstream of any past mining activity is recommended to better define natural background levels of aluminum, cadmium, copper, and zinc loading.

8.6 TMDLS AND ALLOCATIONS

8.6.1 Metals TMDLs

The following Section presents metals TMDLs for impaired waterbodies in the Thompson TMDL Project Area. TMDLs are based on the most stringent water quality criteria or the water quality target, the water hardness if applicable, and the streamflow. All metals TMDLs are calculated using the most stringent target value. Which ensures that the TMDLs are protective of all designated beneficial uses. Target development is discussed in detail above, in **Section 8.4.2**.

Because streamflow and hardness vary seasonally, TMDLs are not expressed as a static value, but as an equation of the appropriate target multiplied by flow. These equations are illustrated in **Figures 8-4** through **8-7**. TMDLs under a specific flow condition are calculated using the following formula:

TMDL = (X) (Y) (k)

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

Three metals impairment causes in the Thompson Project Area have standards for protection of aquatic life that vary according to water hardness as defined within DEQ-7 (Montana Department of Environmental Quality, 2012a). Generally aquatic life standards become more stringent as water hardness decreases. Water hardness may vary seasonally, and instream water hardness is commonly higher under low flow conditions. For calculating example TMDLs in this section, the lowest applicable metals water quality target is based upon the measured hardness corresponding to that sample.

Figure 8-4 is a plot showing TMDLs versus flow for aluminum, which is the only metal in the Thompson Project Area that is not influenced by hardness. **Figures 8-5** through **8-7** show TMDLs versus flow for the hardness-dependent impairment causes (cadmium, copper,and zinc) at hardness conditions of 25mg/L and 400/mg/L. These values represent the complete range of variability of hardness per DEQ-7, as well as the naturally occurring conditions in the Thompson Project Area (**Appendix D**). Although a 10% target exceedance rate is allowed for Chronic Aquatic Life targets, the TMDLs are set so that these targets are satisfied 100% of the time. This provides a margin of safety by focusing remediation and restoration efforts toward 100% compliance to the extent practicable.

The TMDL equation and curves apply to all metals TMDLs within this document and describe TMDLs for each metal under variable flow and hardness conditions. Metals TMDLs apply to any point along the waterbody and therefore protect uses along the entire stream. An exception may be found in a mixing zone established for a MPDES permitted discharge, but that does not apply within the Thompson Project Area since there are no MPDES permitted discharges.

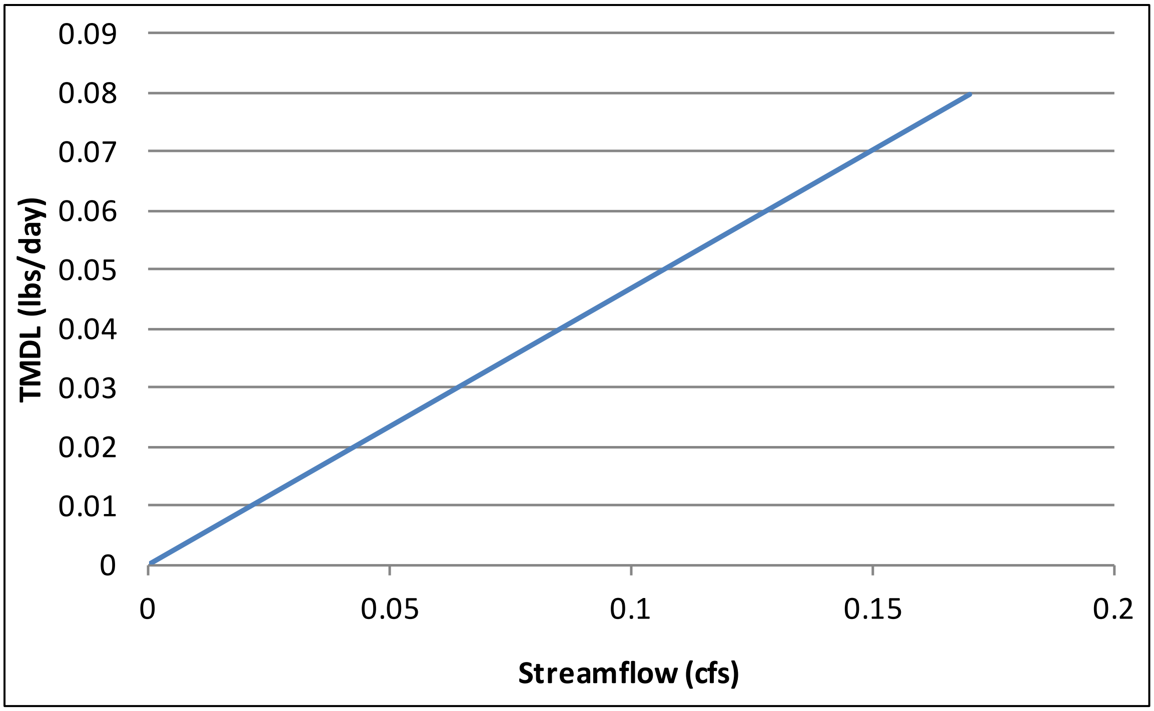


Figure 8-4. Hardness-independent metals TMDLs as functions of flow (aluminum)

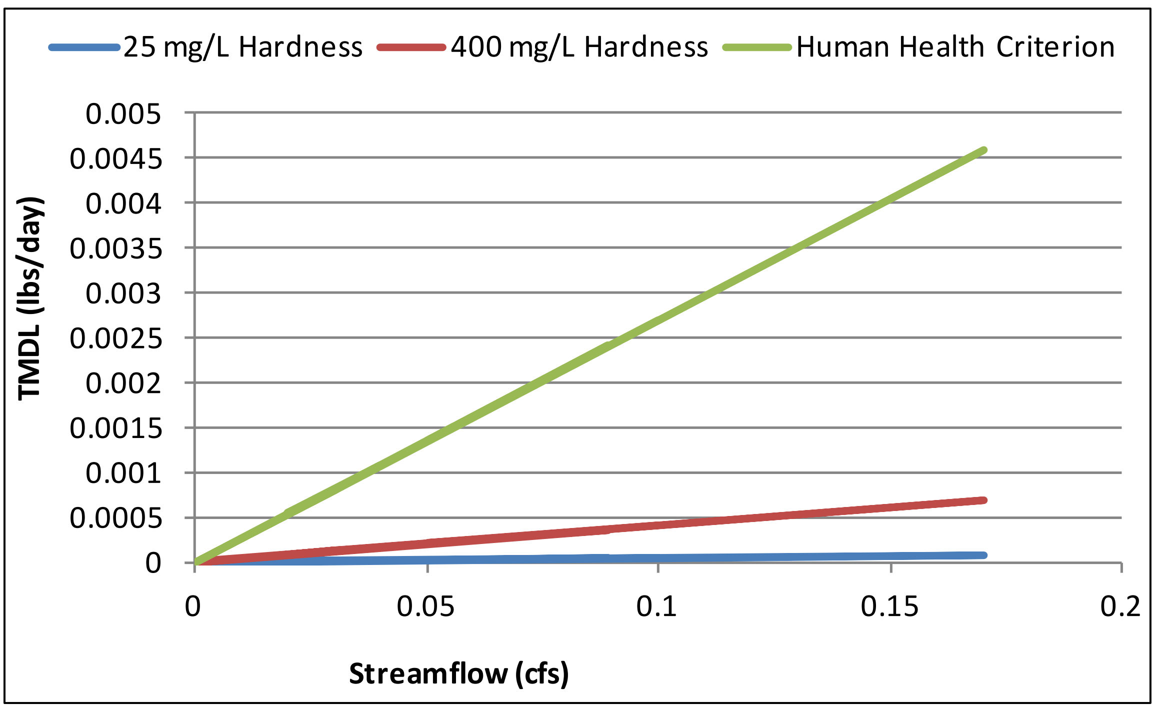


Figure 8-5. Cadmium TMDL as a function of flow

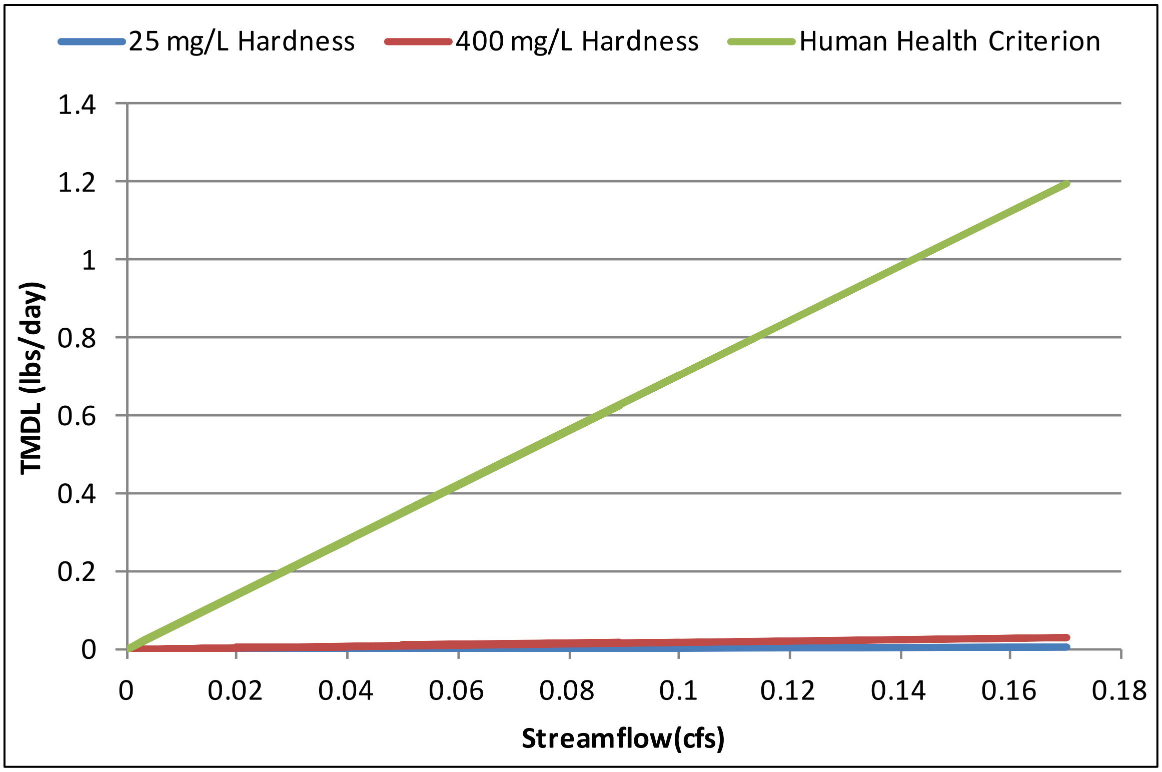


Figure 8-6. Copper TMDL as a function of flow

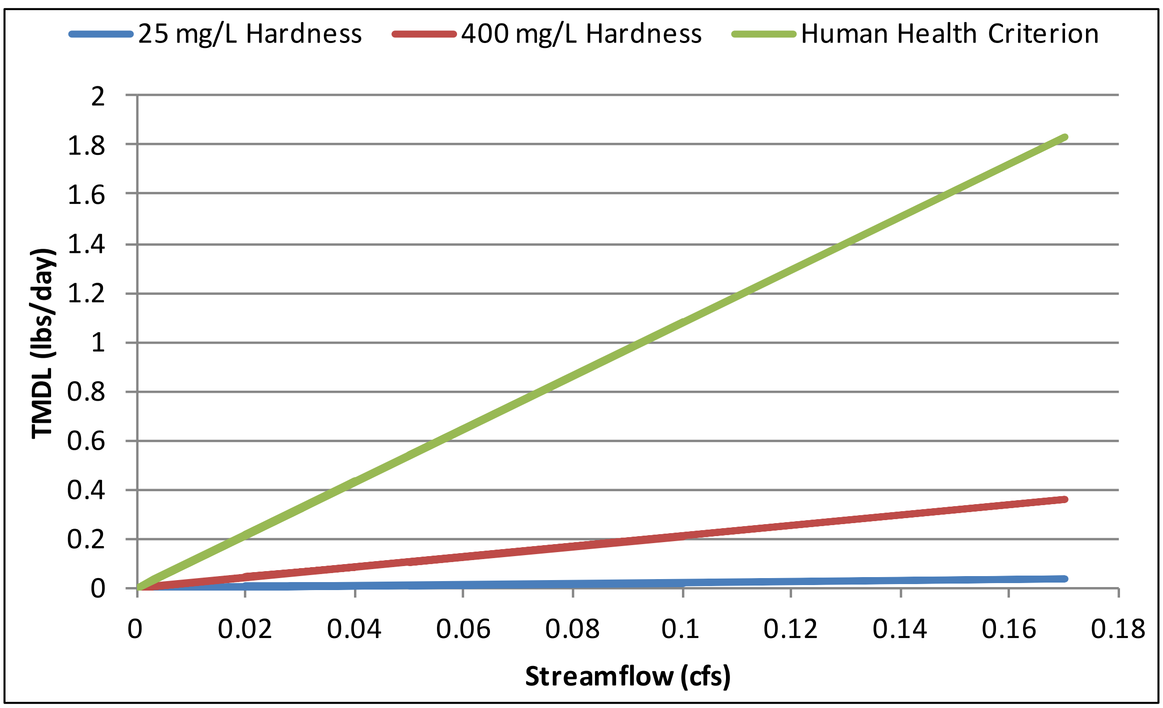


Figure 8-7. Zinc TMDL as a function of flow

Table 8-5 provides example TMDLs and the calculated load reduction requirements necessary to meet each TMDL for each of the four metals impairment causes in the Thompson Project Area (aluminum, cadmium, copper and zinc). The data in **Table 8-5** represent the highest measured concentrations for a given impairment cause at the corresponding low flow since flow in Sullivan Creek is typically low and intermittent. The TMDLs in **Table 8-5** are calculated according to the TMDL equation provided above.

The required percent reduction in total load is calculated by subtracting the TMDL from the existing load (measured concentration multiplied by flow multiplied by 0.0054), and dividing the difference by the existing load.

The required percent reduction is quite high in many examples, since the examples are chosen to demonstrate the highest detected metals concentrations. This may provide a somewhat misleading idea of the magnitude of the impairments, and should be considered in conjunction with the percentage of samples that exceed the lowest applicable water quality target (e.g. "exceedance rates" in **Section 8.4.3**).

Table 8-5. Detailed inputs for example TMDLs in the Thompson TMDL Project Area

Station	Discharge (cfs)*	Hardness (mg/L)	Metal	Measured Conc. (µg/L)	Target Conc. (µg/L)	TMDL (lbs/day)	% Required Load Reduction To Meet TMDL**
C12SLVNC02	0.03	--	Aluminum	10,600	87.00	0.0141	99%
C12SLVNC02	0.03	269	Cadmium	26.5	0.56	9.07 E-05	98%
C12SLVNC02	0.09	193	Copper	40	16.36	0.0079	59%
C12SULLC02	0.17	298	Zinc	16,800	302.22	0.2774	98%

*The highest aluminum and cadmium observations occur at station C12SLNC02 without corresponding flow data. Flow data on the same day from nearby station C12SULLC02, which is approximately 1 mile downstream, are used to represent flow at station C12SLVNC02. Since low flows are typical of the entire length of the impaired section of Sullivan Creek, it is assumed that the flow at station C12SULLC02 is representative of flow at station C12SLVNC02.
**Based on highest single sample concentrations (2004 through 2012).

8.6.2 Metals Allocations

As discussed in **Section 4.0**, a TMDL equals the sum of all the wasteload allocations (WLAs), load allocations (LAs), and a margin of safety (MOS). WLAs are allowable pollutant loads that are assigned to MPDES permitted and some non-permitted point sources. Mining-related waste sources (e.g., adit discharges, tailings accumulations, and waste rock deposits) may represent non-permitted point sources subject to WLAs. LAs are allowable pollutant loads assigned to nonpoint sources and may include the pollutant load from naturally occurring sources, as well as human-caused nonpoint source loading. Where practical, LAs to human sources are provided separately from naturally occurring sources. All mining related sources are provided WLAs unless the allocation is for a mine-related source where it is known that the source loading is consistent with the definition of a nonpoint source.

In addition to metals load allocations, the TMDL must also take into account the seasonal variability of metals loads and adaptive management strategies in order to address uncertainties inherent in environmental analyses. This is known as a Margin of Safety, or MOS.

These elements are combined in the following equation:

TMDL = ∑WLA + ∑LA + MOS

WLA = Wasteload Allocation or the portion of the TMDL allocated to metals point sources.
LA = Load Allocation or the portion of the TMDL allocated to nonpoint metals sources and naturally occurring background

MOS = Margin of Safety or an accounting of uncertainty about the relationship between metals loads and receiving water quality.

Metals allocations in the Thompson Project Area are provided for the following source categories:

- Current and historical mining sources (WLA_{MINE})
- Natural background ($WLA_{NAT)}$

Naturally occurring metals sources
As defined in ARM 17.30.602 (12), naturally occurring sources include loading from non-human (natural background) sources as well as *"those sources from developed areas where all reasonable land, soil and water conservation practices have been applied."* Within the Thompson TMDL Project Area, naturally-occurring metals concentrations were difficult to derive. As water quality data from the mine site was limited, a regional approach was used to derive values that could represent background water quality.

One set of values was calculated by using median concentrations from non-impaired waterbodies adjacent to the Project Area. However these values did not capture the effects of the unique geologic conditions and resulting water quality in Sullivan Creek. Additional water quality data was collected by Pan American Silver (PAS) and DEQ in May of 2014 at the Hog Heaven Mine site to determine if there were appropriate locations onsite that could represent background water quality. Results of this sampling effort were compared to the values from adjacent watersheds in the Project Area. While these metals concentrations were within the same range, there was no means of differentiating the between those sources that could be considered true background, and those that were under the influence of historical mining. Therefore, naturally occurring sources are provided as a composite load allocation with mining sources ($WLA_{MINE+NAT}$).

Current and historical mining sources
Within the Thompson TMDL Project Area, the major metals sources are related to current and historical mining activities. The Hog Heaven mine is the largest of the historical mines in the Sullivan Creek watershed that contains large areas of disturbed ground and exposed mine tailings. Exposed ground and mine tailings are a potential source of metals loading to Sullivan Creek through leaching and stormwater runoff. The mine has a Montana DEQ operating permit (permit #00123). However, the mine has been inactive for many years and there are no surface water discharges to Sullivan Creek. As such there are no active metals loading to surface water associated with a discharge covered under the operating permit. There is no surface water flow data and corresponding metals concentration data to calculate loads from. It is assumed that the metals loading rate from the Hog Heaven mine is similar to the surrounding abandoned mines. Therefore, a composite waste load allocation is provided for all current and historical mining sources including the Hog Heaven mine. If surface water discharges covered under a MPDES permit were to commence, the Hog Heaven mine would need a specific WLA along with a MPDES permit to address these discharges.

Although current and historical mines have been investigated in the Sullivan Creek watershed (**Section 8.5**), data describing individual loading contributions from the historical mines are insufficient to guide allocations for each individual historical mine feature. Furthermore, the nature of Montana's historical mining legacy is such that many small non-permitted point sources (adits, seeps, tailings piles, etc.) may be scattered throughout a watershed and remain undetected. Derivation of background water quality has also proven difficult. No credible background water quality data exists that is not under the influence of mining operations. Therefore, a composite waste load allocation ($WLA_{MINE+NAT}$) for current and historical mining and natural background is provided in pounds/day to any and all metals sources related to current and historical mining practices and background. This composite waste load allocation approach recognizes that abandoned mine remediation is best pursued in an adaptive manner that balances remediation costs with achievable load reductions within each watershed. The use of a composite WLA versus a LA is due to the fact that all pollutant loading pathways to Sullivan Creek are not fully understood and documented, and some may meet the definition of a point source. The $WLA_{MINE+NAT}$ is calculated as being equal to the TMDL (described below).

Margin of Safety (MOS)
DEQ provides an implicit margin of safety (MOS) by using assumptions known to be conservative, discussed further in **Section 8.7.2**. Because an implicit MOS is applied, the MOS in the TMDL equation above equals zero and is not included in the equations provided below.

8.6.2.1 Allocations for Sullivan Creek MT76L002_070
In the sections that follow, a wasteload allocation is provided for each pollutant for which a TMDL is prepared. The allocations are presented in **Table 8-6**. Load estimations and allocations are based on a limited data set and are assumed to approximate general metals loading during low flow conditions. Due to the limited number of samples, examples are based on the highest detected pollutant concentration and the corresponding flow from that sampling event (**Table 8-5**).

Sullivan Creek is also impaired by low pH. The pH impairments in Sullivan Creek will be addressed via a surrogate Cd TMDL, because setting loads for pH is not practical and reclamation activities needed to meet the metals TMDLs will address sources of acid mine drainage causing the pH impairment. Water quality restoration goals for Cd are established based on the numeric water quality criteria as defined in Circular DEQ-7. DEQ believes that once these water quality goals are met, all water uses currently affected by Cd will be restored. In most cases altered pH is related to dissolved metals in water samples associated with metals sources, so the pH impairment is addressed in conjunction with the Cd impairment.

Every TMDL in this document is calculated as follows:

$$TMDL = WLA_{MINE\ +\ NAT}$$

The TMDL and allocation tables in the following sections give example TMDLs for each metal pollutant parameter under low-flow conditions in Sullivan Creek. The TMDLs are calculated according to the TMDL formula (provided in **Section 8.6.1**) of lowest target concentration multiplied by the flow (in this case the low flow), multiplied by a unit conversion factor of 0.0054, to arrive at units of lbs/day. For example, the aluminum TMDL in Sullivan Creek under low flow conditions is 0.0141 pounds per day (lbs/day).

Low flow aluminum TMDL: [87 µg/L X 0.03 cfs X 0.0054 = 0.0141 lbs/day]

The wasteload contributed by current and historic mining sources and natural background sources ($WLA_{MINE+NAT}$) is set equal to the TMDL. Therefore, the $WLA_{MINE+NAT}$ is calculated by this formula:

$$TMDL = WLA_{MINE\ +\ NAT}$$

For aluminum in Sullivan Creek under low flow conditions, this is 0.0141 lbs/day.

The existing loads are calculated using the highest values from the water quality monitoring data for the low flow condition. For example, **Table 8-6** for Sullivan Creek gives value of 1.72 lbs/day for the existing aluminum load. This is calculated by multiplying the highest measured aluminum concentration (10,600 µg/L) by the corresponding observed flow in Sullivan Creek of 0.03 cfs (**Table 8-6**). The product of concentration multiplied by flow is multiplied by the conversion factor of 0.0054, giving an existing aluminum load of 1.72 lbs/day.

The last column in the example tables contains the reductions (expressed in percent) in anthropogenic loading necessary in order to meet the TMDLs. These reductions are calculated by dividing the difference between the $WLA_{MINE+NAT}$ and the existing total load by the existing total load. Note that this is not the same as the percent reduction provided in **Table 8-5**, which is the required reduction of the total load, not the anthropogenic current and historical mine load. The percent reduction required for $WLA_{MINE+NAT}$ is greater than the overall reduction required, since DEQ assumes that the naturally occurring load will not be reduced where abandoned mine remediation is the proposed solution and the very low naturally occurring loads cannot reasonably be reduced. In the case of aluminum in Sullivan Creek under low flow conditions, the $WLA_{MINE+NAT}$ must be reduced by 99.7% in order to meet the TMDL.

Required reduction in aluminum $WLA_{MINE+MAT}$: [(1.72 lbs/day – 0.006 lbs/day) ÷ 1.72 lbs/day = 0.997]

The examples provided for existing loads, TMDLs, LAs, and WLAs are based upon the following conditions:

1. The hardness values used for determining hardness-based standards and associated TMDLs, LAs, and WLAs are the values recorded with the corresponding metals sample.
2. TMDL examples use the streamflow recorded while collecting the metals sample used as the basis for TMDL load examples.
3. Existing condition load summaries use the maximum concentration in a data set.
4. The existing condition and TMDL examples provided in the following metals TMDL sections are located at the most contaminated location that was sampled for each metal.

Table 8-6. Sullivan Creek: Metals TMDLs and Allocation Examples

Metal	TMDL	$WLA_{MINE+NAT}$	Existing Load	WLA_{MINE} % Reduction
Aluminum	0.0141	0.0141	1.72	99.7%
Cadmium	9.07 E-05	9.07 E-05	0.0043	98.1%
Copper	0.0079	0.0079	0.0192	60.4%
Zinc	0.2774	0.2774	15.42	98.2%

Units are lbs/day

8.7 Seasonality and Margin of Safety

Streamflow, water hardness, and climate vary seasonally. All TMDL documents must consider the effects of this variability on water quality impairment conditions, maximum allowable pollutant loads in a stream (TMDLs), and load allocations. TMDL development must also incorporate a margin of safety into the load allocation process to account for uncertainties in pollutant sources and other watershed conditions, and ensure (to the degree practicable) that the TMDL components and requirements are sufficiently protective of water quality and designated uses. This section describes the considerations of seasonality and a margin of safety (MOS) in the Sullivan Creek metal TMDL development process.

8.7.1 Seasonality

Seasonality addresses the need to ensure year round designated use support. Seasonality is considered for assessing loading conditions and for developing water quality targets, TMDLs, and allocation schemes. For metals TMDLs, seasonality is important because metals loading pathways and water hardness change depending on the flow regime. During high flows, loading associated with overland flow and erosion of metals-contaminated soils and mine wastes tend to be the major cause of elevated metals concentrations. During low flow, groundwater transport and/or adit discharges tend to be the major source of elevated metals concentrations. Hardness tends to be lower during higher flow conditions, which leads to more stringent water quality standards for hardness-dependent metals during the runoff season. Seasonality is addressed in this document as follows:

- DEQ's assessment method requires a combination of both high and low flow sampling for target evaluation since abandoned mines and other metals sources can lead to elevated metals loading during high and/or low flow conditions.(Note: Assessment data was collected during the times of the year when flow are typically at their highest, however do to the intermittent flow conditions on Sullivan Creek, there is limited flow data, and all flows are considered low)
- Metals TMDLs incorporate streamflow as part of the TMDL equation.
- Metals concentration targets apply year round, with monitoring criteria for target attainment developed to address seasonal water quality extremes associated with loading and hardness variations.
- The TMDL equation incorporates all potential flow conditions that may occur during any season.

8.7.2 Margin of Safety

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

- DEQ's assessment process includes a mix of high and low flow sampling since abandoned mines and other metals sources can lead to elevated metals loading during high and/or low flow stream conditions. The seasonality considerations help identify the low range of hardness values and thus the lower range of applicable TMDL values shown within the TMDL curves and captured within the example TMDLs.
- Target attainment, refinement of load allocations, and, in some cases, impairment validations and TMDL-development decisions are all based on an adaptive management approach that relies on future monitoring and assessment for updating planning and implementation efforts.
- Although a 10% exceedance rate is allowed for chronic and acute based aquatic life targets, the TMDLs are set so the lowest applicable target is satisfied 100% of the time. This focuses remediation and restoration efforts toward 100% compliance with all targets, thereby providing a margin of safety for the majority of conditions where the most protective (lowest) target value is linked to the numeric aquatic life standard. As part of this, the existing water quality conditions and needed load reductions are based on the highest measured value for a given flow conditionin order to consistently achieve the TMDL.
- The monitoring results used to estimate existing water quality conditions are instantaneous measurement used to estimate a daily load, whereas chronic aquatic life standards are based on average conditions over a 96-hour period. This provides a margin of safety since a four-day loading limit could potentially allow higher daily loads in practice.
- The lowest or most stringent numeric water quality standard was used for TMDL target and impairment determination for all waterbody – pollutant combinations. This ensures protection of all designated beneficial uses.

The TMDLs are based on numeric water quality standards developed at the national level via U.S. Environmental Protection Agency (EPA) and incorporate a margin of safety necessary for the protection of human health and aquatic life.

8.8 Uncertainty and Adaptive Management

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

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

Adaptive management also allows for continual feedback on the progress of restoration and the status of beneficial uses. Additional monitoring and resulting refinements to loading can improve achievement and measurement of success. A remediation and monitoring framework is closely linked to the adaptive management process, and is addressed in **Section 11.0**.

The metals TMDLs developed for the Thompson TMDL Project Area are based on future attainment of water quality standards. In order to achieve this, all significant sources of metals loading must be addressed via all reasonable land, soil, and water conservation practices. DEQ recognizes however, that in spite of all reasonable efforts, this may not be possible due to natural background conditions and/or the potential presence of unalterable human-caused sources that cannot be fully addressed via reasonable remediation approaches. For this reason, an adaptive management approach is adopted for all metals targets described within this document. Under this adaptive management approach, all metals impairments that required TMDLs will ultimately fall into one of the three categories identified below:

- Restoration achieves the metal pollutant targets and all beneficial uses are supported.
- Targets are not attained because of insufficient controls; therefore, impairment remains and additional remedies are needed.
- Targets are not attained after all reasonable Best Management Practices and applicable abandoned mine remediation activities are applied. Under these circumstances, site-specific standards may be necessary.
- Targets are unattainable due to naturally-occurring metals sources. Under this scenario, site-specific water quality standards and/or the reclassification of the waterbody may be necessary. This would then lead to a new target (and TMDL) for the pollutant(s) of concern, and the new target would reflect the background condition.

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

Superfund Bureau (also in the Remediation Division) will provide technical and management assistance to EPA for remedial investigations and cleanup actions at National Priorities List mine sites in federal-lead status.

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

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 Department of Environmental Quality (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 Thompson Project Area on Montana's 2012 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 Best Management Practices 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 2012 Water Quality Integrated Report

Waterbody & Location Description	Waterbody ID	Impairment Cause
HENRY CREEK, headwaters to mouth (Clark Fork River)	MT76N003_170	Alteration in stream-side or littoral vegetative covers
		Low flow alterations
LAZIER CREEK, headwaters to mouth (Thompson River)	MT76N005_060	Alteration in stream-side or littoral vegetative covers
LITTLE BITTERROOT RIVER, Hubbart Reservoir to Flathead Reservation Boundary	MT76L002_060	Other flow regime alterations
LITTLE THOMPSON RIVER, headwaters to mouth (Thompson River**)**	MT76N005_040	Alteration in stream-side or littoral vegetative covers
LYNCH CREEK, headwaters to mouth (Clark Fork River)	MT76N003_010	Alteration in stream-side or littoral vegetative covers
		Low flow alterations
McGINNIS CREEK, headwaters to mouth (Little Thompson River)	MT76N005_070	Fish-Passage Barrier
McGREGOR CREEK, McGregor Lake to mouth (Thompson River)	MT76N005_030	Other flow regime alterations
SULLIVAN CREEK, headwaters to Flathead Reservation	MT76L002_070	Alteration in stream-side or littoral vegetative covers
SWAMP CREEK, West Fork Swamp Creek to mouth (Clark Fork River)	MT76N003_160	Alteration in stream-side or littoral vegetative covers

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.

Other Flow Regime Alterations
Flow alteration refers to a change in the flow characteristics of a waterbody relative to natural conditions. An impairment listing caused by other flow regime alterations could be associated with changes in runoff and streamflow due to activities such as urban development, road construction, or timber harvest. Changes in runoff are commonly linked to elevated peak flows, which can also cause excess sedimentation by increasing streambank erosion and channel scour. Road crossings, particularly where culverts are undersized or inadequately maintained, can also alter flows by causing water to back up upstream of the culvert. An impairment listing for other flow alterations can also be associated with human sources that cause a reduction in surface flow because of excessive sedimentation or channel modifications. Lastly, an impairment listing for other flow alterations may be associated with an impoundment or dam. Flow modifications caused by a dam can affect fish spawning, dissolved gas concentrations, water temperatures, channel form, and suspended and bottom sediment concentrations. Note: under Montana's Administrative Rules (ARM 17.30.602(17)), dams that have been in existence since at least July 1, 1971, and are being operated reasonably, are considered natural.

Low Flow Alterations
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.

Fish Passage Barrier

A fish passage barrier impairment listing refers to any human caused alteration to a waterbody that prevents the upstream and/or downstream passage of fish species. Fish passage barriers fragment habitat and can prevent fish from reaching upstream spawning areas. Fish passage barriers may include, but are not limited to improperly designed road culverts, dams, and diversion structures. Although natural fish passage barriers do exist, this particular impairment listing only refers to human caused alterations. There are certain instances where fish passage barriers can be used as a fisheries management tool to isolate certain native or invasive species, and therefore it is important to consult the area Montana Fish Wildlife and Parks fisheries biologist before removing a fish passage barrier on a stream.

Chlorophyll-*a*

A chlorophyll-*a* 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* impairments are typically addressed by nutrient TMDLs, which are found in **Section 6.0** of this document.

9.2 Monitoring and Best Management Practices 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 Henry, Lazier, Lynch, and Swamp creeks, as well as the Little Thompson River. 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.

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 Thompson 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 Thompson TMDL Project Area (referred to as the Thompson 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
- Confederated Salish-Kootenai Tribe of Idaho
- Eastern Sanders Conservation District
- Five Valleys Land Trust
- Flathead Conservation District
- 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)
- Pan American Silver Corp.
- Plum Creek Timber Company
- Sanders 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 Clark

10.3 Water Quality Restoration Objectives

The water quality restoration objective for the Thompson 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 Thompson 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, metals, and temperature 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 Thompson 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 (NFHCP) developed by Plum Creek Timber Company, Inc. (Plum Creek) for approximately 900,000 acres of company land. Plum Creek is the largest private landowner within the Thompson Project Area. The NFHCP contains mitigation measures to protect coldwater fisheries and includes detailed management prescriptions for grazing, timber harvest, and road construction and maintenance activities. The USFWS 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 NFHCP. These HCPs provide valuable input and can serve as a model for WRPs developed in the Thompson Project Area.

10.4 Overview of Management Recommendations

TMDLs were completed for nine waterbody segments for sediment, six waterbody segments for nutrients, one waterbody segment for metals, and two waterbody segments for temperature. 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 5.0, 6.0, 7.0** and **8.0**.

In general, restoration activities can be separated into two categories: active and passive. Passive restoration allows natural succession to occur within an ecosystem by removing a source of disturbance. Fencing off riparian areas from cattle grazing is a good example of passive restoration. Active restoration, on the other hand involves accelerating natural processes or changing the trajectory of succession. For example, historic placer mining often resulted in the straightening of stream channels and piling of processed rock on the streambank. These impacts would take so long to recover passively that active restoration methods involving removal of waste rock and rerouting of the stream channel would likely be necessary to improve stream and water quality conditions. In general, passive restoration is preferable 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 all nine streams listed as impaired in the Thompson 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 5.0** and in **Appendix C** 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 TMDL have been written for Lynch and McGregor 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 Lynch and McGregor 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, 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.

Lynch Creek was considered chronically dewatered between 1992 and 2005 by FWP, and McGregor Creek macroinvertebrate assemblages indicate that it is periodically dewatered. However, 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 8.0** 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 Lynch and McGregor Creeks, as well as other streams in the Thompson Project Area that show the potential for elevated water temperatures. Though neither Lynch nor McGregor Creeks are within FWP core or nodal bull trout areas, several streams within the Thompson 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

TMDLs have been written for Total Nitrogen and Total Phosphorous for Lazier, Lynch, Sullivan, and Swamp Creeks as well as the Little Bitterroot and Little Thompson Rivers. 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 United States Department of Agriculture (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 Thompson Project Area are also impaired by sediment. Additional sediment-related BMPs are presented in **Section 10.5.**

10.4.4 Metals Restoration Approach

Metals TMDLs have been written for Sullivan Creek. Mining is the principal human-caused source of excess metals loading in the project area. To date, there has been reclamation of some historic mining disturbances, removal of old buildings, closure of hazardous mine openings, and filling of caved stopes at the Hog Heaven site on Sullivan Creek. However, no further reclamation action has been contemplated for this site. Statutory mechanisms and corresponding government agency programs will continue to have the leading role for future restoration. Restoration of metals sources is typically conducted under state and federal cleanup programs. Rather than a detailed discussion of specific BMPs, general restoration programs and funding sources applicable to mining sources of metals loading are provided in **Section 10.5.7.** Past efforts have produced abandoned mine site inventories with enough descriptive detail to prioritize the properties contributing the largest metals loads. Additional monitoring needed to further describe impairment conditions and loading sources is addressed in **Section 11.3.1**

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 Thompson Project Area are described in **Section 9.0**. Typically, habitat impairments are addressed during implementation of associated pollutant TMDLs. Therefore, if restoration goals within the Thompson 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 Thompson Project Area: agricultural sources, 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 Thompson Project Area, however, the recommendations below provide a useful guideline for a variety of agricultural activities. The main BMP recommendations for the Thompson 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, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b).

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) (United States Department of Agriculture, Natural Resources Conservation Service, 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 (Natural Resources Conservation Service, 2010):

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

- Procedures for monitoring forage use on an ongoing basis
- Development plan for off-site watering areas

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

- Minimizing or preventing livestock grazing in riparian and wetland areas
- Providing off-stream watering facilities or using low-impact water gaps to prevent 'loafing' in wet areas
- Managing riparian pastures separately from upland pastures
- Installing salt licks, feeding stations, and shelter fences in areas that prevent 'loafing' in riparian areas and help distribute animals
- Replanting trodden down banks and riparian and wetland areas with native vegetation (this should always be coupled with a reduction in grazing pressure)
- Rotational grazing or intensive pasture management that takes season, frequency, and duration into consideration

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

- 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 Thompson 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 (75-5-705).

Irrigation management is a critical component of attaining both cold water 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 Thompson 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, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b). 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 Nonpoint Source (NPS) Management Plan (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b).

10.5.2 Forestry and Timber Harvest

The Thompson Project Area is part of one of the most productive timber growing regions in Montana. As a result it 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 (75-5-301 through 307). 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 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.

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 Thompson 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

(Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b).

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 (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b). 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 389 identified septic systems within the Thompson Project Area, the majority of which are within the Little Bitterroot River and Lynch Creek watersheds. This number is likely to increase with future residential development within the Thompson 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, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2009a). 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 stormwater is not currently identified as a significant source of pollutant contributions for the streams discussed in this document, stormwater management could 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 (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b). 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 Thompson Project Area. The road sediment reductions provided in this document, and detailed in **Attachment C**, 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, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b). 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 (**Attachment C**) found that approximately 69% of the culverts pass the discharge of a 25-year storm event. The allocation strategy for culverts is no loading from culverts as a result of being undersized, improperly installed, or inadequately maintained. The culvert assessment included 39 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 storm 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 20 assessed culverts with flowing water had a high probability of allowing fish passage; eighteen of these culverts (90%) 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 Thompson 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**.

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

- The State of Montana Mine Waste Cleanup Bureau's Abandoned Mine Lands (AML) Reclamation Program
- The Montana Comprehensive Environmental Cleanup and Responsibility Act (CECRA), which incorporates additional cleanup options under the Controlled Allocation of Liability Act (CALA) and the Voluntary Cleanup and Redevelopment Act (VCRA).
- The federal Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

10.5.7.1 The Surface Mining Control and Reclamation Act (SMCRA)

DEQ's Abandoned Mines Bureau (AMB) is responsible for reclamation of abandoned mines in Montana. The AMB reclamation program is funded through the Surface Mining Control and Reclamation Act of 1977 (SMCRA). SMCRA funding is collected as a per ton fee on coal production that is then distributed to states by the federal Office of Surface Mining Reclamation and Enforcement. Funding eligibility is based on land ownership and date of mining disturbance. Eligible abandoned coal mine sites have a priority for reclamation construction funding over eligible non-coal sites. Areas within federal Superfund sites and areas where there is a reclamation obligation under state or federal laws are not eligible for expenditures from the abandoned mine reclamation program.

The Flathead Mine Complex, on Sullivan Creek, was on Montana's list of priority abandoned mine cleanup sites (Pioneer Technical Services, Inc., 1995), originally ranking 25 on the Abandoned and Inactive Mines Scoring System. According to Montana's Priority Mine List, no further reclamation action has been contemplated for the Flathead Mine Complex (Pioneer Technical Services, Inc., 1995)(http://deq.mt.gov/AbandonedMines/priority.mcpx). The Flathead Mine has become the Hog Heaven Mine and currently has a mining permit although no mining activity has occurred on the site since the permit was granted.

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. 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 Thompson 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, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012b) 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 Thompson River watershed, 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 (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, Department of Environmental Quality (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 et al., 2009). Iterative

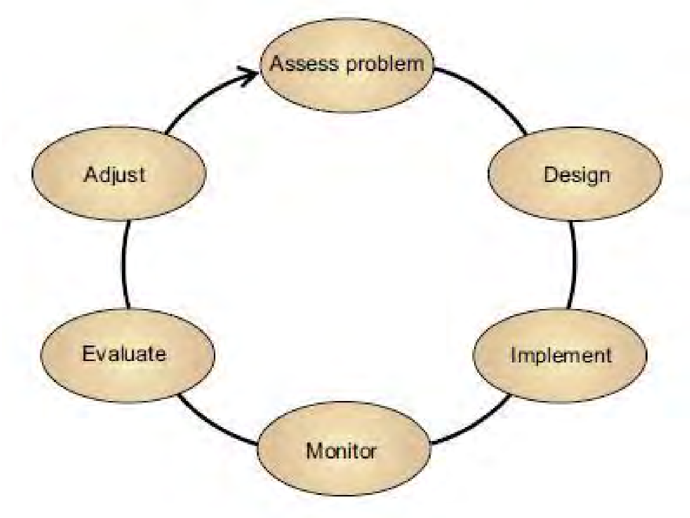


Figure 11-1. Diagram of the adaptive management process

11.3 Future Monitoring Guidance

The objectives for future monitoring in the Thompson 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 Thompson 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 Thompson Project Area, the identification of pollutant sources was conducted largely through tours of the watershed, assessments of aerial photographs, the incorporation of geographic information system information, reviewing and analyzing available data, 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 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 Thompson 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, particularly in the lower portions of Lynch Creek and McGregor Creek watershed where riparian vegetation is dominated by grasses due to present and historical land use
- 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 Lynch Creek and McGregor Creek watershed and the entire Thompson project area
- Assessment of irrigation practices and other water use in Lynch Creek and McGregor Creek watershed and Thompson 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 Thompson 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 Little Bitteroot River, Lynch Creek, and the lower Swamp 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

Metals

The level of detail of the source assessment for this project allowed allocations to broad source categories and geographic areas. Therefore, additional monitoring may be helpful to better partition pollutant loading at mine sites with multiple sources. However, surface flow on Sullivan Creek is limited, which reduces the opportunity for monitoring and load partitioning in many areas. The following are recommended:

- Refinement of the sampling approach and locations at individual mine sites to better partition pollutant loading from discrete sources within the broader mine site. This may require more seasonally stratified sampling or a more detailed field reconnaissance and follow-up sampling. However, the limited surface flow on Sullivan Creek may inhibit further useful refinement.
- Further sampling in the area of Sullivan Creek to verify assumptions about the background metal conditions. The Sullivan Creek watershed has a distinct volcanic geology that differs from other watersheds within the Thompson Project Area, which made it difficult to find a reference site for background metals conditions. Background metals concentrations were based on non-impaired watersheds of the Thompson Project Area.
- Continued monitoring and additional analysis of the elevated metals concentrations in the surface water and wells at the Hog Heaven mine site are recommended in order to assist with TMDL implementation.

11.3.2 Increasing Available Data

While the Thompson 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 Thompson Project Area, each of the streams of interest was stratified into unique reaches based on physical characteristics and human-caused influences. A total of 16 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 Thompson 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 Lynch Creek and McGregor Creek watersheds included eight data loggers, deployed throughout each stream and selected tributaries in summer of 2012 and 2011, respectively. 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 Lynch and McGregor Creeks. In addition, 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 Lynch and McGregor Creeks and their major tributaries is recommended. Finally, coordinating with other organizations to incorporate suitable temperature data will improve future assessments of Thompson Area streams.

Nutrients

Water quality sampling locations for nutrients were distributed spatially along each stream in order to best delineate nutrient sources. Sampling occurred over several seasons from 2004 through 2012, with most data collected after 2009. Lazier Creek, Swamp Creek, and the Little Thompson River met nutrient targets but failed biological targets. According to DEQ's assessment methodology, failure of biological targets while meeting the nutrient targets indicates algae may be taking up excess nutrients in the water column and/or that water quality sampling missed the pulse of nutrients that is causing the biological response. 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.

Metals

Additional monitoring may be helpful to better partition pollutant loading at mine sites with multiple sources, such as those having discrete adit discharges versus more diffuse runoff from mine waste accumulations. The needed refinements may require more seasonally stratified sampling or a more detailed field reconnaissance and follow-up sampling to better locate stream segments in the area representing background loading. Additional data collection is recommended for:

- Runoff from the Hog Heaven mine site of Sullivan Creek, portions of which have already undergone some reclamation work. Future monitoring should be planned to track aluminum, cadmium, copper, and zinc concentrations in Sullivan Creek as well as antimony, arsenic, lead, mercury, and silver concentrations, with attention to any soil and land conservation BMPs that may be implemented to meet the sediment TMDL. Sampling of high runoff events (storm events, snow melt events) is recommended as there is limited surface flow off of this site.
- Uppermost portions of Sullivan Creek or streams in the vicinity of Sullivan Creek to further verify background metals concentration in Sullivan Creek.
- Additional sampling of all flowing surface water in the Sullivan Creek watershed during high and low flow conditions for the parameters listed in **Table 11-1**.

Table 11-1 lists the waterbodies, pollutants, and flow conditions where additional data is needed.

Table 11-1. Waterbodies, metal pollutants, and flow conditions for which additional data is needed

Stream Segment	Pollutant(s)	Flow Condition
Sullivan Creek	Aluminum	High and Low
	Cadmium	High and Low
	Copper	High and Low
	Zinc	High and Low

For the pollutant-waterbody combinations in **Table 11-1**, follow up monitoring should focus on defining the contribution from sources and defining background water quality conditions in Sullivan Creek. As this information becomes available, TMDL allocations may be modified to include load allocations to background sources, as opposed to the current composite wasteload allocations.

11.3.3 Consistent Data Collection and Methodologies

Data has been collected throughout the Thompson 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 be consistent so as to allow for comparison to TMDL targets and track progress toward meeting TMDL goals.

DEQ is the lead agency for developing and conducting impairment status monitoring; however, other agencies or entities may work closely with DEQ to provide compatible data. Water quality impairment determinations are made by DEQ, but data collected by other sources can be used in the impairment determination process. The information in this section provides general guidance for future impairment status monitoring and effectiveness tracking. Future monitoring efforts should consult DEQ on updated monitoring protocols. Improved communication between agencies and stakeholders will further improve accurate and efficient data collection. The development of a DEQ approved Sampling Analysis Plan (SAP) and a Quality Assurance Protection Plan (QAPP) will ensure that the data collected meets 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. For example, reclamation of a mining related source of metals under Comprehensive Environmental Response, Compensation, and Liability Act and Comprehensive Environmental Cleanup and Responsibility Act typically requires source-specific sampling requirements, which cannot be defined at this time, to determine the extent of and the risk posed by contamination, and to evaluate the success of specific remedial actions.

Sediment

Sediment and habitat assessment protocols consistent with 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 Thompson 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)/ASAP	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.

Metals

Metals monitoring should include analysis of a suite of total recoverable metals (e.g., As, Cu, Cd, Pb, Zn), sediment samples, hardness, pH, discharge, and total suspended solids (TSS). **Table 11-3** identifies the current DEQ metals sampling methodologies and reporting limits for the standard metals suite (water and sediment) (Drygas, 2012).

Table 11-3. DEQ Metals Monitoring Parameter Requirements

Parameter*	Preferred Method	Alternate Method	Req. Report Limit ug/L	Holding Time Days	Bottle	Preservative
Water Sample - Physical Parameters and Calculated Results						
Total Hardness as $CaCO_3$	A2340 B (Calc)		1000			
Total Suspended Solids	A2540D		4000	7	1000 ml HDPE/500 ml HDPE	≤6oC
Water Sample - Dissolved Metals (0.45 um filtered)						
Aluminum	EPA 200.7	EPA 200.8	9	180	250 ml HDPE	Filt 0.45 um, HNO_3

Table 11-3. DEQ Metals Monitoring Parameter Requirements

Parameter*	Preferred Method	Alternate Method	Req. Report Limit ug/L	Holding Time Days	Bottle	Preservative
Water Sample - Total Recoverable Metals						
Total Recoverable Metals Digestion	EPA 200.2	APHA3030F (b)	N/A	180	500 ml HDPE/ 250 ml HDPE	HNO_3
Arsenic	EPA 200.8		1			
Cadmium	EPA 200.8		0.03			
Calcium	EPA 200.7		1000			
Chromium	EPA 200.8	EPA 200.7	1			
Copper	EPA 200.8	EPA 200.7	1			
Iron	EPA 200.7		20			
Lead	EPA 200.8		0.3			
Magnesium	EPA 200.7		1000			
Potassium	EPA 200.7		1000			
Selenium	EPA 200.8		1			
Silver	EPA 200.8	EPA 200.7/200.9	0.2			
Sodium	EPA 200.7		1000			
Zinc	EPA 200.7	EPA 200.8	8			
Antimony	EPA 200.8		0.5			
Barium	EPA 200.7	EPA 200.8	3			
Beryllium	EPA 200.7	EPA 200.8	0.8			
Boron	EPA 200.7	EPA 200.8	10			
Manganese	EPA 200.7	EPA 200.8	5			
Nickel	EPA 200.7	EPA 200.8	2			
Thallium	EPA 200.8		0.2			
Uranium, Natural	EPA 200.8		0.2			
Parameter	**Preferred Method**	**Alternate Method**	**Req. Report Limit mg/kg (dry weight)**	**Holding Time Days**	**Bottle**	**Preservative**
Sediment Sample - Total Recoverable Metals						
Total Recoverable Metals Digestion	EPA 200.2		N/A	180	2000 ml HDPE Widemouth	
Arsenic	EPA 200.8	EPA 200.9	1			
Cadmium	EPA 200.8	EPA 200.9	0.2			
Chromium	EPA 200.8	EPA 200.7	9			
Copper	EPA 200.8	EPA 200.7	15			
Iron	EPA 200.7	EPA 200.7	10			
Lead	EPA 200.8	EPA 200.9	5			
Zinc	EPA 200.7	EPA 200.7	20			
Sediment Sample - Total Metals						
Mercury	EPA 7471B		0.05	28	2000 ml HDPE Widemouth	

*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 bank erosion hazard index 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 Thompson 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

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

12.1 Participants and Roles

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

12.1.1 Montana Department of Environmental Quality

Montana state law (MCA 75-5-703) directs DEQ to develop all necessary TMDLs. DEQ has provided resources toward completion of these TMDLs in terms of staff, funding, internal planning, data collection, technical assessments, document development, and stakeholder communication and coordination. DEQ has worked with other state and federal agencies to gather data and conduct technical assessments. DEQ has also partnered with watershed organizations to collect data and coordinate local outreach activities for this project.

12.1.2 U.S. Environmental Protection Agency

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

12.1.3 TMDL Advisory Group

The Thompson Area TMDL Advisory Group consisted of selected resource professionals who possess a familiarity with water quality issues and processes in the Thompson Project Area, and also representatives of applicable interest groups. All members were solicited to participate in an advisory capacity per Montana state law (75-5-703 and 704). DEQ requested participation from the interest groups defined in MCA 75-5-704 and included local county representatives, livestock-oriented and farming-oriented agriculture representatives, conservation groups, watershed groups, state and federal land management agencies, and representatives of recreation and tourism interests. The advisory group also included additional stakeholders and landowners with an interest in maintaining and improving water quality and riparian resources.

Advisory group involvement was voluntary and the level of involvement was at the discretion of the individual members. Members had the opportunity to provide comment and review of technical TMDL assessments and reports and to attend meetings organized by DEQ for the purpose of soliciting feedback on project planning. Typically, draft documents were released to the advisory group for review under a limited timeframe, and their comments were then compiled and evaluated. Final technical decisions regarding document modifications resided with DEQ.

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

12.2 Response to Public Comments

Upon completion of the draft TMDL document, and prior to submittal to EPA, DEQ issues a press release and enters into a public comment period. During this timeframe, the draft TMDL document is made available for general public comment, and DEQ addresses and responds to all formal public comments.

The public review period began on June 11, 2014, and ended on July 11, 2014. DEQ made the draft document available to the public, solicited public input and comments, and announced a public meeting at which the TMDLs were presented to the public. These outreach efforts were conducted via e-mails to watershed advisory group members and other interested parties, posts on the DEQ website, and an announcement in the Clark Fork Valley Press (Plains), Sanders County Ledger (Thompson Falls), and the Daily Inter Lake (Kalispell). DEQ provided an overview of the sediment, nutrient, metals, and temperature TMDLs at a public presentation in Plains on June 24, 2014.

During the public comment period, DEQ received 12 comments. The comments and accompanying responses are provided below. The original comments are held on file at DEQ and are available upon request.

Comment 1

Section 2.3.3, Page 2-9. Plum Creek's Native Fish Habitat Conservation Plan (NFHCP) is described as being "…for Bull Trout." Actually, the NFHCP covers all native salmonid fish species in northwest Montana, including bull trout, westslope cutthroat trout, Columbia River redband rainbow trout, mountain whitefish, and pygmy whitefish. You should also note that the NFHCP was approved by the US Fish and Wildlife Service.

> **Response 1**
>
> Thank you for your input. That particular sentence has been reworded to encompass your suggestions.

Comment 2

Section 2.3. This section is said to describe cultural characteristics, including "….land cover/use…" While timber uses are covered extensively, there is little or no discussion of agricultural uses, rural residential uses, or grazing that is present in many of the affected watersheds. I suggest that this section be reworked to provide this additional context.

> **Response 2**
>
> Additional language has been added to further describe the other land uses in the project area. The purpose of the paragraph mentioned in section 2.3 is to merely identify land cover and land

use throughout the Thompson Project Area based on available land cover data. Since timber harvest is the primary land use, it was originally given the most weight in this paragraph.

Comment 3

Section 5.4 – Water Quality Targets. I agree with the statement on Page 5-8 (Section 5.4.1) that "*Target parameters and values… will have to be assessed during future TMDL reviews for their applicability…"*

Response 3

Reassessment of target parameters is part of the adaptive management process, which DEQ firmly believes is an invaluable component of TMDLs, and is glad you agree with this statement from **Section 5.4**.

Comment 4

Section 5 – Sediment Impairments. We continue to have significant concern about DEQ's decision to use so many indirect indicators of stream sedimentation to determine impairment. These indirect measures include LWD, Pools, width/depth ratio, and percent understory shrub cover. All of these variables tend to be highly variable, and it is unlikely that any one stream will ever meet all targets in all places at all times. We highly encourage DEQ to re-visit its sediment assessment method and place more weight on the direct measures of fine sediment.

Response 4

Reassessment of target parameters is part of the adaptive management process, which DEQ firmly believes is an invaluable component of TMDLs, and is glad you agree with this statement from **Section 5.4**.

Comment 5

Section 6 – Nutrient Impairments. I have significant ongoing concerns with DEQ's nutrient assessment method. These were expressed in a February 25, 2014 letter to DEQ's quality control officer. The problem is that streams can fully meet the nutrient criteria and primary response variable Chl-*a*, yet be listed as impaired for only occasional exceedances of the other biological response metrics. This basically renders the numeric criteria moot, and results in the biological response variables being the de-facto standards. It is my belief that DEQ needs to modify the assessment method to bring a better balance between the criteria and the biological response variables.

Specific streams that illustrate this issue in the Thompson TMDL Planning area are Lazier Creek, Little Thompson River, and Swamp Creek. For Lazier Creek, there have been no (zero) exceedances of the criteria in multiple dates of sampling over two summers. In fact, observations are less than 25% of the standard for Total Nitrogen (TN) and typically less than half the standard for Total Phosphorus (TP). On the biological response side, there have been no exceedances for Chl-*a*. But two of four AFDM samples scored above 35 g/m2. For macroinvertebrates (secondary indicators), two of three samples had Hilsenhoff Biotic Index (HBI) scores above 4.0. There have been four periphyton samples collected, that suggested impairment probabilities of 25%, 23%, 52%, and 68%, for an average probability of impairment of only 47%.

An even more dramatic example exists for the Little Thompson River – no TN, TP, or Chl-*a* exceedances. For AFDM there is one exceedance in six observations. For HBI, there are three exceedances out of 12 observations, and these observations were 4.03, 4.08, and 4.23 respectively (all barely over the 4.0

target). There were two exceedances of the 51% periphyton in eight samples. The weight of evidence clearly does not support impairment.

For Swamp Creek, there was only one exceedance of a numeric standard in fourteen samples (one TP value of 0.27 mg/L), no exceedances for Chl-*a*, one exceedance for AFDM, and three of four HBI scores exceeding the 4.0 criterion (values were 4.58, 3.39, 6.05, and 4.91 respectively).

Something is badly broken with DEQ's assessment method. My recommendation is that DEQ rework the Nutrient Assessment Method to provide more balance in the weight-of-evidence framework.

Response 5

DEQ values your concerns and appreciates your involvement in the TMDL process but your concerns related to the nutrient assessment method are outside the scope of this document. DEQ believes field testing assessment methods are a critical component of method development and will be reviewing its nutrient assessment methodology over the next couple of years to determine if revisions are needed. Your current and previous comments will be taken into consideration at that time. If you have additional concerns or would like to discuss details of the assessment process, DEQ's Quality Control Officer is the best person to contact.

On a side note, DEQ considers AFDM a measurement of stream-bottom biomass, which can be particularly useful if the peak concentration of algal chlorophyll-*a* has passed. Although AFDM may have a slightly higher level of uncertainty than chlorophyll-*a* because it incorporates bacteria and fungi, DEQ considers AFDM a primary response variable (like chlorophyll-*a*). As such, exceedances of the AFDM target are treated with the same weight as exceedances of the chlorophyll-*a* target. Other components of the assessment method that may help you better understand the determinations are as follows: Macroinvertebrates and periphyton are secondary indicators that carry less weight than nutrient concentrations, chlorophyll-*a*, and AFDM. Each biological sample is considered independently (i.e., not averaged) and a single exceedance is considered a failure. Failure of both secondary indicators carries more weight than failure of a single indicator.

Comment 6

Section 7 – My primary concern with the temperature modeling is that DEQ did not solicit input from watershed stakeholders and local technical specialists on the development of site-specific shade scenarios for these streams. Specifically, the problem with both of the shade scenarios on these streams is that moderately-dense shading is deemed feasible in locations where this is not the case. Attached photographs below show McGregor Creek just downstream of McGregor Lake. For several miles the stream is bordered by natural sedge meadows and willow-alder shrubs. It is highly unlikely that this wet meadow area ever had conifers, yet most of this area was modeled as having moderate dense shade right up to the stream edge being feasible. This engagement with stakeholders is required under MCA 75-5-704. While DEQ did ultimately engage watershed stakeholders in this TMDL process, it was after the shade modeling had been finalized. We do not believe that TMDLs developed for temperature on McGregor or Lynch Creeks are physically attainable.

Photographs showing sedge meadows and hardwood shrub riparian communities bordering McGregor Lake below the lake outlet.

Response 6

Engagement with stakeholders in accordance with Montana Code Annotated (MCA) section 75-5-704 was followed according to the language described in the following paragraph. DEQ apologizes for not providing stakeholders an additional opportunity to provide feedback prior to finalization of the temperature model; due to time and resource constraints, and the nature of the temperature model that was ran through a third party contractor, we were not able to provide that additional opportunity for stakeholder feedback. DEQ will make efforts in future TMDL development to solicit stakeholder input prior to and during model development whenever practical. Your suggestions regarding the naturally occurring vegetation communities are noted and will be considered during future TMDL evaluations.

MCA 75-5-704(4) states that, "Prior to and during the development of a TMDL within a particular watershed or basin, the department shall schedule a meeting or meetings with appropriate local conservation districts and watershed advisory groups at a location within the affected geographic area in order to solicit comments on developing the TMDL and information on sources that may be contributing to water quality impairment."

Two watershed advisory group meetings were held prior to and during the development of the TMDLs for the Thompson TMDL Project Area. The first meeting was held in Plains, MT on July 16th, 2013. During this meeting, the TMDL approach for sediment, metals, and temperature was presented to stakeholders to solicit input on TMDL development. At that meeting, concern was expressed for temperature TMDL development on McGregor Creek in regards to the effect of dam operations on water temperatures. Based on this, further research was conducted regarding the dam at the headwaters of McGregor Creek, and this was addressed in the McGregor Creek Modeling Report (Attachment E). Draft TMDL document sections and modeling reports were made available to stakeholders on the DEQ TMDL website throughout the TMDL development process. A second meeting was held on May 22, 2014 in Plains, MT to present the draft TMDLs for stakeholder input prior to the start of the public comment period.

During the development of the temperature model, DEQ used shade and vegetation data collected by Atkins, Tetra Tech, and DEQ staff during field visits on July 14-15 and September 12-13, 2011, as well as September 10, 2012 to determine the existing shade and vegetation conditions on McGregor Creek and Lynch Creek. Best professional judgment was used to estimate the appropriate potential vegetation communities at these sites to be used in temperature model development.

Based on the evidence available at the time of temperature model development, DEQ determined that modeling the naturally occurring condition as a 50 foot riparian buffer of medium density trees with the exception of hydrophytic shrubs, roads, and road right-of-ways seemed appropriate for Lynch Creek and McGregor Creek. This naturally occurring condition also mirrors the Montana Streamside Management Zone (SMZ) law, passed in 1991, which prohibits the harvest of timber within a 50 foot buffer of streams, and represents the application of all reasonable land, soil, and water conservation practices.

DEQ does agree with your statement that a 50 foot buffer of medium density trees may not be attainable in all areas along the stream due to natural variability of the stream corridor, but due to the coarseness of the analysis and uncertainties in the model, DEQ did not have the resources to delineate all of these areas at the time of model development. Although medium density trees may not be the naturally occurring condition right along the stream's edge in some areas, large trees that are offset from the stream can still provide significant shading during certain times of the day. If a 50 foot buffer of medium density trees is not attainable on sections of these streams, with all reasonable land, soil, and water conservation practices in place, future evaluation of the TMDLs may involve readjustment of the temperature model to account for these areas where a 50 foot buffer of medium density trees is not feasible.

Thank you for your input on this matter; the following sections have been updated in the document:

- **Section 7.4.2.2** describes the development of the shade scenario for the temperature model, and language has been updated in **Tables 7-1** and **7-6** to better describe the shade scenario in the model.
- The language in the fourth paragraph in S**ection 7.9** has also been updated to better describe some of the uncertainties involved in using a temperature model to estimate the natural background condition, and using the adaptive management process to potentially re-evaluate TMDL targets in the future.

Comment 7

Section 7.9. In the Third paragraph on Page 7-31, there is a sentence that states "*The target for effective shade from riparian vegetation is intended to represent the reference condition and is based on field observations, communication with stakeholders, and best professional judgment*." I am not aware of any communication with stakeholders on development of shade scenarios. Upon review of the temperature modeling technical report, I was told that the report had been finalized and there was no opportunity for modification. Unless DEQ and EPA have documentation otherwise, this statement that stakeholders were involved must be struck. I also request that this section be revised to state that DEQ and EPA did not solicit input from stakeholders on development of these shade scenarios and that because of this there is serious question about the validity of the temperature TMDLs.

Response 7

See response to the above comment regarding stakeholder involvement. The above referenced sentence on page 7-31 sentence has been modified to read "The target for effective shade from riparian vegetation is intended to represent the reference condition and is based on field observations and best professional judgment." DEQ will make efforts in future TMDL development to solicit stakeholder input prior to and during model development whenever practical.

Comment 8

The Natural Background Loading defined in Section 8.5.3 of the Draft TMDL Report does not reflect the water quality of Sullivan Creek prior to influences from human-caused sources. The outcropping sulfide mineralization in the Sullivan Creek basin is a natural geological condition that is a key factor determining water quality. Section 8.5.3 recognizes this condition in stating that "The Sullivan Creek watershed has distinct volcanic geology that is different from the other watersheds in the Thompson Project Area", however the report goes on to conclude that "The median values for the Thompson Project Area in Table 8-4 are used to calculate the load allocations to natural background sources of metals loading in the Sullivan Creek watershed". PAS submitted water quality monitoring data for monitoring point HSW-15 which is located in the Sullivan Creek watershed headwaters, upstream of any mining disturbance. The Draft TMDL Report correctly recognizes that HSW-15 is upgradient of the Hog Heaven project on page 8-9. Water at HSW-15 was also sampled jointly by DEQ and PAS in May 2014 (see attached inspection report and both PAS and DEQ water quality analysis results). All monitoring results from HSW-15, including PAS and DEQ, show low pH levels (between 3.3 and 5.9, DEQ's sample read pH 4.5) and elevated metals concentrations (DEQ's sample read 12.7 ug/L Cadmium, 9.0 ug/L Copper, and 5,090.0 ug/L Zinc) that are orders of magnitude higher than the Natural Background concentrations adopted in the Draft TMDL Report in Table 8-4. PAS asserts that the water quality at HSW-15 is representative of the Natural Background Loading of the headwaters of Sullivan Creek and considers that the historical and recent water monitoring data for this location should be included in the draft TMDL report analysis and conclusions.

Response 8

DEQ acknowledges that determining background water quality in Sullivan Creek has proven to be difficult. The high metals concentrations that occur in the Sullivan Creek watershed may be a result of the localized geology. That being said, there was limited quality data that could be considered representative of background water quality. As a result DEQ employed a commonly used and scientifically acceptable method of determining background in the TMDL document. This was the use of water quality data from similar watersheds in the immediate area.

DEQ and PAS conducted a site visit of the Hog Heaven mine on May 23, 2014 to discuss potential locations to sample surface waters around the mine site to determine background water quality. During the site visit it was agreed that 4 sites would be sampled. It was agreed that these sites would be used as representative sources of background water quality for the Hog Heaven mine. Both DEQ and PAS collected samples on this date. The DEQ and PAS sample results are provided below. Water quality results for the samples collected by PAS and DEQ were all within the same range of metals concentration.

Metal	HSW-15		HSW-3		HSW-12		HSW-14		Median
	DEQ	PAS	DEQ	PAS	DEQ	PAS	DEQ	PAS	
Aluminum Dissolved, ug/L	-	1250	-	15*	-	60	-	210	210
Cadmium, ug/L	12.7	14	0.015*	0.5*	0.015*	0.5*	0.015*	0.5*	13.35
Copper, ug/L	9	6	1*	2.5*	2	2.5*	5	2.5*	5.5
Zinc, ug/L	5090	4910	33	50	4*	10	16	10	33

*= Sample ware reported as Non-detect. When this occurred a value of one half the detection limit was substituted.
No Dissolved aluminum samples were collected by DEQ

Data from HSW-3, HSW-12 and HSW-14 collected on the same May 2014 sampling date shows lower levels of all metals than at the HSW-15 site. In most cases, the data from these sites are orders of magnitude lower than the sample collected at HSW-15. The median aluminum, cadmium, copper and zinc concentrations described in this comment (10 f) and **Section 8.5.3** of the TMDL document (median concentrations from similar watershed) are consistent with those concentration sampled on site by DEQ and PAS (see table above). DEQ does not agree that basing background concentrations in Sullivan Creek on HSW-15 is a good estimate of background conditions. The HSW-15 sampling site is a ground water seep that is routinely inundated by livestock, and generally does not have a measureable surface flow. Additional language was added to the third paragraph of Section 8.5.2 that describes the physical characteristics of HSW-15, why the data from this site was used in the TMDL document.

DEQ has determined that the limited data does not allow for the differentiation between metals loading by mining sources and metals loading from background sources. Given the uncertainty in determining background water quality, DEQ will adjust the allocations in **Section 8.6.2** of the TMDL document. Instead of allocating an individual load allocation to background sources and an individual waste load allocation to mining sources, DEQ will composite the waste load allocation for mining sources and the load allocation for natural background to a single waste load allocation for natural background and mining sources.

Comment 9

Correction of the Natural Background Loading will require changes to the proposed metals TMDL and conclusions in section 8.6.1 and Table 8-5 of the draft report.

Response 9

TMDLs are based on the water quality standards, the flow volume of a particular water body and a conversion factor. The TMDL is not derived from background water quality data. DEQ cannot change a TMDL based on discrepancies in water quality data that may or may not be characteristic of background. Therefore the revised sources assessment has no effect on the TMDL. However the allocations that comprise the TMDL have been modified. See responses to comment #8, and **Section 8.6.2** of the TMDL document.

Comment 10

PAS objects to the following statements in the report which are not supported by water quality monitoring data:

a. Page 8-4 "Due to the extent of historic mining in the study area, there is a high degree of confidence that the low pH values and high aluminum concentrations can be attributed to a common cause: acid mine drainage."

Response 10a

Historical mining activities have taken place in the Sullivan Creek watershed. It is unclear if low pH conditions and high aluminum concentrations are a direct result of historical mining operations, however it is also unclear if they are not the cause. It is known that acid mine drainage can cause low pH values. Low pH values in a water body will effect how metals behave in an aquatic environment. Land disturbance associated with historical mining is a likely cause of the high aluminum concentrations. The above statement has been changed to read as follows:

"Due to the extent of historic mining in the study area, it is likely that the low pH values and high aluminum concentrations are attributed to acid mine drainage and land disturbances associated with historical mining activity."

Page 8-8 "The major source of metals identified in the Sullivan Creek watershed is mining."

Response 10b

Comment noted and changed to read as follows:

"The metals sources in the Sullivan Creek watershed include historical mining and natural background. Historical mining likely contributes the majority of metals loading. Both sources of metals loading are discussed in the following sections."

b. Page 8-8 "Water quality data for three surface water sites and two wells on the Hog Heaven site were provided by Pan American Silver. Note that the surface water site are not in Sullivan Creek, but from surface water on the Hog Heaven property." This is incorrect since sites HSW-15, HSW-1, and HSW-2 are on Sullivan Creek.

Response 10c

The text in the TMDL document has been changed to read as follows.

"It is important to note that HSW-15 is a ground water seep that is routinely inundated by livestock and generally does not have any measurable surface water flow. Data from HSW-15 were used as there was limited onsite data that were available to represent background water quality. HSW-15 was the only onsite sample location that was up gradient of any obvious legacy mining in the watershed. HSW-1, HSW-2 and HSW-15 are in the Sullivan Creek watershed, however they do not originate from surface water on the Hog Heaven property."

The language in this response also addresses comment #8.

c. Page 8-9 "The low pH values and elevated metals concentrations indicate that Hog Heaven is a probable source"

Response 10d

This sentence was deleted. DEQ has revised the last two paragraphs on **page 8-8** and **8-9** in **Section 8.8.2** as a result of the omission of the above sentence.

d. Page 8-12 "Therefore, all abandoned and active mines in the watershed are considered to be sources of metals to the creek."

Response 10e

The discussion prior to this sentence discussed the water quality data from DEQ monitoring sites C12SLVNC02 and C12SULLC02 and concludes that "The water quality data do not provide much insight on whether a specific mine is causing the metals impairment because only two stations have metals data and both stations are located downstream from most of the mines".

The sentence in question was therefore changed to read as follows:

"Therefore, abandoned and active mines in the watershed are considered to be potential sources of metals loading to Sullivan Creek".

e. Page 8-12 "The median aluminum, cadmium, copper, and zinc concentrations at low flow at 24 stations in the Project Area were assumed to represent background metals concentrations in Sullivan Creek"

Response 10f

The median aluminum, cadmium, copper and zinc concentrations described in this comment (F) and **Section 8.5.3** of the TMDL document (median concentrations from similar watershed) are consistent with those concentration sampled on site by DEQ and PAS. Onsite monitoring results are described in the response to comment # 8.

Section 8.5.3 Paragraph three will be changed to read as follows:

"Due to the lack of reference watersheds with similar geology, metals data in the non-impaired watersheds of the Thompson Project Area were used to estimate background. The median values for aluminum, cadmium, copper, and zinc concentrations for low flows at 24 stations in the project area were used for the purpose of estimation".

f. Page 8-1 Section 8.6.2 "The Hog Heaven mine is the largest metals source in the Sullivan Creek watershed."

Response 10g

A significant portion of the discussion in **Section 8.6.2** regarding allocations of metals has been reworded.

The waste load allocations to mining sources and the load allocation to natural background have been composited. Comment "10g" was changed, and remains in the discussion. The sentence was changed to read as follows: "The Hog Heaven mine is the largest of the historical mines in the Sullivan Creek watershed that contains large areas of disturbed ground and exposed mine tailings. Exposed ground and mine tailings are a potential source of metals loading to Sullivan Creek through leaching and stormwater runoff".

g. Page 8-1 Section 8.6.2 "Although Hog Heaven appears to be the largest metals source in the watershed, there is currently no way to calculate a specific metals load from the site to provide as a WLA"

Response 10h
This statement has been deleted. See the response to comment "10g".

Comment 11
It should be noted that PAS historical database samples for Aluminum were sampled and analyzed as Total Aluminum, rather than Dissolved Aluminum. This historical data cannot therefore be used to define natural background loading, however Dissolved Aluminum was analyzed in PAS sampling in May 2014 and the results are attached.

Response 11
The aluminum standard is based on the dissolved fraction of the collected sample. As such, DEQ requested PAS to collect dissolved aluminum samples in future monitoring efforts during the May 2014 site visit, and confirmed this with subsequent e-mails. The waste load allocation for mining sources and back ground sources will be composited; as such the individual values for aluminum are not needed to calculate individual loads.

Comment 12
PAS is committed to continuing to improve the quality and amount of data that can be used to accurately determine the Natural Background Loading in the Sullivan Creek Watershed. We suggest that the TMDL be adjusted according to the background concentrations measured at HSW-15 and proposed as an "interim" TMDL pending collection of further monitoring data in a joint effort between PAS and DEQ.

Response 12
All TMDLs written by DEQ must be written to the water quality standard. See response to comment # 9. DEQ cannot develop interim TMDLs. Implementation of the TMDL may be done in steps, this would allow PAS to collect additional data to determine background water quality, employ best management practices (BMPs), assess and evaluate different methods of TMDL implementation, and effectiveness of implementation. DEQ would also strongly suggest PAS consider those actions DEQ has recommended in the Cooke City TMDL Implementation Evaluation (Montana Department of Environmental Quality, 2011a). These include, but are not limited to monitoring to evaluate target/standards attainment (both short-term and long-term), monitoring to ensure continued functionality of implemented restoration practices and monitoring to identify and characterize any unknown or previously unevaluated pollutant sources.

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